Scale Invariant Face Recognition with Gabor Wavelets and SVM

Putta Sujitha, Venkatramaphanikumar S, Krishna Kishore K V

ABSTRACT--- Face recognition is one of the prominent and accosting research areas in Biometrics. Extraction of discriminating features ensures the higher recognition accuracy even with limited training data. In this work, a novel framework is proposed with state of methods include Gabor wavelets, principal component analysis and support vector machine. Gabor wavelet is applied to extract rotation and scale invariant features from the normalized face image. Further to reduce the number of features principal component analysis is applied. The reduced feature data is classified using support vector machine with RVF kernel. To evaluate the performance of the proposed work benchmark datasets like ORL, Grimace and AR face datasets are used. The proposed methods outperform the existing methods even with limited training.

Keywords:Face recognition; Gabor Wavelet; Principal Component Analysis; Support VectorMachine

I. INTRODUCTION

The human face is an extremely complex which rich source of information. Representation of face using Gabor wavelets is having continuous attention in Image Processing in Pattern Recognition.Gabor wavelets[5]can exhibit remarkable ocular characteristics which are localization of spatial features and geographical frequency characteristics, considering these as immense potential properties to have great success in recognition of face. The proposed work abodes Gabor wavelet filters to facial picture representation which fabricates recognition in tandem manner with SVM[8]. Detection of face from huddle pictures is highly accosting because face of human-being are indefinite representations with towering grade of differentiability in dimensions like size, shape, facial expression, and objects wearing on face like spectacles, masks, tattoos, etc. In addition to this, variant illuminations, poor quality of image and messy backgrounds also integrate huge trouble to vigorous face identification. Owing to those innumerable possible utilizations, facial recognition has become a huge operating research area. The structures designed until are abruptly classified as bifurcate classes: feature derivation and classification. In view of performance of feature extraction approaches hugely confide on loyal location of face features, which is yielding to biased obstruction, extreme distortion, and picture humiliation. The classification approaches are certified to be most accurate according to the results.

In the proposed approach, the problem of face recognition can be followed as; the input image is processed first then ROI[11] **(**Region of Interest) can be extracted and classifies using SVM classifier, if a match exists with trained image set, then the classifier reports test image with matched training image.

In classification-based method, the recognition of face is done by matching the features of search image over a trained classifier. Numerous classification methods have been identified for identification of face like, Deep Neural Networks (DNN)[4], Bayesian Classifier, and Support Vector Machine (SVM). While extracting the features many of the classification models are used the pixel intense locations of inquiry image as the taking in features of distinguished classifier. So as to improvise the accuracys of detection, a greater number of features should be victimised. Fig 1: Shows the structure of face recognition system, where pre-processing of image data includes normalization and noise reduction. Feature extraction of training samples is done by Gabor wavelets, feature reduction with PCA and then classification is done by using SVM.

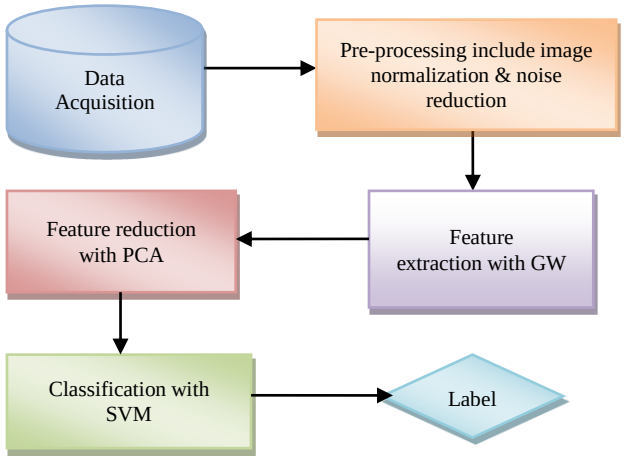

Fig 1: Face Recognition system

An image can be represented by using *M* x *N* matrixof pixel values and a pixel can be viewed as single vector. Detection of facial features in such numerous pixel spaces would be enormously very poor and ineffective. To improve the performance of feature extraction, a realistic solution is dimensionality reduction. The goal of the reduction

Revised Manuscript Received on February 11 , 2019.

Putta Sujitha Department of Computer Science & Engineering, Vignan's Foundation for Science, Technology & Research, Vadlamudi, Guntur, Andhra Pradesh, India (E-mail: sujithacse2012@gmail.com)

Venkatramaphanikumar S Department of Computer Science & Engineering, Vignan's Foundation for Science, Technology & Research, Vadlamudi, Guntur, Andhra Pradesh, India

Krishna Kishore K V Department of Computer Science & Engineering, Vignan's Foundation for Science, Technology & Research, Vadlamudi, Guntur, Andhra Pradesh, India

technique is to transform the original pixel to smaller orientations, while ensuring no loss of useful information in the image.

All the human faces are having the facial parts like nose, mouth, eye lids, eye brows and ears etc which are located at very nearby locations. So that all the vectors that are representing a face form a closed cluster which makes the face representation very difficult. To reduce the problem of closed clustered vectors, Eigen faces [1] are used to better describe the facial images in pixel locations and the Eigen vectors are called as principal components. Because Eigenface method employs the error rate of weight vector which was calculated by the additive union of Eigen faces, and Eigen faces are based on the information of difference image. "Diverse facial pictures of unique background" of human being can give us highly beneficial information. But "diverse facial pictures of diverse background" gives needy but highly trash information. The aim of the proposed work is "detection of face with different background".

II. LITERATURE SURVEY

In the recent years the research in area of face recognition is very rapidly increasing and many of the researchers evolved with enormous results.[1]used PCA based Eigen face method to recognise the face image. The database used to detect the pictures was Indian databases and the face recognition data, University of Essex, UK. The PCA attainment based face detection system is satisfactory.[2] Works on face recognition and detection using PCA by comparing the facial characteristics of one's individual. In this paper ORL database is used for training and classification. Authors of [3]Done work on face recognition using PCA, this work cluster based feature projection method to increase sample difference in various classes as long as sample difference of identical class is decreased. The paper shows the results by using ORL database. In paper[4], authors done their enormous research on face recognition using Gabor wavelet filters, PCA and neural networks. The trained image set was classified by using the neural network. The publicly available ORL database used for analysis of results.

[5]Proposed their work in face recognition using Gabor filters. The neural network used in this work is based on Multi-Layer Perception (MLP). The effectiveness of algorithm was checked by using the morphological facial image database. [6] Worked on classification-based detection of face using Gabor filter features. The feature vectors of Gabor filters are used as data to the Polynomial Neural Network. The algorithm was checked against large set of image dataset.

[7] done work on face recognition approach using Gabor wavelets, PCA and SVM. The input facial image was pre-processed; feature extraction was done with PCA, and classifies the image using SVM. The database used for result analysis was FRGCv2 face database and ORL database. [8]Proposed an algorithm for face recognition using Gabor-fast ICA feature extraction using Linear Kernel SVM. The algorithm mainly concentrated on the lighting, rotation and scaling impacts on the input image. Fast ICA technique is used to represent the high dimensional image into low dimensional image. The thermal face image of IRIS dataset was used for the experimentation purpose.

[9] did the experimentation on automatic face detection using Gabor filters, Kernel PCA and SVM. Gabor filters bank with five different propotions and eight directions applied on input image to get ROI against local distortions.ORL database was used for practical results.[10]Proposed the face recognition with generalized discriminant analysis along with support vector machine. The GDA is one of the dimensionality reduction techniques which yield the better results than the earlier techniques. By using GDA with SVM, the accuracy of the face recognition system yields 85% performance.[11] Proposed the automatic face detection using SVM with the help of robust features. In general the set of features extracted using PCA technique; later the number of dimensions needs to be reduced to better represent the face. So Guang Dai uses Kernel PCA which extracts very powerful features which does not need the dimensionality reduction. ORL database was used for experimentation. In paper [12], authors used discrete wavelet transformation to reduce the number of dimensions, later classification of face images was done by using support vector machines. The accuracy of the system increased to 84.28% for 515 images.

Authors of paper [13], concentrated on implementation of face recognition algorithm which is used for attendance system to automatically recognise the face. The algorithm uses the PCA and LDA (Linear Discriminant Analysis) was used for feature extraction methods. The PCA method used the Eigen faces where as LDA method used Fisher faces.

Authors of [14] used the various classification methods as Support vector machine and neural networks. The experimental results are produced using the publicly available ORL face database.

III. PROPOSED APPROACH

Principal Component Analysis is one of the highly noticeable feature extraction methods which extract the interested regions in given face. The extracted features are then used for the classification of face from the remaining set of images. The PCA is a statistical procedure to transform the orthogonal values into correlated variables which are nothing but principal components.PCA involves an analytical measure that converts most probable coordinated variables to less volume of uncoordinated variables nothing but principal components. Premier component shows volatility in training images as obtainable, and each consecutive principal component considered as most of resting variability as possible. Whereas an input matrix, X^T, with void mean, where every tuple embeds a various chant of the practice, from a particular probe ,each attribute produces outcome, the equation for transformation of PCA is considered as :

$$A^T=B^T W= V\ \Sigma^T \quad (1)$$

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

In the above equation, matrix Σ is i X j orthogonal matrix of positive values in the diagonal, W, Σ and V are eminent value decompositions of B. provided bunch of input points in Euclidean arena, the pioneer principal component related to an edge which goes via mean and reduces squared sum error with valid input points. Single Eigen value represents the chunk of the difference that corresponds to every eigenvector. Presuming nil mean, principal component w1 of a data set B can be shown as:

$$W_1=\max Var\{w^T b\}=\max E\{(w^T b)^2\} \quad (2)$$

Using first k − 1 components, by deducting the first k − 1 components from b, the k^{th}can be found.

Eigen face is one of the applications of PCA in computer vision. First all the set of training images are transformed into Eigen faces E. Then for each image calculated weights are stored in set W.

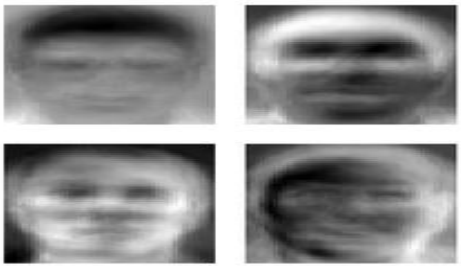

Fig 2: Eigen face calculated from ORL database

Let consider a single input image, and the weight of that image was calculated and stored in W_x. Then $W_x$is compared with the all the remaining weight vectors. The comparison of $W_x$can be done by calculating the average Euclidian distance from $W_x$towards to the W-$W_x$remaining weight vectors. Then finally the minimal Euclidian distance between the weight vectors of respected eigenfaces is considered as a correct match.

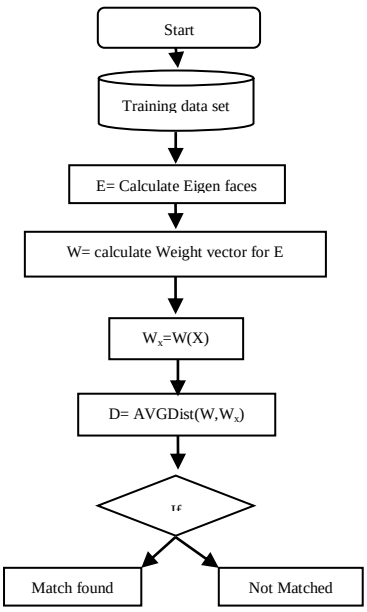

Fig 3: Flowchart of face detection with Eigen vectors

Feature extraction with Gabor wavelets

For representing the texture, discrimination properties of Gabor wavelets like scale and orientation are important. The Gabor features are collected from gray scale input faces. The spatial domain of 2-D Gabor filter is a Gaussian kernel function which was modulated by sine wave. Gabor wavelet filters can be practiced to numerous detection problems for extraction of features because of its flawless localization properties in pair of spatial and frequency domain. The regular functional form of a two dimensional Gabor wavelet described in domain of spatial frequency is given as the following equation.

$$\mathbf{g(x,y) = exp\left[\frac{x^2+y^2}{2\sigma_{xy}^2}\right] cos(u_0 x + v_0 y)} \quad (3)$$

Where, σ_{xy} is the standard deviation of the Gaussian coverage which represents the extent of spatial domain and the transmission capacity of the Gaussian filter. The parameters (u_0, v_0) characterize the spatial frequency of sine curve, which is represented in 2-dimensional coordinates as radial frequency r0 and orientation θ :

$$\mathbf{r_0^2 = u_0^2 + v_0^2,\ \tan\theta = \frac{v_0}{u_0}} \quad (4)$$

The density and angular-discriminatory characteristics of Gabor wavelets are more accurate in its density range representation that shows the quantity by which the Gaussian filter changes each density component of the input image.

Feature classification with SVM

Support Vector Machines can perform pattern recognition in binary classes by identifying a decision plane that has farther distance to the nearest points of training set which are known as support vectors. There may be numerous numbers of feasible linear planes that can the classify training data, but there is only one plane that maximizes the margin between the two binary classes. The classifier which separates the input data to highest separable rate is termed the optimal separating hyper plane (OSH).

In the above figure H is the correct separable line which is nothing but OSH, H1 and H2 are equidistance lines of H. H1 and H2 pass via the closest points from H. H is the only line which can both separate the data and maximize the margin, namely optimal line. In high-dimension space, the ideal plane becomes optimal separating hyper plane.

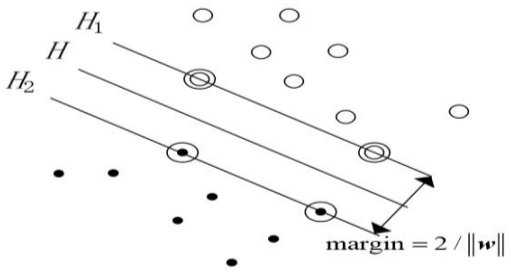

Fig 4: Optimal Separating Hyper plane

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

A Support Vector Machine is a classifier for categorization and regulation of regression from the trained data. The SVM is used for binary classification. SVM classifies the image dataset by using the best separating hyper plane. The closest patterns to the hyper plane are nothing but support vectors. The equation marginal hyper plane can be considered as

$$W^T X+ b=0$$

Where, X is input vector, W is weight vector and b is bias constant.

The input vector which belongs to false class, can satisfy the inequality,

$$W^T X+ b \leq 0$$

The input vector which belongs to true class, can satisfy the inequality,

$$W^T X+ b \geq 0$$

IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

While many of the researchers are working on automatic face recognition, different researchers used various kinds of image datasets for their experimentation.

ORL Dataset:

The dataset which we used for the training and automatic face recognition is ORL [11] openly available image database. ORL dataset is collected in between 1992 -1994 April by Cambridge university Engineering Department which contains 40 samples of both male and female, where each sample have 10 facial images with slight orientations and negligible expressions. Fig 5: Shows the example faces from the ORL face database.All the images in dataset are gray scaled, and vertically frontal position. Low head rotations are considerable and prepared under almost persistent illumination. All the faces in the training set are represented in terms of weight vectors and calculated using linear combination of Eigen face with highest value of Eigen value.

Fig 5: sample images from ORL face dataset

AR Dataset:

The AR facial image database was created by Aliex M Martinez, contains total 4000 images of 126 subjects which are of 70 men and 56 women. The images of all the subjects are collected with various facial expressions and different illuminations and occulsions like glasses and mask. All images are coloured images and mostly having the frontal face. The Fig 6, shows the one individual subject with different objects on face with varying illuminatiion.

Fig 6: Sample images from AR dataset

Grimace Dataset:

This face image database was created with 18 persons where each individual sanpped 20 sequencial images continously while they are moving head to smaller variation with different expressions. All the images are having nearly same lighting conditions and a same plain background as those all are taken in a single session.

Fig 7: Example images from Grimace face dataset

The proposed algorithm was implemented in MATLAB. The experiment was conducted with AR, ORL and Grimace image dataset. Table 1, shows the training time and performance with all the datasets.

Table 1: Training and performance of PCA & Gabor Filtering with various datasets.

S.No	Dataset used	Training Time & Performance	PCA	Gabor Filter
1	ORL	Training Time	0.0074	14.5038
		Performance	34.57%	97.6571%
2	AR	Training Time	0.054	22.756
		Performance	45.78%	92.312%
3	Grimace	Training Time	0.745	9.365
		Performance	57.84%	100%

After the successful training of input images to the classifier,the given input image set was normalized, then test the system against the input data set. The observed results from the Table 1, describing that the performance of face recognition system is rapidly increasing with the Gabor wavelets as feature extraction technique.Table 2, shows the performance accuracy of face recognition system with varied number of training images for 3 face datasets. Eventhough the number of training samples are chhanged, the performance of the system remains constant.

Table 2: Accuracy of face recognition system with various number of training samples.

Dataset	No. of training samples	Accuracy %
ORL	2	97.65
	3	97.65
	4	97.65
AR	2	92.31
	3	92.31
	4	92.31
Grimace	2	100
	3	100
	4	100

V. CONCLUSION

This paper did an outstanding work on face recognition system with different facial image datasets. The performance of the proposed system with PCA rapidly varies with Gabor wavelets. So finally, we can conclude that Gabor wavelets for local feature extraction and support vector machine are immense methods to better yield the accuracy in face recognition.

REFERENCES

1. S. Lee, S. Jung, J. Kwon, and S. Hong, “Face Detection and Recognition Using PCA,” pp. 84–87, 1999.
2. S. Venkatramaphanikumar and V. K. Prasad, "Gabor based face recognition with dynamic time warping," 2013 Sixth International Conference on Contemporary Computing (IC3), Noida, 2013, pp. 349-353.doi: 10.1109/IC3.2013.6612218
3. H. Duan, R. Yan, and K. Lin, “Research on Face Recognition Based on PCA *,” no. 2007, pp. 29–32, 2008.
4. I. Systems, “Face Recognition Based on PCA and SVM Optimized by MEB,” no. 2, 2010.
5. T. Rahman and A. Bhuiyan, “Face Recognition using Gabor Filters,” vol. 2, no. Iccit, pp. 25–27, 2008.
6. L. Huang, A. Shimizu, and H. Kobatake, “Classification-Based Face Detection Using Gabor Filter Features 3 . Gabor Feature Extraction,” pp. 2–7, 2004.
7. F. Bellakhdhar and K. Loukil, “Face recognition approach using Gabor Wavelets , PCA and,” vol. 10, no. 2, pp. 201–207, 2013.
8. G. Majumder, “Gabor-FastICA Feature Extraction for Thermal Face Recognition using Linear Kernel Support Vector Machine,” 2015.
9. S. Meshgini, A. Aghagolzadeh, and H. Seyedarabi, “Automatic face recognition using Gabor filters , kernel principal component analysis and support vector machine Automatic Face Recognition using Gabor Filters , Kernel Principle Component Analysis and Support Vector Machine,” no. March, 2011.
10. I. K. Timotius, T. C. Linasari, I. Setyawan, and A. A. Febrianto, “Face Recognition Using Support Vector Machines and Generalized Discriminant Analysis,” no. 2, pp. 9–11, 2011.
11. “Face Recognition Using Support Vector Machines with the Robust Feature 1,” pp. 49–53, 2003.
12. I. Frolov and R. Sadykhov, “Face Recognition System using SVM-Based Classifier,” no. September, pp. 394–399, 2009.
13. A. Rhesa, S. Siswanto, A. S. Nugroho, and M. Galinium, “Implementation of Face Recognition Algorithm for Biometrics Based Time Attendance System,” *2014 Int. Conf. ICT Smart Soc.*, pp. 149–154.
14. C. Zhen, “Research about human face recognition technology,” *2009 Int. Conf. Test Meas.*, vol. 1, pp. 420–422, 2009.