www.icgst.com

Intelligent Face Recognition Techniques: A Comparative Study

S.T.Gandhe[1], K.T.Talele[2], A.G.Keskar[3]
S.T.Gandhe[1], Research Scholar, Visvesvaraya National Institute of Technology, Nagpur
star_stg@yahoo.com
K.T. Talele[2], Assistant Professor (Electronics) S.P.College of Engg, Andheri(w)Mumbai-58, India
kttalele@yahoo.co.uk
Dr.A.G. Keskar[3], Professor (Electronics) and Dean R & D, Visvesvaraya National Institute of Technology, Nagpur, India, avinashkeskar@yahoo.com

Abstract

In this paper we discuss and an implemented different method of face recognition namely Principal Component Analysis, Discrete Wavelet Transform Cascaded with Principal Component Analysis, Contour Matching and Isodensity Line Maps Cascaded with Hopfield Neural Network. All these algorithms are tested on ORL Database and/or BioID Database. The feasibility of these algorithms for human face identification is presented through experimental investigation. We were able to design these prototype systems, which provides user authentication via facial features. These proposed systems of face recognition may be applied in identification systems, document control and access control.

Keywords: *Face and gesture recognition, image processing and computer vision, pattern analysis, pattern recognition*

1. Introduction

Face recognition [1] is a form of biometric identification. A biometrics is, "Automated methods of recognizing an individual based on their unique physical or behavioral characteristics." The process of facial recognition involves automated methods to determine identity, using facial features as essential elements of distinction. The automated methods of facial recognition, even though work very well, do not recognize subjects in the same manner as a human brain. The way we interact with other people is firmly based on our ability to recognize them. One of the main aspects of face identification is its robustness. Least obtrusive of all biometric measures, a face recognition system would allow a user to be identified by simply walking past a surveillance camera. Robust face recognition scheme require both low dimensional feature representation for data compression purposes & enhanced discrimination abilities for subsequent image retrieval. The representation methods usually start with a dimensionality reduction procedure since the high dimensionality of the original visual space makes the statistical estimation very difficult & time consuming. In this paper we will discuss different methods of face recognition [2, 3, 8,] with their advantages and disadvantages.

The paper is organized as follows: Section (2) focuses on survey of face recognition, section (3) theory and advantages of four different face recognition methods; section (4) discusses algorithms of four different methods of face recognition. Section (5) emphasizes on result analysis and conclusion..

2. Survey of the Face Recognition [2, 3, 8, 10, 17]

The solution to the problem of machine recognition of faces involves three phases: segmentation of faces (face detection) from cluttered scenes, feature extraction from the face regions, recognition or verification.

2.1 Segmentation/Detection:

The first step in any automatic face recognition systems is the detection (segmentation) of faces in Images. Up to the mid-1990s, most work on Segmentation was focused on single-face segmentation from a simple or complex background. These approaches included using a whole-face template, a deformable feature-based template, skin color, and a neural network. Significant advances have been made in recent years in achieving automatic face detection under various conditions [2, 3]. Compared to feature-based methods and template-matching methods, appearance or image based methods that train machine systems on large numbers of samples have achieved the best results. More recently, detection of faces under rotation in depth has been studied. One approach is based on training on multipleview samples.

2.2 Feature Extraction Methods:

The importance of facial features for face recognition cannot be overstated. Many face recognition systems need facial features in addition to the holistic face. Three types of feature extraction methods can be distinguished: (1) generic methods based on edges, lines, and curves; (2) feature-template-based methods that are used to detect facial features such as eyes; (3) structural matching methods that take into consideration geometrical constraints on the features. Early approaches focused on individual features; for example, a template-based approach was described to detect and recognize the human eye in a frontal face. These methods have difficulty when the appearances of the features change significantly, for example, closed eyes, eyes with glasses, open mouth.

To detect the features more reliably, recent approaches have used structural matching methods, for example, the Active Shape Model. Compared to earlier methods, these recent statistical methods are much more robust in terms of handling variations in image intensity and feature shape. An even more Challenging situation for feature extraction is feature "Restoration," which tries to recover features that are invisible due to large variations in head pose. The best solution here might be to hallucinate the missing features by either using the bilateral symmetry of the face or using learned information. For example, a view-based statistical method claims to be able to handle even profile views in which many local features are invisible.

2.3 Recognition from Intensity Images:

Different methods have been proposed over the last few decades. In literature these methods are classified into three main categories: holistic matching methods, feature-based matching methods and hybrid methods. Holistic matching methods use the whole face region as the raw input to a recognition system. One of the most widely used representations of the face region is eigen pictures [12,13], which are based on Principal Component Analysis (PCA). Using PCA, many face recognition techniques have been developed: eigenfaces, which use a nearest neighbor classifier; feature-line-based methods, which replace the point-to-point distance with the distance between a point and the feature line linking two stored sample points; Fisher faces which use linear/Fisher discriminant analysis (FLD/LDA); Bayesian methods, which use a probabilistic distance metric; and SVM methods, which use a support vector machine as the classifier. Utilizing higher order statistics, independent-component analysis (ICA) is argued to have more representative power than PCA, and hence may provide better recognition performance than PCA. Being able to offer potentially greater generalization through learning, neural networks/learning methods have also been applied to face recognition. One example is the Probabilistic Decision-Based Neural Network (PDBNN) method and the other is the evolution pursuit (EP) method.

Typically in Feature-based matching methods, local features such as the eyes, nose, and mouth are first extracted and their locations and local statistics (geometric and/or appearance) are fed into a structural classifier. Earlier methods belong to the Feature-based matching methods, using the width of the head, the distances between the eyes and from the eyes to the mouth, etc, or the distances and angles between eye corners, mouth extrema, nostrils, and chin top. More recently, a mixture-distance based approach using manually extracted distances was reported. Without finding the exact locations of facial features, Hidden Markov Model (HMM) based methods use strips of pixels that cover the forehead, eye, nose, mouth, and chin reported better performance than by using the KL projection coefficients instead of the strips of raw pixels. One of the most successful systems in this category is the graph matching system, which is based on the Dynamic Link Architecture (DLA) Using an unsupervised learning method based on a self-organizing map (SOM), a system based on a conventional neural network (CNN) has been developed. Hybrid methods are based on using both local features and the whole face region to recognize a face, as the human perception system uses. One can argue that these methods could potentially offer the better of the two types of methods.

3. Strengths of Efficient Face Recognition Methods:

In this paper we will discuss four different methods namely principal component analysis (PCA), PCA+DWT, Contour Matching; Isodensity Line Maps cascaded with Hopfield Neural Network with their advantages, algorithms and analysis.

The PCAmethod is a low dimensional procedure for the characterization of human faces based on Principal Component Analysis (PCA) also known as Karhunen-Loeve (K-L) or eigenspace, seeks the direction in the input space along which most of the image variations lies. This approach reduces the dimension size of an image greatly. [4, 9, 12, 13, 16, 21]. As % recognition using PCA is low. We propose a system in which we first find out Discrete Wavelet Transform of a given image and then cascaded with PCA. In the proposed algorithm we have cascaded DWT with PCA.Some of the advantages of wavelet transformations are to preserve the structure of data, computation complexity (space complexity is linear), vanishing moments (where noisy data can be eliminated), compact support (processing the data inside the wavelet region without affecting the data outside its region), and decorrelared coefficients (used to reduce complex process in time domain to simple process in wavelet domain). DWT is analogues to Human Visual System. Wavelets are an efficient and practical way to represent edge and image information at multiple spatial levels [15, 18].

The Contour Matching method has advantages in storage space requirements. For matching purposes, storage of the whole registered picture is not required. Only the contours extracted from a face need be stored. Since the lines are made of binary pixels, the corresponding gray level information does not have to be stored. It is estimated that the storage requirement can be decreased substantionally. Since only simple template matching is used, a parallel architecture can speed up the whole process. [6, 20]

The advantage of Isodensity Line Maps cascaded with Hopfield Neural Network is the learning ability of neural network. The extraction information is stable over a range of normal face positions and characteristics. The description of the whole face can be very easily compared to the conventional methods based on feature point extraction.[19]

4. Algorithm of Various Methods

4.1 Algorithm of PCA Method:

The algorithm for the facial recognition in spatial domain using eigenfaces is described in figure 1. The original images of the training set are transformed into a set of eigenspaces E. Afterwards the weights are calculated for each image of the training set and stored in the set W.

For an unknown image X, the weights are calculated for that image and stored in the vector Wx. The Wx is compared with the weights of the training set W. It is compared using distance measures, which is calculated using Euclidean distance. If this average distance exceeds some threshold value θ, then the weight vector of the unknown image Wx lies too far apart from the weights of the faces. In this case, the unknown X is considered to be not a face. Otherwise if X is actually a face, its weight vector Wx is stored for later classification. The optimal threshold value θ is determined empirically.

***4.2 Algorithm of* DWT+*PCA approach* [18] :**

We use term Wavelet PCA to refer to computing principle components for a masked or modified set of wavelet coefficient to find Wavelet PCA eigenspectra in spectral domain and then projecting the original image onto the wavelet PCA eigenspectra basis. In this way, features at a particular scale are indirectly emphasized by the computed projection basis enhancing the reduced dimensionality images without filtering artifacts.

4.2.1Algorithm for Calculation of DWT Of A Given Image:

The Square Two-Dimensional DWT is calculated using a series of one dimensional DWTs which is as follows: [7, 8]

Step 1: Replace each image row with its 1D DWT

Step 2: Replace each image column with its 1D DWT

Step 3: Repeat steps (1) and (2) on the lowest sub-band to create the next scale

Step 4: Repeat step (3) until the desired number of scales has been created

Figure 2 shows different steps of the two dimensional DWT. Figure 3 shows one level decomposition of a given image. Figure3(a) shows input image which of the size 64× 64. Figure 3(b) shows frequency bands of DWT. Figure 3 (c) shows DWT image of a given image.

4.3 Contour Matching Method [20]:

The proposed face recognition system is a three step process i.e.

1)Preprocessing and normalization.

2)Contour Generation.

3)Matching Algorithm.

4.3.1Contour Generation:

This is the core of the project in which the contour of the face is generated from the image. The whole face is treated as a contour map, with the areas of "constant gray-level brightness" (i.e. the plains) enclosed by the contour lines. Thus contour for a given face can be generated. Figure 4 shows feature extracted as a contour of a given image.

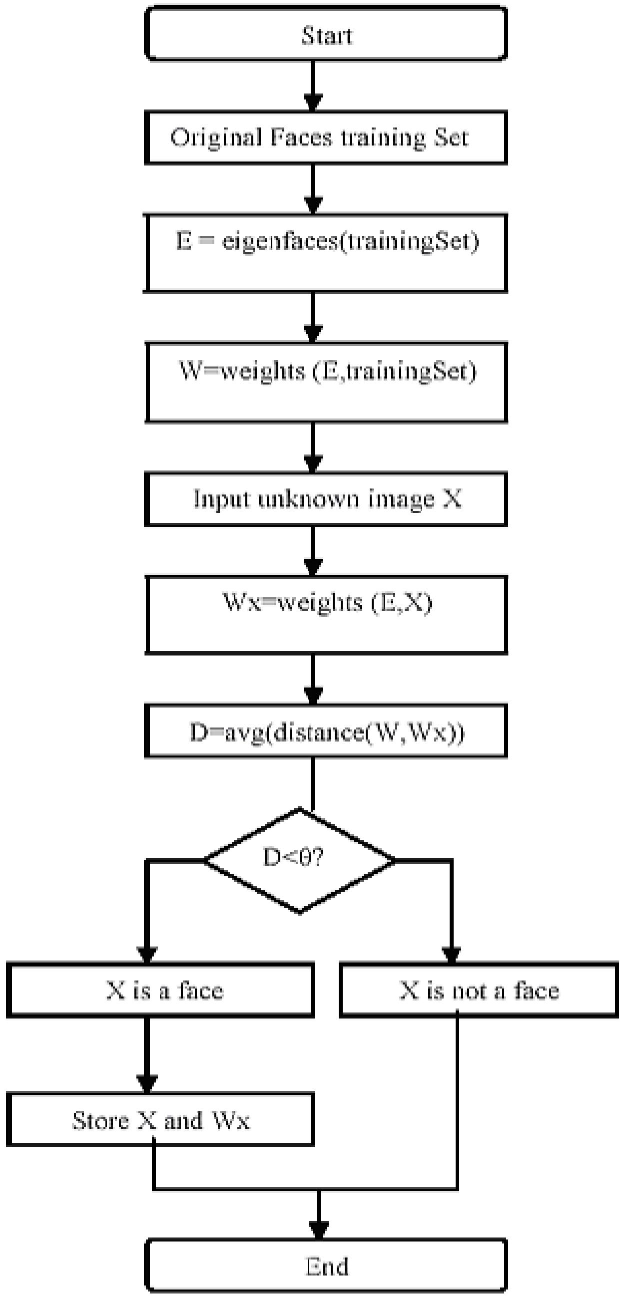

Figure 1: High-level functioning principle of the Eigen face-based facial recognition algorithm

4.3.2 Matching:

In general, it is quite difficult to extract facial area information using only simple techniques. In two face images of the same person, similar features can still be found in their contours. On the contrary, there are remarkable differences, not only in the shape but also in the size of the contours for images of different persons. Hence, identification is done using the matching of contours of two faces. The picture which is to be matched is called the *input* picture, and the picture it has to be matched to is called the *registered* picture. Only simple template matching has been adopted from the practical point of view

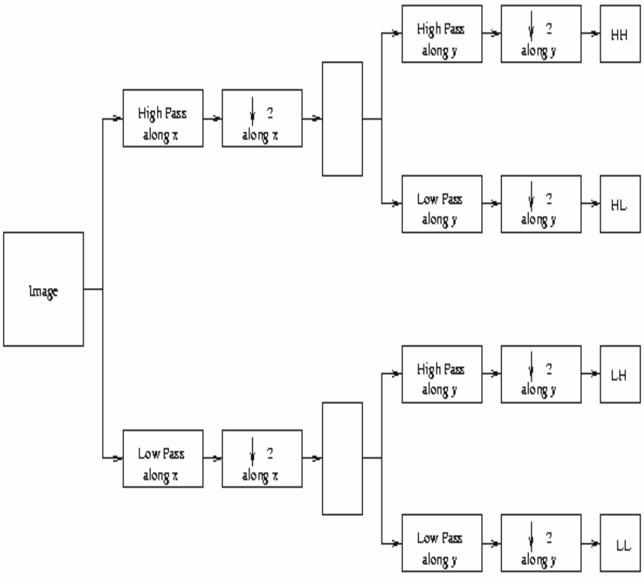

Figure 2 : Forward DWT

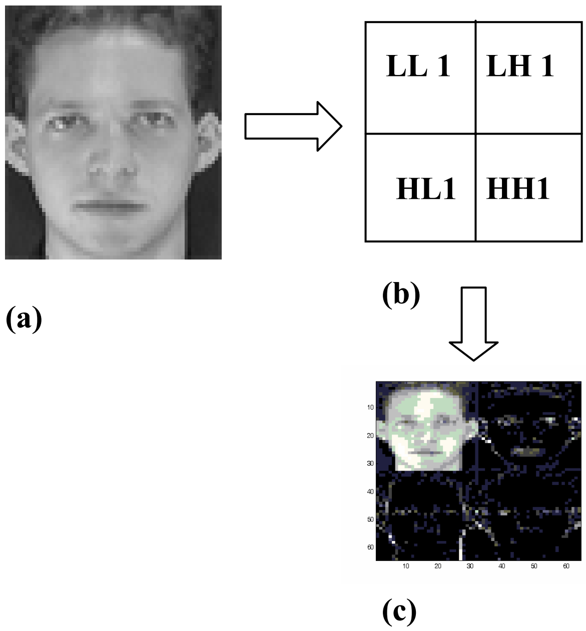

Figure 3. : One level decomposition (a) Input image (b) Frequency bands (c) DWT image

4. 3.2.1 Calculation of Matching Ratio: [6]

Calculation of Matching Ratio is a two step process:

1) Overlapping of Captured and registered contours.
2) Fragment Removal

The steps of the matching algorithm is to find the 'Matching Ratio' *H(f, g)* are as follows: To find maximum similarity between input and registered contour, the template matching technique is used. That is,
the input image is slid pixel-by-pixel across the registered image in a top to bottom and left to right fashion. If f(i,j) and g(k,l) are the pixels at position (i, j) and (k, l) of input and registered contour respectively, then α ,β measure the horizontal and vertical displacement between the two pixels f(i,j) and g(k,l) during the sliding process. If α ,β are the horizontal and vertical displacement respectively, which give the best matching result, then the maximum similarity defined by equation(1)between corresponding contour is obtained.[5]

$$h_{i.j}^{(i)}\left(\overline{\alpha},\overline{\beta}\right) \overset{\Delta}{=} \max_{\alpha,\beta} \sum_{i.j} h_{i.j}^{(i)}\left(\alpha,\beta\right) \quad \text{--(1)}$$

$$h_{i.j}^{(i)}\left(\alpha,\beta\right) = \phi\left[\sum_{x=-2}^{2}\sum_{y=-2}^{2}\left(f_{i.j}^{(i)} . g_{k+x,l+y}^{l}\right)\right] \quad \text{--(2)}$$

$$k = i \pm \alpha,\ l = j \pm \beta,$$

$$\alpha = 0,1,2,..........150,\quad \beta = 0,1,2,........,112$$

$$\phi[x] = \begin{cases} 1 & for\ x \geq 1 \\ 0 & for\ x = 0 \end{cases}$$

For pictures of the same person, after template matching, long segments of overlapping (in the sense of equation 2) contour should be obtained. On the other hand, for different persons, even if high matching ratio is obtained from equation 1 the existence of a great number of short segments overlapped by chance can be expected. Therefore, if these short segments can be eliminated effectively, a stable performance of the discrimination method can be achieved. The short segments are denoted as $S^{(n)}$ (n: a label for the segment, l : the length of the segment,θ_t: the threshold value for the segment length).The final matching ratio H(f, g) can be calculated from equation 3.

$$H(f,g) = \frac{2}{F+G}.\sum \hat{h}_{i.j}(\hat{\alpha}\hat{\beta})$$

$$\hat{h}_{i.j}(\hat{\alpha},\hat{\beta}) = \hat{0}\ \ if\ \ \hat{h}_{i.j}(\hat{\alpha},\beta) \in S^{(n)}(\ l \leq \theta_t\ ) \quad (3)$$

Where F and G denote the number of pixels in the contour of input and registered picture respectively. H (f , g)is the matching ratio for the given contour and θ_t is the fragment removal threshold. The fragment removal threshold and matching ratio threshold used for the identification/discrimination of the faces were determined by experimental means.

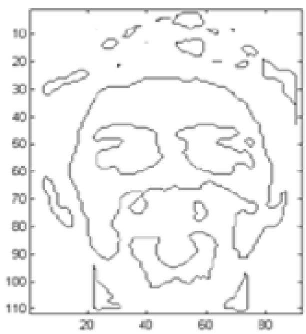

Figure4: Contour of a given image

4.4 Isodensity Line Maps+ Hopfield Neural Network [5, 6, 11, 19]:

Proposed Face Recognition Algorithm using Isodensity Line Maps+ Hopfield Neural Network consists of three major steps. The detailed algorithm is as follows.

Step-I Preprocess the Input Image.

1. Enter following input specifications
   a) Name of input and output image.
   b) Lower and upper threshold value of quantization.
   c) 'X' and 'Y' co-ordinate of left eye.
   d) 'X' and 'Y' co-ordinate of right eye.
2. Pre-process the image using Gaussian filtering.
3. Perform geometric normalization to locate & upright position of the face in an image.
4. Apply mask on the image to segment face part of an image from the background.
5. Perform pixel value normalization to get optimum brightness. To normalize pixel value, calculate sum, mean and standard deviation. For every pixel, subtract the mean and divide by standard deviation.
6. Binarize the image-using threshold.

Step-II Train the Neural Network.

1. Generate isodensity maps from the processed image.
2. Train the network from isodensity maps using Hopfield neural network.

Step-III Test the image.

Test the image using the concept of covariance.

This is the core of the project, in which isodensity maps[5] are generated from the face image. Isodensity lines are the boundaries of constant gray-level areas after quantizing an image. The whole face is treated as a contour map, with the areas of "constant gray-level brightness" (i.e. the plains) enclosed by the isodensity lines (i.e. contour lines). After the isodensity lines are generated, they can be of varying brightness. They are then normalized to generally 8 levels, and then all lines of a particular brightness level are separated out to form a "map" for that level.
The figure-5 shows isodensity lines maps for various levels. Each map conveys the varying amounts of information. The isodensity line maps can then be used to train Hopfield neural network [5, 6, 11, 19] which will be used for face recognition.

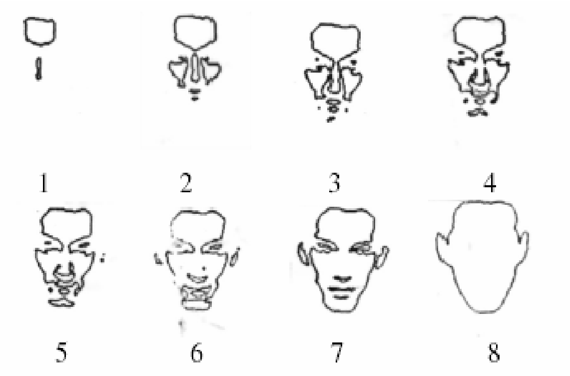

Figure5: Isodensity Line maps for various levels

5. Conclusions

5.1Data preparation:

We have used BioId database[7] and ORL database [14] as our testbed to compare algorithm. The frontal face images of the 20 subjects in BioId database each with 5 different expression provide variation in views of the individual such as lighting, facial features (such as glasses) and slight changes in head orientation. and the frontal face images of the 20 subjects in ORL database each with 10 different expression provide variation in views of the individual such as lighting, facial features (such as glasses) and slight changes in head orientation are used for evaluation..

***5.2Result Analysis of PCA Method*:**

We have taken image of the size 92×112Performance evaluation of proposed algorithm on different databases is given in table-1. Figure6 gives a graph between numbers of Eigen values versus % recognition rate, train time per model, test time per image. Series1 gives % recognition rate, series 2 gives train time per model, and series3 gives test time per model. From the graph as number of eigen values goes on increasing the recognition rate is also goes on increasing. But computational time goes on increasing. Also an investigation is made into the recognition rate at different resolution using ORL database. The results of the findings are given in table2.

TABLE 1: PERFORMANCE EVALUATION OF PCA ALGORITHM [21]

Sr No	Parameters	BioID Database	ORL Database
1	No of subjects	20	20
2	No of different expressions per subjects	05	10
3	Total no of images	100	200
4	Recognition Rate	95 %	80 %
5	False Acceptance Rate	Nil	Nil
6	False Rejection Rate	5 %	20 %

TABLE 2: RESULTS OF RECOGNITION AT DIFFERENT RESOLUTIONS FOR THE PROPOSED PCA BASED FACE RECOGNITION SCHEME ON ORL DATABASE [21].

Image Size	% Recognition Rate	Train Time per Model	Test Time per Image
92×112	80	6.52sec	2.79sec
64×64	93	6.33 sec	2.35 sec

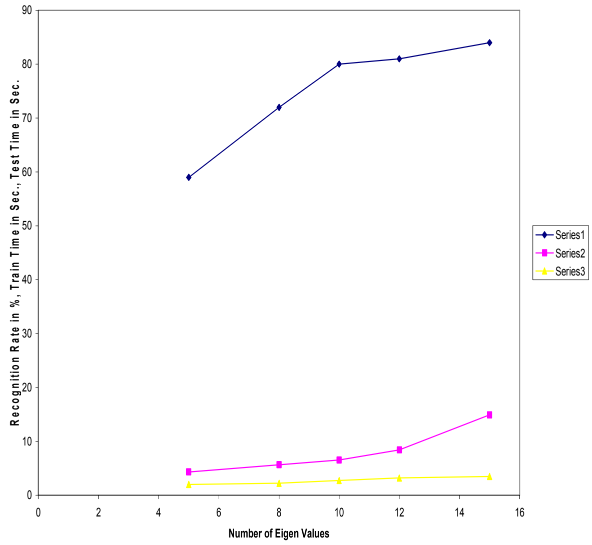

Figure 6: No. of eigen values verses % recognition rate, train time per model, test time per image on ORL database

5.3 Result Analysis of DWT+ PCA Method:

First we have scaled the image from 92× 112 to 64× 64. Then DWT of 64× 64 image is taken and then eigenspace is generated.

Performance evaluation of proposed algorithm of DWT+PCA with PCA method on ORL databases is given in table-3.

TABLE 3: PERFORMANCE OF DWT+PCA WITH PCA ALGORITHM ON ORL DATABASE.[18]

Sr No	Parameters	DWT+PCA	PCA
1	No of subjects	20	20
2	No of different expressions per subjects	10	10
3	Total no of images	200	200
4	Recognition Rate	89.5 %	80 %
5	False Acceptance Rate	Nil	Nil
6	False Rejection Rate	10.5%	20%

The recognition rate is dependent on the selected wavelet function and the level of decomposition.

5.4 Result Analysis of Contour Matching Method:

Based on the contour comparison the result of the user authentication is given. If the Final matching ratio is greater than threshold then the user is authenticated. In our case we have taken threshold value is 0.1990 which was determined by experimental means. Performance evaluation of proposed algorithm on BioID databases is given in table-4. Figure7 shows graph between % recognition rate versus number of training images. As number of training images increases the recognition rate goes on increasing.

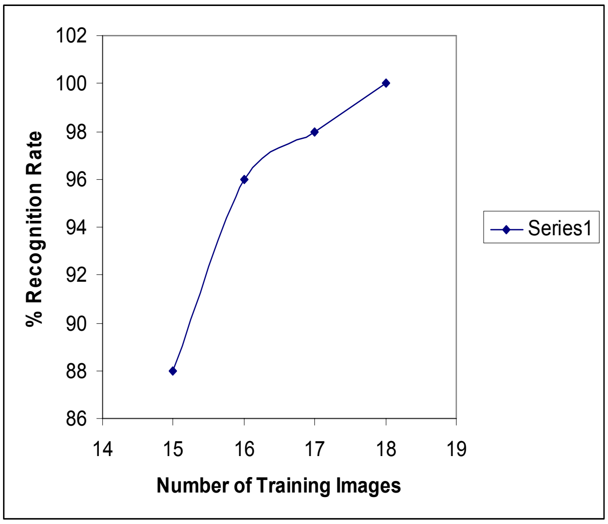

Figure 7: % Recognition Rate versus Number of Training Images[24]

TABLE 4: PERFORMANCE EVALUATION OF CONTOURING MATCHING ALGORITHM [20]

Sr No	Parameters	BioID Database
1	No of subjects	15
2	No of different expressions per subjects	05
3	Total no of images	75
4	Recognition Rate	100 %
5	False Acceptance Rate	Nil
6	False Rejection Rate	Nil

5.5 Result Analysis of Isodensity Line Maps+ Hopfield Neural Network Method:

We have taken 40 images from BioID database out of which 8 images are used for training purpose. The proposed system is tested with 40 images for different number of features. For each person, we have taken single image for training and 4 images for testing. Test images with up to two variations such as eyes closed or opened, mouth closed or opened, minute facial expressions, change in hair style are successfully authenticated. Rejected images have more than two variations in expression. Experimental result of proposed system is as shown in figure8[19]. Performance evaluation of proposed algorithm on BioID databases is given in table-5. The recognition rate was found to be 85%. We have also check the algorithm by increasing number of test images. As the number of test image goes on increasing the recognition rate goes on decreasing. Research shows that number of spurious states equal to 0.15N, where N is the number of neurons in the Hopfield network. As no. of spurious states is increased, it may converge to any one of the spurious state. The figure 9 shows a graph of time required to train the images versus no. of training images.

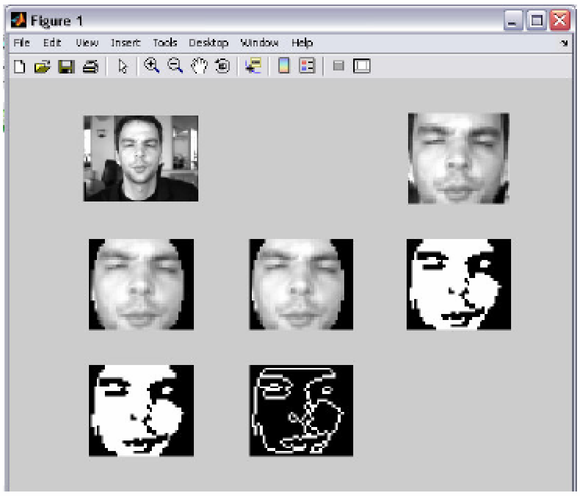

Figure8: Intermediate stages of preprocessing and contour tracing

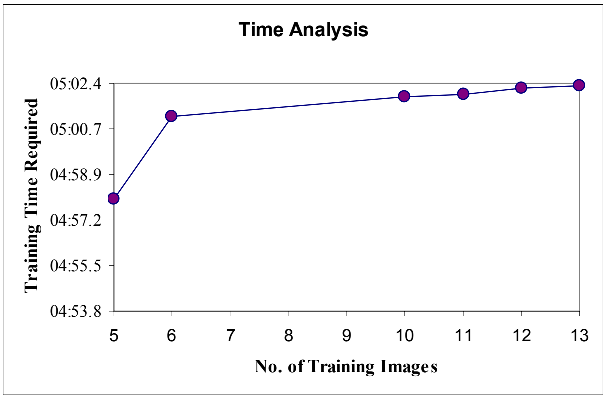

Figure 9 Training time required (in minutes) versus Number of Training Images

.

Table 5: Performance of Isodensity Line Maps Hopfield Neural NETWORK [23]

Sr No	Parameters	BioID Database
1	No of subjects	08
2	No of different expressions per subjects	05
3	Total no of images	40
4	Recognition Rate	85%
5	False Acceptance Rate	Nil
6	False Rejection Rate	15 %

5.6 Summary:

The face similarity meter was found to perform satisfactorily in constrained conditions of exposure, illumination and contrast variations.

In contour matching though recognition rate is very high but recognition time per image is very high.

In Isodensity Line Maps+ Hopfield Neural Network Method no of spurious states equal to 0.15N, where N is the no. of neurons in the Hopfield neural network. A future research direction is

1. To rescale the energy function in Hopfield network to avoid the spurious states and to improve the recognition rate.
2. Use neurofuzzy approach to improve recognition rate.

Though some problems are still to be experimented (such as effect of a more tilting of the head etc) and the algorithm needs to be tested for large variations of pose

The proposed system of face recognition may be applied in identification systems, document control and access control. Biometric technologies are found application in four broad application categories: surveillance, screening, enrollment identification, and identity verification. General security tasks, such as access control to buildings, can be accomplished by a face recognition system. Banking operations and credit card transactions could also be verified by matching the image encoded in the magnetic strip of the card with the person using the card at any time. Finally, a robust system could be used to index video-documents (video-mail messages, for example) and image archives. An image archive indexed in such a way would be useful for criminal identification by the investigation department.

6. References

[1] Anil K. Jain, , Arun Ross, , and Salil Prabhakar ," An Introduction to Biometric Recognition ," IEEE Transactions On Circuits And Systems For Video Technology, Vol. 14, No.1, January 2004 (Invited paper)

[2] Rama Chellappa, Charles L. Wilson and Saad Sirohey, "Human and machine recognition of faces: A survey," Proceedings of the IEEE vol.83,no.5.pp.705-740 May1995.

[3] Mehmoud Ismail, Reda A. El-Khoribi "HMT of the Ranklet Transform for Face Recognition and Verification," ICGST's Graphics Vision and Image Processing Journal, vol.6,issue3,dec06,pp7-13.

[4] M.Turk and A.Pentland, "Eigenfaces for recognition," Journal of. Cognitive Neuroscience,vol.3, pp.71-86, 1991.

[5] S.T.Gandhe, K.T.Talele, A.G.Keskar, " Face Recognition Using Isodensity Maps-A Neural Network Approach", 1st International Conference on Emerging Applications of Information Technology (EAIT) organized by Computer Society Of India, Kolkata, pp.129-132, 11&12 February 2006.

[6] Osamu Nakamura, Shailendra Mathur, Toshi Minami, " Identification of Human Faces Based on Isodensity Maps", IEEE Proceedings on Pattern Recognition, Vol.24, No.3, pp.263-272, 1991.

[7] BioID face database: www.humanscan.de/support/downloads/facedb.php

[8] W.Zhao, " Face Recognition-A Literature Survey", ACM Computing Surveys, Vol., No. 4,December 2003, pp. 399–458.

[9] Turk, Pentland, " Face Recognition using Eigen Faces", In Proceedings of Computer Vision and Pattern Recognition ,IEEE,june1991b,pp586-591.

[10] Tolba, El-Baz, El-Harby, " Face Recognition- A Literature Review", International Journal of Signal Processing, Vol.2, No.2, 2005, pp.88-103.

[11] S.T.Gandhe and Dr. A.G. Keskar Image analysis and inference using soft computing tools: Acomparison of algorithms",in proceedings of National Conference on High Performance Computing (VISION 05),Government College of Engineering Tirunelveli, Tamilnadu ,pp331-335 , 8th April 2005

[12] L.Sirovich and M. Kirby, "Low dimensional procedure for the characterization of human faces," Journal of optical society of America, vol.4, March1987,pp519-524.
[13] Kirby M. and Sirovich L., "Application of the Karhunen-Loeve Procedure for the characterization of Human Faces", IEEE trans. On pattern recognition and machine intelligence,12(1), page no.103-108.
[14] AT&T Laboratories Cambridge. The ORL Database of Faces. http://www.cam-orl.co.uk/facedatabase.html.
[15] Kenny Teng, James Auwaerter," Face Recognition Using Wavelet Representations Obtained From Different Pruning Strategies," Carnegie Mellon University ,Pittsburgh, PA 15213.
[16] K.Y. Tan,A.K.B. See "Comparison and Implementation of Various Methods in Facial Recognition Technology," ICGST's GVIP Journal, vol.5,issue9, dec05,pp11-19.
[17] Khalid Chougdali, M. Jedra, N. zahid " Face Recognition Using Relevance Weighted LDA with QR decomposition ," ICGST's GVIP Journal, vol.6,issue 2, Sept06,pp27-31.
[18] S.T.Gandhe, K.T.Talele, A.G.Keskar, " Face Recognition Using DWT+PCA" Selected in IEEE International Conference –Indicon2007 ,Bangalore on 6,7,8th Sept 2007
Journal Paper under Review:
[19] S.T.Gandhe, K.T.Talele, A.G.Keskar, "Face Recognition Using Hopfield Neural Network "IEE Transactions on Image Processing submitted on 15May2007.
[20] S.T.Gandhe, K.T.Talele, A.G.Keskar, " Face Recognition Using Contour Matching "KES Journal submitted on 6 July2007.
[21] S.T.Gandhe, K.T.Talele, A.G.Keskar, "Face Recognition Using Principle Component Analysis" International Journal of Computer Science submitted on 18August2007.

Biographies:

S.T.Gandhe is Assistant Professor in Electronics Engg Department, S. P. College of Engineering, Mumbai, India. He is a member of IEEE. His area of interest includes Image Processing, Pattern recognition and Robotics. He has published ten papers in National Conferences and four papers in International conference.
star_stg@yahoo.comDr.

K.T.Talele is Assistant Professor in Electronics Engg Dept, S. P. College of Engineering, Mumbai., India He is a member of IEEE. His area of interest includes DSP, Image Processing and Multimedia Comm. He has published twenty five papers in National Conferences and four papers in International conference.
kttalele@yahoo.co.uk

A.G.Keskar is Professor in Electronics Engg. Dept and Dean R & D, Visvesvaraya National Institute of Technology, Nagpur. He is a senior member of IEEE. He has published 10 Journal papers and published 15 papers in International Conferences. His area of interest includes Fuzzy logic, Embedded System and Machine Vision.
avinashkeskar@yahoo.com