

Face Recognition by Using Back Propagation Artificial Neural Network and Windowing Method

Mehmet Korkmaz and Nihat Yilmaz

Department of Electrical and Electronics Engineering, Selcuk University, Konya, Turkey

Email: {mkorkmaz, nyilmaz}@selcuk.edu.tr

Abstract—Biometric recognition have been getting popular in recent years. In this paper one of the biometric recognition techniques, face recognition, is purposed by using windowing feature extraction method and artificial neural network classifier. In the paper, ORL database which consist of ten images of forty people is used to test our software and method. First of all, images are separated to the different size windows, 4 by 4 and 8 by 8. Then, it is obtained the means of each window and totally sixteen by one and sixty four by one vectors features are obtained, respectively. According to the created features of each images, Artificial Neural Network (ANN) is trained by using different learning rate, momentum factor etc. Finally, the network is tested as to testing values and it's observed the remarkable results of the study. As it expected, the methods which separate the images 8 by 8 is more successful than the other one. On the other hand, 4 by 4 windowing feature have also remarkable results, although it has less features.

Index Terms—artificial neural network, biometric recognition, face recognition, feature extraction

I. INTRODUCTION

Biometric recognition has recently one of the techniques which used on recognition. It is based on the automatic recognition of people with respect to human's physical or behavioral specialties. There are four main components of biometrics that are sensor part which provides us getting biometric data; feature extraction module which is necessary for recognition; matching module that compare to values with database; decision module where it is decided to mismatching or correct recognition. In addition to this, features either physical or behavioral are in need of some requirements to have biometric characteristics [1], [2]. These requirements are universality, uniqueness, permanence, collectability, performance, acceptability, circumvention and etc. When the biometric recognition are investigated as to physical and behavioral specialties, the main difference between them physical specialties are autonomic differ from learning although behavioral specialties are faced training methods. For instance, face, iris tissue, fingerprint are physical when signature, gait, speech are behavioral characteristics. The main requirement on necessity of

biometric recognition is the problem of authentication. In many cases, nowadays, it is needed to have passwords such as, using bank cards, labor entrance chase tables, entrance of personal computers, web site passwords etc. For this reason, there are two main disadvantage of this case that firstly, current methods are obliged to people memorize many passwords or keys secondly, the passwords which are possible to guess, make possible to fraud and any other cheating matters. To sum up, biometric recognition methods which are carry person's features on itself are very important, secure, more user-friendly and suitable.

There are many methods for biometric recognition which are iris recognition, fingerprint, face recognition etc. Fingerprint recognition is the oldest method of biometrics and still it is commonly used in many applications. On the other hand, the method which based on iris tissues, iris recognition, is the most secure and expensive. Furthermore, face recognition is both user-friendly, universality and easy applicable in terms of sensor module.

It can be accepted as a first paper on face recognition is related to eigenfaces by Sirovich ve Kirby [3]. In addition to this, there are many papers on face recognition recent years both in software developments and application. Jain and friends are investigated face recognition on criminal cases that are related to aging, high liability recognition, future research etc. [4]. Klare and friends pay attention to application on demographic influence of face recognition [5]. Harguess and Aggarwal are questioned different question; face symmetry and recognition [6].

II. FACE RECOGNITION

As mentioned previous section, one of the most significant methods on biometric recognition is face recognition. This is due to the fact that face has enough characteristic specifications to use on biometric recognition, effectively.

A. Face Databases

The face recognition has increasingly attracted the researchers to this area to aim of finding a new method, improvement on fast-reply software etc. With this idea, researchers need some databases that will be accepted for everyone to do experiments in order to verify their studies.

In the literature there are many types of databases that are used for this aim and some of them will be expressed with following list to give review about this issue.

The Color FERET Database is some of the big databases of facial images that are collected from developers independently and Dr. Harry Wechsler was the chief of this study. One of the differences of this database is to be gathered images in years that provide seeing aging affect. The database consist of 1564 sets of images for a total of 14126 images that includes 1199 individuals and 365 duplicate sets of image.

The Yale Face Database has grayscale GIF format images of different 165 images of 15 people where each person has 11 different images such as glasses/no glasses, sad, sleepy etc.

As distinct from these databases, The Bosphorus Database is both 3D and contains different specifications which are rich set of expressions, systematic variation of poses and different types of occlusions. Because of the unique specifications of this database it is utilized for experience of lots of new software and methods.

The Iranian Face Database (IFDB), differs in from the existed database with being the first image database in middle-east, contains color facial imagery of a large number of Iranian subjects. This database, which contains over 3600 color images, it is allowed to use classification on aging, facial ratio extraction, race detection etc.

Apart from these databases, there are lots of databases which support the researchers' studies. Some of them are SCface - Surveillance Cameras Face Database, Cohn-Kanade AU Coded Facial Expression Database, MIT-CBCL Face Recognition Database, Face Recognition Data, University of Essex, UK, The AR Face Database, The Ohio State University, USA, Japanese Female Facial Expression (JAFFE) Database, Indian Face Database, Plastic Surgery Face Database, The Hong Kong Polytechnic University NIR Face Database and AT&T "The Database of Faces" (formerly "The ORL Database of Faces") which will be touched on next section in detail.

B. Recognition Methods

First of all, the methods for acquiring images vary in terms of different ways. For instance, the face data may be captured by using video recording, on the other hand in some cases, it is necessary to assess images high quality, 3D or infra-red. Such these cases, using of special capturing methods/means are needed. Face recognition methods are investigated in two main categories; feature-based and holistic approaches. Feature based approach is based on the geometric shape of face including dimensions of different distances on the face. For instance, eyes distance between each other, ear distance, circumolar, supraorbital, forehead distance etc. are some features of facial expressions. In the lights of this approach, early works are done by Kanade [7], using simple Euclidian distance measure for determination of face, Brunelli and Poggio [8] are improved the Kanade's method using more features and assured 100% accuracy. In addition to geometrical method, elastic bunch graph matching method. Wiskott *et al.* [9]. According to this method, graph for each face are generated to create

feature database and matching the image. Another method for recognition is to use profile images. This kind of works is seen in the papers of Kaufman and Breeding [10], Harmon *et al.* [11] Liposcak and Loncaric [12]. Nearly, twelve fiducial points are chosen for determining of feature vectors of each face.

Contrary to this type of features, face feature vector can be obtained by using holistic approach. Face is thought totally as to this method. For the simplest way of this method, face can be taken into account 2D array and this data is compared as to all another face data. After the matching it can be detected the true or false reply. But of course, it is obviously that input or another data will be very high dimensions. In order to prevent this disadvantage, several methods are applied to implement this kind of data. For example, Sirovich and Kirby [3] were the first to utilize Principal Components Analysis (PCA) [13], [14] to economically represent face images; Turk and Pentland [15], [16] implemented, based on Sirovich and Kirby's findings, that projections along eigenpictures could be used as classification features to recognize faces; Moses *et al.* [17] are utilized from Linear Discriminant Analysis (LDA) [18], which take into account variations on face. In addition to these essential papers, there are many methods have been enhanced which, multi-linear subspace analysis [19], symmetrical PCA [20], two-dimensional PCA [21], [22], Kernel PCA [23], [24], Direct-weighted LDA [25], Nullspace LDA [26], [27], windowing average method [28] etc.

III. MATERIAL AND METHODS

A. ORL Database

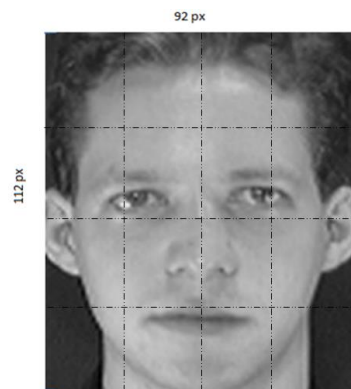


Figure 1. s1 person's image of 1.pgm in the size 4×4

In this paper, it is applied ORL database for recognition of faces. This database has high acceptability in terms of face recognition system in the literature. As it's known, in the ORL database, there have been totally forty hundred images that belong to forty people's ten different pictures. With respect to this, database some specifications are come to the forefront which, the images were taken at different times, varying the lighting, facial expressions (open / closed eyes, smiling / not smiling) and facial details (glasses / no glasses). Beside these different points, all the images were taken against a dark homogeneous background with the subjects in an upright,

frontal position (with tolerance for some side movement). Each file has the name of s1, s2, ..., s40 and files have 10 different images of person. In the Fig. 1, it is seen the first picture of s1 person.

B. Artificial Neural Network

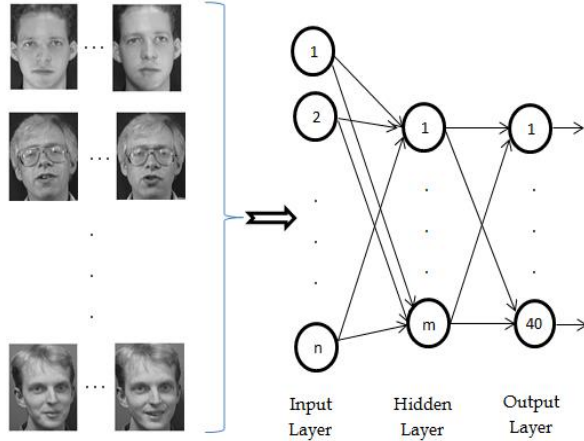


Figure 2. Used ANN structure

Artificial neural network, which is inspired from biological nervous system, is mainly ground on human brain's activities. The activities between neurons lead to learning, memorizing etc. In this way ANN have form of 'learning rule' which modifies the weights of the connections as to input and error rate. Although there are many type of learning algorithm, the delta rule is used in the paper for learning process. The delta rule is generally utilized by the most common class of ANNs called 'Backpropagational Neural Networks' (BPNs). Although system information is forward, the error which consists of the output system is back. BPN algorithm optimizes the system by finding best optimal weights coefficients and minimal error. Uses of ANN and its derivatives are widespread of many scientific areas. With this thought, biometric recognition have also utilized from the benefits of ANNs. In the paper, it is benefit from back propagation neural network algorithm to implement of the proposed recognition system. In the Fig. 2, it is

seen that the used artificial neural network structure with the training data and output of system. In this structure, n and m are number of input and hidden layer which are relevant to input feature vector.

C. Feature Extraction

The most important point of the data processing is the pre-processing of the raw data and feature extraction. There have been many methods for feature extraction up to now. Especially, for face recognition there are methods which differ from each other. A face can be thought in two ways for face recognition or feature extraction. Firstly, there are many points in the face that provide us to obtain feature extraction vectors. This method is also known as a component based. According to this, specific points of a face can be measure pixel by pixel and feature vector can be created for example, head width, eye brow distance, ear distance, eye width, forehead distance etc. The other method uses the whole face for determination of images. According to this method, feature vector can be extracted using different type algorithms, such as, PCA, LDA, LBP, windowing.

In this project, it is thought the whole face for determination of feature vector and is benefit from windowing method. The images which are ORL database have the size of 112 by 92 pixels. These whole faces are divided to windows that are in the size of 4×4 and 8×8 . After separating windows that are average of each window and obtained feature vector. Feature vector are consist of in two different size that are 16 by 400 for 4×4 windowing and 64 by 400 for 8×8 windowing. After that each feature cluster are normalized between 0 and 1 in order to apply ANN input. Table I and Table II point out features of s40 10.pgm as to different windowing size.

TABLE I. MEAN VALUE OF S40 OF 10.PGM (4×4)

133,3944	120,4425	133,455	112,4239
130,4503	177,5792	139,9332	66,8618
131,0947	144,6118	137,2655	84,84006
102,2547	122,9969	102,8199	47,00466

TABLE II. MEAN VALUE OF S40 OF 10.PGM (8×8)

125,41	132,10	113,60	112,97	144,23	147,60	126,92	117,395
125,34	149,88	129,60	122,52	133,80	117,21	104,50	105,587
106,46	164,02	190,55	189,68	165,76	121,27	97,38	63,95
109,65	136,05	169,49	162,73	146,57	146,70	92,19	49,3
114,96	138,03	161,01	142,12	128,42	125,90	107,86	75,6
111,82	155,42	141,32	133,86	164,31	143,17	108,22	74,6
99,94	119,63	115,69	110,73	131,46	107,18	69,86	44,09
94,48	89,24	135,86	132,99	98,03	84,26	66,56	38,53

IV. IMPLEMENTATION

First of all the each images of each person are obtained from the publicly available AT&T (formerly known as ORL) database and all of them are pre-processed. It is not necessary to convert images gray level this is due to the fact that in the database, they are in the format of .pgm which means gray level images. Finally, images in the gray level are separated to 4×4 and 8×8 windows and averaged of the windows to extract feature (Fig. 3).

After the features are extracted input of the system are given to ANN structure. First 8 images of people are used as a training data, and the rest of the images are used for the test data. As a result of this methodology, input matrix size is determined 16×320 and 64×320 . Similar to input matrix, test matrix size are also formed 16×80 and 64×80 . In order to train the net, target matrix are composed for the input values and considering this matrix, train of net are completed to reach target matrix values.

The trained net is tested with the rest of 2 images of each person. Obtained different test accuracies are showed in the Table III as to different iterations and learning rate.

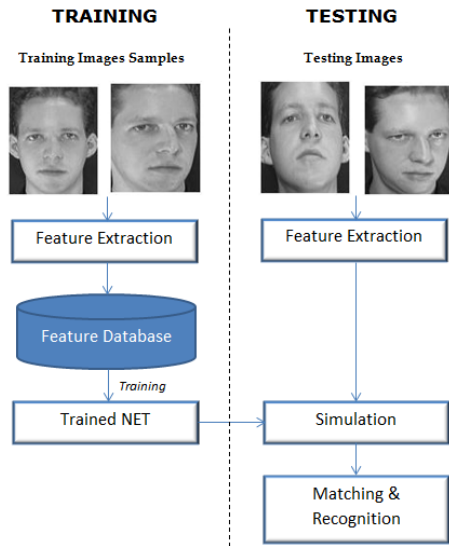


Figure 3. The structure of face recognition system

TABLE III. ITERATION RESULTS

	iteration	lr.	mc.	%acc(max)	%acc(mean)
4×4	500	0.1	0.9	65	61,5
	500	0.5	0.9	68,75	63,75
	500	0.9	0.9	72,5	60
	500	2.0	0.9	63,75	59
4×4	1000	0.1	0.9	78,75	68
	1000	0.5	0.9	78,75	69
	1000	0.9	0.9	70	64,75
	1000	2.0	0.9	75	69
4×4	2000	0.1	0.9	81,25	74,5
	2000	0.5	0.9	86,25	72,75
	2000	0.9	0.9	83,75	78
	2000	2.0	0.9	81,25	71,25
4×4	5000	0.1	0.9	85	79,75
	5000	0.5	0.9	85	77,5
	5000	0.9	0.9	88,75	79,5
	5000	2.0	0.9	81,25	76,25
8×8	500	0.1	0.9	81,25	74
	500	0.5	0.9	77,5	71
	500	0.9	0.9	78,75	74,25
	500	2.0	0.9	77,5	74
8×8	1000	0.1	0.9	95	85,25
	1000	0.5	0.9	90	84,25
	1000	0.9	0.9	92,5	86,75
	1000	2.0	0.9	86,25	81,75
8×8	2000	0.1	0.9	93,75	92,25
	2000	0.5	0.9	93,75	91,5
	2000	0.9	0.9	93,75	91,5
	2000	2.0	0.9	93,75	92,75
8×8	5000	0.1	0.9	96,25	94,25
	5000	0.5	0.9	96,25	93,25
	5000	0.9	0.9	93,75	92,25
	5000	2.0	0.9	93,75	92

According to these results, worked software to recognition of face is guaranteed of good level of success which is approximated 94%.

V. CONCLUSION

In this study, it is aimed to face recognition in the ORL database by using windowing average feature extraction method and classified artificial neural network. The other

aim of the paper is to present compared result related with different size windowing average method. For this reason, the 400 images belong to the different 40 people are determined as a database. Each person has ten different images, which are the challenge point of this database, and these images are separated to the training and testing data as first 8 used training while 2 used test. Firstly, images are divided to 4×4 windows and token the average of these windows so that reason feature vector belongs to the one image has 16×1 vector features. Same procedures are realized for the other type windows that are 8×8. Separating images to this size matrix 64×1 vector features are obtained. After taking feature vectors, ANN system are trained and tested considering the feature vectors.

Consequently, used method is verified with the testing accuracy in the rate of approximated 96% by using 8×8 windowing average method. Beside this, 4×4 windowing is showed not bad results as to testing accuracy that provide also us to do less working time. According to the results, it can be done more windowing size pictures and may get more valuable results, also different classifiers can be used for the decreasing of calculation time and PCA can be used to reduce of feature vector numbers.

ACKNOWLEDGMENT

This work is supported by Selcuk University.

REFERENCES

- [1] K. Delac and M. Grgic, "A survey of biometric recognition methods," in *Proc. 46th International Symposium on Electronics in Marine*, June 2004, pp. 184-193.
- [2] A. K. Jain, "Biometric recognition: How do I know who you are?" in *Proc. IEEE 12th Signal Processing and Communications Applications Conference*, April 28-30, 2004, pp. 3-5.
- [3] L. Sirovich and M. Kirby, "Low-Dimensional procedure for the characterization of human faces," *Journal of the Optical Society of America A*, vol. 4, pp. 519-524, 1987.
- [4] A. K. Jain, B. Klare, and P. Unsang, "Face recognition: Some challenges in forensics," in *Proc. IEEE International Conference on Automatic Face and Gesture Recognition and Workshops*, March 21-25, 2011, pp. 726-733.
- [5] B. F. Klare, M. J. Burge, J. C. Klontz, R. W. V. Bruegge, and A. K. Jain, "Face recognition performance: Role of demographic information," *IEEE Transactions on Information Forensics and Security*, vol. 7, no. 6, pp. 1789-1801, Dec. 2012.
- [6] J. Harguass and J. K. Aggarwal, "Is there a connection between face symmetry and face recognition?" in *Proc. IEEE Computer Society Conference on Computer Vision and Pattern Recognition Workshops*, June 2011, pp. 66-73.
- [7] T. Kanade, "Picture processing system by computer complex and recognition of human faces," PhD. thesis, Kyoto University, Japan, 1973.
- [8] R. Brunelli and T. Poggio, "Face recognition: Features versus templates," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 15, pp. 1042-1052, 1993.
- [9] L. Wiskott, J. M. Fellous, N. Krüger, and C. V. D. Malsburg, "Face recognition by elastic bunch graph matching," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 19, pp. 775-779, 1997.
- [10] G. J. Kaufman and K. J. Breeding, "Automatic recognition of human faces from profile silhouettes," *IEEE Transactions on Systems Man and Cybernetics, SMC*, vol. 6, pp. 113-121, 1976.
- [11] L. D. Harmon, M. K. Khan, R. LAsch, and P. F. Raming, "Machine identification of human faces," *Pattern Recognition*, vol. 13, pp. 97-110, 1981.

- [12] Z. Liposcak and S. Loncaric, "A scale-space approach to face recognition from profiles," in *Proc. 8th International Conference on Computer Analysis of Images and Patterns*, 1999.
- [13] A. K. Jain and R. C. Dubes, *Algorithms for Clustering Data*, New Jersey: Prentice-Hall, 1988.
- [14] K. Fukunaga, *Introduction to Statistical Pattern Recognition*, 2nd ed., Boston, MA: Academic Press, 1990.
- [15] M. Turk and A. Pentland, "Face recognition using eigenfaces," in *Proc. IEEE Conference on Computer Vision and Pattern Recognition*, 1991, pp. 586-591.
- [16] M. Turk and A. Pentland, "Eigenfaces for recognition," *Journal of Cognitive Neuroscience*, vol. 3, pp. 71-86, 1991.
- [17] Y. Moses, Y. Adini, and S. Ullman, "Face recognition: The problem of compensating for changes in illumination direction," in *Proc. European Conf. Computer Vision*, 1994, pp. 286-296.
- [18] R. A. Fisher, "The use of multiple measures in taxonomic problems," *Annals of Eugenics*, vol. 7, pp. 179-188, 1936.
- [19] M. A. O. Vasilescu and D. Terzopoulos, "Multilinear subspace analysis of image ensembles," in *Proc. IEEE Int'l Conf. on Computer Vision and Pattern Recognition*, 2003, pp. 93-99.
- [20] Q. Yang and X. Q. Ding, "Symmetrical principal component analysis and its application in face recognition," *Chinese Journal of Computers*, vol. 26, pp. 1146-1151, 2003.
- [21] J. Yang and D. Zhang, "Two-Dimensional PCA: A new approach to appearance-based face representation and recognition," *IEEE Trans. Pattern Analysis and Machine Intelligence*, vol. 28, pp. 131-137, 2004.
- [22] J. Meng and W. Zhang, "Volume measure in 2DPCA-based face recognition," *Pattern Recognition Letters*, vol. 28, pp. 1203-1208, 2007.
- [23] V. D. M. Nhat and S. Lee, "An improvement on PCA algorithm for face recognition," in *Advances in Neural Networks*, Springer Berlin Heidelberg, 2005, pp. 1016-1021.
- [24] N. Sun, H. X. Wang, Z. H. Ji, C. R. Zou, and L. Zhao, "An efficient algorithm for Kernel two-dimensional principal component analysis," *Neural Computing & Applications*, vol. 17, pp. 59-64, 2008.
- [25] D. Zhou and X. Yang, "Face recognition using direct-weighted LDA," in *Proc. 8th Pacific Rim International Conference on Artificial Intelligence*, Auckland, New Zealand, 2004, pp. 760-768.
- [26] L. Chen, H. Liao, M. Ko, J. Liu, and G. Yu, "A new LDA-based face recognition system which can solve the small samples size problem," *Journal of Pattern Recognition*, vol. 33, pp. 1713-1726, 2000.
- [27] W. Liu, Y. Wang, S. Z. Li, and T. Tan, "Null space approach of fisher discriminant analysis for face recognition," in *Biometric Authentication*, Springer Berlin/Heidelberg, 2004, pp. 32-44.
- [28] A. Ötkün and B. Karlık, "YSA ve pencere ortalamaları kullanılarak yüz tanıma sistemi," in *Proc. TOK Otomatik Kontrol Ulusal Toplantısı*, Sept. 26-28, 2013, pp. 996-1000.



Mehmet Korkmaz received the B.S and M.S. degrees from Department of Electrical and Electronics Engineering, Selcuk University, Konya, Turkey, in 2009 and 2013. Mr. Korkmaz has been working as a researcher and PhD. student in Department of Electrical and Electronics Engineering in Selçuk University. His main studies are fractional control and mobile robotics.



Nihat Yılmaz received the B.Sc., M.S. and PhD. degrees from Department of Electrical and Electronics Engineering, Selcuk University, Konya, Turkey, in 1996, 1998 and 2005 respectively. Mr. Yılmaz has been an Associate Professor in Department of Electrical and Electronics Engineering in Selçuk University. He has many publications in different areas of robotics and still maintains the studies in same focus.