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Face Recognition Using Gabor Wavelet, LBP and its Variants

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***Abstract* – This paper comprises with different methods of facial feature extraction of Face Recognition using Gabor, Local Binary Pattern and its fusion. In addition, Principle Component Analysis (PCA) is applied for dimension reduction. For similarity measurement, Euclidean, City-block, and Cosine distance metrics are used. Results are taken with different databases having major/minor variations in pose, illumination and expression.**

***Keywords* – Face Recognition (FR), Local Binary Pattern (LBP), Principle Component Analysis (PCA), Gabor Wavelet, Eigenspace.**

I. Introduction

Biometrics has become a ubiquitous technology in human identification system. It includes various human physical characteristics like voice, face, iris, fingerprint, veins, ear and so on. Among these, facial features have acquired special attention in research as it involves various challenges. The challenges includes *non-ideal* nature of the available images like misalignment, out of pose (non-frontal), blur, very low resolution, occlusion (like partial face, glasses), aging, illumination variation, expressions, facial marks (such as scars, moles, warts) and so on.

Face recognition, in general, refers to the ability to identify one or more human faces with the help of given dataset of images or videos. Face recognition technology can be used for various applications including surveillance, authentication, law enforcement, security, human-computer interaction and so on.

A typical face recognition system consists of four modules; acquisition and detection (localization), preprocessing (face alignment/normalization, illumination or correction), feature extraction, and matching as shown in Fig. 1.

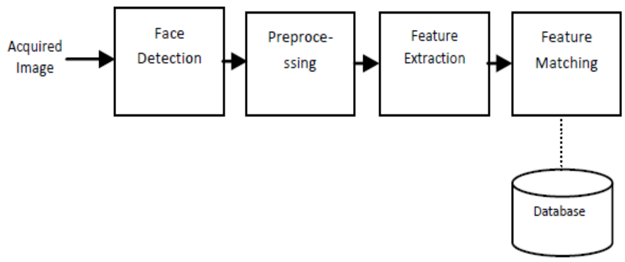

Fig.1. A typical face recognition system

This paper is organized as follows. Section II gives a glimpse on few available techniques of efficient face recognition and current advances in face recognition. Section III gives the prerequisites of our approach. Section IV describes the feature extraction. Finally, conclusions are drawn in Section V.

II. Existing Techniques

Face recognition techniques can be broadly classified into holistic and feature based approaches. Moreover, combination of holistic and feature based approaches are named as hybrid approaches.

The well known holistic approach towards face recognition was given by Turk *et. al*. [1]. Other examples of holistic approach are Fisher Linear Discriminant (FLD), Independent Component Analysis (ICA) [2], [3], [4].
Feature based approaches of face recognition has a long history. Work by M. Yanget. al. [5] and Y. Xu [6] are few to list.

Recent efforts are taken to deal with such challenges. Wilman W. W. Zou*et al.* [7] discusses learning based super-resolution method to learn relationship between very low and high resolution image space. In this approach the relation between low resolution and high resolution images is formed in the training phase using a linear regression model. Rui Min et. al. [8] used local binary patterns (LBP) based descriptors and sparse representation based classification for face recognition.

III. Prerequisites

A. Gabor wavelet

Feature extraction using wavelets represents the image under consideration in multiresolution fashion. Gabor wavelet gives flexibility to extract the features along any direction and in multiple scales. Gabor wavelet representation of a face image is given by [9][10],

$$G_{\mu,\upsilon}(z) = I(z) * \psi_{\mu,\upsilon}(z) \quad (1)$$

where, $I(z)$ represents the 2D facial image under consideration, * denotes the convolution operation, z denotes the pixels (x, y) and $\psi_{\mu,\upsilon}(\cdot)$ represents the 2D Gabor wavelet kernel with orientation μ and scale υ which is given by,

$$\psi_{\mu,\upsilon}(z) = \frac{\|k_{\mu,\upsilon}\|^2}{\sigma^2} e^{\left(-\frac{\|k_{\mu,\upsilon}\|^2 \|z\|^2}{2\sigma^2}\right)} \left[e^{ik_{\mu,\upsilon}z} - e^{-\sigma^2/2} \right] \quad (2)$$

$\|\bullet\|$ denotes the norm operator and the wave operator $k_{\mu,\upsilon}$ is defined as follows,

$$k_{\mu,\upsilon} = k_{\upsilon} e^{i\phi_{\mu}} \quad (3)$$

Where, $k_v = k_{\max} / f^{v}$ and $\phi_\mu = \pi\mu/8$; $k_{\max}$ is the maximum frequency, and f is the spacing between kernels in the frequency domain. For each Gabor kernel, at every image pixel z, a complex number containing two

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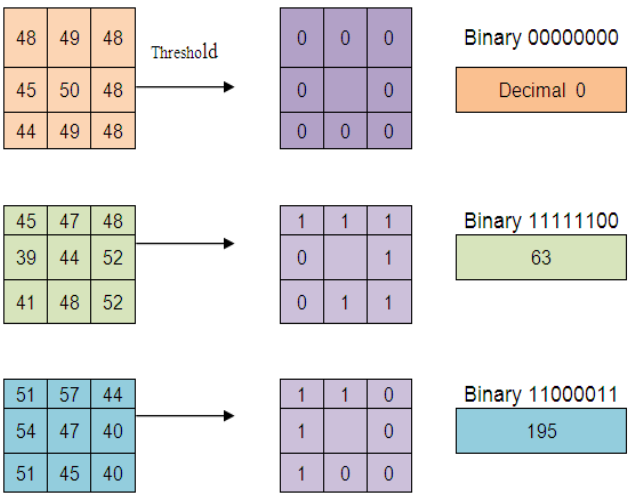
Gabor parts, i.e., real part $\mathrm{Re}_{\mu,\nu}(z)$ and imaginary part $\mathrm{Im}_{\mu,\nu}(z)$, can be generated. Based on these two parts, magnitude $A_{\mu,\nu}(z)$ and phase $\phi_{\mu,\nu}(z)$ are given respectively by,

$$A_{\mu,\nu}(z) = \sqrt{\mathrm{Im}^2{}_{\mu,\nu}(z) + \mathrm{Re}^2{}_{\mu,\nu}(z)} \qquad (4)$$

$$\phi_{\mu,\nu}(z) = \arctan(\mathrm{Im}_{\mu,\nu}(z)/\mathrm{Re}_{\mu,\nu}(z)) \qquad (5)$$

48	49	48	45	47	48	51	57	44
45	50	48	39	44	52	54	47	40
44	49	48	41	48	52	51	45	40
8	48	47	45	48	50	50	47	42
48	46	46	47	47	48	49	46	43
46	46	46	48	49	49	45	40	41
47	46	46	48	51	46	39	35	38
45	47	48	46	51	42	32	36	41
47	48	48	47	55	48	37	31	49

(a)



(b)

0	63	195	44	143	143	7	7	143
135	254	131	58	124	240	224	223	128
56	34	93	124	24	199	7	245	125
228	34	4	104	142	195	182	124	12

Sample output of 1.bmp after LBP (42 x 42)

(c)

Fig.2. (a) Sample image and starting pixel values of 1.bmp of ORL face database. (b) LBP operator applied with 3x3 neighborhoods. (c) Resulting Output after applying LBP operator.

B. *Local Binary Pattern (LBP)*

The local binary pattern of an image is a descriptor which assigns a 3×3 neighborhood; a value calculated by thresholding these neighboring pixels with the center pixel. Interpolation can be used to calculate a sampling point that does not fall in the center of a pixel [11].

For feature extraction, the LBP operator can be applied to a face image by dividing the image into 3×3 blocks. Then a block processing can be done to get the resultant LBP operated image. This is illustrated with the help of an example shown in Fig. 2.

C. *Principle Component Analysis (PCA)*

PCA is a dimensionality reduction technique to project the higher dimension image data onto a comparatively smaller dimension feature space, called as *eigenspace*. The algorithm steps are as follows.

Step 1. Concatenate each face image to form a single column vector x_i. This creates the database matrix, $X = \{x_1, x_2, ..., x_n\}$.

Step 2. Calculate the mean vector μ using, $\mu = \frac{1}{n}\sum_{i=1}^{n} x_i$

Step 3. Select highest eigenvectors corresponding to highest eigen values. These eigenvectors are called *principal components*.

Step 4. Project the mean subtracted column vectors calculated in Step 3 onto the eigenvectors calculated in Step 6. These projections are stored as features vectors of the training images.

Step 5. Concatenate probe image to form a single column vector, in the same way as that of the training images.

Step 6. The probe image feature vector is then searched for closest match among the database images using different distance metrics. Minimum distance finds the closest match in the database.

IV. Experimental Results

A. *Face databases*

Our experiments are performed on following seven databases.

a) *Yale face database*

The Yale face database [12] contains 165 images of 15 subjects. There are 11 images per subject, one for each of the following facial expressions or configurations: center-light, with glasses, happy, left-light, without glasses, normal, right-light, sad, sleepy, surprised, and wink.

b) *Computer Vision Science Research CVSR face database*

The CVSR database [13] contains a sequence of 20 images of 18 different individual, using a fixed camera. During the sequence the subject moves his/her head and makes grimaces which get more extreme towards the end of the sequence

c) *University of Bern face database*

The University of Bern face database [14] contains frontal views of 30 people. For each person 10 gray level images with slight variations of the head positions (right into the camera, looking to the right, looking to the left, downwards, and upwards).

d) *Japanese Female Facial Expression (JAFFE)*

The JAFFE database [15] contains 213 images of 7 facial expressions (6 basic facial expressions + 1 neutral) posed by 10 Japanese female models. Each image has been rated on 6 emotion adjectives by 60 Japanese subjects.

e) Olivetti Research Laboratory(ORL) face database

The ORL face database [16] contains ten different images of each of 40 distinct subjects. For some subjects, the images were taken at different times, varying the lighting, facial expressions (open/ closed eyes, smiling/ not smiling) and facial details (glasses/ no glasses). All the images were taken against a dark homogeneous background with the subjects in an upright, frontal position (with tolerance for some side movement). There are 10 images per subject.

f) S.G.G.S (Indian) face database

The SGGS database [17] contains 25 different images of each of 30 distinct people taken in one session at Shri Guru Gobind Singhji (S.G.G.S.) Institute of Engineering and Technology, Nanded (MS), India. For some subjects, some additional photographs are included. All the images were taken in plain background, variation in illumination, pose, facial expressions and facial details (glasses / no glasses) in robust environment. Figure 3 shows samples from each of the above databases.

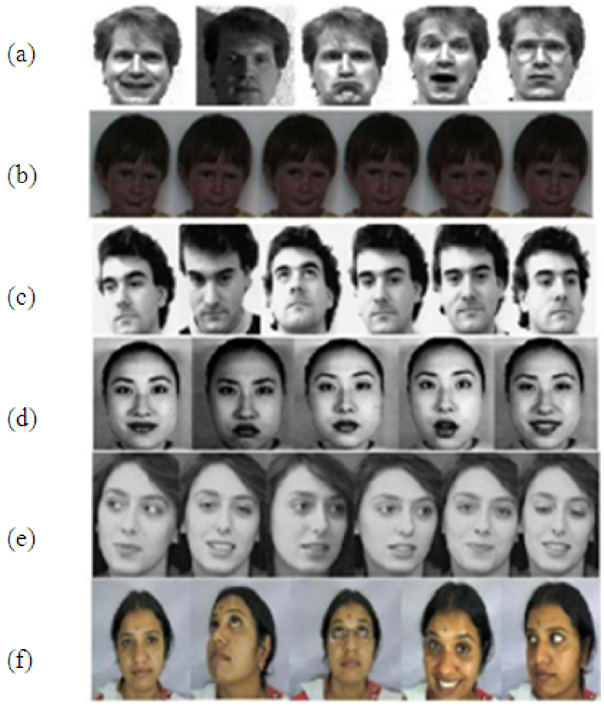


Fig.3. Database samples: (a) Yale, (b) CVSR [Grimace], (c) University of Bern, (d) JAFFE, (e) ORL, (f) S.G.G.S.

B. Feature extraction

Experiments are carried out using following methods.

(a) Gabor Magnitude
(b) Local Binary Pattern (LBP)
(c) Principle Component Analysis (PCA)
(d) PCA applied on Gabor magnitude features
(e) PCA applied on fusion of Gabor magnitude with LBP

For feature extraction using Gabor wavelet, initially, a Gabor kernel is formed with empirically calculated variances and initial frequencies. This kernel is then convolved with the input face images to extract features in the desired direction. The LBP is then applied on the Gabor convolved face images. Further PCA is applied to reduce the dimension of the feature vector. The results are tabulated in Table 1.

C. Distance Measures

The distance between training image and test image is calculated by three different traditional distance metrics. The various distance metrics used are as follows: City-block distance, Euclidean distance, Cosine (COS). All these equations assume that x, y, z are k-dimensional vectors and x_i, y_i and z_i are the i^{th} components of the vectors.

1) City Block Distance:

$$d(x,y) = |x-y| = \sum_{i=1}^{k} |x_i - y_i|$$

2) Squared Euclidian Distance:

$$d(x,y) = \|x-y\|^2 = \sum_{i=1}^{k} (x_i - y_i)^2$$

3) Cosine Distance

$$d(x,y) = \frac{x,y}{\|x\|\|y\|} = \frac{\sum_{i=1}^{k} x_i y_i}{\sqrt{\sum_{i=1}^{k}(x_i)^2 \sum_{i=1}^{k}(y_i)^2}}$$

V. Conclusion

In this paper, face recognition using LBP, Gabor wavelet and its fusion with PCA is analyzed in detail. Comparison of Gabor Magnitude, LBP, PCA, PCA applied on Gabor magnitude features, and fusion of Gabor magnitude with LBP followed by PCA is done.

Considering the variation in the database, combination of Gabor magnitude and LBP is found to be the best. This is verified across all three distance metrics and the results also comply with Asian database. However slight variations are observed with other databases. These results exempt dimensionality reduction (PCA) of feature vectors.

As a future scope, accuracy in face recognition with the challenges of change in pose can be improved by combining face and ear features as additional biometric.

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Table 1: Experimental results

Distance Metrics	Data- bases	(Subjects /Faces) (Train / Test faces)	Face Recognition Efficiency (%) Gabor (Mag)	LBP	PCA	G_mag LBP	G_mag_ LBP (PCA
Euclidean	Yale	(15/11), (6/5)	93.33	96	80	96	85.33
	CVSR	(18/20), (10/10)	93.88	95.56	96.66	93.33	95
	University of Bern	(30/10), (5/5)	78	77.33	82.66	78.66	68
	JAFFE	(10/20), (10/10)	99	88	80	97	99
	ORL	(40/10), (5/5)	75.5	50	83.5	75	70
	SGGS	(30/25) (13/12)	65.83	73.61	56.94	77.77	72.22
Cityblock	Yale	(15/11), (6/5)	93.33	98.66	81.33	97.33	92
	CVSR	(18/20) , (10/10)	95	95	96.66	93.33	93.33
	University of Bern	(30/10), (5/5)	86	81.33	87.33	84	70.66
	JAFFE	(10/20), (10/10)	98	88	87	98	96
	ORL	(40/10), (5/5)	81.5	57.5	88.5	77.5	73
	SGGS	(30/25) (13/12)	75.3	75	67.8	78.46	76.66
Cosine	Yale	(15/11), (6/5)	96	96	80	94.66	80
	CVSR	(18/20), (10/10)	93.88	93.33	96.11	93.88	93.33
	University of Bern	(30/10), (5/5)	76	78.66	78	79.33	63.33
	JAFFE	(10/20), (10/10)	99	74	79	97	96
	ORL	(40/10), (5/5)	75	43.5	83.5	75.5	69.5
	SGGS	(30/25) (13/12)	66.38	70.27	55.83	78.33	74.72

REFERENCES

[1] M. A. Turk, A. P. Pentland. "Face Recognition using Eigenfaces". Proceedings of the International Conference on *Pattern Recognition*, pp: 586-591, 1991.

[2] W. Zhao, R. Chellappa, P.J. Phillips, A. Rosenfeld, "Face recognition: A Literature Survey", ACM Computing. Surveys, vol.35 no.4, 399-458, 2003.

[3] R. M. Bolle, J.H. Connell and N. K. Ratha. "Biometric Perils and Patches". *Pattern Recognition*, vol.35, pp. 2727-2738, 2002.

[4] O. Deniz, M. Castrillon, M. Hernandez. "Face Recognition using Independent Component Analysis And Vector Machines". *Pattern Recognition Letters* vol.24. (2003), pp.2153-2157.

[5] M. Yang, D. Kriegman and N. Ahuja. "Detecting Faces in Images: Survey". IEEE Transaction on PAMI, vol.24, no.1, pp. 34-58, 2002.

[6] Y.Xu, J. Yang, Z. Tang and C. Zhao. "Two Dimensional Technique for Presentation and its Application". In proceedings of the 5th International conference on Machine Learning and Cybernetics, Dalian, pp.4376-4382, 2006.

[7] Zou, W.W.W.; Yuen, P.C., "Very Low Resolution Face Recognition Problem," *Biometrics: Theory Applications and Systems (BTAS), 2010 Fourth IEEE International Conference on* , vol., no., pp.1,6, 27-29 Sept. 2010.

[8] Rui Min; Dugelay, Jean-Luc, "Improved combination of LBP and sparse representation based classification (SRC) for face recognition," Multimedia and Expo (ICME), 2011 IEEE International Conference on , vol., no., pp.1,6, 11-15 July 2011

[9] ShufuXie, Shiguang Shan, Xilin Chen, and Jie Chen. "Fusing local patterns of Gabor magnitude and phase for face recognition". IEEE Transactions on Image Processing, 19(5):1349-1361, 2010.

[10] Chengjun Liu; Wechsler, H., "Gabor feature based classification using the enhanced fisher linear discriminant model for face recognition," *Image Processing, IEEE Transactions*, vol.11, no.4, pp.467, 476, Apr 2002.

[11] Ahonen, T.; Hadid, A.; Pietikainen, M., "Face Description with Local Binary Patterns: Application to Face Recognition," *Pattern Analysis and Machine Intelligence, IEEE Transaction*, vol.28, no.12, pp.2037, 2041, Dec. 2006.

[12] The Yale face database. Website. http://cvc.yale.edu/projects/yalefaces/yalefaces.html.

[13] The CVSR Grimace database. Website. http://cswww.essex. ac.uk /mv/allfaces/index.html.
[14] The University of Bern face database. Website. http://www.ph.tn.tudelft.nl/PRInfo/data/msg00010.html.
[15] The Japanese Female Facial Expression (JAFFE) database. Website. http://www.kasrl.org/jaffe.html.
[16] AT & T: The database of faces (formerly: The ORL database of faces). Website. http://www.cl.cam.ac.uk/Research/DTG/attarchive/facedatabase. html.
[17] The SGGS face database. Website. http://sggs.ac.in.

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He received the "Young Scientist Award" by URSI, Italy in 2003. He had Collaborative research programme at Cardiff University Wales, UK. He has published 10 books, 50+ papers in referred Journals and more than 120 papers in National and International Conferences. He has guided about 60 students for projects at ME/M.Tech and supervised 10 students for PhDs and additional 10 Research Scholars are working towards their Ph D. He is a life member of System Society of India, Indian Society for Technical Education and Fellow, Institution of Electronics and Telecommunication Engineers. His research interests includes Image processing, Multimedia Computing, Biometrics and Embedded System Design. Prof. Talbar's Biography is included in Marquis Who's Who Publication, NJ, USA 2012.