

Feature Based Face Recognition Using Slopes

Isra Anwar, Shah Nawaz, Ghulam Kibria, Syed Farooq Ali, Malik Tahir Hassan and Jeong-Bae Kim

Abstract— Face recognition from an image is a popular problem in biometrics research. In the last decade, a lot of research has been done in this area. The advantage of face based identification over other biometrics is its wide acceptability as it does not require any keys, tokens, smart cards, PINs, plastic cards or passwords etc. In this work, face recognition has been done using several feature based approaches. Two new methods are presented in which simple yet useful new features are proposed and evaluated. The main contribution of this paper is usage of a slope table along with other features for face recognition. The slopes of different fiducial points of facial components (left eye, right eye, nose and lips) are computed to fill the slope table. These two methods are compared with the existing approaches based on popular features like principal components and ratios of facial components. The results show that our proposed methods outperform these existing approaches.

I. INTRODUCTION

OVER the last decade or so, a very popular area of interest undoubtedly is the face recognition. This reputation has been established in multiple domains including computer vision, image processing, pattern recognition, neural networks, neuroscience, cognitive science, psychology and physiology. In recent years Biometric-based systems have become the most skillful preference for recognizing personnel and, one of the imperative Biometric technique is, face recognition in which passwords, smart cards, PINs, plastic cards, tokens and keys are not obligatory for authentication. Passwords and PINs are sturdy to remember; keys, tokens, cards can cause nuisance if misplaced, stolen, duplicated or become unreadable. On the other hand, an individual's biological personality cannot be misplaced, forgotten, stolen or fictitious. What lays down facial recognition apart from other biometrics is that it can be used for the intention of

surveillance. All the way through the past few years, face recognition has acknowledged an immense level of interest. There are two reasons for this vigorous growth in biometric systems, first is the wide range of commercial and law enforcement applications and second is the easy availability and feasibility of required hardware resources.

II. RELATED WORK

The idea of face recognition was implemented in 1960 with semi-automated system. A photograph was marked to locate the major features such as ears, eyes, mouth and nose. Ratios and distances of the facial features were computed from common reference point as marked in the image and then compared with other data. Lesk, Harmon and Goldstein created a system of finding 21 points including lips thickness and hair color. Although, these points proved difficult to be identified automatically [5].

Another approach known as Eigen faces was founded by Kirby and Sirovich at Brown University [33]. Since then many people have developed and extended the Eigen faces on the basic ideas described in the original paper. Fisher et al. explained to measure different features of the face and mapped them all onto a global shape, although later it was found that these features do not contain enough unique data to represent an adult face [3].

Ping Du et al. [21] proposed an approach for face recognition in which SVM was combined with nearest centre classification (NCC). The principal component analysis (PCA) was used to reduce dimension and extract features. Then support vector machine based classifier was applied in combination with the nearest centre classifier for the task of classification. The experimental results show that the combination of SVMs with nearest centre is a better discriminative algorithm than the individual BP neural network [26], sole SVMs or the nearest centre classification approach for face recognition. The philosophy behind this is based on the idea that their discriminative capabilities are not totally overlapped so NCC may work on the samples where SVMs fail.

Hua Gu Guangda Su Cheng Du [22] presented an approach that could automatically locate the feature points with high accuracy. Although its accuracy was not good in scenarios having large angle rotation, yet the method provided a feasible way to locate the positions of two eyeballs, near and far corners of the eyes, the midpoint of nostrils, and the

Manuscript received October 14, 2014. This work was supported by the ICT R&D program of MSIP/IITP. [14-824-09-002, Development of global multi-target tracking and event prediction techniques based on real-time large-scale video analysis]

Isra Anwar, shah Nawaz and Ghulam Kibriya are students at the University of Management and Technology, Lahore, Pakistan (e-mail: 101620142@umt.edu.pk, shani.umt@hotmail.com, gk.dogar@gmail.com).

Syed Farooq Ali is working as an Assistant Professor at the University of Management and Technology, Lahore, Pakistan (e-mail: farooq.ali@umt.edu.pk).

Malik Tahir Hassan is working as a post doctorate researcher at Gwangju Institute of Science and Technology (GIST), Gwangju, Korea (e-mail: mhassan@gist.ac.kr).

Jeong-Bae Kim is working as a professor at the Department of System Management, Pukyong National University, Korea (e-mail: jbkim@pknu.ac.kr).

corners of mouth from a face image. By using this approach it could be helpful to extract useful face features of the human face automatically and improve the accuracy of face recognition.

Gregory et al. [1] described techniques in unevenly sequential order that identify and analyze linear and non-linear subspaces of the facial features. They applied the Eigen faces and the Bayesian methods [27] for probabilistic data analysis, and discussed the results of these techniques. Practical issues related to the application of subspace methods for expression varying pose and illuminations were also discussed.

Shivani Gupta et al. [19] investigated Support Vector Machines (SVMs) in their paper. They explained the working of SVMs on the Cambridge ORL face dataset [28] that comprises of 400 images of 40 persons, which contained a high amount of inconsistency in pose, expression, and other facial details. Face recognition system comprised of two key phases, an automation of facial feature extraction process and an approach to choose the finest feature among the measured ones that considerably increases face recognition effectiveness of SVM. James Peters introduced, Near Set approach, as an outcome of generalization of rough set theory [29]. They have also presented that by consuming SVM with face feature selection by near set approach on ORL face database has error rate of 0.2% which is comparatively very less as compared to the error rates found in the previous works done on the ORL face database [19].

Irene Kotsia et al. [20] presented two approaches for face expression recognition in sequences of facial images. The user physically places some of Candide grid nodes to face breakthroughs showed at the first frame of the image order in analysis. By using the deformation and grid-tracking system, which is typically based on deformable models that tracks the grid in successive video frames over the period, facial expression are changing, up until the frame resembles to the highest facial expression strength. As the definite selected Candide nodes make a geometrical displacement, this displacement is well-defined as the dissimilarity of the node matches among the first and the highest facial expression strength frame. This is then used as an input to a multiclass Support Vector Machine. The results when concluded for facial expression recognition using the suggested multiclass SVMs, Cohn–Kanade database [30] show a recognition accurateness of 99.7% and facial expression recognition on FAU detection showed 95.1% accuracy.

Ce Zhan et al. [23] proposes that restraining of facial feature points locally is a significant phase for numerous successive facial image studies. A method for extracting 20 facial feature points from image sequences is presented that

works from abstract to finer direction. Specifically, the Viola-Jones face detection method is extended to detect small-scale facial components with wide shape variations, and linear Kalman filters are used to smoothly track the feature points by handling detection errors and head rotations. The proposed method achieved higher than 90% detection rate when tested on the Bio ID face database [31] and the FG-NET facial expression database [32]. Moreover, the method shows robust performance against the variation of face resolutions and facial expressions.

Vinay Hiremath et al. [17] presented that it is superior to study only a subspace with lesser dimensionality to signify the face space. Whereas the current system represents some face space with advanced dimensionality and it is not that effective.

Another algorithm Principal Component Analysis (PCA) that is based on an Eigen Face approach which represents a small set of significant features has been used to describe the variation between face images. The Principal Component Analysis (PCA) algorithm has been applied to the face recognition problem. Experimental results for different numbers of Eigen faces are shown to verify the viability of the proposed method. The method was proposed by M. Slavković et al. [18].

Different approaches of face recognition can be divided into different categories. These categories are as follows:

- Holistic e.g., Eigen Faces
- Machine Learning
- Statistical e.g., PCA, ICA, LDA
- Feature Based

In this paper, we propose different interesting features that outperform many existing feature based approaches for face recognition.

A. Feature Based Recognition

Feature-based approaches first process the input image to identify, extract and measure distinctive facial components such as the eyes, mouth, nose, etc., as well as other fiducial points, and then compute the geometric relationships among those facial points, thus reducing the input facial image to a vector of geometric features. Standard statistical pattern recognition techniques are then employed to match faces using these measurements.

The procedure used for feature based recognition is semi-automatic [33]. In literature, some of the experimental results determine that feature based technique is 100% independent of brightness and contrast. The zoom factor of the input image is handled by 90% and blurriness up to 95%. The angle orientation of image can be managed up to 10% [33]. Table I summarizes this information.

TABLE I
FEATURE BASED FACE RECOGNITION [33]

Criterion	Experimental Results
Procedure	Semi-automatic
Same image with different name	100% accuracy
Same image with different brightness	Independent of brightness - 100%
Same image with different contrast	Independent of contrast -100%
Different image of same person	With same posture & head orientation- 85% cannot work if features are not visible
Zoom and Blur	zoom factor handled up to – 90% Blur - 95%
Angle Orientation	Can manage the rotation up to 10%

III. OUR METHODOLOGY

A. Existing and Proposed Approaches

We elaborate the 4 approaches that we implemented and compared.

1) Existing approaches

Two existing approaches that we discuss are brute force approach and feature based approach using ratios.

a) Brute Force

In this approach, brute force method is used for comparison purposes. If there are two frontal images and we want to check both images are either same or not then we compare all the pixel values (Fig. 1). If pixel values are different more than a given threshold, it will not recognize the image.

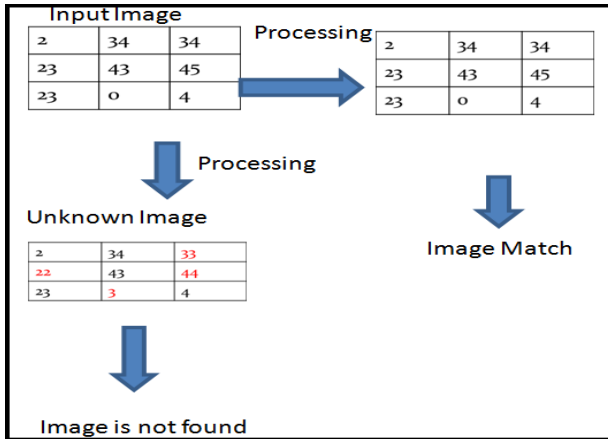


Fig. 1. (Working of Brute Force)

b) Feature based approach using Ratios

In this approach, Ratios are used for comparison. Ratios of the boundary points of eyes, nose and lips are used.

Ratio between eyes, nose and lips can be obtained by using this formula

$$v_1 = [\sum (P_B - P_A)^2]^{1/2} \quad (1)$$

$$v_2 = [\sum (P_G - P_F)^2]^{1/2} \quad (2)$$

$$\text{Ratio} = v_1 / v_2 \quad (3)$$

Whereas P_A and P_B are the left and right points of the eye, P_F and P_G are the upper and lower mid points of the lips respectively.

2) Our Proposed Approaches

In our experiments, features are extracted using BoRMaN method [15]. BoRMaN iteratively uses support vector regression and local appearance based features to provide an initial prediction of 22 points like eyes, mouth, eyebrows etc. The methodology presented in this research paper is taken by an idea of Caricature research paper by Jiye Lee et al. [13]. Hence, ratio of different invariant features was calculated and we formulated two approaches as following:

- Feature based approach using Angles (with BoRMaN),
- Feature based approach using Slope Table (with BoRMaN), it also uses ratios.

a) Feature based Approach using Angles (with BoRMaN)

BoRMaN extracts 22 facial points on a face, these points are used to detect facial features; it gives three files with following formats:

- .mat file
- .png files with features
- Xml file which gives you coordinates Info.

Fig. (2a) shows the distribution of these 22 points in face organ. Five points are used for the left eye and five points mark the right eye. Similarly, two points are used for each eyebrow, three for nose, four for lips and one point is used to spot chin.

Algorithm of this approach works in the following way; run BoRMaN and detect all 22 face points for database images as shown in Fig.4a. Using these facial points calculate the ratios and angles between facial features (Fig.2b). Give input image from testing phase and repeat step 1, 2 and 3. Find Euclidean distance of calculated ratios and angles between database images and input image. Sum of Absolute difference (SAD) can also be used rather than Euclidian distance for this purpose. Results have been generated using both of these measures. Apply the threshold. If Euclidean distance or (SAD) < threshold, then recognize otherwise report that the current image does not exist in our database.

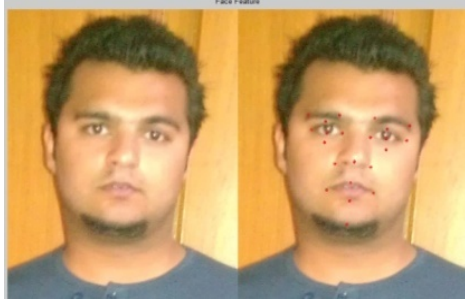


Fig.2a. (Detecting facial features points from image)



Fig.2b. (Calculating angles and ratios from the detected facial feature points)

Angles between eyes, nose and lips are obtained by using these formulae:

$$v_1 = P_Q - P_P \quad (4)$$

$$v_2 = P_R - P_P \quad (5)$$

$$\theta = \cos^{-1}(\mathbf{v}_1 \cdot \mathbf{v}_2 / |\mathbf{v}_1| \cdot |\mathbf{v}_2|) \quad (6)$$

Whereas P_Q and P_P are the left points of both the eyes and P_R is the left point of the nose.

Standard Absolute difference is measured by:

$$SAD = 100 * (\text{actual} - \text{calculated}) / \text{actual} \quad (7)$$

Euclidean distance is measured by the formula:

$$\text{Euclidean distance} = \left[\sum_{i=1}^n (Q_i - P_i)^2 \right]^{1/2}$$

b) Feature based approach using Slope Table

We have designed a novel approach in which a slope table is used as a feature for face recognition along with the other features. The slopes of different fiducial points of facial components (left eye, right eye, nose and lips) are computed to fill the slope table.

For each face, four boundary points (obtained from ASM or BoRMaN) of left and right eye are extracted. Centroid of each facial component such as (left eye, right eye, nose and lips) are computed. Euclidean distance is calculated between centroid and the rest of the points which were detected by (ASM and BoRMaN). The slope of each point of left eye is

computed and the slope table is filled. Similarly, slope table of right eye is computed. Four boundary points (obtained from ASM and BoRMaN) of lips are extracted. The slope of each point of lips is computed and the slope table is filled. Slope table for nose is also computed similarly.

Centroid of a facial component is calculated as:

$$C = (\sum x_i / n, \sum y_i / n) \quad (8)$$

Where (x_i, y_i) are the two coordinates of i-th point of a facial component.

We calculate distances between the points and the centroid of each facial component using Euclidean distance.

Let P_x and P_y be the distance along x-axis and distance along y-axis of the boundary point to the centroid i.e. if we draw a line P from boundary point to centroid then P_x is the x component of that line P. P_y is the y-component of the line P. These P_x and P_y are used to compute the slope as below.

$$m = \tan \theta = P_y / P_x \quad (9)$$

The SVM classifier is trained using these face features and testing is performed. The results show that this approach outperforms all the other approaches discussed in this paper.

B. Dataset

Our proposed feature based approaches are evaluated on two datasets. First is the UMT face database and the second is a part of the PUT Face database publicly available [25]. UMT face database contains 180 face images. We divide the dataset into two parts: one is the training set containing 150 face images; the other is the testing set containing 30 face images. Some original sample images of UMT dataset are shown in Fig. 3. After preprocessing by a face detecting system the detected face images serve as the inputs to the proposed algorithm.

The part of PUT face database which we selected, contains 154 face images. Data Set was divided into two parts: one is the training set containing 112 face images; the other is the testing set containing 42 face images. Some original sample images of PUT dataset are shown in Fig. 4.

More description of both the Datasets is given in the Table II and Table III respectively.



Fig. 3. (Some images from UMT Face Dataset)

TABLE II
UMT FACE DATA SET DESCRIPTION

Properties	Description
Number of subjects	5
Number of images/ Videos	180 (150 training and 30 testing)
Static/ Videos	Static
Single/ Multiple faces	Single
Gray/ Color	Color
Resolution	500*375
Face Pose	Various Pose
Facial Expression	Various Expression
Illumination	Constant Illumination
3D data	-

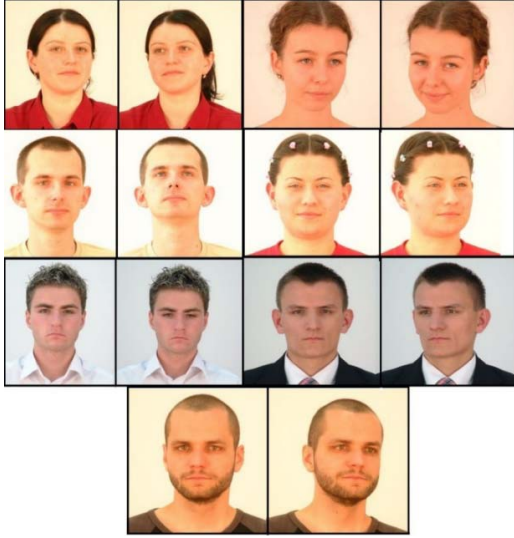


Fig.4. (Some images from PUT Face Dataset)

TABLE III
PUT FACE DATA SET DESCRIPTION

Properties	Description
Number of subjects	7
Number of images/ Videos	154 (112 training and 42 testing)
Static/ Videos	Static
Single/ Multiple faces	Single
Gray/ Color	Color
Resolution	520*390
Face Pose	Various Pose
Facial Expression	Various Expression
Illumination	Various Illumination
3D data	-

IV. RESULTS AND DISCUSSION

Table IV and Table V summarize the results of our experiments. The percentage accuracy is reported on two data sets using various features. Table IV shows results for features that are computed using BoRMaN whereas Table V shows the results for features computed using ASM. It is clear from the results that slope table is working as a very useful face recognition feature, achieving highest accuracy in both of the data sets.

TABLE IV
FACE RECOGNITION ACCURACY (USING BORMAN)

Features (using BoRMaN)	UMT Face Data (% Accuracy)	PUT Face Data (% Accuracy)
Ratio	64.00%	58.00%
Angle	66.67%	61.67%
All features (without slope table)	88.00%	84.41%
Slope table	80.00%	72.70%
All features (with slope table)	97.33%	92.85%

Percent accuracy for two data sets using BoRMaN and computed features. SVM is used as the classifier.

TABLE V
FACE RECOGNITION ACCURACY (USING ASM)

Features (using ASM)	UMT Face Data (% Accuracy)	PUT Face Data (% Accuracy)
Ratio	40.00%	36.00%
Angle	30.00%	27.27%
Area	30.67%	26.00%
All features	58.67%	53.24%

Face recognition percentage accuracy for two data sets using ASM and different features. SVM is used as the classifier.

The same individual image with the same camera appear dramatically different with changes in the lighting conditions so to solve this problem every image has been normalized using this formula:

$$(Image_{\text{pixel}} - Min_{\text{pixel}}) / (Max_{\text{pixel}} - Min_{\text{pixel}}) * 255$$

After getting invariant features we have calculated the width and height of eyes, nose and mouth. This information was not sufficient because images are scaled according to their height and width. Hence system fails to recognize same images to solve this problem we have calculated the ratios, angles and slopes between facial features such as eyes, nose and mouth, to perform face recognition than just taking length of eye or width of eye etc.

Selecting the distance threshold value is a critical point for face recognition. Cross validation was done to select the threshold value that gave the best accuracy.

Experimental evaluation on other data sets will be carried out in future to test the error rate in challenging and varying conditions including situations when facial characteristics are changed like wearing glasses or grown beard etc.

V. CONCLUSION

In this paper, we experiment with various features for face recognition problem and propose the use of BorMaN and slopes. BorMan gives important points of the facial components. Results prove that feature based face recognition using BoRMaN and the slopes is the best approach among all the discussed approaches. BoRMaN gives 22 invariant face features by which we can easily calculate features like ratios, angles etc. and match faces. Besides other extensions, implementing a complete and accurate attendance system is our future direction in which a camera is placed on the wall. User will stand in front of the

camera for a moment and if her photo exists in the database, her attendance will be marked.

ACKNOWLEDGMENT

Authors wish to express their gratitude to Mr. Mubashir Baig, Mr. Touqeer Attique and Mr. Mohsin Ejaz who were abundantly helpful and offered their support, invaluable assistance and guidance whenever required.

REFERENCES

- [1] Gregory Shakhnarovich Baback Moghadda. *Face Recognition in Subspaces*. Published In: Handbook Of Face Recognition, Eds. Stan Z. Li & Anil K. Jain, Springer-Verlag, 2004
- [2] M. Turk, *A Random Walk Through Eigen Space*, IEICE Transactions On Information And Systems, Vol. E84-D, No. 12, December 2001, Pp. 1586-15950
- [3] M. A. Fischler and R. A. Elschlager, "The Representation and Matching of Pictorial Structures," IEEE Transaction On Computer, Vol. C-22, Pp. 67-92, 1973
- [4] Drexel University, *Eigen Face Tutorial* <http://www.Pages.Drexel.Edu/~Sis26/Eigenface%20Tutorial.htm>
- [5] Nirmalya Kar, Mrinal Kanti Debbarma, Ashim Saha, and Dwijen Rudra Pal, Study of Implementing Automated Attendance System Using Face Recognition Technique. International Journal of Computer and Communication Engineering, Vol. 1, No. 2, July 2012
- [6] M. Slavković, D. Jevtić. *Face Recognition Using Eigen face Approach*. Serbian Journal of Electrical Engineering Vol. 9, No. 1, February 2012, 121-130
- [7] Sheifaligupta, O.P.Sahoo, Ajay Goel, Rupesh Gupta. *A New Optimized Approach to Face Recognition Using Eigen faces*. Global Journal of Computer Science and Technology Vol. 10 Issue 1 (Ver1.0), April 2010 P A G E | 15
- [8] Yogeshtayal, Pramod Kumar Pandey, D. B. V. Singh. *Face Recognition Using Eigen face*. International Journal of Emerging Technologies in Computational and Applied Sciences 12-325; Page 50
- [9] Ping Du, Yankun Zhang, Chongqing Liu. *Face Recognition Using Multi-Class SVM*. ACCV2002: The 5th Asian Conference on Computer Vision, 23--25 January 2002, Melbourne, Australia
- [10] Shivani Gupta, K.S.Patnaik. *Enhancing Performance of Face Recognition System by Using Near Set Approach for Selecting Facial Features*. Journal of Theoretical and Applied Information Technology 2005 - 2008 JATIT, Pp 9
- [11] Irene Kotsiaand Ioannis Pitas. *Facial Expression Recognition in Image Sequences Using Geometric Deformation Features and Support Vector Machines*. IEEE Transactions on Image Processing, Vol. 16, No. 1, January 2007
- [12] Michel F. Valstar, Brais Martinez, Xavier Binefa, and Maja Pantic' *Facial Point Detection Using Boosted Regression and Graph Models'*, IEEE Int'l Conf. Computer Vision and Pattern Recognition, Pp. 2729-2736, San Francisco, USA, June 2010
- [13] Jiye Lee, And Hae Won Byun, *Caricature System Using Moving Least Squares Based On Justin*, Published In International Journal of Multimedia and Ubiquitous Engineering Vol. 7, No. 3, July, 2012
- [14] *Feret Database*: National Institute of Standards and Technology, <http://www.nist.gov/Itl/lad/Ig/Colorferet.cfm>
- [15] Valstar, Michel, Et Al. "Facial Point Detection Using Boosted Regression and Graph Models." Computer Vision and Pattern Recognition (CVPR), 2010 IEEE Conference On. IEEE, 2010.
- [16] A. J. Goldstein, L. D. Harmon, and A. B. Lesk, "Identification Of Human Faces," In *Proc. IEEE Conference on Computer Vision and Pattern Recognition*, Vol. 59, Pp 748 – 760, May 1971
- [17] Vinay Hiremath, Ashwini Mayakar. *Face Recognition Using Eigenface Approach*,
- [18] M. Slavković, D. Jevtić. *Face Recognition Using Eigenface Approach*. Serbian Journal of Electrical Engineering Vol. 9, No. 1, February 2012, 121-130
- [19] Shivani Gupta, K.S.Patnaik. *Enhancing Performance of Face Recognition System by Using Near Set Approach for Selecting Facial Features*. Journal of Theoretical and Applied Information Technology 2005 - 2008 Jatit, Pp 9
- [20] Irene Kotsiaand Ioannis Pitas. *Facial Expression Recognition In Image Sequences Using Geometric Deformation Features and Support Vector Machines*. IEEE Transactions on Image Processing, Vol. 16, No. 1, January 2007
- [21] Ping Du, Yankun Zhang, Chongqing Liu. *Face Recognition Using Multi-Class SVM*. Published In: ACCV2002: The 5th Asian Conference on Computer Vision, 23--25 January 2002, Melbourne, Australia.
- [22] Hua GuGuangda Su Cheng Du. *Feature Points Extraction from Faces*. Published In: Image and Vision Computing NZ, Palmerston North, November 2003
- [23] Ce Zhan., Li, W., Ogunbona, P. O. & Safaei, F. (2007). *Real-Time Facial Feature Point Extraction*. Pacific-Rim Conference on Multimedia (Pp. 88-97). Germany: Spinger.
- [24] Garg, Ravi. "A Comparative Study of Different Face Recognition Algorithms." (2009).
- [25] *PUT Face Database*, CIE Biometrics. https://Biometrics.Cie.Put.Poznan.Pl/Index.Php?Option=Com_Content&View=Article&Id=4&Itemid=2&Lang=En
- [26] Wen Jin; Zhao Jia Li; Luo Si Wei; Han Zhen, "The improvements of BP neural network learning algorithm," Signal Processing Proceedings, 2000. WCCC-ICSP 2000. 5th International Conference on vol.3, no., pp.1647, 1649 vol.3, 2000
- [27] Cooper, Gregory F., and Edward Herskovits. "A Bayesian method for the induction of probabilistic networks from data." Machine learning 9.4 (1992): 309-347.
- [28] *The Database of Faces*, AT&T Laboratories Cambridge. <http://www.cl.cam.ac.uk/research/dtg/attarchive/facedatabase.html>
- [29] Anna Maria Radzikowska, Etienne E. Kerre, *A comparative study of fuzzy rough sets*, *Fuzzy Sets and Systems*, Volume 126, Issue 2, 1 March 2002, Pages 137-155, ISSN 0165-0114
- [30] *Affect Analysis Group*, the University of Pittsburgh, <http://www.pitt.edu/~emotion/downloads.html>
- [31] *BioID-Face-Database*, BioID AG, Bruenigstrasse 95, 6072 Sachseln Switzerland, <https://www.bioid.com/About/BioID-Face-Database>
- [32] Singh, S.K.; Mayank Vatsa; Richa Singh; Shukla, K.K., "A Comparative study of various face recognition algorithms (feature based, Eigen based, line based, neural network approaches)," Computer Architectures for Machine Perception, 2003 IEEE International Workshop on , vol., no., pp.12 pp.,171, 12-16 May 2003
- [33] Kirby, Michael, and Lawrence Sirovich. "Application of the Karhunen-Loeve procedure for the characterization of human faces." Pattern Analysis and Machine Intelligence, IEEE Transactions on 12.1 (1990): 103-108.