Research Journal of Recent Sciences _____ ISSN 2277-2502
Vol. **3(4),** 56-62, April **(2014)** *Res.J.Recent Sci.*

A Survey on Face Detection and Recognition Approaches

Waqas Haider[1], Hadia Bashir[2], Abida Sharif[3], Irfan Sharif[1] and Abdul Wahab[1]
[1]Computer Science Department COMSATS Institute of Information Technology Wah Cantt, PAKISTAN
[2]Department of Computer Science University of Engineering and Technology Taxila, PAKISTAN
[3]Department of Electrical Engineering, the University of Lahore – Islamabad Campus, PAKISTAN

Available online at: www.isca.in, www.isca.me
Received 24th April 2013, revised 15th July 2013, accepted 9th August 2013

Abstract

Face detection and recognition are major concerns in the area of biometric based security systems and purposes. These processes must ensure the recognition accuracy and minimum processing time. In this paper a review of existing face detection and recognition approaches is conducted to investigate the results of different approaches in terms of recognition accuracy and some of them are discussed for minimizing processing time point of view. The techniques for face detection and recognition are classified on the bases of their target application. Also, the techniques are classified and analyzed on the bases of their working domain as spatial, frequency, integrated and hardware support.

Keywords: Biometrics, security, FPGA, real-time surveillance.

Introduction

The task of searching faces from a source image or video is referred as face detection. The process of automatic identification or verification, of people from digital video frames or images, according to given database is called as face recognition. Face detection has becoming the most mature and important research topic, due to increase in security concerns and many other applications (human computer interaction, biometrics, surveillance etc). In the literature there are number of techniques are available for face detection and recognition. Some techniques have shown efficient results in achieving accuracy and reducing processing time[1]. In this survey, many face detection and recognition approaches are analyzed under recognition accuracy and processing time. Furthermore, it is investigated that which approach is based on which domain as spatial, frequency or integrated and which approach have better recognition accuracy. Also for speeding face recognition process which approach performed better with and without hardware support.

Some contributors of this domain have presented their surveys on different issues as a survey[2] on linear and non linear PCA based techniques for face recognition is presented. A survey[3] on face recognition methods for tackling facial expression is presented. A survey is presented different face recognition techniques[4], in which one of the approaches is based on the issue of partial occlusion dilemma, where faces are making unrecognized to cheat the security system. Similarly, a survey[5] state of the art face recognition techniques is given. Therefore, in this survey some question are tried to explore that, which face detection and recognition approach have better detection and recognition accuracy. Also, which face recognition approach has minimum processing time?

Face Recognition Techniques

The author presented a 3D face recognition[6], which is considered as a hybrid approach that is worked on horizontal vertical stripes and cloud conversion calculation method to achieve accuracy while tackling facial expression. Presented framework, first converted face model to point cloud, then by finding the nose tip face area is extracted and normalized. After this, average row column value is calculated by dividing face region into vertical horizontal stripes, this value used as a threshold to match faces from database. The results are tested on GAVAB database, presented method shows better recognition results as compare to previous approaches and the accuracy results are elaborated in table 1, where it achieve 95.08% accuracy on GAVAB data set. The presented method achieves robustness and provides an efficient feature extracting approach. Utilizing the spatial domain for improving face detection and recognition process a technique is presented by Sharif M. et.al[7], which is based on Hexagonal image processing. The technique computationally less expensive and achieves averagely 98% accuracy on CVL, Indian and ORL face datasets.

A face recognition approach is presented by Sharif M. et.al[8], which utilizes better edge based segmentation method to represent face images with enriched information. The purpose of edge based segmentation is to down sample image size. Furthermore for the representation of face images in low dimension space, DCT[9] is utilized and this approach behaves well in changing illumination conditions. The approach achieves averagely 93.2% accuracy on different data set as shown in table 1. An approach is presented by Sharif M. et.al[10] which works at face recognition preprocessing stage. The approach tackles illumination problems and it is tested on Yale data sets, where it shows significant improvement in facial recognition accuracy. An approach is presented by Zhu X. and Ramanan

D.[11] which utilized local binary patterns operator for face recognition, which works in three stages i.e. face detection, localization and finally recognition. For face localization, LBP-based eye-pupil detection technique is proposed, that significantly reduce computational memory and power. All three stages are tested on the colour FERET database, where 77.8% face localization and high match rank in face recognition is achieved successfully.

An Elastic Bunch Graph Map (EBGM) algorithm is presented[12] for face recognition which utilized Gabor filters. In the approach, 40 different Gabor filters are applied on an image to be recognized, and then fiducial points are identified on Gabor filtered 40 images. The resultant fiducial points are optimized using distance formula. At last the optimized distance is compared with database for recognition. According to table 1 the approach achieves 94.29 % accuracy on face 94 standard face database. A variant of SVD combined with DWT is utilized[13] to develop a better face recognition method. The presented approach tackles several problems as single image per person problem, illumination and facial expression. As mentioned in table 1 the approach achieves 93.6% recognition accuracy on different facial data sets. Tackling the problem of facial expression the author suggested an algorithm[14] which is based on local directional pattern variance and the algorithm have better recognition accuracy in varying facial expression conditions. Gabor features based face recognition method is presented in literatures[15,16,17] it works on the basic face points, like eyes, eyebrows, mouth and nose, which carry maximum, face information. The algorithm is tested using ORL and the Yale datasets, which performs well against disguised variations problems and system achieves 92% recognition accuracy. Another approach is presented for tackling single image per person problem[18]. The technique utilized laplacian of Gaussian and DCT and achieves 97% accuracy. 3S and pose variation problems are dealt with[19] as firstly, Linear Discriminate Analysis is considered to minimize the singularity problem that arises when small samples of individuals are available. In the next step, the framework utilizes global and local facial features and constructs a combined subspace using enhanced LDA. The approach is tested on different data sets where it shows improved facial recognition accuracy.

Table-1
Accuracy comparison of face recognition approaches on different data sets

Sr. No	Techniques for face Recognition	Working Domain	Additional Hardware Support	Face Data Bases	Hit	Miss
1.	Horizontal and Vertical Marked Strips for 3D Face Recognition	Spatial Domain	No	GAVAB	95.08%	4.92%
2.	Face Detection and Recognition Through Hexagonal Image Processing	Spatial Domain	No	CVL, Indian and ORL	Avg 98%	Avg 2%
3.	Face Recognition using Gabor Filters	Integrated	No	Face94	94.29	6.3%
4.	Enhanced SVD Based Face Recognition	Integrated	No	Yale, PIE, and AR	Avg 93.6%	6.4%
5.	Disguised Variations Using Gabor Feature Extraction approach	Integrated	No	ORL and Yale	92%	8%
6.	Face Recognition Using Laplacian of Gaussian and Discrete Cosine Transform	Integrated	No	Yale, PIE, MSRA and ORL	97%	3%
7.	LDA algorithm based face recognition	Integrated	No	ORL data set	90.8%	9.2%
8.	Face recognition by independent component analysis	Integrated	No	FERET database	91%	9%

A face recognition methodology is presented which utilized multiple techniques[20], the methodology is tested on FERET dataset where it achieves averagely 97% recognition accuracy. Hua et al presented[21] a face recognition based on direct LDA algorithm for high-dimensional data. System is tested on 400 frontal face images from ORL data set, which successfully achieve average recognition accuracy of 90.8% as mentioned in table 1. A face recognition using Independent Component Analysis is put forward by Bartlett, Stewart[22]. This frame work use PCA and ICA algorithm on FERET database and tested on different architectures. System achieves best performance when classifier combined with two ICA and show overall 91% accuracy, as mentioned in table 1. An accurate face recognition approach is demonstrated[23] by Georghiades et al that works under Variable Lighting and Pose conditions. Presented system is tested on Yale Face Database, containing 4,050 images and 405 viewing conditions. Face recognition is achieved by using Euclidean distance and approximated illumination cone, this approach gives almost error free results in extreme lighting directions. Furthermore, just recently M. Sharif et al presented a methodology for face detection, facial features extraction and face recognition[24]. In the approach, the first phase is to detect faces and to extract region of interest from input source. In second phase, features are extracted i.e., eyes, nose and lips. In the last phase, face recognition is achieved by utilizing extracted left eye and combining features of Eigen features and Fisher features. M. Sharif et al demonstrated the data reductionality technique for the process of face recognition[25]. In the technique, data reduction i.e., compression of image data, is achieved by utilizing through Discrete Cosine Transform (DCT) and PCA. In the work the author tried, to get the reduced dimensions of image without losing necessary information. The approach has brought significant improvement in traditional PCA working. Similarly, to assist preprocessing stage of face detection and recognition, the author suggested the enhanced image segmentation algorithms, which can improve facial recognition accuracy[26,28].

Face Detection and Recognition approaches for videos

For the detection of human faces in color images, an approach is presented by Sharif M. et.al[29] which utilize HSV color space. In real time video this approach works in two steps. Initially statistical model to get H (Hue) and S (Saturation) ratios for skin region is applied. Secondly, to get approximation of face location in an image with respect to the detected skin is on the bases of defined ratios for scene width and height region. Finally to verify the face from the previous roughly detected skin region, an eye template matching algorithm is applied. With fairly acceptable performance, presented model has been tested in real time environment. A novel face detection technique is presented by Salih and Muhittin, based on accelerated GPU object detection system which can successfully detect 90.8% faces from real time environment (high resolution video ranging from 640×480 to 1920×1080) without sacrificing accuracy[30]. A real-time face feature detection based on conditional regression forests on low quality images is presented. The system is tested on Labelled Faces in the wild database which contain 5749 individuals facial images and achieve 87.5% accuracy, that show better results as compare to previously designed face features detection systems[31]. Similarly, the contributors presented a human face retrieval frame work for video database, by applying fast Haar-like features based algorithm and Kanade-Lucas-Tomasi (KLT) tracker. The approach is implemented using Open CV and it achieves 94.17% accuracy[32].

Table-2
Accuracy comparison of different Face Detection and Recognition approaches for videos

Sr. #	Approaches	Environment	Hardware Support	Hit	Miss	Speeds up face detection and recognition process
1.	Skin Detection based	REAL TIME	No	_	_	No
2.	Modified Census Transform based	REAL TIME	Yes	90.8%	9.2%	No
3.	Conditional regression forests based	REAL TIME	No	87.5%	12.5%	No
5.	Face detection from video data base	Video Database	No	94.17%	5.83%	No
6.	Human Shape Analysis And Skin Colour Information based	Offline video	No	97.5%	2.5%	No
7.	Fusion and skin colour based	Video Datasets	No	90%	10%	Yes
8.	Local Binary Patterns based	MultiPIE database	No	99.9%	0.1%	No
9.	Face recognition from caption-based supervision	Video Database	No	90%	10%	No
10.	Adaboost and PCA based	REAL TIME	No	-	-	Yes
11.	Lighting-variable AdaBoost based	Video Database		95%	5%	

A novel approach for face area localization is proposed by Dibakar[33], proposed algorithm detect face based on analyzing human body shape characteristics and skin colour information, which successfully detects about 97.5% face correctly. A reliable face detection technique is proposed by Wei Ren et al which is based on skin colour detection in colour images[34], with 2D Gaussian modal and histogram, proposed system required no training that significantly reduces computational cost. To gain efficiency and robustness, fusion strategy is addressed, which gives accurate results with 0.904 probability on Stottinger dataset. Zhu, et al, suggested a Face Detection and Pose Estimation technique utilizing Tree structured and shape model, moreover system is trained under fully supervised circumstances. System is tested on multi-view point, illumination and expression conditions, with around 750,000 images of 337 people. System achieves 99.9% accuracy, when allowing ±15º error tolerance on MultiPIE database[35]. Similarly, efficient face recognition technique is presented by Guillaumin[36] by utilizing caption based supervision. The approach works in two stages: initially face retrieval from video frames is performed and then establishing correct association of face from database. The approach is verified on Wild database and it achieves 90% accuracy as mentioned in table 2. The human face recognition for a real time attendance system is proposed by Susheel, et al[37]. Presented system works in two main stages: in first, face detection base on AdaBoost with Haar cascade is used and in second, face recognition based on fast and simple PCA and LDA is implemented. Presented system is tested on 500 images, after face detection, in JPEG format images are store in 100 x 100 matrix size for face recognition, this approach achieve accurate results for general purpose online attendance system. Wood et al presented a robust face detection based on lighting-variable adaboosting, which is adaptive for varying illuminations and depend on multiple features such as global and local intensities variations[38]. System is tested on standard datasets Caltech-101, which successfully achieve overall 95% accuracy in different lighting levels, as mentioned in table 2.

Techniques for speeding face detection and recognition process

Recently, Jing and Chen proposed the probability based face mask pre-filtering and hierarchical feature ada-boosting[39], for complexity reduced face detection. Ada-boost classifiers are combination of weak classifiers that produce efficient and simple results as compare to Haar-like features, which require more training time in practical applications. The approach utilized MIT-CBCL data base for training. A speedy application specific processor design for face detection is presented by Jin S.[40], using Xilinx Virtex-5 LX330 FPGA. The system with an operating frequency of 125.6MHz is able to detect standard VGA 307 fps.

From given database, a fast face image searching technique is presented. In this approach to speed up the searching process, recognized image is segmented in different parts and each part is searched in different nodes simultaneously[41]. A face hashing technique for fast face recognition is presented by Sharif M. et.al[42]. The technique employs the two existing algorithms, i.e., 2-D discrete cosine transformation and K-means clustering, which ultimately improves the speed of face recognition[43]. A computationally low cost algorithm for recognition is presented which achieves better recognition rates at different standard facial data sets[44]. Similarly a face detection and tracking algorithm is presented which is based on hybrid approach which offers trade off between hardware and computational software resources[45]. The system is able to handle more complex set of classifiers more easily and detect faces from video at the rate of 30 fps.

Table-3
Comparison of approaches for speeding face detection and recognition process

Sr. No.	Technique	Hardware Support	Environment or Data Set	Improves face detection and recognition time
1.	Probability-Based Face Mask Prefiltering and Pixel-Based Hierarchical Feature Adaboosting	No	MIT-CBCL	Yes
2.	Pipelined datapath assisted high-speed face detection using FPGA	Yes	Video	Yes
3.	Using nose Heuristics[36]	No	Face Data Base	Yes
4.	Real Time Face Detection	No	Image	Yes
5.	Adaptive Margin Fisher's Criterion and Linear Discriminant Analysis based	No	Face Data Base	Yes
6.	Advanced Hardware Real Time Face Detector	Yes	Video	Yes
7.	An FPGA-based real-time face recognition system	Yes	Video	Yes
8.	Haar classifiers based	Yes	Video	Yes
9.	Approach for detecting face from compressed video and monitoring environment	No	Video	Yes
10.	Real-time face detection and tracking	No	Video	Yes
11.	FPGA based Haar classifier based face detection algorithm	Yes	Video	Yes

An approach is presented by Matai et al works in real time; system is implemented on Virtex-5 FPGA. Initially, according to given scenario location of face is detected based on Viola-Jones algorithm, and then face recognition has done using Eigenface algorithm. Presented system achieves successful face recognition at 45 fps on VGA data. In table 2 the approaches which contribute to speed up face detection and recognition process are mentioned, where it is observed that the approaches can work in different environment as on facial data base and videos. Also some approaches have just better software support and some are required hardware support as well[46]. A fast FPGA-Based Face Detection approach is demonstrated by Cho et al[47], based on AdaBoost algorithm Using Haar Classifiers. This approach works on, parallel multi-classifiers to accelerate the face detection mechanism. System is implemented on Xilinx Virtex-5 FPGA using Verilog HDL, achieves 35 times better results over equivalent software implementation. A face detection approach from compressed video streams, are discussed respectively by Gorbenko. Presented approaches based on Haar cascades, which efficiently achieves 30 fps for standard quality JPEG images[48,49]. A real time face detection and tracking approach for the monitoring of crowded areas is presented by Mustafah et al. Input is acquired from high resolution smart camera, face detection is achieved using skin colour detection and Viola-Jones approaches, which significantly reduce computational load. System is implemented on OpenCV, which successfully achieve fast face detection[50]. A FPGA based face detection method is demonstrated by Gao, Changjian, and Shih , based on Haar-classifier[51]. This approach reduce computational load, successfully achieve real time performance by utilizing pipelined architecture and parallel arithmetic units. System is implemented on Xilinx XC5VLX110T FPGA chip, with16-classifier system achieve detection rate of 98 frames/sec.

Conclusion

The survey reflects the analytical comparison of different techniques in the domain of face detection and recognition. In the literature, the contributors have different goals in the domain of face detection and recognition, as some of the contributors have tackled recognition accuracy and some of them have approached improving processing time of face detection and recognition. On the bases of this survey, it is concluded that, in order to have better recognition accuracy and minimum computational cost, the trend of face detection and recognition is moving towards complexity reduced software and application specific processors along with integrated domain processing.

References

1. Sharif M., Shah J. H., Mohsin S. and Raza M., Sub-Holistic Hidden Markov Model for Face Recognition, *Research Journal of Recent Sciences*, **2(5)**, 10-14 **(2013)**

2. Shah J., Sharif M., Raza M. and Azeem A., A Survey: Linear and Nonlinear PCA Based Face Recognition Techniques, *The International Arab journal of Information technology*, **10(6)**, **(2013)**

3. Murtaza M., Sharif M., Raza M. and Shah J. H., *Analysis of Face Recognition Under Varying Facial Expression: A Survey*, *The International Arab journal of Information technology*, **10(4)**, **(2013)**

4. Azeem A., Sharif M., Raza M. and Murtaza M., A Survey: Face Recognition Techniques under Partial Occlusion, *The International Arab Journal of Information Technology (IAJIT)*, **11(1)**, **(2014)**

5. Sharif M., Mohsin S. and Javed M. Y., A Survey: Face Recognition Techniques, *Research Journal of Applied Sciences*, **4(23)**, 4979-4990 **(2012)**

6. Sharif M., Mohsin S., Hanan R., Javed M. and Raza M., 3D Face Recognition using Horizontal and Vertical Marked Strips, *Sindh University Research Journal (SURJ)*, **43(01-A)**, **(2011)**

7. Sharif M., Khalid A., Raza M. and Mohsin S., Face Detection and Recognition Through Hexagonal Image Processing, *Sindh Univ. Res. Jour. (Sci. Ser.)*, **44(2)**, 541-548 **(2012)**

8. Sharif M., Raza M. and Mohsin S., Face Recognition Using Edge Information and DCT, *Sindh Univ. Res. Jour. (Sci. Ser.)*, **43(2)**, 209-214 **(2011)**

9. Sharif M., Mohsin S., Javed M. Y. and Ali M. A., Single Image Face Recognition Using Laplacian of Gaussian and Discrete Cosine Transforms, *Int. Arab J. Inf. Technol.*, **9(6)**, 562-570 **(2012)**

10. Sharif M., Mohsin S., Jamal M. J. and Raza M., Illumination Normalization Preprocessing for face recognition, *Environmental Science and Information Application Technology (ESIAT), 2010 International Conference on*, IEEE, 44-47 **(2010)**

11. Zhu X. and Ramanan D., Face detection, pose estimation, and landmark localization in the wild, *Computer Vision and Pattern Recognition (CVPR), 2012 IEEE Conference on*, IEEE, 2879-2886 **(2012)**

12. Rahman M. T. and Bhuiyan M. A., Face Recognition using Gabor Filters, *Computer and Information Technology, 2008. ICCIT 2008. 11th International Conference on*, IEEE, 510-515 **(2008)**

13. SHARIF M. and Saad A., Enhanced SVD Based Face Recognition, *Journal of Applied Computer Science & Mathematics*, **6(12)**, 49-53 **(2012)**

14. Kabir M. H., Jabid T. and Chae O., Local directional pattern variance (ldpv): a robust feature descriptor for facial expression recognition, *Int. Arab J. Inf. Technol.*, **9(4)**, 382-391 **(2012)**

15. Muhammad Sharif, Sajjad Mohsin, Muhammad Jawad Jamal, Muhammad Younas Javed and Raza M., Face

Recognition for Disguised Variations Using Gabor Feature Extraction, *Australian Journal of Basic and Applied Sciences, 5(6): 1648-1656, 2011*, **5(6)**, 1648-1656 **(2011)**

16. Yang M. and Zhang L., Gabor feature based sparse representation for face recognition with gabor occlusion dictionary, *Computer Vision–ECCV 2010*, *Springer***,** 448-461.**(2010)**

17. Sharif M., Khalid A., Mudassar R. and Mohsin S., Face Recognition using Gabor Filters, *Journal of Applied Computer Science & Mathematics*, **5(11)**, 53-57 **(2011)**

18. Turk M. and Pentland A., Eigenfaces for recognition, *Journal of cognitive neuroscience*, **3(1)**, 71-86 **(1991)**

19. Shah J. H., Sharif M., Raza M. and Azeem A., Face recognition across pose variation and 3S problem, *Turkish Journal of Electrical Engineering & Computer Science*, **(2012)**

20. Klare B., Yampolskiy R. V. and Jain A. K., Face recognition in the virtual world: recognizing avatar faces, *Michigan State University, East Lansing, MI2010*, **(2011)**

21. Lu J., Plataniotis K. N. and Venetsanopoulos A. N., Face recognition using LDA-based algorithms, *Neural Networks, IEEE Transactions on*, **14(1)**, 195-200 **(2003)**

22. Bartlett M. S., Movellan J. R. and Sejnowski T. J., Face recognition by independent component analysis, *Neural Networks, IEEE Transactions on*, **13(6)**, 1450-1464 **(2002)**

23. Georghiades A. S., Belhumeur P. N. and Kriegman D. J., From few to many: Illumination cone models for face recognition under variable lighting and pose, *Pattern Analysis and Machine Intelligence, IEEE Transactions on*, **23(6)**, 643-660 **(2001)**

24. Sharif M., Javed M. Y. and Mohsin S., Face Recognition Based on Facial Features, *Research Journal of Applied Sciences, Engineering and Technology*, **4(17)**, 2879-2886 **(2012)**

25. Sharif M., Ayub M. K., Raza M. and Mohsin S., Data Reductionality Technique for Face Recognition, *Proceedings of the Pakistan Academy of Sciences*, **48(4)**, 229-234 **(2011)**

26. Salman N., Image Segmentation and Edge Detection Based on Chan-Vese Algorithm, *Int. Arab J. Inf. Technol.*, **3(1)**, 69-74 **(2006)**

27. Shahab W., Al-Otum H. and Al-Ghoul F., A modified 2D chain code algorithm for object segmentation and contour tracing, *Int. Arab J. Inf. Technol.*, **6(3)**, 250-257 **(2009)**

28. Robot H. W., ICIIT 2010 Session, **(2010)**

29. Sharif M., Mohsin S. and Javed M. Y., Real Time Face Detection Using Skin Detection (Block Approach), *Journal of Applied Computer Science & Mathematics***10(5)**, 75-81 **(2011)**

30. Tek S. C. and Gökmen M., GPU Accelerated Real-time Object Detection on High Resolution Videos using Modified Census Transform, *VISAPP (1)*, 685-688 (**2012)**

31. Dantone M., Gall J., Fanelli G. and Van Gool L., Real-time facial feature detection using conditional regression forests, *Computer Vision and Pattern Recognition (CVPR), 2012 IEEE Conference on*, IEEE, 2578-2585 (**2012)**

32. Sheikh Z. G., Thakare D. V. and Sherekar D. S., Towards Retrieval of Human Face from Video Database: A novel framework, *International Journal of Information Systems and Communication, ISSN*, 0976-8742 **(2012)**

33. Chakraborty D., An illumination invariant face detection based on human shape analysis and skin color information, *Signal*, **3**, **(2012)**

34. Tan W. R., Chan C. S., Yogarajah P. and Condell J., A fusion approach for efficient human skin detection, *Industrial Informatics, IEEE Transactions on*, **8(1)**, 138-147 **(2012)**

35. Nikisins O. and Greitans M., Reduced complexity automatic face recognition algorithm based on Local Binary Patterns, *Systems, Signals and Image Processing (IWSSIP), 2012 19th International Conference on*, IEEE, 433-436 (**2012)**

36. Guillaumin M., Mensink T., Verbeek J. and Schmid C., Face recognition from caption-based supervision, *International Journal of Computer Vision*, **96(1)**, 64-82 **(2012)**

37. Susheel Kumar K., Bhaskar Semwal V. and Tripathi R., Real time face recognition using adaboost improved fast PCA algorithm, **(2011)**

38. Wood R. and Olszewska J. I., Lighting-variable AdaBoost based-on system for robust face detection, *Proceedings of the 5th International Conference on Bio-Inspired Systems and Signal Processing*, SciTePress Digital Library., 494-497 (**2012)**

39. Guo J.-M., Lin C.-C., Wu M.-F., Chang C.-H. and Lee H., Complexity reduced face detection using probability-based face mask prefiltering and pixel-based hierarchical-feature adaboosting, *Signal Processing Letters, IEEE*, **18(8)**, 447-450 **(2011)**

40. Jin S., Kim D., Nguyen T. T., Kim D., Kim M. and Jeon J. W., Design and implementation of a pipelined datapath for high-speed face detection using FPGA, *Industrial Informatics, IEEE Transactions on*, **8(1)**, 158-167 **(2012)**

41. Sharif M., Mohsin S., Hanan R., Javed M. and Raza M., Using nose Heuristics for Efficient face Recognition, *SINDH University Research Journal (Science Series)*, **43(1-A)**, 63-68 **(2011)**

42. Sharif M., Ayub K., Sattar D., Raza M. and Mohsin S., Enhanced and Fast Face Recognition by Hashing

Algorithm, *Journal of Applied Research and Technology (JART)*, **10(4)**, 607-617 **(2012)**

43. SHARIF M., AYUB K., SATTAR D. and RAZA M., Real Time Face Detection, *Sindh Univ. Res. Jour. (Sci. Ser.)*, **44(4)**, 597-600 **(2012)**

44. Murtaza M., Sharif M., Raza M. and Shah J. H., Face Recognition Using Adaptive Margin Fisher's Criterion and Linear Discriminant Analysis, *The International Arab Journal of Information Technology (IAJIT)*, **11(2)**, **(2014)**

45. Bigioi P., Zaharia C. and Corcoran P., Advanced hardware real time face detector, *Consumer Electronics (ICCE), 2012 IEEE International Conference on*, IEEE, 528-529 (**2012)**

46. Matai J., Irturk A. and Kastner R., Design and implementation of an FPGA-based real-time face recognition system, *Field-Programmable Custom Computing Machines (FCCM), 2011 IEEE 19th Annual International Symposium on*, IEEE, 97-100 (**2011)**

47. Cho J., Mirzaei S., Oberg J. and Kastner R., Fpga-based face detection system using Haar classifiers, *Proceedings of the ACM/SIGDA international symposium on Field programmable gate arrays*, ACM, 103-112 (**2009)**

48. Gorbenko A. and Popov V., On Face Detection from Compressed Video Streams, *Applied Mathematical Sciences*, **6(96)**, 4763-4766 **(2012)**

49. Gorbenko A. and Popov V., Face Detection and Visual Landmarks Approach to Monitoring of the Environment, *International Journal of Mathematical Analysis*, **7**, 213-217 **(2013)**

50. Mustafah Y., Shan T., Azman A. W., Bigdeli A. and Lovell B. C., Real-time face detection and tracking for high resolution smart camera system, *Digital Image Computing Techniques and Applications, 9th Biennial Conference of the Australian Pattern Recognition Society on*, IEEE, 387-393 (**2007)**

51. Gao C. and Lu S.-L., Novel FPGA based Haar classifier face detection algorithm acceleration, *Field Programmable Logic and Applications, 2008. FPL 2008. International Conference on*, IEEE, 373-378 (**2008)**