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A Survey: Face Recognition Techniques

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Abstract: In this study, the existing techniques of face recognition are to be encountered along with their pros and cons to conduct a brief survey. The most general methods include Eigenface (Eigenfeatures), Hidden Markov Model (HMM), geometric based and template matching approaches. This survey actually performs analysis on these approaches in order to constitute face representations which will be discussed as under. In the second phase of the survey, factors affecting the recognition rates and processes are also discussed along with the solutions provided by different authors.

Keywords: Face, recognition, review, pros and cons

INTRODUCTION

In computer vision tasks face recognition systems have gained immense significance ever since security concern has reached its peaks. For such systems Artificial Intelligence (AI) plays a pivotal role in recognition and authentication tasks. Human beings have an inherit capability of easily identifying a person by the use of memory but computer systems lack memory issues. It can be made to remember things via artificially inducing codes and features and through learning mechanisms named as supervised learning and unsupervised learning. But this learning can be successfully applied only if images of individuals are given in controlled conditions i.e., static background, neutral frontal face etc. but recognition becomes difficult when uncontrolled condition occurs. Uncontrolled condition may arise due to facial expression changes, head orientations, partial occlusions and varying lighting conditions etc. In such situation feature extraction and classification becomes critical task for computer vision applications. For this, methods like PCA (Sirovich and Kirby, 1987), LDA (Zhao and Yuen, 2008), neural networks (Lawrence *et al*., 1997) and several variations of them are used but each one has its limitations. Although successful in many applications, they do not show fine performance when the face image is partially occluded. Since they are linear in nature they do not work well in non-linear cases. Several non-linear methods namely Kernel-machine-based Discriminate Analysis (KDA) (Chen *et al*., 2005), neural networks (Lawrence *et al*., 1997), Flexible Discriminate Analysis (FDA) (Hastie *et al*., 1994) and Generalized Discriminate Analysis (GDA) (Baudat *et al*., 2000) are used. But a major drawback of these methods is that they have a high computational cost in terms of training and testing the data.

In this study, a survey is conducted to analyze the face recognition techniques and timeline view on different methods to handle general face recognition problems. The more important factors affecting the recognition rates like expression, occlusion, pose variation and Illumination are also discussed along with the solutions provided by different authors.

OVERVIEW OF FACE RECOGNITION METHODS

In this section comparison is done among various face recognition methods including Eigenfaces (Eigenfeatures), Hidden Markov Model (HMM), geometric based and template matching algorithms. These algorithms are evaluated on the basis of their performance by comparing their results. After evaluating the family of face recognition techniques, the issues arising in recognition process are investigated.

Eigenfaces: The Eigenfaces methods so called Eigenvector or Principal Component Analysis (PCA) methods are the general methods of face recognition. Sirovich and Kirby (1987) and Kirby and Sirovich (1990) exploit PCA to effectively characterize geometry of faces. According to him, face can be easily reconstructed by only considering small amount of information that can be obtained using Eigenfaces. Turk and Pentland (1991)

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motivated from Kirby and Sirovich and makes use of Eigenfaces for face detection.

Mathematically, Eigenfaces are the principal components that actually divide the face into feature vectors. The feature vector information is obtained from covariance matrix. These Eigenvectors are used to quantify the variation among multiple faces. The faces are characterized by the linear combination of highest Eigenvalues. The M Eigenfaces represent M dimensional face space. Here the researcher showed 96, 85 and 64% right categorization under varying lighting condition respectively, orientation and size by exploiting 2500 images of 16 each. The low face recognition rate is due to the silhouti background just at the back of the face. Similarly (Grudin, 1997) reveals that correlation of entire face does not show reasonable results. However, illumination normalization is essential to deal with Eigenfaces (Kirby and Sirovich, 1990).

Reference (Zhao and Yang, 1999) introduces a new technique to find out the covariance matrix by taking three images of different lighting conditions for Lambertian object. Pentland *et al*. (1994) used Eigenfeatures like eyes, nose, mouth, cheeks etc. instead of Eigenfaces. This approach is less sensitive as compared to the Eigenface method. In this case the system attains 95% recognition rate on 7562 FERET images of 3000 per person. In short, Eigenface approach is most reliable, fast and efficient that endows invariance information also in the presence of varying lighting and scaling conditions.

In Chang *et al*. (2003) showed that the standard principal component method provides the same recognition results for ear as well as for face images and can also be combined for multimodal enhanced recognition outcomes. This can be revealed from the results obtained that are 90.9% for multimodal biometric, 71.6% for ear and 70.5% for face images over 197 images. Hong and Jain (1998) exploits face and fingerprint for biometric identification. Similarly (Verlinde *et al*., 1998) uses face and voice. Consequently, ear and face are the most reliable and efficient approach. Nicholl and Amira (2008) finds out the most discriminative coefficient vector of between and within class on the basis of DWT/PCA based face recognition system. In Poon *et al*. (2009), the authors analyze multiple face recognition rates on different databases by taking the results in different ways i.e., by varying training set and test set, varying size of the images, varying noise on the image and by varying blurring effect on faces. Karim *et al*. (2010) performs comparison analysis between different face recognition methods like Sum of Absolute Difference (SAD), Sum of Squared Difference (SSD) and Normalized Cross Correlation (NCC) with PCA and finds more satisfactory results using PCA. Recently in Kshirsagar *et al*. (2011), a new approach of face recognition is used in which the information theory of coding and decoding face is used for the same purpose. Here the features are discriminating using PCA while recognition is done using back propagation neural network.

In recent developments, Shermina (2011) presented a face recognition technique which is based on Multi linear principal component analysis and locality preserving projection to improve the performance of face recognition system. Shermina used MPCA for facial image preprocessing and LPP for extraction of facial features. Experimental results reveal good facial recognition accuracy. Also as compared to other methods like MPCA and LDA, the presented approach has improved performance rate. In Zhengya *et al*. (2011) a feature based scheme for fast face recognition is presented. The technique comprises of shape feature based reference control, facial feature extraction technique and method to compute the difference between two faces using extracted set of features. Along with countering face recognition problems as expression, pose and illumination, the presented approach is robust with high performance factor for face recognition systems. In real time object detection environment, the feature selection methods can also be used to train effective object detector (Chunhua *et al*., 2011). To cope with efficient training of object detector and improving computational efficiency, the author in Chunhua *et al*. (2011) presented an approach based on Eigen vectors. Experimental results reveal high detection rate in real time face recognition environments. Similarly in Deva and Simon (2011) Deva Ramanan highlights the taxonomy and evaluation of modern algorithms which assist local distance function for calculating tensor matrix.

Neural networks: Neural Networks is another approach used for face recognition. It is more reliable as compared to linear methods like Karhunen-Loeve technique. Artificial Neural Network (ANN) is a very first method that is used with single layer adaptive network (WISARD) (Stonham, 1984). The face recognition using ANN depends on the intended applications. Multilayer perceptron (Sung *et al*., 1995) and convolution neural network (Sung *et al*., 1995) are used for face detection. In Sung *et al*. (1995) the authors propose the combined different methods of Neural Network. The convolutional network projects large amount of features on subspace. The correct recognition rate corresponds to 96.2% on ORL database on 400 images with 40 images per person or subject.

As far as speed of the system is concerned, the feature extraction time is approximately 0.5 sec while it takes 4 h for training data set. Lin *et al*. (1997) innate the modular geometry based PDBNN (Kung and Taur, 1995). The PDBNN is basically used three fold i.e., for face detection, eyes detection and face recognition. It actually categorizes the network into K subnets used to identify a

single person in a database. The face subnet calculates the probability with Guassian model. Comparatively, Guassian materials endow changeable and complicated model for probability calculation.

The learning strategy of PDNN performs in two step process. In the first step, all the subnets are trained from their own images while in the second step, the subnets are trained on decision basis with different samples. For second step, the limited training samples of misclassified patterns are used. Neural Networks and statistical methods are optional approaches for PDBNN while distributed computed principle is practical approach for parallel computers. In Lin *et al*. (1997) it is observed that the recognition rate for PDBNN is 96% in real time for limited persons. Nevertheless, the recognition rate goes down for large data set due to the increased computational cost.

In Jie *et al*. (2008) the unusual partial occlusion is handled using probabilistic based decision neural networks. It actually works in such a way that it processes only the matching features. Pazoki and Farokhi (2010) commenced a new idea related to Correspondence Analysis (CA) for feature extraction and exploits these feature vectors into multilayer perceptron as well as trained artificial neural network with 98% accuracy rate. In (Raja and JosephRaj, 2010) the author uses Self Organizing Maps (SOM) in order to recognize faces and does verification and identification on the basis of ear and hand geometry etc. The result of proposed RJSOM method is taken on different databases and concludes that it is more reliable and efficient approach. Sudha *et al*. (2011) proposed a new method of neural network based principal component analysis for face recognition process. The result is taken on FRGC and Yale databases for checking the performance of the proposed system based on Hebbian learning and achieves 85% recognition rate. Its primary contribution is to develop the fine grained systolized Signal Flow Graphs (SFGs). In Yee *et al*. (2011) the problem encountered during face recognition when new data is added and required learning for recognition purpose is handled using Radial Basis Function (RBF) with Regularized Orthogonal Least Square (ROLS) based learning process. The retraining of the new data is not necessary during face recognition which actually releases the extra computational cost. Consequently, from the above research it is stated that neural networks are not good for large data set and not an ideal approach for single face image recognition.

Graph matching: Another method for face recognition is the graph matching approach. Lades *et al*. (1993) performs recognition on the basis of stored graph matching algorithms. These are the dynamic graphs that are used to build the decision based neural networks. The feature vectors are represented onto the vertices while the dynamic edges constitute the geometrical distance vector. For recognition the matching criterion of stored graph are specified which is done under some computational cost. The experimental results show that it works well for the limited data set, say 87 to 100 individuals with varying expression and with 15 degree rotated images.

These graph approaches are not ideal for real time environment where it takes too much time for matching stored graphs. The results are taken on different databases and show that it takes about 25 sec to match 87 stored objects. In Wiskott and von der (1996) exploits 112 stored images and used for graph matching. The results are affected due to varied facial expressions that are also in depth rotation. Although it takes processing time but also produced reasonable results that meet the recognition process of about 86.5 and 66.4% for matching 111 images of 15 degree rotated images. Consequently, it is stated that geometrical based graph matching is computationally expensive approach.

In Ho-Chul *et al*. (2007) suggested a new idea that is an amalgamation of elastic bunch graph and discriminative feature analysis. The faces under varying pose and expression are selected in order to take the experimental results. The Gabor based Fourier transform of cost function is used for the same process. Here an important thing is that it also solves the most important problem of discriminate analysis called Small Sample Size problem while handling the error rate. The result is taken on FERET face database and attains high performance as compared to other approaches. In the reference (Zafeiriou and Pitas, 2008), the facial expressions are matched with the gallery image using the matching criterion of elastic graph matching. In this case only the most discriminative features are specified for recognition. Additionally, kernel based technique is used for feature extraction. In Kisku *et al*. (2009), the author stated that multiple biometrics performance is based on the material that is matched or unmatched with the target image. In this research, the researcher uses the image fusion convention based on wavelet decomposition while features are extracted using SIFT operator termed as SIFT features. The experimental result shows that the proposed system highly performs feature level fusion.

With the advent importance of face recognition, the recognition of objects is trying to perform in real time environment (Pervaiz *et al*., 2010). In this study, the system is introduced with the robust recognition rate under varying illumination and expression. At last, face graph matching is used to recognize the faces with the reference image.

HIDDEN MARKOV MODELS (HMMs)

Inactive Stochastic modeling that depends on HMM is an ideal approach for speech applications.(Samaria and

Fallside (1993) uses the same approach to identify the human face while categorizing the intuitive face into number of features like eyes, nose, mouth, etc. Given that, HMMs need a series of experimental 1D and 2D images; images should be transformed to either a chronological sequence of 1D or 1D spatial.

In Samaria and Harter (1994) a series of interpretation was obtained from a group of facial image pixels using spatial sampling technique. All facial image pixels are constituted by 1D vector series. Each examined vector is represented in the form of block containing L Lines which is comprised of M lines. An examined sequence of an unidentified test image is sampled for the first time. Then it matches with the gallery images stored in the database. Probably the best match is considered to be high and the model exposes the identity of test face. Castellani *et al*. (2008) introduced a new method that works on 3D meshes and operates only to the discriminant features of face using dynamic HMM. At the end, the author exposes from the recognition rate that the system works well under varying facial expressions and also good for real time environment.

A brief analysis is conducted by Sun *et al*. (2010) on different facial patterns via adaptive 3D face model series. The role of tracking model based method is usually used to accommodate the lack of feature vector. Similarly, spatial temporal face model descriptor is used in order to evaluate the system. One of the major drawbacks of HMM is that it is sensitive to geometrical shape. In order to cope with such problem, a confirmation based Hidden Markov Model is appreciated while the experimental results reveal that the proposed model is highly preferable as compared to traditional HMMs and various standards based HMM models.

Geometrical feature matching: Geometric feature matching technique is based on the computation of a group of photos from the face geometry.

The hidden truth is that it probably identifies a face even in the improper resolution as low as 8×6 pixels (Tamura *et al*., 1996) when the facial features exposed barely one in the details which means that the general geometric configuration of facial features is enough to recognize. Representative of overall configuration can be described as the key facial features like eyes and eyebrows, nose, etc.

Literature (Bruneli and Poggio, 1993) operates on the discriminant features and a series of geometric features such as jaw shape. Thirty five extracted facial features form 35 dimensional vectors which are further used for recognition using a Bayes classifier and produce outperformed recognition rate of 90% tested on 47 different individuals. In Manjunath *et al*. (1992) makes an attempt to minimize the log space by already calculating the control feature points for all images using Gabor wavelet decomposition. In general, the average 45-35 feature points were produced. Topological feature points during the process of matching present information in a graphical format. After correcting a different center of gravity, the cost of the two phases were evaluated. It achieved the accuracy of about 86 to 94% that best matches the persons stored in database. In short, the functional geometric matching based on distance measured accurately during feature points may be the most valuable for calculating likely matches in huge databases such as mug shot database. Nevertheless, this will be reliant on the function of positioning accuracy of the algorithm. Present automatic facial feature location algorithm does not offer high accuracy and takes a lot of totaling time.

In recent developments, in Basavaraj and Nagaraj (2006) proposed a geometrical model for facial feature extraction. The basic process involves improvement of frontal face images including ears and chin and also of potential features because it enhances the development of methods in face recognition process. The face model proposed by the ability to identify is divided into four steps. The starting step is pre-processing. The main ambition of this step is to eliminate the noise and the input image is converted into a binary one. The second step contains labeling of facial features and then finding the origin of these labeled features. Finally, it calculates the estimated distance used for matching purpose. In Khalid *et al*. (2008) the author makes an effort to reduce the search space by minimizing the facial features information. The information is limited by extracting 60 fiducially control points of face with varying light and expression images. The functional classification of these features is large-scale point of distance and angle measurement. Matching criterion finds 86% recognition rate. In Mahoor and Abdel-Mottaleb (2008) 2D and 3D multimodal are introduced which comprise of 3D ridge lines on the face and used for face recognition. For matching purpose, principal curvature is used to locate these lines. This method actually reduces the computational cost. In Huiyu and Sadka (2011) the diffusion distance over the calculation of face images is produced. These images describe the shape of Gabor filters which includes the size and extent. Gabor filter results for the discriminatory image are used to distinguish between face representations in the database. In Zhen *et al*. (2011) presented a recognition approach based on facial geometry. In this approach, first the face image is decomposed into multiple facial geometrical domains such as image space and image orientation at different scale. Secondly LBP is calculated. The presented approach provides good face representation by exploring facial information from different domains which ultimately gives efficient face recognition systems. Similarly in Pavan *et al*. (2011) presented a geometry

based face recognition method which makes use of subspace based models. These models provide geometrical properties of the face space which can assist efficient recognition system for number of image applications.

Template matching: In template matching, we can exploit other face templates from different prospects in order to characterize single face. Primarily, grey levels that match the face image can also be processed in proper format (Bichsel, 1991). In Bruneli and Poggio (1993) the Pop and Bruneli is available for all aspects of developing automatic four template features i.e., eyes, nose, mouth, face and selecting the entire set. The system is evaluated by comparing results from geometrical based algorithms on 188 images of 47 subjects. The pattern matching algorithm is a very practical approach, very simple to use and approximately achieves 100% recognition rate. The Principal Component Analysis using Eigenface provides the linear arrangement of templates. The main advantage of this approach is that it is easy to implement and is less expensive than any other feature classifier. Comparatively, template based algorithms are more expensive and cannot be easily processed. However, the recognition process is easily handled between the given template and input image. The complexity arises only during the extraction of template.

Generally template based techniques outperform as compared to feature based methods. In short, every algorithm has some disadvantages as well.

In recent development, (Karungaru *et al*., 2004) uses template based genetic algorithm and exposes different results on target image by adjusting the size of the template as preprocessing. The edge detection and YIQ color templates are exploited. The results are taken around the distance measure face recognition approach and comparison is performed with existing methods. In Anlong *et al*. (2005) the author works on the grid to construct reliable and proper infrastructure. This method is highly effective for larger databases that solve the problem of face recognition under reasonable computational cost. In Sao and Yegnanarayana (2007) an algorithm is proposed for person verification using template based face recognition method. Primarily, the edginess based face representation is calculated to process one dimensional images. The system is somehow associated with Neural Networks to test the images under varying pose and illumination conditions. Similarly in Wang and Yang (2008) a face detection algorithm is proposed rather than face recognition algorithm as preprocessing steps. Now the advantage is taken from template based algorithm for face detection by constructing a general frame work for hierarchical face detection. The features are extracted using PCA from 2D images. At the end, it concludes that it is good to use template algorithms for face detection because it gives highest recognition rate. Similarly in Levada *et al*. (2008) Dynamic Time Warping (DTW) and Long Short Term Memory (LSTM) are investigated under the Neural Network classification in which a single feature template is large enough for feature extraction. It actually implements the gradient based learning algorithm by handling associated gradient problems. The experimental result reveals that both methods perform well for face recognition while the learning strategy gives robust recognition rate.

The working of this approach is summed up by saying that further improvements are still required in order to solve the recognition problem that seems to be very common in real world.

3D morphable model: Construction, shape and texture of any example of a convex combination of vector describe a real face (Vetter and Poggio, 1997). Accessories of 3D image deformation model can be identified in two ways in different screening environment. Model 1: A Model accessory confirms that the model can be based on the coefficient representing the shape and texture inherent in the face and independent of imaging conditions (Georghiades *et al*., 2001; Zhao and Chellappa, 2000). Currently, (Zhao and Chellappa, 2000) amalgamates 3D Morphable model with computer aided system. As a single image, the algorithm repeatedly calculates three-dimensional shape, texture and all relevant consideration of three-dimensional scene. Lambertian reflection is limited to lighting, specular reflections and shadows having a significant impact on the appearance of human skin that should not be considered into account.

This method is based on three-dimensional facial deformation model to confine the exact properties of faces that can be routinely learned from the data set. Deformable model actually constitutes geometry and texture of the face and includes probability density function as face space.

In recent development, in Bustard and Nixon (2010) uses ear identification as a biometric. Everyone has a unique ear pattern. In this paper, the author focuses on 3D Morphable model for head and ear. In (Shu-Fan and Shang-Hong, 2011) facial expressions are handled using the same approach of Morphable model in order to produce and synthesize animation. For this the author introduced a model of Weighted Feature Map. The experimental result reveals high performance and robustness of the system against existing methods. In Unsang *et al*. (2010) the 3D aging model is presented to overcome facial aging problem. Experimental results reveal improved performance for face recognition systems with tackling facial aging problem. Similarly in Utsav *et al*. (2011), presented a face recognition system based on 3D generic elastic model for tackling the problem of

pose variation during recognition of face. The presented 3D model comprises a database of 2D pose views which are further adjusted for matching process. Experimental results reveal high recognition accuracy under controlled as well as uncontrolled real-world scenarios.

Similarly Muhammad *et al*. (2011) represents the 3D face recognition method using horizontal and vertical stripes.

MODERN TECHNIQUES

To make a grip on lighting factors appeared on the images, edge detection is a good approach to shape the facial features that can be hidden due to unusual lighting conditions. The Line Edge Map algorithms are not used for pattern recognition but widely used to handle the lighting factors. The edge images are mostly used during object recognition and confer equivalent results as obtained after preprocessing the image. Takács (1998) finds out similarity measures using edge maps and attains 92% accuracy. Some authors' used line edges to extract the shape of facial features. This approach can be used with template matching and geometrical algorithms. It actually works in such a way that jumbles the sequence of pixels in one line and constitutes geometrical information (purdue Univ. Face Database, 2002). It is a pattern recognition learning technique used for face recognition. It endows additional accuracy although it does not require some extra information. It can classify same features in one class and different in another class by calculating the hyper plane on the vector space. The SVM approach is good to classify medium size facial features (Manikandan and Venkataramani, 2011). Guo *et al*. (2000) exposes binary tree recognition policy to handle face recognition problem and adopts SVM classifier for feature extraction. Deniz *et al*. (2003) mingles Principal Component Analysis (PCA) with Independent Component Analysis (ICA) using similar properties. In order to catch accurate and perfect results, MCSs group together multiple outputs obtained from different classifiers. Usually, this approach is used in pattern recognition in such a way that it chooses the mature output from multiple classifiers and is used for face recognition. Tackling the problem of pose variation, in Antitza and Dugelay (2011) presented an approach for face recognition in video. The approach is based on multimodal soft biometric traits specifically those taken from patches of hair, skin and clothes. Another technique for real-time face recognition using skin is presented in Muhammad *et al*. (2011a); the proposed method made use of skin detection (in RGB color space) and block approach.

Similarly to handle pose variation problem in face recognition, presented an approach in Ritwik Kumar et Barmpoutis *et al*. (2011); the technique is based on Lambertion-Tensor-Spline frame work. Using such framework the BRDF field can be estimated accurately as well as the same model can be used for the recovery of 3D shape of face with LBP information. Experimental results reveal efficiency in face recognition and face recovery. To speed up the process of recognition in Muhammad *et al*. (2011b), a face recognition technique uses nose heuristics. Similarly in order to overcome the problem of occlusion and facial corruption, presented an approach for face recognition in Ran *et al*. (2011). In this approach particularly nonnegative constraints are imposed in maximum correntropy criterion to obtain the approximate maximized objective function to handle the problem of occlusion and corruption in face recognition systems efficiently. The presented method is compared with existing state of the art methods and ensures comparatively high robustness and efficiency. Similarly in Joe *et al*. (2011) an accurate face recognition system is demonstrated using face recognition engines and online social network's photos. Although the system is capable of ensuring high accuracy rate but only for those faces which are available on any online social network data.

Adding to the modern hybrid techniques for face recognition, a face identification method is presented in Muhammad *et al*. (2011c). In Muhammad *et al*. (2012) another hybrid face recognition technique is presented which is based on Laplacian of Gaussian (LOG) and Discrete Cosine Transform (DCT). The proposed concept highlights a major concerned area of face recognition i.e., single image per person problem where the availability of images is limited to one at training side. To address the problem, the author used filtration and transforms property of LOG and DCT to recognize faces. As opposed to conventional methods, the proposed idea works at pre-processing stage by filtering images up to four levels and then using the filtered image as an input to DCT for feature extraction using mid frequency values of image. Then, covariance matrix is computed from mean of DCT and Principal component analysis is performed. Finally, distinct feature vector of each image is computed using top Eigenvectors in conjunction with two LOG and DCT images. The experimental comparison for LOG (DCT) was conducted on different standard data sets like ORL, Yale, PIE and MSRA which shows that the proposed technique provides better recognition accuracy than the previous conventional methods of single image per person i.e., (PC) 2A and PCA, 2DPCA, B-2DPCA etc. Similarly in Muhammad *et al*. (2011d,e), face recognition techniques used are Gabor feature extraction and Gabor filter.

Factors affecting face recognition: Though aforementioned techniques solve the face recognition problem but there are some other issues that actually degrade the performance of face recognition. These issues actually rise in real life because in real situation the person's face is not always neutral (not expressionless).

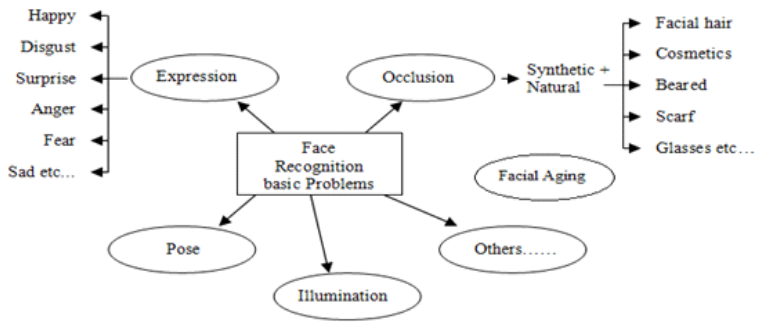

Fig. 1: Factors affecting face recognition

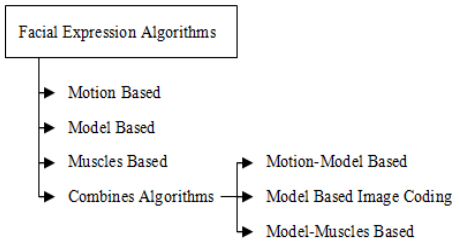

Fig. 2: Facial expressions algorithms

Other face recognition issues occur due to varied pose, expression, lighting conditions on the image and occluded objects etc. as shown in Fig. 1.

Facial expression: Facial expression poses a nonlinear structure in face recognition tasks. By nature every person has expressions on his/her face used for non verbal communication. Facial expression causes a change in both transient and intransient facial features which is a form of local and global features of the face (Ghanem *et al*., 2010; Zhengya *et al*., 2011). Categorically these transient and intransient facial features are divided into number of algorithms to handle this issue. These algorithms are motion based, model based and muscles based approaches while the others are the combination of these three as revealed in Fig. 2.

Motion based approaches are pixel estimation algorithms in order to calculate the intensity across pixels. Numerous algorithms are used to calculate the pixel variation like face plane algorithm with displacement vector, geometric deformation of facial features etc. The contribution of different researchers shows remarkable advancements in this type of approach (Park and Kim, 2008). For facial expression, model based algorithms have shown promising application in the field of face recognition. Model based algorithms exploit model as a reference image and used it to shape deformed facial features. Image modeling uses candied models as a reference image (Ramachandran *et al*., 2005). In fact, facial features are disturbed with tightening of facial muscles which is more composite to approximate facial expressions (Sun *et al*., 2010). Likewise, facial expressions engendered with the contraction of subcutaneous muscles. The muscles based algorithms are very complex but confer outstanding results during face recognition. Two parameterization techniques are commonly used in this type of approach i.e., Facial Action Coding System (FACs) (Pantic and Rothkrantz, 2004) and Facial Animation Parameter FAPs Takami *et al*., (2008). These two coding systems are the standard that offers uniform functionality as optic flow and emphasizes on synthetic and animation respectively. Similarly, hybrid approaches are the combination of these three algorithms i.e., motion-model based, model based image coding and model-muscles based algorithms etc.

Partial occlusion: Partial occlusion is basically a hindrance in the view of an object. Work under this category is still immature so lots of efforts are needed to find new discoveries (Ran *et al*., 2011). Concerning face recognition systems people cheat the implemented security systems by intentionally covering their face with hand, sunglasses or scarf etc. A graphical representation of above factors is handled.

The anticipated work of most of the authors is grouped under three classes namely part based methods, feature based methods and fractals based methods. In part based methods the face image is divided into various overlapping and/or non-overlapping parts which are then used for recognition (Kim *et al*., 2007). Feature based methods (Farb *et al*., 2007) deal with the problem of occlusion by taking into consideration the individual features like areas around eye, nose and mouth region and ignoring the other features that can be distinctive among various individuals. Methods presented deal with partial occlusion and imprecise localization. An additional algorithm is the Fractal based method that handles this issue. Various authors deal with the same problem by proposing various outstanding algorithms (Marsico *et al*., 2010).

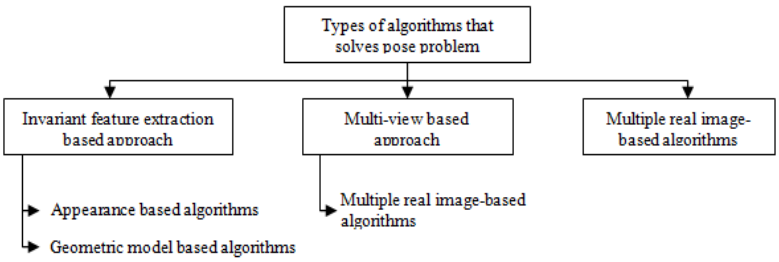

Fig. 3: Types of algorithms used to solve pose invariant problem

Pose variation: Another more challenging case is varying head orientation of subject that varies from 90 degree to 45 or even 60-degree rotation. In this case feature extraction is more challenging task (Antitza and Dugelay, 2011). Again a lot of work under this category has been done which highly depends on the application being used. For non-frontal faces at least two normalized facial features are required but in a situation where the faces are in depth rotated, geometrical normalization is practically impossible (Hu *et al*., 2010; Zhengya *et al*., 2011). In order to handle pose variation problems, different researchers suggest following algorithms as revealed in Fig. 2, 3.

In Invariant features extraction-based approach, facial feature extraction algorithms are applied that are invariant to pose variation (Utsav *et al*., 2011; Manikandan and Venkataramani, 2011). Categorically these types of approaches are divided into two algorithms as appearance based approaches and geometric model based algorithms. On the other hand as the name indicates, multi view based algorithms store large datasets of different multi view images of various poses. The stored multi view images are used to recognize faces under varying poses. Subsequently, face recognition is carried out. As stated earlier, most of the advancement in the vicinity of face recognition is in normal 2D grey scale intensity images of the face and normally it is the major demand of face recognition in real time environment. A 3D model is constructed as an intermediate step process in both 2D and 3D generic model based algorithms (Kalavdekar, 2010).

Illumination conditions: Illumination greatly affects the performance of face recognition systems. Varying lighting factors cast a shadow on the face images hence making the recognition process a challenging case. A number of datasets are available that help in testing the robustness of the method under such variability (Zhengya *et al*., 2011; Manikandan and Venkataramani, 2011).

The first approach uses image processing technique/model to normalize face images under varying illumination conditions. The second approach handles the illumination problem by constructing 3D face model. It can confer approximately good results through low dimensional linear subspace. However, it requires multiple face images under different illumination conditions. A segmented linear subspace model is presented in Shim *et al*. (2008); However, these methods based on 3D model either require the assumptions of light source or need many training samples which are not practical for real applications. To overcome the problem of illumination condition in Muhammad *et al*. (2010), the author presented an illumination normalization technique.

Facial aging: Facial aging cause texture and shape changes which ultimately effect the performance of face recognition systems (Unsang *et al*., 2010). Physically facial aging creates wrinkles which can also effect 3D model of the face for face recognition. To overcome facial aging problem, Unsang Prang *et al.* (2010) presented a technique in there study (Unsang *et al*., 2010) which is based on 3D aging model to improve the performance factor of face recognition system.

CONCLUSION

In this survey, a general time-line based face recognition techniques along with factors affecting face recognition system in different aspects as accuracy, performance etc are discussed. It is observed that to tackle different factors as pose variation, illumination conditions, facial aging etc. different techniques are used independently. Similarly some integrated approaches are used to tackle multiple face recognition factors in a single face recognition system. So in order to develop a universal face recognition system which can handle all face recognition factors, the integrated approach could be a choice.

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