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A new hybrid method for face recognition

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***Abstract* — Now a days, security is a major concern for any organization. It is very difficult to have enough faith in any person as far as security of the organization is concerned. Due to these reasons, face recognition gets popularity in the security domain. Many conventional methods are available to do the face recognition. In this paper, we have discussed few of them covering advantages, disadvantages and applications. It is not possible to have a single face recognition method to cover all underlying applications of face recognition system. We have also device a new hybrid method by combining existing approaches of Local Binary Pattern (LBP) and Histogram. This hybrid approach has been tested on standard dataset and compared with LBP. Simulation results shows that proposed hybrid approach outperforms compared to LBP as far as security and speed is concerned.**

***Index Terms*—Histogram, Pronciple component analysis, local binary pattern, local derivative pattern, neural network.**

I. INTRODUCTION

Face Recognition system deals with recognizing individual from face. Face Recognition is a biometric technique. Biometric techniques are preferred for authorization compared to classical techniques like password access, Personal Identification Number (PIN) access just named a few. Major reasons for getting prefrences to biometric techniques compared to classical techniques are i) It is very difficult to remember PIN and passwords ii) It is very hard to maintain secrecy of the PIN and passwords as many tools are available to read PIN or passwords.

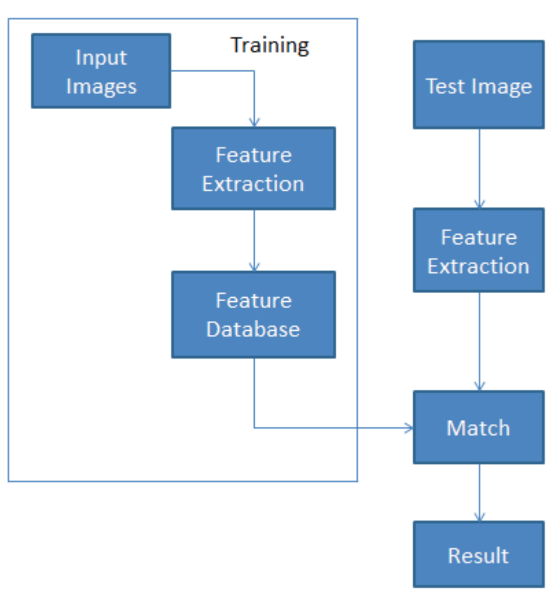

Fig. 1. Procedure for face recognition

Biometric techniques include identification and/or verification of a person using his face, finger print, palm, eye, ear, voice etc. In [1], authors have shown that face recognition technique is beneficial compared to other biometrics methods. A person is required to intract with finger print system to complete the process of identification or verification. Voice recognition is more vulnerable to background noise in public environment[1]. In a face recognition, system can take pictures of a person from distance to determine identity of that person. This system does not require physical interaction of a person. This advantage of face recognition caters needs of security and surveillance system.

The generalized process for face recognition is shown in Fig. 1 and it has two phases i) training phase ii) testing phase. System is given set of training dataset images during the training phase. In next stage, system populates feature database by extracting important features from training dataset using feature extraction algorithms. Features may vary depending on the algorithms being used for feature extraction. Few of them are Principle Component Analysis (PCA), Local Binary Pattern (LBP), Local Derivative Pattern (LDP), Artificial Neural Network (ANN). An image, which is required to be identified, given to the system during testing phase. System does feature extraction for the test image and these features are compared with features stores in database. A thresholding function is used to find most similar images for the given testing image. Other approaches for face detection and feature extraction can be found in [31-38].

We have used standard data set -- 'face94' Essex face database [14] and The University of Oulu Physics-Based Face Database [19] -- to test our new hybrid method for face recognition

Remaining parts of the paper is organized as follows: Applications and classification for face recognition is

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discussed in Section II. Problem and challenges to design face recognition system is discussed in Section III. Face recognition algorithms to cater demands of different applications is explained in Section IV. A new hybrid method using LBP with histogram which has advantages of both LBP and histogram along with the results is shown in Section V. Concluding remarks are given in Section VI.

II. APPLICATION & CLASSIFICATION

Depending on requirements of the underlying application, Face recognition can be classified as follow:

A. Face Verification

A system is initialized by providing training dataset of the authorized persons. During verification, system compares identity of a person with the images stored in the dataset to determine that given identity is true or not. Such systems are used in highly sensitive area where we required two layer security. Face of person and its identity is provided to system to determine if person is authorized or not. Face verification do not check for whole dataset but only check for images of given person. Thresholding is used to decide that given image is of the same person or not.

B. Face Identification

In Face identification, face recognition system recognises a person from its face by matching it with dataset provided to system. Face identification takes more time compared to face verification process as it need to match test image with all train images to find the best match. In this method, system is initialized using training dataset, and test image is provided during the testing phase. Now system extract features from test image and matches it with features of all train images in dataset. Result is calculated from similarity of features.

There are many application areas in which face recognition can be applied. Few of them are as follows:

- Security (Access control to sensitive places [2,3])
- Attendance Management System (We can deploy face recognition system for attendance management in industry or in academic institution. We can take pictures of persons entering hall and identifying person from database we can put his/her attendance directly without interacting with people physically.)
- Surveillance System (We can arrange large number of system taking images at interval and sending to recognition server to recognize thieves, criminals, terrorists, etc. Authorities can be informed whenever match founded. This procedure was used in Super bowl 2001 game at Florida [4].)
- Identity Verification (Identity Verification for driving license, passport, smart card, etc.)
- Video indexing (labeling faces in video) [16, 17]
- Witness face reconstruction [18].

Face recognition can be used for application such as gender classification [5-7] and expression recognition [8,9].

III. PROBLEMS IN FACE RECOGNITION

Face recognition system faces many problems that are discussed in this section.

A. Illumination

First problem that normally occur in face recognition is illumination problem. Two captures of a same person in same situation may not have same illumination as shown in Figure 2. It is a most common problem that we need to deal with.

Fig. 2. Illumination problem

B. Scaling

Scaling is also a common problem in face recognition It is possible that images of a same person is captured at different distances of a camera. So as the distance of camera changes, size of face in image changes which leads to a scaling problem. This problem can be overcome by performing face detection and normalization or using scale invariant feature transform[25]-[26].

C. Shifting

Shifting problem arises when position of a person's face changes in image. Normally during image capture slight change in position of face is experienced. So this problem

Fig. 3. Shifting problem

need to be addressed by different face recognition algorithms. Shifting problem is shown in Figure 3. As shown in Figure 3, the second (right) part of the image contains face of person on right side as compared to the first (left) part of the same image.

D. Different poses

Single person may give images with different poses like smilimg, angry, confused. This is also a problem for face recognition that should be addressed by face reconition algorithms. Figure 4 Shows example of different poses.

Fig. 4. Different pose

E. Rotation

Rotation is also a one of the problems in face recognition. Faces in image can be found rotated by some angle, so it is difficult for the system to recognize the person. Fig. 5. Shows example of rotation. Common solution to solve this problem is use of rotation invariant transformation.

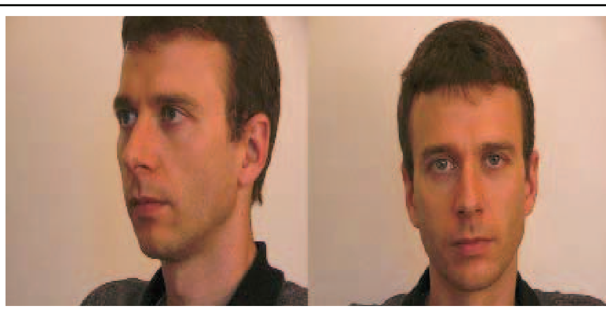

Fig. 5. Rotation problem

IV. Algorithms for Face Recognition

Faces are images so one can think of comparing two images of faces directly. The reason for not having any algorithmic method to do so is faces may not be captured in same situations all the time. Hence, there is a need to design algorithms to perform face recognition. Also, it is not possible for one algorithm to address and overcome al the issues. Each algorithm has its own advantages and disadvantages. Few algorithms are discussed in this section.

A. Histogram

Histogram is a graph that shows frequency of an element in the data set. X-axis in Histogram represents unique elements set. Ex. For gray scale image, each pixel is represented by a value between 0-255. For histogram of any image has all unique pixel values on X axis and its corresponding frequency on Y axis. There is a high Euclidean distance for similar images but they are slightly shifted in any direction compared directly. However, if histogram compared for the same images then Euclidean distance between both will be much lower compared to direct comparision. An image and its corresponding Histogram is shown in Fig. 6.

Advantages of Histogram is that it is used to solve shifting problem that can occur during image capture. Disadvantage of histogram method is that histogram of two different images can be same because histogram only calculates count of pixel value but it does not consider its position. So histogram can be merged with some other methods to get better result. One hybrid method is discussed at the end of this section.

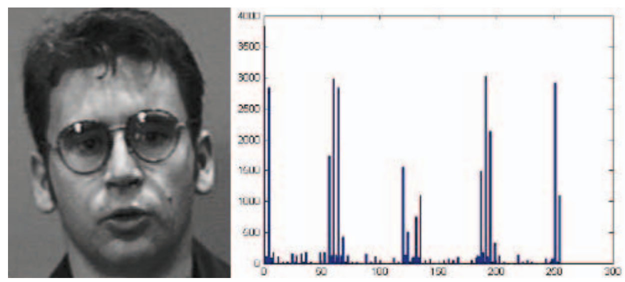

Fig. 6. Histogram example.

B. Principle component analysis

Principle component analysis is method used for image compression and image recognition. PCA can be used for prediction, removing redundancy, data compression and feature extraction. The principle component analysis is used for reducing amount of data to be processed upon resulting in reducing dimensionality of data. It is very difficult to deal with higher dimension data. Hence, PCA can be used to reduce the dimensions of data to be dealt with.

Any image is a 2D matrix of pixels. Now we need to convert this 2D matrix image in to 1D vector representing image. If we have total M images then we will have total M vectors of size N (=Rows x Columns) then each vector is represented by (1) where Pi is a pixel value corresponds to pixel i

$$X_i = [\, P_1 \ldots P_N \,]^T \quad i=1,2,\ldots,M \qquad (1)$$

We can find the mean image by taking the average of values. Mean of the image is given by (2).

$$m = \frac{1}{M}\sum_{i=1}^{M} X_i \qquad (2)$$

Mean centered image is defined as distance of image from mean image. So mathematically it is given by (3).

$$w_i = X_i - m \tag{3}$$

Now, we need to find Eigen vectors e_i for each centered image which has highest projection on centered image. We need to find M eigen vectors for which the quantity specified in (4) holds.

$$\mu_i = \frac{1}{M}\sum_{n=1}^{M} (e_i^T w_n)^2 \tag{4}$$

Here e_i is Eigen vectors of the covariance matrix and μ_i is respective eigen values.

$$C = W\, W^T \tag{5}$$

In (5) C is known as Covariance matrix. Where W is the matrix composed of w_i column vectors placed side by side. Here size of W is N X M so C will be of dimension N X N. Now let us assume that each image is of dimension 50 X 50. So N=2500. So it will create Covariance matrix of dimension 2500 X 2500. It is not practical to find the eigen values and eigen vectors for this dimension. So linear algebra suggest that we can find eigen vector e_i and eigen values μ_i by solving the eigen vectors and eigen values for M X M matrix W^TW. Let d_i and α_i be eigen vectors and eigen values for matrix W^TW respectively,

$$W^T W d_i = \alpha_i d_i \tag{6}$$

Multiplying both the side of (6) with W we get (7).

$$W W^T W d_i = \alpha_i (W d_i) \tag{7}$$

So, from (7) we can say that e_i and μ_i for $W W^T$ is given by $W d_i$ and α_i respectively. For Wd_i equals to e_i , it need to be normalized. The eigen vectors are sorted from High to Low according to eigen values. Eigen vector with high eigen value shows high variation from mean image. Eigen vector with lowest eigen value shows minimum variance from mean image. The decrease in eigen values is exponential in nature means 90% of total variance is contained in first 5-10% dimensions.

Now we can create facial image of Dimension M'(M' <= M) from eigen vector.

$$\Omega=[v_1\, v_2 \,..\, v_{M'}]^T \tag{8}$$

Where $v_i = e_i^T w_i$. Where v_i is the i^{th} coordinate of facial image in new space which is principle component of this method. Here e_i is also image known as eigen faces, which was first named by [11].

Now for comparing two faces for face recognition we need to find eigen faces for all the dataset and then we need to find Euclidean distance between eigen face for test image and eigen face for all dataset images. One with minimum Euclidean distance and is also less than some threshold π then image match is founded.

$$\text{€}_i = | e_t - e_i | \tag{9}$$

Where e_i is eigen face for i^{th} image, e_t is eigen face for test image, €_I is Euclidean distance of i^{th} image with test image.

$$\text{€}_{min} \begin{cases} \le \pi, \text{Match found} \\ > \pi, \text{Match not Found} \end{cases} \tag{10}$$

$$\text{€}_i = | e_t - e_i | \tag{9}$$

Where e_i is eigen face for i^{th} image, e_t is eigen face for test image, €_I is Euclidean distance of i^{th} image with test image.

$$\text{€}_{min} \begin{cases} \le \pi, \text{Match found} \\ > \pi, \text{Match not Found} \end{cases} \tag{10}$$

Where π is Threshold value, and €_{min} is minimum value for Euclidean distance. In [10], authors have given some limitations of algorithm.

1. Face images should be normalized[10].
2. It is difficult to decide threshold[10].

Advantages of this algorithm are as follow:

1. When merged with other algorthms it is highly accurate[10].
2. It reduces dimensionality of data.
3. It can work at high efficiency in case of less number of sample images where most of algorithms fail[20].

C. Local Binary Pattern

Local Binary Pattern (LBP) is applied for facial expression analysis, background modeling and face recognition. This method gives better performance and better result than traditional method like principle component analysis (PCA) used for face recognition.

Faces can be seen as a form of micro pattern. This is basic idea behind a Local Binary Pattern. LBP represent the first order derivative pattern of images, micro pattern generated by concatenation of the binary gradient direction. However, first order derivation pattern fail to extract more information about images. To extract more discriminative information of image we need to use high order derivative pattern.

LBP is defined as invariant texture measure for gray scale image[22]. LBP uses a local neighborhood. To define a central pixel LBP operator uses its 8 neighbors. To define central pixel for a 3*3 pixels matrice, this method uses threshold function with all 8 pixels with a central pixel and concatenating them. The thresholding function for a basic LBP operator is as follow.

$$f(I(Z_0),I(Z_i)) = \begin{cases} 0, \text{if } I(Z_i) - I(Z_0) \le \text{threshold} \\ 1, \text{if } I(Z_i) - I(Z_0) > \text{threshold} \end{cases} \tag{11}$$

where i=1,2,…,8.

8 neighborhoods points of Z_0 is shown in Figure 7 with Z1 to Z8 . Fig. 8. shows an image with a micro pattern represented by 3*3 matrixes. For central pixel if we apply thresholding function then equivalent result also shown in Fig.8. Now this equivalent binary or decimal is used for representing that central pixel. LBP is first order derivative pattern so it is used to solve the illumination problem[23][24]. LBP gives execellent performance in many comparative studies, in terms of speed and discrimination performance[13].

D. Local Derivative Pattern

LBP (Local Binary Pattern) is encoding binary result of first order derivative only which cannot extract more information from image. That's why there is a need to use high order derivative pattern to extract more information from image. For that we defined a LDP (Local Derivative

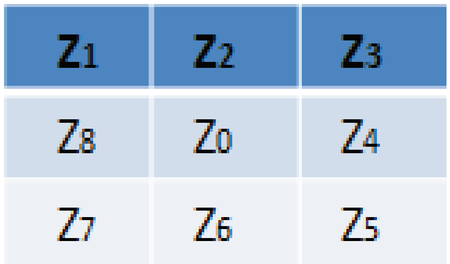

Fig. 7. Pixel Formation

Pattern) operator which is n-1th derivative direction variation based on binary coding function.

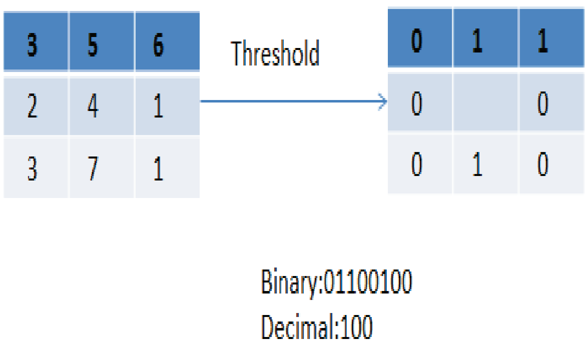

Fig.8.Finding LBP Pattern

For an image I(J) the first order derivative information along 0°,45°,90° and 135° direction are donated as $I'_\beta(J)$ where

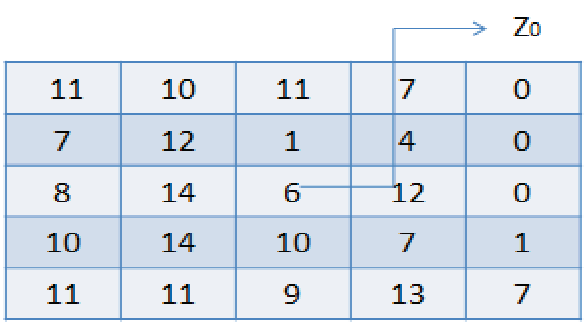

Fig. 9. Pixel Arrangements

β=0°,45°,90° and 135°. Let β0 central point for 3*3 pixels matrix with neighborhoods point βi where i=1,2,…,8. First order derivative for $J=J_0$ are shown in (12):

$$\begin{aligned} I'_{0^\circ}(J_0) &= I(J_0) - I(J_4) \\ I'_{45^\circ}(J_0) &= I(J_0) - I(J_3) \\ I'_{90^\circ}(J_0) &= I(J_0) - I(J_2) \\ I'_{135^\circ}(J_0) &= I(J_0) - I(J_1). \end{aligned} \tag{12}$$

Equations (12),(13),(14),(15),(16) all reffered from [13].

The second order direction LDP, $LDP^2{}_\beta(J_0)$ in a direction at $J=J_0$ defined in (13).

$$LDP^2{}_\beta(J_0)=\{f(I'_\beta(J_0), I'_\beta(J_1)),\ldots, f(I'_\beta(J_0), I'_\beta(J_8))\} \tag{13}$$

Where function f determine type of local pattern transition defined by (14).

$$f(I'_\beta(J_0), I'_\beta(J_i)) = \begin{cases} 0, & \text{if } I'_\beta(J_i) - I'_\beta(J_0) > 0 \\ 1, & \text{if } I'_\beta(J_i) - I'_\beta(J_0) \leq 0 \end{cases} \tag{14}$$

where i=1,2,…,8.

Thus second order $LDP^2{}_\beta(J)$ defined by (15).

$$LDP^2(J)=\{ LDP^2{}_\beta(J) \mid \beta = 0^\circ, 45^\circ, 90^\circ, 135^\circ \} \tag{15}$$

LDP operator compares derivative pattern of pixel with its neighbours and generates 32 bit sequence code for each pixel because 0^0 will have 8 bit code and same for other 3 values of β , So total 32 bit code. To calculate nth order Local Derivative Pattern we need to compute first n-1th LDP along β = 0° , 45° , 90° , 135° directions donated as $LDP^n{}_\beta(J_0)$ in β direction at $J=J_0$ defined by (16).

$$LDP^n{}_\beta(J_0)=\{f(I^{n-1}{}_\beta(J_0), I^{n-1}{}_\beta(J_1)),\ldots, f(I^{n-1}{}_\beta(J_0), I^{n-1}{}_\beta(J_8))\} \tag{16}$$

Where $I^{n-1}{}_\beta(J_0)$ is the n-1th order derivative in β direction at $J=J_0$. $f(I^{n-1}{}_\beta(J_0), I^{n-1}{}_\beta(J_i))$ same as a $f(I'_\beta(J_0), I'_\beta(J_i))$ but for n-1th derivative.

$f(I^{n-1}{}_\beta(J_0), I^{n-1}{}_\beta(J_i))$ encodes the n-1th gradient transitions into binary pattern providing extra order pattern information to local region. The high order local pattern described detailed texture information than a first order local pattern used in LBP. . However n become high they will become very sensitive to noise and performance may be decrease than lower order LDP[27]. The nth order LDP is local pattern string

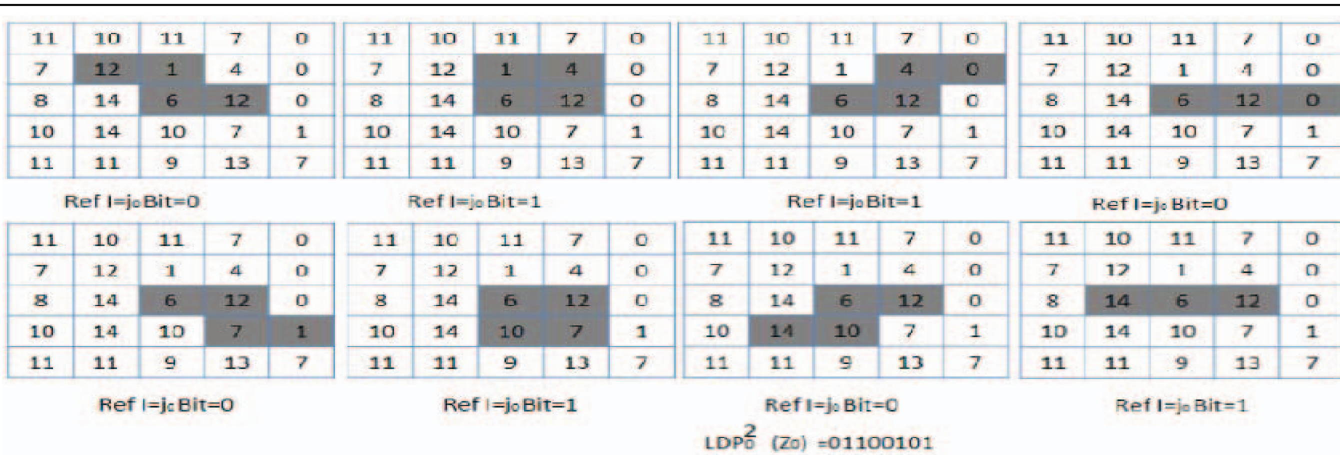

Fig. 10. LDP for Second-order Derivative calculation

defined by (17).

$$LDP^n(J)=\{ LDP^n_{\beta}(J)| \beta = 0^{\circ}, 45^{\circ}, 90^{\circ}, 135^{\circ} \} \quad (17)$$

The LDP method is better than LBP because LDP provide more information than LBP. LBP encode a relation between central point and its 8 neighborhood point only while LDP encode various distinctive spatial relationship in local region. Here in fig I have shown that LDP operator extract high-order information. Here in Fig.10. I have shown a second order derivative for LDP to get more information than first order and find a local region.

In Fig.9. we have show a 5*5 matrix of pixel and central pixel is indicated by Z_0.Here we want to find second order derivative for Z_0 with reapect to direction $\beta = 0^{\circ}$ which is shown in Fig.10. Same way we can find second derivative for $\beta = 45^{\circ}, 90^{\circ}, 135^{\circ}$ also. Then we can find 32-bit binary sequence for $Z_{0.}$

Experiments shows that when LDP operates on more than forth order then noise is introduced. Hence, pattern becomes noisy which makes difficult to identify information. It leads to performance drop. But second and third order LDP gives better performance than first order LBP[13].

LDP is having same advantage of derivative pattern of solving illumination problem. LDP contain more information about image so it is more effective method over LBP[24].

E. Neural Network

Humans are considered to be more powerful than computers in matter of pattern matching and face recognition. So if we can design our system similar to our

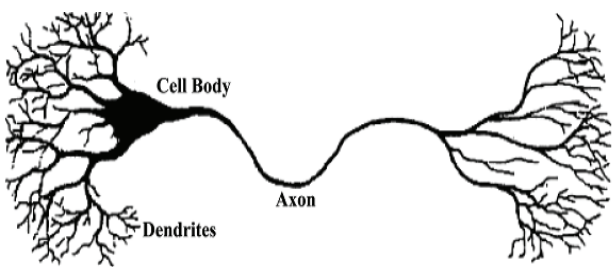

Fig. 11. Human neural network[12]

human mind then we can improve efficiency of face recognition. Working of human mind with neurons is shown in Figure. 11.

Human mind is a neural network which has elements like nucleus and axon. Nucleus is node in neural network and axon is line connecting two nucleus. Now if we create artificial neural network it would be look like the one shown in Figure. 12. Where x_1, x_2, x_3 are neurons and w_{i1},w_{i2},w_{i3} are weights associated with respective lines connecting other neurons. $\sum$ is summation function to add values coming from different neurons and it is forwarded in the network. Design of artificial neural network is pictiorically shown in Fig. 13.

In Figure 13, Input layer is used for providing input. Output is generated by artificial neural network and it will be available at output layer. Hidden layer are processing layers. No of hidden layers vary for different applications. No of nodes in hidden layer is decided by thumb rule[28]. Neural network mostly works in two phases.(i) Training (ii) Testing

For face recognition no of inputs are set to the fix resolution of input images. For example, if all images are of 50 X 50 resolution then number of input nodes will be 2500 (50 X 50) . We have total 50 persons to be identified then size of output layer is set to 50 nodes. Now in training phase

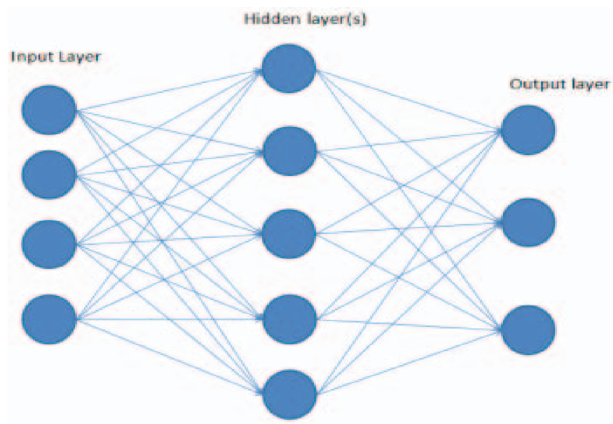

Fig. 13. Artificial neural network

we supply training data set to neural network where we provide input images to network and supply desired output. So that neural network set the weights on each line according to inputs. Each training image changes weights on lines. Now in testing phase we can supply test image and neural network will give output in output layer.

Few characteristics of Neural networks is listed below:

- It takes more time in training phase but it is fast for testing phase.
- Identifying person with less number of sample images is difficult.
- It easily accommodate itself with changes
- If count of hidden layer is increased it becomes complex.

V. A NEW HYBRID APPROACH USING LPP WITH HISTOGRAM

We can combine more than one methods to combine the advantages of multiple methods. We have proposed one such hybrid approach using combination of LBP with histogram. Experiments show that if we combine LBP and histogram method we get better performance than a LBP or a histogram. For that first we need to apply LBP method to find a local binary pattern of the dataset. We can apply histogram method on LBP instead of storing LBP as feature in database. This histogram of lbp is stored as features in the database which will be used in testing phase for face recognition purpose.

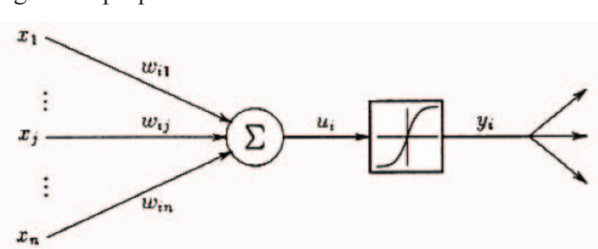

Fig. 12. Artificial neural network node[12]

Here Fig.14 and Fig. 15 shows histogram of LBP of two differenct images of a same person. From the images we can notice that the similarity of histogram of both the images and another benefit of this method is that it consumes less time in

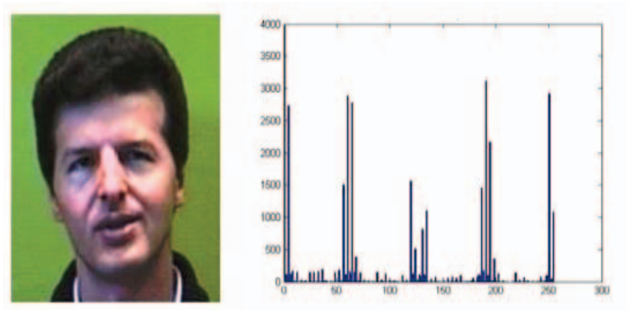

Fig. 14. LBP with histogram test image

testing phase which is proved with experiment result in next section. So, LBP with histogram enables us to find the correct result in less time with higher accuracy.

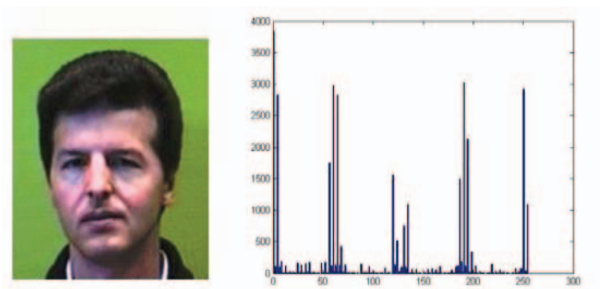

Fig. 15 Match image in training set

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A. Analysis of the proposed hybrid approach

Accuracy analysis of this method is compared with simple LBP method and results are shown in Table 1.

Method	Dataset	Total images	Match	Accuracy
LBP	Face94	304	265	87.17%
LBP with Histogram	Face94	304	286	94.07%

Table 1. Accuracy comparision of hybrid method

Table 1. clearly shows that method proposed hybrid method LBP with histogram gives better accuracy compared to LBP alone. Speed of the algorithm is also better for our proposed approach than LBP. This method takes more time in training phase than simple LBP but training phase is not continuous so time load is acceptable because training phase is not completed in small time. Time load in testing phase is not acceptable because testing phase should be completed in as small time as possible. This method allows us to complete testing phase in short duration. Time load for both LBP and LBP with Histogram method in testing phase is shown in Table 2.. This experimets were performed on computer having Core2Duo 2.16 GHz processor, 3GB RAM and other parameters that can affect the results are kept constant during the simulation.

Total Images	LBP		LBP with Histogram	
	Total time	Comparision time	Total time	Comparision time
152	0.251	0.034	0.265	0.020
304	0.281	0.064	0.266	0.021
760	0.37	0.147	0.272	0.027
1216	0.454	0.235	0.278	0.032
2736	0.764	0.545	0.298	0.054

Table 2. Time load of both algorithms

Table 2. clearly shows that LBP with hisogram is far more better than LBP. In addition time load of LBP increases as the size of image increase but time load in LBP with Histogram is independent of size of image.

VI. Conclusion

We have proposed a new hybrid approach by combining two methods of face recognition LBP and HISTOGRAM. We have tested our approach in terms of accuracy and speed. Our proposed approach outperforms compared to LBP alone. In future, we will device a new hybrid approach based on Nueral Network and Ant Colony Optimization.

References

[1] A Survey of Face Recognition Techniques by Rabia Jafri and Hamid R. Arabnia *Journal of Information Processing Systems.*

[2] K. Kim, "Intelligent Immigration Control System by Using Passport Recognition and Face Verification," in *International Symposium on Neural Networks*. Chongqing, China, 2005, pp.147-156.

[3] J. N. K. Liu, M. Wang, and B. Feng, "iBotGuard: an Internet-based intelligent robot security system using invariant face recognition against intruder,"*IEEE Transactions on Systems Man And Cybernetics Part C-Applications And Reviews*, Vol.35, pp.97-105, 2005.

[4] Woodward Jr, John D. Super Bowl surveillance: Facing up to biometrics. RAND ARROYO CENTER SANTA MONICA CA, 2001.

[5] K. Balci and V. Atalay, "PCA for Gender Estimation: Which Eigenvectors Contribute?" in *Proceedings of Sixteenth International Conference on Pattern Recognition*, Vol.3. Quebec City, Canada, 2002, pp. 363-366.

[6] B. Moghaddam and M. H. Yang, "Learning Gender with Support Faces," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol.24, pp.707- 711, 2002.

[7] R. Brunelli and T. Poggio, "HyperBF Networks for Gender Classification," *Proceedings of DARPA, Image Understanding Workshop*, pp.311-314, 1992.

[8] A. Colmenarez, B. J. Frey, and T. S. Huang, "A probabilistic framework for embedded face and facial expression recognition," in *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, Vol.1. Ft. ollins, CO, USA, 1999, pp. 1592-1597.

[9] Y. Shinohara and N. Otsu, "Facial Expression Recognition Using Fisher Weight Maps," in *Sixth IEEE International Conference on Automatic Face and Gesture Recognition*, Vol.100, 2004, pp.499-504.

[10] Kim, K. (1996). Face recognition using principle component analysis. In International Conference on Computer Vision and Pattern Recognition (pp. 586-591).

[11] M.A. Turk and A.P. Pentland, "Face Recognition Using Eigenfaces", *IEEE Conf. on Computer Vision and Pattern Recognition*, pp. 586-591, 1991.

[12] Mantri, Shamla, and Kalpana Bapat. "Neural Network Based Face Recognition Using Matlab." (2011): 6-9.

[13] Zhang, Baochang, Yongsheng Gao, Sanqiang Zhao, and Jianzhuang Liu. "Local derivative pattern versus local binary pattern: face recognition with high-order local pattern descriptor." *Image Processing, IEEE Transactions on* 19, no. 2 (2010): 533-544..

[14] Available at: http://cswww.essex.ac.uk/mv/allfaces/faces94.zip

[15] P. N. Belhumeur, J. Hespanha, and D. J. Kriegman. Eigenfaces vs. Fisherfaces: Recognition using class specific linear projection. In ECCV (1), pages 45--58, 1996.

[16] E. Acosta, L. Torres, A. Albiol, and E. J. Delp, "An automatic face detection and recognition system for video indexing applications," in Proceedings of the IEEE International Conference on Acoustics, Speech and Signal Processing, Vol.4. Orlando, Florida, 2002, pp.3644-3647.

[17] J.-H. Lee and W.-Y. Kim, "Video Summarization and Retrieval System Using Face Recognition and MPEG-7 Descriptors," in Image and Video Retrieval, Vol.3115, Lecture Notes in Computer Science: Springer Berlin / Heidelberg, 2004, pp.179-188.

[18] C. G. Tredoux, Y. Rosenthal, L. d. Costa, and D. Nunez, "Face reconstruction using a configural, eigenface-based composite system," in 3rd Biennial Meeting of the Society for Applied Research in Memory and Cognition (SARMAC). Boulder, Colorado, USA, 1999.

[19] Available at: http://www.cse.oulu.fi/CMV/Downloads/Pbfd

[20] Xiaoyang Tan, Songcan Chen, Zhi-Hua Zhou, Fuyan Zhang, Face recognition from a single image per person: A survey, Pattern Recognition, Volume 39, Issue 9, September 2006, Pages 1725-1745

[21] Mäenpää, Topi. *The Local Binary Pattern Approach to Texture Analysis: Extenxions and Applications*. Oulun yliopisto, 2003.

[22] Zou, Xuan, Josef Kittler, and Kieron Messer. "Illumination invariant face recognition: A survey." In *Biometrics: Theory, Applications, and Systems, 2007. BTAS 2007. First IEEE International Conference on*, pp. 1-8. IEEE, 2007.

[23] Tao, Qian, and Raymond Veldhuis. "Illumination normalization based on simplified local binary patterns for a face verification system." In *Biometrics Symposium, 2007*, pp. 1-6. IEEE, 2007.

[24] Ahonen, Timo, Abdenour Hadid, and Matti Pietikainen. "Face description with local binary patterns: Application to face recognition." *Pattern Analysis and Machine Intelligence, IEEE Transactions on* 28, no. 12 (2006): 2037-2041.

[25] Luo, J., Ma, Y., Takikawa, E., Lao, S., Kawade, M., & Lu, B. L. (2007, April). Person-specific SIFT features for face recognition. In *Acoustics, Speech and Signal Processing, 2007. ICASSP 2007. IEEE International Conference on*(Vol. 2, pp. II-593). IEEE.

[26] Lowe, D. G. (1999). Object recognition from local scale-invariant features. In*Computer vision, 1999. The proceedings of the seventh IEEE international conference on* (Vol. 2, pp. 1150-1157). IEEE.

[27] Zhao, Guoying, and Matti Pietikainen. "Dynamic texture recognition using local binary patterns with an application to facial expressions." *Pattern Analysis and Machine Intelligence, IEEE Transactions on* 29, no. 6 (2007): 915-928.

[28] Rafiq, M. Y., G. Bugmann, and D. J. Easterbrook. "Neural network design for engineering applications." *Computers & Structures* 79.17 (2001): 1541-1552.

[29] Martínez, Aleix M., and Avinash C. Kak. "Pca versus lda." *Pattern Analysis and Machine Intelligence, IEEE Transactions on* 23.2 (2001): 228-233.

[30] Kim, Dong-Ju, Sang-Heon Lee, and Myoung-Kyu Sohn. "Two-Dimensional Principal Component Analysis with Local Direction Descriptor."

[31] Chirag I Patel and Sanjay Garg. Article: Robust Face Detection using Fusion of Haar and Daubechies Orthogonal Wavelet Template. *International Journal of Computer Applications* 46(6):38-44, May 2012. Published by Foundation of Computer Science, New York, USA.

[32] Ripal Patel, Nidhi Rathod and Ami Shah, Comparative Analysis of Face Recognition Approaches: A Survey. *International Journal of Computer Applications* 57(17):50-69, November 2012. Published by Foundation of Computer Science, New York, USA.

[33] Patel, Chirag I., Ripal Patel, and Ankit Thakkar. "Object Detection and Segmentation using Local and Global Property." *International Journal of Computer Science* 2.

[34] Chirag I Patel and Ripal Patel 'Goal Detection from unsupervised Video Surveillance' *in proceeding of ACITY-2011, Chennai, India, July 2011 published in Springer (LNCS) in communications in computer and information science (CCIS) series.* ISSN:1865-0929

[35] Chirag. I. Patel and Ripal Patel, "Contour Based Object Tracking," *International Journal of Computer and Electrical Engineering* vol. 4, no. 4, pp. 525-528, 2012.

[36] Chirag I. Patel and Ripal Patel, "Illumination Invariant Moving Object Detection," *International Journal of Computer and Electrical Engineering* vol. 5, no. 1, pp. 73-75, 2013.

[37] Chirag I. Patel and Ripal Patel, "Robust Face Recognition Using Distance Matrice," *International Journal of Computer and Electrical Engineering* vol. 5, no. 4, pp. 401-404, 2013.

[38] Patel, Ripal, Chirag I. Patel, and Ankit Thakkar. "Aggregate features approach for texture analysis." *Engineering (NUiCONE), 2012 Nirma University International Conference on*. IEEE, 2012.