Face Detection and Recognition Through Hexagonal Image Processing

Article · January 2012

CITATIONS
7

READS
272

4 authors, including:

Muhammad Sharif
COMSATS Institute of Information Technology Wah Cantt, Pakistan
142 PUBLICATIONS **767** CITATIONS
SEE PROFILE

Mudassar Raza
University of Science and Technology of China
85 PUBLICATIONS **548** CITATIONS
SEE PROFILE

Sajjad Mohsin
COMSATS Institute of Information Technology
79 PUBLICATIONS **596** CITATIONS
SEE PROFILE

Sindh Univ. Res. Jour. (Sci. Ser.) Vol.44 (4) 541- 548 (2012)

SINDH UNIVERSITY RESEARCH JOURNAL (SCIENCE SERIES)

Face Detection and Recognition Through Hexagonal Image Processing

M. SHARIF, A. KHALID, M. RAZA, S. MOHSIN

Department of Computer Sciences, COMSATS Institute of Information Technology, Wah Cantt, 47040, Pakistan
E-mail, adeelkhalid9@gmail.com, mudassarkazmi@yahoo.com, smohsin@comsats.edu.pk

Received 07th January 2011 and Revised 03th May 2012

Abstract: Hexagonal image processing benefits from less computational power and better performance ratios. A lot of research is encompassing this area nowadays. This paper presents the effect of hexagonal image processing in face recognition area where the proposed hexagonal techniques are applied to the domains of face detection, edge detection and face recognition. The face detection, converts face image to hexagonal image and then the face detection algorithm is applied on the basis of face color. The edge detection technique is applied to the resultant detected hexagonal face image. For face recognition, the technique proposed is based on PCA. To overcome the limitations of conventional PCA based face recognition, the face features extraction with hexagonal edge detection is used. Experimental results are presented in later sections, which prove that the hexagonal image processing is far better than the conventional existing techniques based on square image processing.

Keywords: Hexagon, Image, Face, Recognition, Detection, Edge

1. INTRODUCTION

Hexagon Image Processing is an emerging image processing technique that is being used in place of common square image processing. One of the most attractive features of hexagonal image processing is the use of hexagonal lattice, where all neighboring pixels are at a distance of 1 unit as shown in **(Fig. 1)**. Whereas the distance between neighboring pixels, in case of square image processing, which uses square lattice, is not equal except in the case of four connected pixels.

Since the image pixels are closer to each other in hexagonal image thus making the edges more clear and sharp as compared to square image. The reasons to use hexagonal image processing are:

- To make the face recognition algorithm efficient.
- To reduce the complexity of the image and make processing fast.
- To achieve accuracy. Because the pixels of the image are closer to each other in hexagonal image, therefore, the edges (Middleton *et. Al. 2001*) are clear and sharp when the pixels are packed. As a result the features of face can be detected more accurately.

This paper covers the following three major aspects of face biometrics.

- Human face detection
- Edge Detection and
- Face Recognition

This section gives the brief description on each of them. It is a challenging task to automatically detect human face from an image. Skin color of face is an important factor in different fundamental applications of face detection. The main focus of face detection is to fragment all image areas containing the face which is not possible because faces are non-rigid and have a high degree of variability in size, shape, color and texture. Edge is an image characteristic which is clearly considered as an important feature in image processing and machine vision. It is one of the elemental subjects in the area of image processing. Edge detection is a method of image segmentation based on non-continuity. It is an issue which has not been resolved completely so far due to the fact that different images have different properties in terms of type of image, purpose of image and structures inside an image. Besides, noise and illumination factors also have a critical role. The existing edge detection methods take advantage of the gradient of images and arithmetic operators. In digital image processing different algorithms are used to

lattice.

Face recognition is a challenging problem and a lot of research is done in this area. A face database is needed through which the face image to be recognized is searched.

2. EXISTING WORK

The classical face detection techniques follow sliding window phenomenon. There are a lot of

++Corresponding author: M. SHARIF, e-mail : muhammadsharifmalik@yahoo.com Cell.No.+92-3335188872
*Centre For Pure And Applied Geology, University of Sindh, Jamshoro
**Hydrocarbon Development Institute of Pakistan, Islamabad

classical face detection techniques which use square images. Some of these based on color images can be studied from (Cai *et. al.,* 1998) (Hsu *et. al.,* 2002) (Yang *et. al.,* 2002) (Garcia *et. al.,* 1999).

Many traditional edge detection methods are available. The most widely used algorithms are: Sobel, Roberts, gradient operator, Prewitt operator etc. (Mohamed *et. al,.* 2006). These algorithms are suspect to noise and a lot of room is available for improvement in them.

The methods proposed in past for face recognition were based on statistical techniques such as PCA (Turk *et. al.,* 1991), Bayes (Moghaddam *et. al.,* 2000), LDA (Belhumeur *et. al.,* 1997) and ICA (Yunen *et. al.,* 2002). These methods use low dimensional features form the image intensities and use them for recognition. The disadvantage of these techniques is that they are sensitive to different lighting conditions which prevent to achieve high accuracy results n the image. Therefore, such techniques are best for the images with uniform-lighting conditions to avoid such problems. A method named as elastic graph matching (EGM) (Wiskott, *et. al.,* 1997) has recently been proposed. This method uses the facial points for recognition and distance between these points is used to avoid the lighting problems.

PCA is the simplest method which was first used in efficient face representation by Sirovich and Kirby (Sirovich *et. al.,* 1987). PCA is most commonly used technique for face recognition (Gottumukkal *et. Al. 2004*) (Yisu *et. al.,* 2009) but still it is not effective in some conditions like lighting directions, face expression and pose variation. To minimize the false recognition, technique in (Gottumukkal *et. al.,* 2004) is proposed in which one input face image is divided into sub images and then conventional PCA is applied on those sub images. This method minimizes the problem of false recognition but on the other hand it is very slow because PCA is to be applied more than once an image.

3. MATERIAL AND METHODS

In common image processing the images are displayed and processed using square image. An algorithm has been developed that converts an image into hexagonal images for further processing on it. The proposed algorithm successfully implements face detection using skin color on hexagonal images after which the face recognition is applied. Our purposed system converts the square image into hexagonal image and then applies skin extraction on it. Next step finds the features within the skin region. After marking the features on the face through the distance ratios between the features, decision is made that either the skin area is face or non face. If it is face, the image is marked as face otherwise it is considered as non face.

The proposed system for face recognition consists of the following phases: **(Fig. 1).**

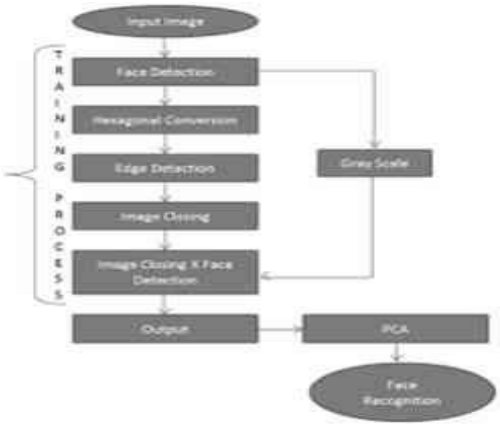

Fig.1 Proposed System Block Diagram

3.1. Hexagonal Image Conversion

Fig. 2 shows how a square pixels image (a) can be converted into hexagonal image (b). But in real it is not possible because a pixel cannot be divided into two parts and also cannot be moved at 0.5 distances.

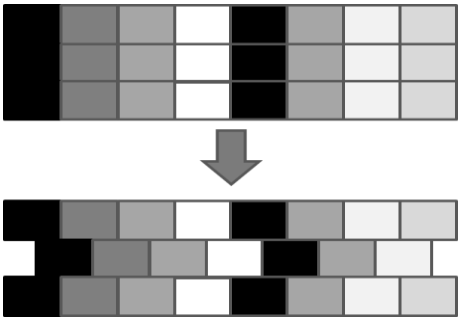

Fig. 2. Figure Hexagon re-sampling

The proposed algorithm for hexagon conversion consists of two steps:

Step 1. Conversion of image into Square Boxes

In this step the image is converted into square boxes so that these boxes can be converted into the hexagon shape. A square box consists of more than one

be varying from application to application.

$$SB_k = (\sum_{i=1}^{N}\sum_{j=1}^{N} I_{i,j})/(N \times N) \qquad (1)$$

where, $B_k = K^{th}$ Block

I =Intensity at coordinate i, j

N=Height and width of the box and will be equal.

The whole block $\mathbf{B_k}$ is filled with the calculated average intensity $\mathbf{SB_k}$. **(Fig. 3,4).**

Fig. 3 Input Images

Fig. 4. Square Boxes

Step 2. Conversion of image into Hexagonal image

In this step the square boxes are converted into the hexagonal shaped pixels. To do so we move from center to center and pick the intensity of the box in order to make the hexagon of the same intensity. This is shown in **(Fig. 5).**

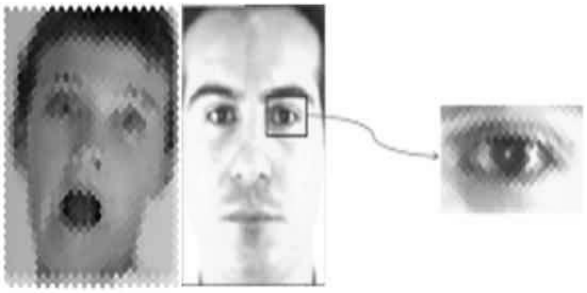

Fig. 5. Hexagonal Images

To convert an image into hexagonal pixels, first the intensity of the input image is taken by using the equation below after which a hexagon pixel is drawn by using the same intensity.

$$HB_k = \left(\sum_{i=1}^{M} \sum_{j=1}^{N} Hexagon(I_{i,j})\right) \quad (2)$$

where,

B_k = k_{th} Hexagon Pixel

I = Intensity at coordinate i, j

M = The height of the image

N = The width of the image

The whole hexagonal pixel B_k is filled with the calculated intensity HB_k.

3.2. Face Detection

In proposed algorithm first the skin region is detected for the three color spaces (RGB, YCbCr and HSV) and then the skin detected region is combined into one image to give the best result on face features extraction which is then used in the face mark. **(Fig. 6).**

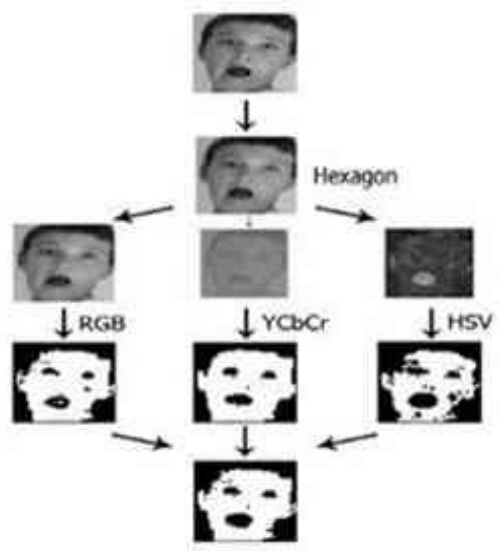

Fig. 6. Proposed work

The efficiency of the proposed algorithm lies in the fact that it uses three skin detection algorithms to get the accurate results, as depicted in Figure 6. The skin region extracted after applying these algorithms is then combined by using the equation given below:

$$\text{Skin region} = \sum_{x=1}^{w} \sum_{y=1}^{h} [(R_{xy} \vee HS_{xy}) \wedge YC_{xy}] \quad (3)$$

where, R = RGB skin extracted image

HS = HSV skin extracted image

YC = YCbCr skin extracted image

w and h are width and height of the image

which is calculated by the above equation.

Using RGB Color Space: The proposed system uses RGB color space for skin color detection by applying the simplest algorithm by Crowley and Coutaz (Sirovich *et. al. 1997*) which is further used for face detection. For skin detection, the skin pixel values are according to the database and then the process of skin detection is performed.

In **(Fig. 7),** the result is shown after skin detection in the RGB space.

Fig. 7. RGB Skin Color Detection

Using YCbCr Color Space: For YCbCr skin detection, skin color classification algorithm is used (Cahi *et.al.* 1999).

In **(Fig. 8),** the result is shown after skin detection in the YCbCr color space.

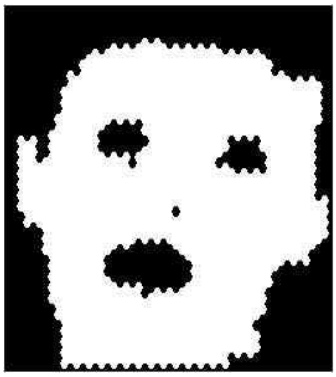

Fig. 8. YCBCR Skin Color Detection

Using HSV Color Space: In the proposed system, HSV color space is used for skin color detection which is further used for face detection. For skin detection here, first the skin pixel values are taken according to the selected database and then the process of detection is done.

In **(Fig. 9)** the result is shown after skin detection in the HSV space.

Fig. 9. HSV Skin Color Detection

Background Extraction

In the next step, the background of the image is extracted so that the face features can be marked easily and accurately. To defer the background, the color is changed by moving from left to right and up to down until skin region is not achieved. **(Fig. 10)** shows the non-face area which is the background of the image in green color.

Fig. 10. Background Extraction

Feature Extraction

After background extraction, next step is to mark face features which are further used for face detection. As it can be seen in the image of Figure 10 that the eyes and mouth are the darker areas in the image and these features need to be marked. To mark them, first the black points (which are hexagonal pixels) are collected from the image and then the distances between the points can be calculated by using the distance formula.

$$D = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \qquad (4)$$

where,

D = Distance between the two points

(x1, y1) and (x_2,y_2) are the two points

differentiated and marked as face features. As shown **(Fig. 11),** the features are marked with the feature center points.

Fig. 11 Face Features

From the centers of the marked features a triangle is drawn and the distances between the centers are calculated. If there is frontal face then isosceles

triangle is achieved and the distance between eyes is 90-110% of the distances between the eyes and face. After marking the features and drawing the triangle, it is easy to get the face corner points and mark the face.

Face Detection

After features extraction, the three points are found which are two eyes and the mouth. By using these points the face corner points can be found. the face can be marked by moving towards left, right, top and bottom corner points of the skin region as shown in **(Fig. 12).**

Fig. 12. Face Detection

3.3. Edge Detection

An algorithm has been developed that detects edges in a hexagonal image. First, the image is converted into hexagon image using our own hexagon image processing algorithm. The basic advantage of converting an image into the hexagonal image is that the pixels become close to each other and the edges become sharp and accurate because the diagonal distance between pixels becomes equal to one unit whereas in conventional square image, the diagonal distance is not equal and the edges are not much sharp and accurate. **(Fig. 13).** shows the block diagram of the edge detection phase.

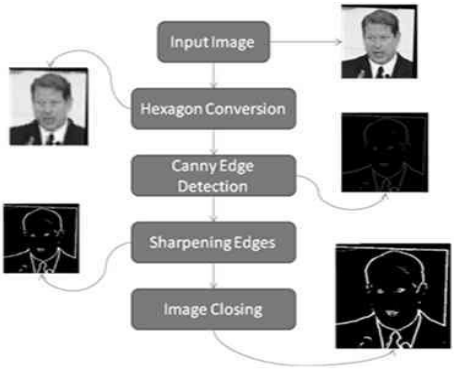

Fig. 13. Proposed Edge Detection Diagram

Canny edge detection

Canny edge detection is used to detect edges on hexagonal image. The results are shown in **(Fig. 14).** (Mohamed *et. al. 2006*)

Fig. 14. Canny Edge Detection on Hexagonal Image

$$k = \sqrt{Ax^2 + Ay^2} \quad (5)$$

For detection of edge $|Ax^2| + |Ay^2|$

$$\theta = arc\tan^{-1}\left(\frac{Ax}{Ay}\right)\sqrt{Ax^2 + Ay^2} \quad (6)$$

Sharpening Edges

In the previous techniques there are maximum edges which are not sharp and not connected with each other. The proposed technique, sharp the edges as well as connect the disconnected edges with each other. First of all, the threshold area is specified and the edge or white pixels are searched. Now, the midpoint of these edge points is calculated in that area. The existing edge point is replaced by the new ones that were calculated previously. The output of this step is shown in **(Fig.15)**.

Fig.15. Proposed Sharp Technique

Image Closing

Most of the edges in the face lie in the area of eyes as shown in Figure 15. In this paper a technique is proposed to find the region of maximum edges i.e., eyes region. In the eyes region the edges are close to each other and to find this region image closing is applied. Image closing is a morphological operation which is a dilation technique followed by erosion. In this technique image closing is applied by using a square box of size 10. The size 10 square box is chosen because it gives best results which are proven through experiments as shown in **(Fig. 16).**

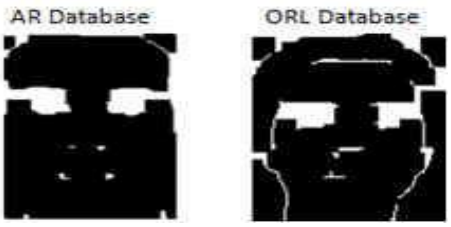

Fig. 16. Image closing

Convolution

The image obtained from previous step is in binary form where the required region of the face is in white color and all other neglected area is in black color. To get the required area of the face i.e., eyes and boundaries convolution of binary image with the input face image is applied by using the equation below:

$$H(x) = B(x) \times F(x) \quad (7)$$

where,

$B(x)$ is binary image

$F(x)$ is the input face image

The above steps are the part of training process which is performed only one time. After the training process all the images are like as shown in **(Fig. 17).** In the proposed training process, only the required face features are extracted and rest of face area is neglected. The advantages of this process are:

Fig.17. Convolution Output Image $H(x)$

- The processing is fast because proposed technique considers limited information for recognition
- It is more accurate because in this technique facial features are used for the recognition of which there is less effect of pose variation and lighting conditions.

3.4. Face Recognition

The face recognition technique proposed is based on PCA with edge detection on the hexagonal image. In the proposed method, the problems with the conventional PCA face recognition are eliminated by using the face feature detection with hexagonal edge detection. Face feature recognition has been introduced especially for eyes and boundaries of the face so that the rotation of face has less effects and the recognition is faster and accurate. The proposed algorithm uses less information and produces more efficient results.

The image obtained from the training process has facial features. This image is used as input for Principal Component Analysis (PCA) without any change. In this technique the old PCA algorithm is used except that the input is changed to achieve maximum results. It extracts the most related information inside the face region.

4. RESULTS

The **(Table I).** experiments were performed on the databases like CVL and Indian face database and the results obtained are presented below.

Table I. Results on Indian face database

Images	Matched	Not Matched	Total	Result Accuracy
Male	59	1	60	98.33%
Female	44	0	44	100%
Total	103	1	104	99.03%

Total 60 images of males and 44 images of females were selected from the Indian Database. Average accuracy of face detection using the proposed technique is calculated as 99.03%.

Similarly **(Table 2)** shows the results of the proposed system on 82 images of males and 18 images of females selected from the CVL Database. The average accuracy of face detection using the proposed technique is calculated to be 97 %.

Table 2 Results on CVL database

Images	Matched	Not Matched	Total	Result
Male	80	2	82	97.56%
Female	17	1	18	94.44%
Total	97	3	100	97%

(Fig. 18) shows the results of hexagon based face detection.

Face Detection and Recognition Through Hexagonal Image Processing

(Fig. 18) Hexagon based face detection.

(Fig. 19) shows the comparison results of edge detection of proposed technique with different existing techniques.

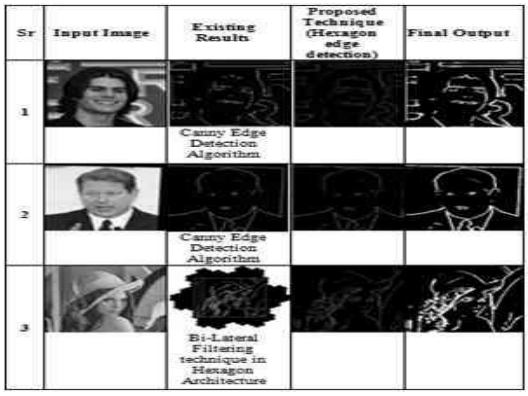

Fig. 19 Edge Detection Results

In the above **Fig. Sr. No.1 and 2** canny edge detection technique was compared with our hexagon image algorithm. The proposed technique is found precise and provided more accurate results.

The second technique **Column 3** involved the novel edge detection method which was based on the bi-lateral filtering technique. In this technique, the spatial closeness and intensity similarity of the pixels preserved the important visual characteristics and reduced the sharpness in intensity values as well.

The overall edge detection results using the proposed technique are found better than the existing techniques.

For the evolution of face recognition using the proposed technique, results have been taken on two databases ORL and AR. ORL is a gray scale database and not much complex. AR is a bit complex database having more lighting effects and variety of facial expressions. The results on AR database are shown in **(Table 3).**

Table 3. Results comparison on AR database

Techniques	Left Light On	Right Light On	Both Light On
Proposed Technique	65%	72%	71%
Entropy Weighted Patch PCA (Kanan *et. al.* 2009)	55%	18%	63%
Sub-Pattern PCA (Chen *et. al.* 2004)	44%	11%	42%
Modular PCA (Gottumukkal *et. al.* 2004)	42%	26%	47%
PCA (Turk *et. al.* 1991)	12%	8%	2%

In the above table results have been shown on AR database (Mart´inez *et. al.,* 1998) with different lighting conditions. The proposed technique gives overall better results because it uses face features having no effect of light on them.

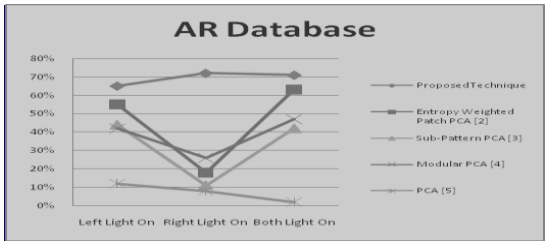

Fig.20. Results comparison on AR database

(Table 4) compares the results of proposed method with existing face recognition techniques (Gabor + Bayes) (Xiaogang *et. al.* 2003), Binary Decision (James *et. al.* 2008) and NMPPCA (Gundimada *et. al.* 2009) in different lighting conditions and expressions.

(Table 4)Results comparison on AR database

Techniques	Expression	NMPPCA(Gundimada *et. al.* 2009)
Proposed Technique	92.50%	92.50%
Gabor+Bayes (Xiaogang *et. al.* 2003)	86%	83%

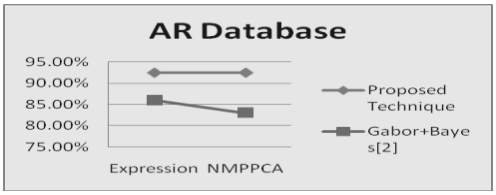

Fig. 21. Results comparison on AR database

In WT&ASNP (Xiao *et. al.* 2009), the results have been calculated using leaving-one-out approach by classifying each image using the remaining 399 as training set. Besides the images are also cropped to size 16x16 whereas in proposed technique the images have not been cropped or resized. The proposed method gives 100% results on ORL database as shown in the **(Table 5)**.

Table 5 Results comparison on ORL database

ORL Database	
Proposed Technique	100%
WT&ASNP (Zhou *et. al.* 2009)	99.05%

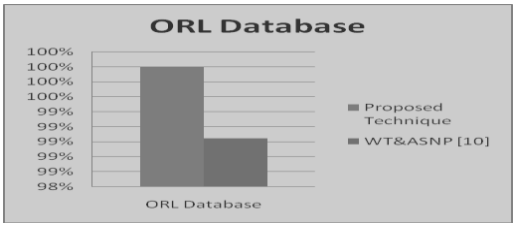

Fig. 22. Results comparison on ORL database

with the Gabor+2DPCA+SVM (Xiao *et. al.* 2009) on unitary face and on full face.

Table 6. Results comparison on ORL database

	Unitary	**Full Face**
Proposed Technique	100%	100.00%
Gabor+2DPCA+SVM (Xiao *et.al.* 2009)	98.00%	99%

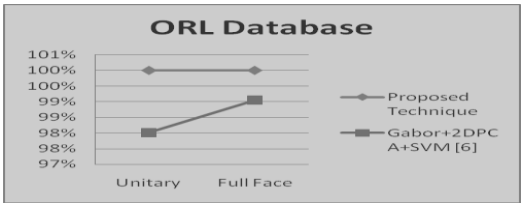

Fig 23. Results comparison on ORL database

5. CONCLUSION

This paper proposed a new face recognition technique that utilizes PCA to enhance the performance and results. The proposed technique performs recognition using facial features i.e., eyes mainly. Eyes are extracted using the proposed method for hexagonal

conversion and then through edge detection. Fast processing is the main advantage of this technique because it uses less information which is accurate as well. Further, the proposed technique has less effects of lighting condition and poses variation.

REFRENCES:

Belhumeur, P. N., J. P. Hespanda, and D. J. Kiregeman, (1997) "Eigenfaces vs. Fisherfaces: Recognition Using Class Specific Linear Projection", IEEE Trans. on PAMI, Vol. **(19)**: No. 7, 711-720.

Cai, J., A. Goshtasby and C. Yu, (1998) "Detecting Human Faces in Color Images," Proceedings of International Workshop on Multi-Media Database Management Systems, 124-131.

Cahi, D. and K. N. Ngan (1999) "Face Segmentation Using Skin-Color Map in Videophone Applications," IEEE Transaction on Circuit and Systems for Video Technology, Vol. **(9)**: 551-564.

Chen, S., and Y. Zhu, (2004) "Subpattern-based principle component analysis" Pattern recognition **(37)**, 5, 1081-1083.

Crowley, J. L., and J. Coutaz (1997) "Vision for Man Machine Interaction," Robotics and Autonomous Systems, Vol. **(19)**: 347-358.

Garcia, C. and G. Tziritas, (1999) "Face detection using quantized skin color regions merging and wavelet packet analysis", IEEE Trans. Multimedia, 1 **(3):** 264–277.

Gottumukkal, R., V. K. Asari, (2004) "An Improved Face Recognition TechniqueBased on Modular PCA Approach", Pattern Recognition Letters 25 **(4):** 429-436.

Gundimada, S. and V. K. Asari, (2009) "Facial Recognition Using Multisensor Images Based on Localized Kernel Eigen Spaces", IEEE Transactions on Image Processing, Vol. **(18)**: Issue: 6, 1314 – 1325.

Hsu, R. L., M. Abdel-Mottaleb, and A.K. Jain, (2002) "Face detection in color images", IEEE Trans. Pattern Anal. Mach. Intell. 24 **(5):** 695–705.

James, A.P. and S. Dimitrijev, (2008) "Face Recognition Using Local Binary Decisions", IEEE Signal Processing Letters, Vol. **(15)**: 821– 824.

Kanan, H.R. and M.S. Moin (2009) "Face recognition using Entropy Weighted Patch PCA Array under variation of lighting conditions from a single sample image per person", 7th International Conference on Digital Object Information, Communications and Signal Processing, CICS 2009.1-5.

Mart´inez, A.M. and R. Benavente, (1998) "The AR Face Database", CVC Technical Report No. 24, URL: http://www2.ece.ohio-state.edu/~aleix/ARdatabase.html last opened December 2011.

Middleton L. and J. Sivaswamy (2001) "Edge detection in a hexagonal-image processing framework". Image and Vision Computing, Vol. **(19)**: No. 1, 1071-1081.

Moghaddam, B., T. Jebara, and A. Pentland, (2000) "Bayesian Face Recognition", Pattern Recognition, Vol. **(33):** 1771-1782.

Mohamed, R., (2006) "Comparative Study of Edge Detection Algorithms Applying on the Grayscale Noisy Image Using Morphological Filter", ICGST International Journal on Graphics, Vision and Image Processing, Vol. **(6):** 4. 99-104.

Sirovich, L., and M. Kirby, (1987) "Low-dimensionalprocedure for the characterization of human faces", Journalof the Optical Society of America, Vol. **(4)**: No. 3,519-514.

Turk M., A. Pentland, (1991)"Eigenfaces for Recognition", J. of Cognitive Neuroscience, Vol. **(3):** No. 1, 71-86.

Wiskott, L., J. M. Fellous, N. Krüger, C. von der Malsburg, (1997) "Face Recognition by Elastic Bunch Graph Matching," IEEE Trans. on PAMI, Vol. **(19):** No.7, 775-779.

Xiao, M. W., C. Huang, G.Y.Ni; J.G. Liu, (2009) "Face Recognition Based on Face Gabor Image and SVM", 2nd International Congress onDigital Object Image and Signal Processing, CISP'09.1–4.

Xiaogang W., and X. Tang. (2003) "Bayesian face recognition using Gabor features", In *Proceedings of the 2003 ACM SIGMM workshop on Biometrics methods and applications* (WBMA '03). ACM, New York, NY, USA, 70-73.

Yang, M. H., D. Kriegman, and N. Ahuja, (2002)"Detecting faces in images: a survey", IEEE Trans. Pattern Anal. Mach. Intell. 24 **(1):** 34–58.

Yisu, Z., N. D. X.Georganas, and E.M. Petriu, (2009) "Part-based PCA for facial feature extraction and classification", IEEE International Workshop on Haptic Audio visual Environments and Games, 99–104.

Yunen, P. C. and J. H. Lai, (2002) "Face Representation Using Independent Component Analysis", Pattern Recognition, Vol. **(35)**: 1247-1257.

Zhou, X., and S. Yong, (2009) "Affine Subspace Nearest Points Classification Algorithm for Wavelet Face Recognition", WRI World Congress on Computer Science and Vol. **(3)**: 684 – 688.