Face Recognition: A Survey

Shailaja A Patil[1] and Dr. P. J. Deore[2]

[1,2]Department of Electronics & Telecommunication Engineering, R. C. Patel Institute of Technology, Dist: Maharashtra.

ABSTRACT

Face Recognition plays a major role in Biometrics. Feature selection is a measure issue in face recognition. This paper proposes a survey on face recognition. There are many methods to extract face features. In some advanced methods it can be extracted faster in a single scan through the raw image and lie in a lower dimensional space, but still retaining facial information efficiently. The methods which are used to extract features are robust to low-resolution images. The method is a trainable system for selecting face features. After the feature selection procedure next procedure is matching for face recognition. The recognition accuracy is increased by advanced methods.

KEYWORDS

Face features, feature selection, local binary pattern.

1. INTRODUCTION

The face is one of the most acceptable biometrics, and it has also been the most common method of recognition that human use in their visual interactions. The problem with authentication systems based on fingerprint, voice, iris and the most recent gene structure (DNA fingerprint) has been the problem of data acquisition. For example, for fingerprint the concerned person should keep his/her finger in proper position and orientation and in case of speaker recognition the microphone should be kept in proper position and distance from the speaker. But, the method of acquiring face images is non-intrusive and thus face can be used as a biometric trait for covert (where user is unaware that he is being subjected) system. Face is a universal feature of human beings. Face recognition is important not only due to the capability of its lot of potential applications in research fields but also due to the capability of its solution which would help in solving other classification problems like object recognition.

In face recognition system it identifies faces present in the images and videos automatically. It is classified into two modes:

1. face verification (or authentication)
2. face identification (or recognition)

In face verification or authentication there is a one-to-one matching that compares a query face image against a template face image whose identity is being claimed. In face identification or recognition there is a one-to-many matching that compare a query face image against all the

template face images in the database to determine the identity of the query face image. Another face recognition scenario involves a watch-list check, where a query face is matched to a list of suspects (one-to-few matches). The performance of face recognition systems has improved significantly since the first automatic face recognition system was developed by Kanade (T. Kanade, 1973). Furthermore, face detection, facial feature extraction, and recognition can now be performed in real-time for images captured under favorable (i.e. constrained) situations.

Although progress in face recognition has been encouraging, but still there are some unconstrained tasks where viewpoint, illumination, expression, occlusion, accessories, and so on vary considerably.

It is natural, nonintrusive, and easy to use. There are many biometric systems but among the six famous biometric attributes considered by Hietmeyer (R. Hietmeyer, 2000), In a Machine Readable Travel Documents (MRTD) system facial features scored the highest compatibility, such as enrollment, security system, machine requirements, renewal, surveillance system and public perception, shown in Figure 1.

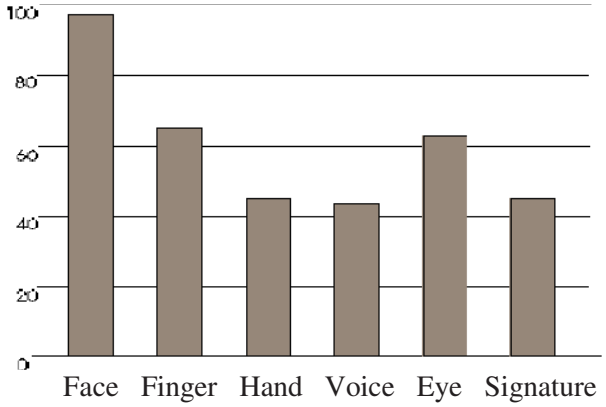

Figure 1: A comparison of various biometric features based on MRTD compatibility (R Hietmeyer,2000).

Face Recognition Processing

Face recognition is a visual pattern recognition problem. There, a face as a three-dimensional object subject to varying illumination, pose, expression and so on is to be identified based on its two-dimensional image (three-dimensional images e.g., obtained from laser may also be used). A face recognition system generally consists of four modules as depicted in Figure 2: detection, alignment, feature extraction, and matching, where localization and normalization (face detection and alignment) are processing steps before face recognition (facial feature extraction and matching) is performed.

Face detection segments the face areas from the background. In the case of video, the detected faces may need to be tracked using a *face tracking* component. *Face alignment* is aimed at achieving more accurate localization and at normalizing faces thereby whereas face detection provides coarse estimates of the location and scale of each detected face. Facial components, such

as eyes, nose, and mouth and facial outline, are located; based on the location points, the input face image is normalized with respect to geometrical properties, such as size and pose, using geometrical transforms or morphing. The face is usually further normalized with respect to photometrical properties such illumination and gray scale.

After a face is normalized geometrically and photo-metrically, *feature extraction* is performed to provide effective information that is useful for distinguishing between faces of different persons and stable with respect to the geometrical and photometrical variations. For *face matching*, the extracted feature vector of the input face is matched against those of enrolled faces in the database; it outputs the identity of the face when a match is found with sufficient confidence or indicates an unknown face otherwise.

Face recognition results depend highly on features that are extracted to represent the face pattern and classification methods used to distinguish between faces whereas face localization and normalization are the basis for extracting effective features. These problems may be analyzed from the viewpoint of face subspaces or manifolds, as follows.

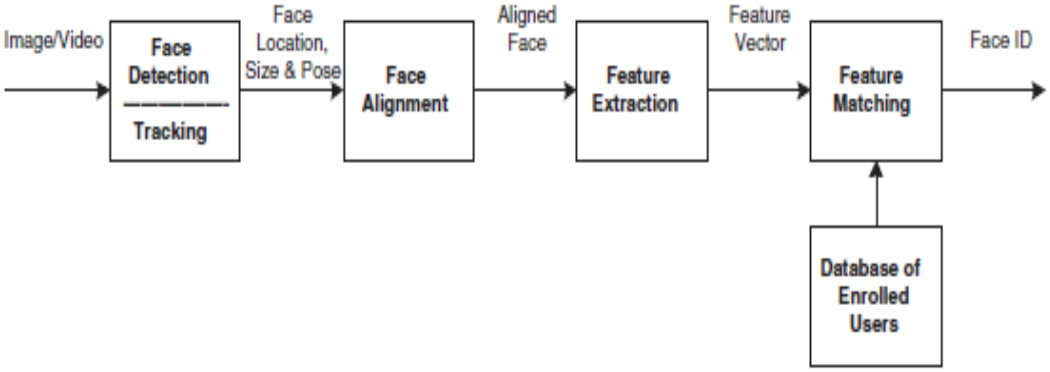

Figure 2: Face Recognition processing flow.

2. LITERATURE SURVEY

Face recognition has been an active research area over last 40 years. The face recognition research has several disciplines such as image processing, machine learning approach, pattern recognition, computer vision, and neural networks. Face recognition has many applications in the fields of biometrics, security system, surveillance systems, and access control and law enforcement. The limitation of face recognition system can be stated as given still face images or video of a scene, identifying or detecting one or more persons in the given video by using a stored database of face images [R. Chellappa et. al. 1995]. Classification is the main problem. In the process of face recognition it includes, to train the face images from the known individuals and then to classify the newly coming test images into one of the classes.

The problem of face recognition is easily solved by humans where limited memory can be the main problem. The problems or limitations for a machine learning face recognition system are:

1. Facial expression change
2. Illumination variation
3. Ageing
4. Pose change
5. Scaling factor (i.e. size of the image)
6. Frontal vs. profile
7. Presence and absence of spectacles, beard, mustache etc.
8. Occlusion due to scarf, mask or obstacles in front.

In automatic face recognition system the main complicated task is that it involves detection of faces from a cluttered background, facial feature extraction, and face recognition. A complete face recognition system has to solve all sub-problems, where each one is a separate research problem.

Image template based and geometry feature-based are the two classes of face recognition system algorithms. In template based method it (Robert J. 1981) compute the correlation between a face image and one or more model of face image templates to estimate the face image identity from the database. Brunelli and Poggio (R. Brunelli, 1993) suggest the optimal strategy for face recognition system which is holistic and corresponds to template matching. The statistical tools such as Support Vector Machines (SVM) (E. Osuna, 1997), (Vladimir N, 1995) Independent component Analysis, Principal Component Analysis (PCA) (L. Sirovich, 1987), (Matthew Turk, 1991), Linear Discriminant Analysis (LDA) (Peter N. Belhumeur et.al, 1997), kernel methods (Bernhard Scholkopf et.al, 1998), (M. H. Yang, 2002), and neural networks (A. Jonathan, 1995), (Steve Lawrence, 1998), (T. Poggio, 1994) used to construct a suitable database of face image templates.

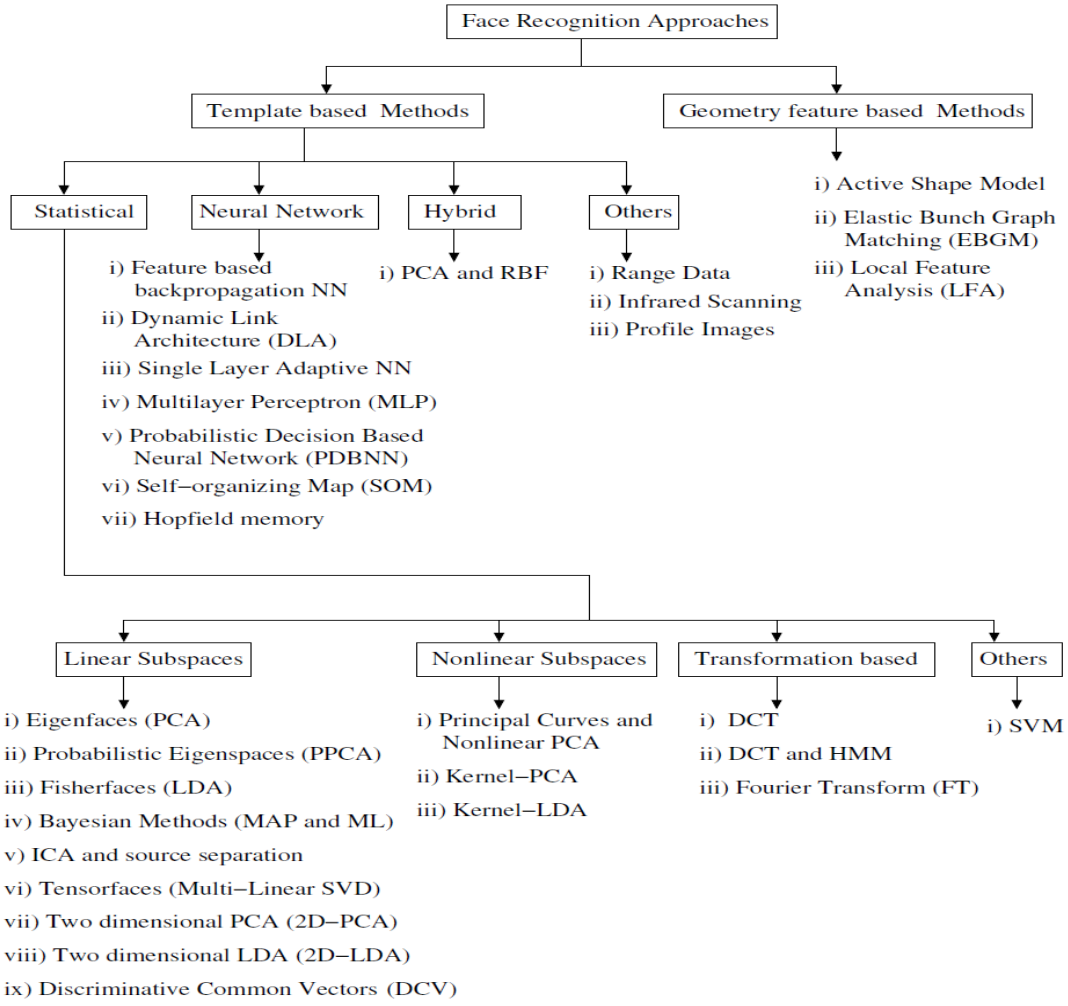

Figure 3: Summary of approaches to face recognition.

Other than neural network approach and statistical approach there are other approaches known as hybrid approaches which are the combination of both statistical pattern recognition techniques and neural network systems. Examples for hybrid approaches include the combination of PCA and Radial Basis Function (RBF) neural network (M. J. Er, 1999), (C. E. Thomaz et. al, 1998). Among other methods, people have used range (R. Chellappa, 1995), infra-red scanned (Y. Yoshitomi et. al, 1997) and profile (Z. Liposcak, 1999) images for face recognition. While templates can be viewed as features, they mostly capture global features of the face image. Facial occlusion (Face images with goggles, specs, scarf etc) and low resolution is often difficult to handle in these given approaches.

In the geometry feature based methods the explicit local facial features are found, and their geometric relationships. Cootes et al. (Andreas Lanitis et.al, 1997) have presented an active shape model which was the extending approach by Yuille (Alan L, 1991). Wiskott et al.(Laurenz Wiskott, 1997) developed an elastic bunch graph matching algorithm for face identification. Penev et al. (P. Penev, 1996) developed PCA into Local Feature Analysis (LFA). This technique

is one of the most successful and useful commercial face recognition systems, FaceIt. The summary of approaches to face recognition is shown in Fig. 3.

Template based Methods

Template matching is conceptually related to holistic approach which attempts to identify faces using global representations (J. Huang, 1998). These types of methods approach the face image as a whole and try to extract features from the whole face region and then classify the image by applying a pattern classifier. One of the methods used to extract features in a holistic system, is based on statistical approaches which are discussed in the following section.

Statistical Approaches

There are some techniques that identify, parameterize and analyze linear subspaces. Other than linear subspaces there are some statistical face recognition techniques which are based on non-linear subspaces (like kernel-PCA and kernel-LDA), transformation (like DCT, DCT & HMM and Fourier Transform) and Support Vector Machine (SVM). Appearance-based approaches for face recognition like PCA, LDA, and probabilistic subspace view a 2D face image as a vector in image space.

Neural Network based Approaches

Artificial Neural Network (ANN) (B. Yegnanarayana, 1999) is a most successful tool for pattern recognition problems. In Kohonen's associative map (T. Kohonen, 1998), one of the earliest demonstrations of neural network for face image recall applications is reported. Using a small set of face images, accurate recall was reported even when input image is very noisy, low resolution and dimension or when portions of the images are missing. A few NN based face recognition techniques are discussed in the following.

Single Layer adaptive NN: A single layer adaptive NN (one for each person) for face recognition, expression analysis and face verification was reported in (T. J. Stonham, 1984). A system named Wilke, Aleksander and Stonham's recognition devise (WISARD) was devised. It needs typically 200-400 presentations for training each classifier where the training patterns included translation and identification in facial expressions. One classifier was constructed corresponding to one subject in the database.

Multilayer Perceptron (MLP): Most of the present literature on face recognition system with neural networks present results with a small number of classes (often below 20). In (D. Demers, 1993) the first 50 principal components of the face images were extracted and reduced to five dimensions using auto associative neural network. The resulting representation was classified using a standard multilayer perceptron (MLP).

Self-Organizing map (SOM): The self-organizing map describes a quantization of the face image samples into a topological space are also nearby in the output space, it provides dimensionality reduction and invariance to minor changes in the face image sample. The convolutional neural network provides partial invariance to translation, rotation, scale and deformation.

Hop-field memory model: In (Y. Dai, 1998), a Hop-field memory model for the facial images is organized and the optimal procedure of learning is determined. A method for face recognition using Hop-field memory model combined with the pattern matching is proposed. It shows better performance of database having 20 faces of 40 subjects.

Others: A hierarchical neural network is grown automatically and not trained with gradient descent was used for face recognition or identification by Weng (J. Weng, 1995). They found good and more accurate results for discrimination of ten subjects. The ability of the compression networks was demonstrated by Cottrell and Fleming in (G. W. Cottrell, 1990).

In (Vladimir N, 1995) linear auto associative networks, non-linear auto-associative (or compression) and/or hetero-associative back propagation networks are explored for face processing. In (Shang-Hung, 1997) Lin et al. proposed a face recognition technique based on Probabilistic Decision based Neural network (PDBNN). It adopts a hierarchical network structures with non-linear basis functions and competitive credit assignment scheme. It demonstrated a successful application of PDBNN on FERET and ORL databases.

The mixture consists of ensembles of radial basis functions (RBFs). Inductive Decision Trees (IDTs) and SVMs implement the “gating network" components. Experimental results yield good results on gender, ethnic and pose classification, which can be effectively used in face recognition.

Hybrid Approaches

The hybrid approaches use both statistical pattern face recognition techniques and neural networks.

PCA and RBF: The use of RBF on the data extracted by discriminant eigen-features suggested by Er et al. They used a hybrid means the combination of learning algorithm to decrease the dimension of the search space in the gradient method, which is very complicated for optimization of high dimension problem in face images. Firstly, they tried to extract the face image features by principal component analysis, Independent component analysis and linear discriminant analysis methods. Secondly, they developed a hybrid learning algorithm to train the RBF Neural Networks, so the dimension of the search memory space is significantly decreased in the gradient method. Thomaz et al. also studied on combining two methods PCA and RBF neural network.

Other Approaches

Range Data: The different method used in face recognition task is using the range face images. The database of face image is obtained by scanning the individual person with a laser scanner system in some methods. This system consist of the more information so the system processes 3-dimensional data to classify face images.

Infra-red Scanning: Another method used for face recognition system is scanning the face image by an infra-red light source. Thermal sensors are used to detect temperature distribution of a face image data by Yoshitomi et al. In this method, the front view of face image in input image is normalized in terms of location, dimension and size, resolution followed by measuring the

temperature distribution, the locally averaged temperature and the shape factors of face image. The disadvantage of visible ray face image analysis is that the performance is strongly influenced by lighting condition including variation of shadow, reflection and darkness ie the illumination variation. These limitations of face recognition system can be overcome by the method using infra-red rays.

Profile Images: Liposcak and Loncaric (Z. Liposcak, 1999) worked on profile face images instead of frontal face images. The method is based on the representation of the original and morphological derived profile face images. The aim of this method was to use the profile outline template that bounds the face and the hair. They take a gray-level profile face image and threshold it to produce a binary face image representing the face region. Then, they simulate hair growth and haircut and produce two new profile face image silhouettes. From these three profile face image shapes they obtain the feature vectors. After normalizing the vector components of profile face image, they use the Euclidean distance matching measure for measuring and matching the similarity of the feature vectors derived from different face image profiles.

Geometry Feature based Methods

Geometry feature based methods uses the facial feature measures such as distance between eyes, ratio of distance between eyes and nose etc., but it is significantly different from the feature-based techniques that it constructs the topological graph using the facial features of each subject.

Graph Matching based Methods: In (M. Lades, 1997) Lades et al. presented dynamic link architecture for noise invariant object recognition which employs elastic bunch graph matching to find the closed stored graph. Objects were produced with sparse graphs whose vertices were labeled with geometrical distances. Only the magnitudes of the coefficients were used for matching and recognition of face images. When recognizing or identifying a face of a new image, each graph in the model gallery was matched to the image separately and the best match indicated the recognized person which is the output result. They presented good results with a database of 87 subjects and test images composed of different facial expressions and faces turned 15 degree. The matching process was taking roughly 25 seconds to compare an image with 87 stored objects when using a parallel machine with 23 transputer's.

Wiskott et al. extended the system to handle larger variations in pose and to increase the matching accuracy of face recognition. Then, they employ object adapted graphs of face images, so that nodes refer to Specific facial landmarks or facial specification, called fiducial points. The correspondences between two face images can be found across large viewpoint of face image changes. Thirdly, a new data structure called the elastic bunch graph matching was introduced which serves as generalized representation of faces by combining jets of a small set of individual faces. This allows the system to find the fiducial points in one matching process of face recognition, which eliminates the need for matching of face image of each model graph individually. This also reduces computational effort significantly. It offers good performance of about 98% for FERET database. But the drawback in this feature matching approach is that it requires manual intervention to select the fiducial points in the facial image and it requires precise location of those points.

Feature based PCA: Cagnoni and Poggi suggested a feature based approach to face recognition system. They applied the eigen-face method to sub-images (eye, nose and mouth).

They also applied a rotation correction of face image to the faces in order to obtain better results of face recognition system.

3. DISCUSSION AND REMARKS

In this paper, we presented some major issues on face recognition. These are as follows: Face detection: For the constrained conditions, many face detection methods for static image are not directly suitable to the task in video. We classified current approaches into groups, and summarized their pros and cons. Face tracking: In face tracking head rotation and pose variations are measure issues. Face tracking is a significant procedure in face recognition. It usually exploits statistical model, examplar-based model, and skin color information to accomplish the tracking task. In addition, for these methods it also exploits CAMSHIFT, condensation, adaptive Kalman filter algorithms. Face recognition: Since the spatio-temporal information plays a significant role in face recognition, how to fully exploit redundancy information in the video sequence is a key issue for video based recognition. One of the chief advantages of video over still frames is that fact accumulation over multiple frames can provide better face recognition performance. Consequently, face recognition in video possesses more challenges to the current face recognition systems. Use of three dimensional face image models has been suggested as a way to compensate for low resolution, low dimension, poor contrast and non-frontal pose. By the way of constructing a 3D face model from multiple non-frontal frames in a video, and then generating a frontal view from the derived 3D model, and finally using a 2D face recognition algorithm to recognize the synthesized frontal view, the spatio-temporal information can be fully employed. Meantime, it will help solve the problem of occlusion, pose variance and illumination issues caused by video frame's poor quality.

ACKNOWLEDGEMENT

I wish my sincere thanks to my guide Prof. Dr. P. J. Deore for his continuous support. Also I am very much thankful to Prof. Dr. J. B. Patil. Finally I would like to thanks my husband Mr. Dinesh A Patil for his continuous support.

References

[1] R. Chellappa, C. L. Wilson, and S. Sirohey, 1995. Human and Machine Recognition of Faces: A Survey, Proc.of the IEEE, vol.83, no.5, pp.705-740.

[2] Robert J. Baron, 1981. Mechanisms of Human Facial Recognition, International Journal of Man-Machine Studies, vol.15, no.2, pp.137-178.

[3] R. Brunelli and T. Poggio, 1993. Face Recognition: Features versus Templates, IEEE Tran. on Pattern Analysis and Machine Intelligence, vol.15, no.10, pp.1042-1052.

[4] E. Osuna, R. Freund, and F. Girosi, 1997. Training Support Vector Machines: An Application to Face Detection, In IEEE Conference on Computer Vision and Pattern Recognition, pp.193-199.

[5] Vladimir N. Vapnik, 1995. The Nature of Statistical Learning Theory", Springer Verlog, Heidelberg, DE.

[6] L. Sirovich and M. Kirby, 1987. Low-dimensional Procedure for the Characterization of Human Faces, Journal of Optical Society of America, vol.4, no.3, pp.519-524.

[7] Matthew Turk and Alex Paul Pentland,1991. Eigenfaces for Recognition, Journal of Cognitive Neuroscience, vol.3, no.1, pp.71-86.

[8] Peter N. Belhumeur, Joao P. Hespanha, and David J. Kriegman, 1997. Eigenfaces vs. Fisherfaces: Recognition Using Class Specific Linear Projection, IEEE Tran. On Pattern Analysis and Machine

Intelligence, vol.19, no.7, pp.711-720.
[9] Bernhard Scholkopf, Alex J. Smola, and Andre Bernhardt, 1998. Non-linear Component Analysis as a Kernel Eigenvalue Problem, Neural Computation, vol.10, no.5, pp.1299-1319.
[10] M. H. Yang,2002. Kernel Eigenfaces vs. Kernel Fisherfaces: Face Recognition using Kernel Methods, In IEEE International Conference on Face and Gesture Recognition, pp.215-220, Washington.
[11] A. Jonathan Howell and Hilary Buxton, 1995. Invariance in Radial Basis Function Neural Networks in Human Face Classification, Neural Processing Letters, vol.2, no.3, pp.26- 30.
[12] Steve Lawrence, C. Lee Giles, Ah Chung Tsoi, and Andrew D. Back, 1998. Face Recognition: A Convectional Neural Network Approach, IEEE Trans. on Neural Networks, vol.8, no.1, pp.98-113.
[13] T. Poggio and K. K. Sung, 1994. Example-based Learning for View-based Human Face Detection, ARPA Image Understanding Workshop.
[14] M. J. Er, S. Wu, and J. Lu,1999. Face Recognition using Radial Basis Function (RBF) Neural Networks, In 38th Conference on Decision & Control, Phoenix, Arizona USA, pp.2162-2167.
[15] C. E. Thomaz, R. Q. Feitosa, and A. Veiga, 1998. Design of Radial Basis Function Network as Classifier in face Recognition using Eigenfaces, In V th Brazilian Symposium on Neural Networks, pp.118-123.
[16] Y. Yoshitomi, T. Miyaura, S. Tomito, and S. Kimura, 1997. Face Identification using Thermal Image Processing, In IEEE InternationalWorkshop on Robot and Human Communication, pp.374-379.
[17] Z. Liposcak and S. Loncaric, 1999. Face Recognition from Profiles using Morphological Operations, In International Workshop on Recognition, Analysis, and Tracking of faces and Gestures in Real-Time Systems, pp.47-52.
[18] Andreas Lanitis, Christopher J. Taylor, and Timothy Francis Cootes, 1997. Automatic Interpretation and Coding of Face Images using Flexible Models, IEEE Tran. On Pattern Analysis and Machine Intelligence, vol.19, no.7, pp.743-756.
[19] Alan L. Yuille,1991. Deformable Templates for Face Recognition, Journal of Cognitive Neuroscience, vol.3,no.1, pp.59-70.
[20] P. Penev and J. Atick, 1996. Local Feature Analysis: A General Statistical Theory for Object Representation, Network:Computation in Neural Systems, vol.7, pp.477-500.
[21] B. Yegnanarayana, 1999. Artificial Neural Networks, Prentice-Hall of India, New Delhi.
[22] Simon Haykin, 1999. Neural networks: A Comprehensive Foundation, Prentice-Hall International, New Jersey.
[23] C. M. Bishop, 1995. Neural Networks for Pattern Recognition, Oxford University Press Inc., New York.
[24] R. J. Mammone, 1993. Artificial Neural Networks for Speech and Vision, Chapman and Hall, Cambridge.
[25] T. Kohonen, 1988. Self-Organization and Associative Memory, Springer-Verlag, New York.
[26] T. J. Stonham, 1984. Practical Face Recognition and Verification with WISARD, In Aspects of Face Processing, pp.426-441.
[27] D. Demers and G. W. Cottrell, 1993. Non-linear Dimensionality Reduction, In Advances in Neural Information Processing Systems, pp.580-587.
[28] S. Lawrence, C. L. Giles, A. C. Tsoi, and A. D. Back, 1997. Face Recognition: A Convolutional Neural Network Approach, IEEE Trans. on Neural Networks, vol.8, no.1, pp.98-112.
[29] Y. Dai and Y. Nakano, 1998. Recognition of Facial Images with Low Resolution using a Hop field Memory Model, Pattern Recognition, vol.31, no.2, pp.159-167.
[30] J. Weng, N. Ahuja, and T. S. Huang, 1995. Learning Recognition Segmentation of 3-D Objects from 2-D Images, In Int. Workshop Face Gesture Recognition, Zurich, Switzerland.
[31] G. W. Cottrell and M. K. Fleming, 1990. Face Recognition using Unsupervised Feature Extraction, In Int. J. Conf. on Neural Networks, pp.322-325, Paris.
[32] Vladimir N. Vapnik, 1995. The Nature of Statistical Learning Theory, Springer Verlog, Heidelberg, DE.
[33] Shang-Hung Lin, Sun-Yuan Kung, and Long ji Lin, 1997. Face Recognition/Detection by Probabilistic Decision-based Neural Network, IEEE Trans. on Neural Networks, vol.8, no.1, pp.114-131.

[34] S. Gutta, J. R. J. Huang, P. Jonathan, and H. Wechsler, 2000. Mixture of Experts for Classification of Gender, Ethnic Origin, and Pose of Human Faces, IEEE Trans. on Neural Networks, vol.11, pp.948-959.
[35] R. Hietmeyer, 2000. Biometric identification promises fast and secure processing of airline passengers, The International Civil Aviation Organization Journal, vol.55, no.9, pp.10-11.
[36] Machine Readable Travel Documents(MRTD). http://www.icao.int/mrtd/overview/overview.cfm.
[37] T. Kanade, 1973. Picture Processing by Computer Complex and Recognition of Human Faces, PhD thesis,Kyoto University.
[38] S. Cagnoni, A. Poggi, 1999. A Modified Modular Eigenspace Approach to Face Recognition, In 10th International Conference on Image Analysis and Processing (ICIAP99), Venice, Italy, pp.490-495.
[39] Laurenz Wiskott, Jean-Marc Fellous, Norbert Kruger, Christoph von der Malsburg,1997. Face Recognition by Elastic Bunch Graph Matching, IEEE Tran. on Pattern Analysis and Machine Intelligence, vol.19, no.7, pp.775-779.
[40] M. Lades, J. C. Vorbruggen, J. Buhmann, J. Lange, C. Vonser Malburg, R. P. Wurtz, and W. Konen, 1997. Distortion Invariant Object Recognition in the Dynamic Link Architecture, IEEE Transactions on Computers, vol.42, pp.300-310.
[41] I. S. Topkaya and N. G. Bayazit, 2008, Improving face recognition from videos with pre-processed representative faces, in Proceedings of the 23rd International Symposiumon Computer and Information Sciences (ISCIS '08).
[42] L. Wolf, T. Hassner, and I. Maoz, 2011. Face Recognition in Unconstrained Videos with Matched Background Similarity, IEEE Conference on Computer Vision and Pattern Recognition (CVPR).
[43] A. J. OToole, P. J. Phillips, S. Weimer, D. A. Roark, J. Ayyad, R. Barwick, and J.Dunlop, 2011. Recognizing people from dynamic and static faces and bodies: Dissecting identity with a fusion approach", Vision Research.
[44] G. Zhao, X. Huang, M. Taini, S. Li, and M. Pietikainen, 2011. Facial expression recognition from near-infra-red videos, Image Vis. Comput, vol.29, no.9, pp.607619.
[45] G. Zhao, T. Ahonen, Jiri Matas, and M. Pietikainen, 2012. Rotation-Invariant Image and Video Description With Local Binary Pattern Features, IEEE Trans. Image Process, vol.21, no.4, pp.1465-1477.

Authors

Name: Prof. Dr. Pramod. J. Deore
Institute: R. C. Patel Institute of Technology
City: Shirpur, Tal: Shirpur, Dist: Dhule, Maharashtra.
Country: India
Email: pjdeore@yahoo.com

Name: Shailaja A. Patil
Institute: R. C. Patel Institute of Technology
City: Shirpur, Tal: Shirpur, Dist: Dhule, Maharashtra.
Country: India
Email: shailajadp@yahoo.co.in