Survey Paper on the Timeline of Face Detection Techniques

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ABSTRACT
Research scholars have found face recognition as an important area for their work because our face is a combination of various features (facial features)like the eyes ,ears ,nose etc. Various research works have been also carried out in this area.
This paper focuses on a brief survey over the currently employed techniques of face recognition along with their advantages and disadvantages applications and constraints. Some of the most general methods include Eigenface (Eigenvectors or PCA), Neural Networks, Geometric Based Template Matching approaches etc. Further this paper performs an analysis on these face recognition approaches in order to constitute face representations .This survey also deals with the factors affecting the recognition processes, recognition rates and other features that affect the face detection and face recognition techniques.

KEYWORDS
HCI ,Face recognition, Eigen faces, PCA,Neural Networks, Geometric Based Template Matching.

1. INTRODUCTION
Computer since its inception has never lagged in proving itself as an important asset for mankind. This led to coinage of term HCI i.e. Human Computer Interaction. In the computer human interaction (HCI)[1] tasks , face identification and recognition systems have received massive importance ever since the security related concerns has reached up to its peak. Since the faces represent complex, multidimensional, meaningful visual stimuli and developing a computational model for face recognition is difficult.These recognition and authentication tasks are lame without their integration with Artificial Intelligence (AI). Human beings are blessed with the inherited capability of easily identifying a person by the use their of memory but computer systems have no such feature or we can say that the computer systems lag behind us in this issue. It can be made to remember things via artificially prompting codes and features and through learning mechanisms i.e. supervised learning and unsupervised learning[2]. Prior to the application of these learnings there should be proper control conditions i.e., static background, neutral frontal face etc., as the recognition processes become difficult when uncontrolled condition occurs. These conditions may arise due to changes in facial expressions, head orientations, partial occlusions and varying conditions in lightening and illuminations etc. These conditions give rise to many obstacles in feature extraction and classification for computer vision applications. Since the inception of the technology for face detection there has been a very much enhancement in the techniques for face detection. For this, methods like PCA (Sirovich & Kirby, 1987 and Turk & Pentland, 1991)[3], Neural Networks (Lawrence, 1997)[4], LDA (Zhao & Yuen, 2008)[5]and some of their variations are used but each of them have their own constraints. Even though they are capable of being applied successfully in many applications, they seem to fail to show an efficient performance when the face image is partially corked. As these methods are linear in nature they fail to employ themselves in non-linear conditions. Several non-linear methods like Flexible Discriminate Analysis (FDA) (Hastie et al., 1994),Neural networks (Lawrence, 1997),Generalized Discriminate Analysis (GDA)[6][7] (Baudat., 2000), the Kernel-machine-based Discriminate Analysis (KDA)[8] (Chen et al., 2005) are used, but a major drawback of these methods is that they have very high computational cost in terms of training and testing the data. This paper deals in a survey to analyze the face recognition techniques and view on different methods to handle general face recognition problems. Here, we have also provided a discussion over the major factors affecting the recognition rates like expression, occlusion, pose variation and illumination.

2. DIFFERENT APPROACHES
Face recognition has always been a critical task to perform nevertheless many related works have emerged in this area. These have employed various approaches .The three main approaches in face recognition are :

i. Holistic Approach
ii. Feature–Based Approach
iii. Hybrid Approach

2.1 Holistic Approach : In this approach the whole face region is taken into account for the face detection purpose. They are all based on principal compon ent-analysis (PCA) techniques that can be used to simplify a dataset into lower dimension while reta ining the characteristics of dataset. Some of the examples are eigenfaces, fisherfaces etc.

2.2 Feature-Based Approach: The characteristic features of the face like the lips, nose are segmented and then used as input data for detection methods.

2.3 Hybrid Approach: As the name suggests, this approach is combination of the methods that use local features(like nose ,lips etc.) as well as the whole face into account for the recognition process.

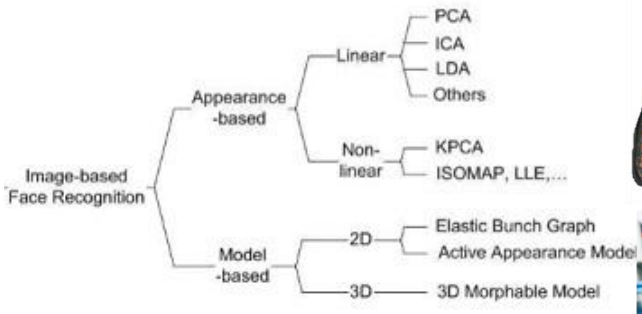

Fig.1 Some face recognition methods

The above figure shows some of the face recognition methods based on the appearance and model based. It shows a generalized view of various techniques employed and the mechanism behind them.

3.LITERATURE REVIEW

The face recognition tasks has been a topic of immense interest and research over the years. There has been research works carried out and depending upon the above mentioned approaches many methods being invented for the intended purpose. Here we'll have a look at some of the most important methods in this area.

3.1 Eigenface and PCA: This method is based on the eigenfaces technique in which the Principal Component Analysis (PCA) is used. Principal Component analysis was developed by Karl Pearson in 1901[9].PCA is a statistical method which is used to reduce the high dimensional data space to the low dimensional characterized space .This method is best suited for data compression and removal of redundancy .It is the most successful technique that is prevalent in image recognition and compression. The foundation of using Eigenfaces in face recognition is based o n
the fact that each image can be represented as a matrix. A matrix has a set of eigenvectors that represents the principal components of the matrix. Eigenfaces are the eigenvectors of the covariance matrix of all faces. Similar faces can be described in a space with lower dimensionality. In mathematical terms, Eigenfaces are the principal components that divide the face into feature vectors (or we can say that basic approach of using PCA in a face recognition is to put across the large 1-D vector of pixels built from 2-D facial image into its discrete components of the feature space. This can be said to be as an Eigen Face projection. A covariance matrix gives us the information about these featured vectors. These eigenvectors are the basis for measurement of variation among several faces. The faces are described by a linear combination of highest Eigenvalues. Each face can be considered as a linear combination of the eigenfaces. Then the face can be estimated by using the eigenvectors occupying the largest eigenvalues. The best N eigenfaces define an N dimensional space, known as the "face space". Principal Component Analysis has been employed by L. Sirovich & M. Kirby (1987) to efficiently represent pictures of faces. They defined that a face images could be approximately reconstructed using a small collection of weights for each face and a standard face picture. The weights describing each face are obtained by projecting the face image onto the eigenpicture. Eigenface also found its application in the research work of M.A Turk & Alex Pentland (1991)[10] who produced a comparatively more efficient technique in the face recognition system using PCA.

Fig 2. RGB Images in training set

A collection of different pictures of different angles or emotions of a same person is needed to estimate the actual face. The more

sample picture of a person is given; the better accuracy will be fo u
nd to recognize that person.

Fig 1. Eigenface of images in training set(after normalizing)

Eigenface is one among the various practical approaches for face recognition. As it has a simple algorithm, it can be applied very easily. It is efficient in processing time and storage. PCA reduces the dimension size of an image in a short period of time. As it takes the pixel value as comparison for the projection, the accuracy would decrease with varying light intensity. Preprocessing of image is required to achieve satisfactory result. An advantage of this algorithm is that the eigenfaces were invented exactly for those purpose what makes the system very efficient. Eigenface approach is most reliable, fast and efficient that endows invariance information also in the presence of varying lighting and scaling conditions.

Disadvantages: A drawback is that finding the eigenvectors and eigenvalues are time consuming on PPC. The size and location of each face image must remain similar PCA (Eigenface) approach maps features to principle subspaces that contain most energy

3.2 Neural Networks: The neural networks which have found their usability in character matching, robot driving etc. have also found immense application in the field of face recognition. Since the neural networks are non-linear in network, so it is widely used in face recognition .The main objective of the neural network in the face recognition is the practicality of training a system to capture the complex class of face patterns[10]. To get the best performance by the neural network, it has to be extensively tuned

number of layers, number of nodes etc. So, the feature extraction step seems to be more efficient than the Principal Component Analysis. The authors achieved approximately 96.2% accuracy in the face recognition process when conducted a research on 400 images of 40 individuals. As far as the speed is concerned the classification time comes down to less than 0.5 second, but the training time is about 4 hours. 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. There has been optional as well as practical approaches for parallel computers. Neural Networks and statistical methods are optional approaches for PDBNN and on the other hand the distributed computed principle is practical approach for parallel computers. Nevertheless, the recognition rate goes down for large data set due to the increased computational cost.

Gabor wavelets & feed forward neural network emerged as a new approach in this research area. The method used Gabor wavelet transform and feed forward neural network for both finding feature points and extracting feature vectors. The experimental results have shown that proposed method achieves better results compared to other successful algorithm like the graph matching and eigenfaces methods. The concept of hybrid neural network i.e. combining local image sampling, a self-organizing map neural network, and a convolutional neural network was also introduced. A new approach that was introduced later known as the Self Organizing Maps (SOM) recognize faces and does verification and identification on the basis of ear and hand geometry etc. The SOM provides a quantization of the image samples into a topological space where inputs that are nearby in the original space are also nearby in the output space, therefore providing dimensionality reduction and invariance to minor changes in the image sample. The Convolutional Neural Network (CNN) implies for partial invariance to translation, rotation, scale, and deformation. The combination of PCA and CNN & SOM and CNN methods are both superior to eigenface technique even when there is only one training image per person. An integration of SOM and CNN method consistently performs better than the combination of PCA and CNN method. A new face detection method is proposed using polynomial neural network (PNN)[11][12]. Here the PCA technique is used to reduce the dimensionality of image patterns and extract features for the PNN. Using a single network the author had achieved fairly high detection rate and low false positive rate on images with complex backgrounds. In comparison with a multilayer perceptron, the performance of PNN is superior. To enhance the geometry of the 3D face manifold and improve recognition, Spectral Regression Kernel Discriminate Analysis (SRKDA) which is based on regression and spectral graph analysis introduced in proposed method [13]. When the sample vectors are non-linear , SRKDA can efficiently give exact solutions than ordinary subspace learning approaches. It solves high dimensional and small sample size problems, as well as enhances feature extraction from a face local non-linear structure. SRKDA gives a huge saving in computational cost this has to only solve a set of regularized regression problems and no eigenvector computation involved[14].

3.3 Fisherfaces: Developed in 1930 by R.A Fisher ,this method is one of the most widely and successfully used method in the process face recognition[15]. He developed the Fisher Discriminant Analysis method also known as the Linear Discriminant Analysis method (LDA). LDA method find set of basis images which maximizes the ratio of between-class scatter to within-class scatter[16]. The disadvantage of LDA is due to the fact that number of pixels in images is larger than the number of images so it can increase detection of error rate if there is a variation in pose and lighting condition within same images. So to overcome this problem many algorithms has been proposed. Because the fisherfaces technique uses the advantage of within-class information so it minimizes the variation within class, so the problem with variations in the same images such as lighting variations can be overcome[17].

The fisherface method for face recognition described by Belhumeur uses both PCA and LDA which produces a subspace projection matrix similar to that of eigenface methods. But the fisherface method is capable in taking the advantage of within-class information and thus, minimizing variation within each class meanwhile maximizing the class separation. Similar to the eigenface detection technique, the first step of the fisherface technique is to take each (NxM) image array and reshape into a ((N*M)x1) vector. Fisherface is similar to Eigenface but implies a better classification of . With FLD, one can classify the training set to deal with different people and different facial expression.The fisherface is more efficient with facial expressions as well as in light invariant changes.

Disadvantages: The Fisherface and LDA approach has also some disadvantages. Some of them lie in complexity of finding the projection of face space which is better in eigenface approach. Calculation of ratio of inter-class scatter to intra-class scatter requires a lot of processing time. Besides, due to the need of better classification, the dimension of projection in face space is not as compact as Eigenface, results in larger storage of the face and more processing time in recognition[18].

3.4 Template matching : Template matching is a technique in digital image processing for finding small parts of an image which match a template image. It can be used in manufacturing as a part of quality control, a way to navigate a mobile robot, or as a way to detect edges in images. It has also found its importance in the method of face recognition processes. In template matching, we can exploit other face templates from different prospects to characterize single face. 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[19]. 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. A simple version of template matching is that a test image represented as a two-dimensional array of intensity values is compared using a suitable metric, such as the Euclidean distance, with a single template representing the whole face. There are several other more sophisticated versions of template matching on face recognition. One can use more than one face template from different viewpoints to represent an individual's face. A face from a single viewpoint can also be represented by a set of multiple distinctive smaller templates. The face image of gray levels may also be properly processed before matching. In Bruneli and Poggio automatically selected a set of four features templates, i.e., the eyes, nose, mouth, and the whole face, for all of the available faces. They compared the performance of their geometrical matching algorithm and template matching algorithm on the same database of faces which contains 188 images of 47 individuals. The template matching is better in recognition (app 100% rate) to

geometrical matching (app 90% rate) and was also simpler. Since the principal components (eigenfaces) are linear combinations of the templates in the data basis, the technique cannot achieve better results than correlation, but it may be less computationally expensive.

Disadvantages: One drawback of template matching is its computational complexity. Another problem lies in the description of these templates. Since the recognition system has to be tolerant to certain discrepancies between the template and the test image, this tolerance might average out the differences that make individual faces unique. In summary, no existing technique is free from limitations. Further efforts are required to improve the environments encountered in real world. Improvements can be made to the matching method by using more than one template (eigenspaces), these other templates can have different scales and rotations.
It is also possible to improve the accuracy of the matching method by hybridizing the feature-based and template-based approaches

3.5 Elastic Bunch Graph Matching: Elastic Bunch Graph Matching is an algorithm in computer vision for recognizing objects or object classes in an image based on a graph representation extracted from other images**.** It has been prominently used in face recognition and analysis but also for gestures and other object classes[20]. This process goes through the undermentioned various steps in the recognition process. First of all a bunch face graph is made in which a single face is taken and then node locations are defined on the face features like (nose, lips etc.).After that all the nodes are joined to give a graph which constitutes the first face graph .The single face graph defined above can be taken as a bunch graph with just one instance in it. It can be matched onto the second face image, but if the first two face images are not very similar, the match is of poor quality. For instance, the tip-of-the-nose node might by placed at the cheek, so we need to move the node onto the tip of the nose by hand. After some such manual corrections the graph is acceptable and constitutes the second instance in the bunch graph. The bunch graph with two instances is then matched onto the third image, and after some manual corrections we have a third instance for the bunch graph. By repeating this process, the bunch graph grows, and as it grows the match onto new images gets more and more reliable. If we are satisfied with the quality of the matches and only little manual correction is needed, we are done with building the bunch graph. After this we make a model gallery of graphs. For a new image first we need to create a graph for the image. This process works exactly as for the model images based on which the matching and recognition process is further carried out. This algorithm system has achieved 98% correct recognition rates on a gallery of 250 frontal view faces, 57% on half profiles, and 84% profiles
Disadvantages: This algorithm is very sensitive to lightening conditions and a lot of graphs have to be placed manually on the face. When the changes in lighting are large, the result will have a significant decrease in the recognition rate.

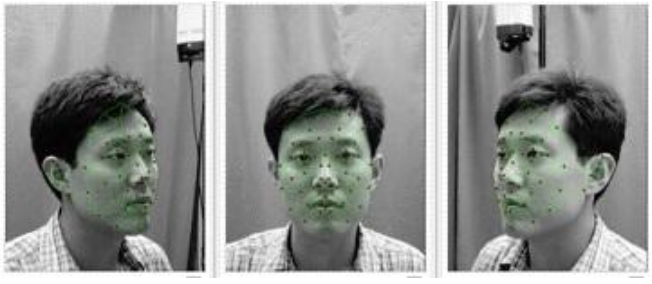

Fig 3. Matching in different poses(face orientations)

3.6 Geometrical feature matching: This method is based on the computation of a set of geometrical features from the picture of a face. The detailed description of the overall method can be given by a vector which represents the position and size of the main features of the face like eyes and eyebrows, nose, mouth, and outline of the face. This method had its inception in 1973. This system achieved approximately 75% recognition rate on a database of 20 people using two pictures per person(one as the model and other as test image). In 1993 R. Bruneli and T. Poggio gave an automation to extract a set of geometrical features(like nose, chin, face outline etc.) from the picture of a face. Total 35 features were extracted form a 35 dimensional vector. The recognition was then performed with a Bayes classifier. They achieved recognition rate 90% on a database of 47 people.
Moving ahead , I.J. Cox[21] introduced a mixture-distance technique which achieved 95% recognition rate on a database of 685 individuals. Each face was represented by 30 manually extracted distances. He employed Gabor wavelet decomposition to detect feature points for each face image which minimized the storage necessity for the database[22]. Typically, 35-45 feature points per face were generated. Two cost values, the topological cost, and similarity cost, were evaluated. The recognition accuracy of the right person was 86% and 94% of the correct person's faces were in the top three candidate matches.
An another efficient model was introduced by Basavaraj and Nagaraj in 2006 in which the basic process included enhancement of frontal face images including ears and chin and also of potential features as it ensured more accuracy. The face model proposed by the ability to identify is divided into four steps. The first step is pre-processing. The main aim of this step is to reduce 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. At last, it calculates the estimated distance used for matching purpose.
Thus we can say that geometrical feature matching is based on precisely measured distances between the face features that may be used for face recognition in large database.
Disadvantages : The current automated face feature location algorithms lag in providing a high degree of accuracy as well as require a high computational time.

3.7 3D Morphable Model: Construction, shape and texture of any example of a convex combination of vector describe a real face [23]. 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[5].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)[24] 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) [25] 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's model (2010)[26] 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.

4. CONCLUSION

Although face recognition has been a challenging issue in the field of image processing and computer human interaction but due to its application in various fields it has received immense attention over the years.

This survey dealt with a discussion over general time-line based face recognition techniques along with factors affecting them in different aspects as such as accuracy, performance etc. are discussed. It is also observed that to tackle different obstacles such as the pose variation, illumination conditions, facial aging etc. different techniques can be employed independent of each other. Moreover we have also observed here that some integrated approaches have also been used to get over multiple face recognition factors in a single system. In case of single algorithms approach as well as in case of integrated approaches the obstacles in terms of illumination and lightening conditions can be dealt with setting a common default value for the images that needs to be recognized. Talking about the pose variation the approximation based on morphing can give us the efficiency up to a certain satisfactory extent. The main problem in the integrated approaches is the computational cost involved in them. In a true sense of any algorithm or technology we need to satisfy the system in terms of space as well as time complexity .Thus, to handle all the obstacles of a face detection and recognition an integrated system with an accurate algorithm in terms of space and time complexity can be developed (and can be feasible as well) that contains the features of various face recognition and detection techniques.

5. REFERENCES

[1] Fakhreddine Karray, Milad Alemzadeh, Jamil Abou Saleh and Mo Nours Arab "Human-Computer Interaction: Overview on State of the Art" International Journal On Smart Sensing and Intelligent Systems, Vol.1, No.1, March 2008.

[2] A Survey: Face Recognition Techniques Muhammad Sharif, Sajjad Mohsin and Muhammad Younas Javed ,Research Journal of Applied Sciences, Engineering and Technology 4(23):4979- 4990, 2012.

[3] M.A. Turk and A. Pentland "Eigen faces for recognition" Journal of cognitive Neuroscience, March 1991.

[4] Lawrence, S., C.L. Giles, A.C. Tsoi and A.D. Back, 1997. Face recognition: A convolutional neural-network approach. IEEE T. Neural Networks., 8: 98-113.

[5] Zhao, H. and P. Yuen, 2008. Incremental linear discriminant analysis for face recognition. IEEE T. Syst. Man Cy. B., 38(1): 210-221

[6] Hastie, T., R. Tibshirani and A. Buja, 1994. Flexible discriminant analysis by optimal scoring. J. Amer. Statist. Assoc., 89: 1255-1270.

[7] Baudat, G. and F. Anouar, 2000. Generalized discriminant analysis using a kernel approach. Neural Comput., 12: 2385-2404.

[8] Chen, W., P. Yuen, J. Huang and D. Dai, 2005. Kernel machine-based one-parameter regularized fisher discriminant method for face recognition. IEEE T. Syst. Man Cy. B., 35(4): 659-669.

[9] www.en.wikipedia.org

[10] A Literature Survey on Face Recognition Techniques, International Journal of Computer Trends and Technology (IJCTT) – volume 5 number 4 –Nov 2013,

[11] Ming-Hsuan Yang, David J. Kriegman and NarendraAhuja, "Detecting Faces in Images: A Survey," IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE, VOL. 24, NO. 1, JANUARY 2002.

[12] Lin-Lin Huang, Akinobu Shimizu, Yoshihiro Hagihara, Hidefumi Kobatake ,"Face detection from cluttered images using a polynomial neural network", Elsevier Science 2002

[13] U. KreQel, J. SchRurmann, "Pattern classification techniques based on function approximation, in: H.Bunke, P.S.P. Wang (Eds.), Handbook of Character Recognition and Document Image Analysis", World Scienti5c, Singapore, 1997, pp. 49–78.

[14] Yue Ming, Qiuqi Ruan, Xiaoli Li, Meiru Mu, " Efficient Kernel Discriminate Spectral Regression for 3D Face Recognition", Proceedings Of ICSP 2010

[15] R. A. Fisher, "The Use of Multiple Measurements in Taxonomic Problems", 1936.

[16] A Literature Survey on Face Recognition Techniques, International Journal of Computer Trends and Technology (IJCTT) – volume 5 number 4 –Nov 2013.

[17] Jyoti S. Bedre ,Shubhangi Sapkal, "Comparative Study of Face Recognition Techniques: A Review", Emerging Trends in Computer Science and Information Technology – 2012(ETCSIT2012) Proceedings published in International Journal of Computer Applications® (IJCA) 12

[18] Sushma Jaiswal, Dr. (Smt.) Sarita Singh Bhadauria, Dr. Rakesh Singh Jadon," COMPARISON BETWEEN FACE RECOGNITION ALGORITHM-EIGENFACES, FISHERFACES AND ELASTIC BUNCH GRAPH MATCHING", Volume 2, No. 7, July 2011 Journal of Global Research in Computer Science.

[19] R. Bruneli and T. Poggio, "Face recognition: features versus templates," IEEE Trans. Pattern Analysis and Machine Intelligence, vol. 15, pp. 1042-1052, 1993.

[20]www.scholarpedia.org/article/Elastic_Bunch_Graph_Matching

[21] I.J. Cox, J. Ghosn, and P.N. Yianios, "Feature-Based face recognition using mixture-distance," Computer Vision and Pattern Recognition,1996.

[22] B.S. Manjunath, R. Chellappa, and C. von der Malsburg, "A Feature based approach to face recognition," Proc. IEEE CS

Conf. Computer Vision and Pattern Recognition, pp. 373-378, 1992.

[23] Vetter, T. and T. Poggio, 1997. Linear object classes and image synthesis from a single example image. IEEE T. Pattern Anal., 19(7): 733-742.

[24] Bustard, J.D. and M.S. Nixon. 2010. 3D morphable model construction for robust ear and face recognition. IEEE Conference on Computer Vision and Pattern Recognition, CVPR 10, San Francisco, pp: 2582-2589.

[25] Shu-Fan, W. and L. Shang-Hong, 2011. Reconstructing 3D face model with associated expression deformation from a single faceimage via constructing a low-dimensional deformation manifold. IEEE T. Pattern Anal.33(10): 2115-2121.

[26] Unsang, P., T. Yiying and A.K. A.K. Jain, 2010. Age-invariant face recognition. IEEE T. Pattern Anal., 32(5): 947-54.