An Approach for Pose Invariant Face Recognition System Using Log-Gabor Feature

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Abstract. Biometrics is the process based on humans’ characters like behavioural and physical. Among the biometrics traits, face recognition has attained much importance for the authentication of individuals. Face recognition with pose variation is one of the major challenges among the illumination and expression. The system is widely used as surveillance which can withstand in places like ATMs, Airports, and Streets to track the criminals. The face recognizing mainly depends on the feature extraction from the face. Project aim is to extract those features which are invariant even though the pose changes. In the proposed work face recognition by using Log Gabor features is addressed. Firstly, colour images with variation in poses are captured followed by the extraction of facial features components like eyes, nose, mouth, and chin through Log Gabor features. The identification of the person is done using KNN classifier where the matching is carried out by calculating the Euclidean distance between the training and test pairs. Finally, experimental results show the performance of the system for different number of the users.

Keyword: Pose invariant face, Viola jones, Log gabor features, Knn classifier.

1. Introduction

Biometrics is the field where the human characters are relating to the identification and access controls. Nowadays, biometrics products are widely used in the Colleges, offices and schools to monitor the organization. The face recognition has added significant contribution to the biometrics domain and it is used as video surveillance which can be used in the places like ATMs, Airports, and streets in the city to track the criminals and terrorist’s activities. Face recognition process consists of three important phases: face detection, face feature extraction and face identification. In face detection, the face of the person is being detected from the image or scene, followed by face feature extraction which deals with identifying facial features like eyes, length of the nose, width of the mouth, these extracted features are used in the application as input data and finally identification of the face is carried out by comparing with the Created database. Across the globe surroundings several other elements would influence the recognition rate of the face recognition system considerably, like pose, illumination, expression and age. To recognize the frontal views of the faces, various methods of face recognition were developed where the candidate was posing the camera very straight and this type of frontal face recognition system are appropriate for the application like where the person always poses the same way from session to session. But in some other cases the user or person might not look in to camera for reason of being caught, possibly not aware of that face image has been clicked. In these the system has to handle faces
with different poses. Thus, aim of the project is to build efficient pose invariant face recognition system, where the system has to be capable of identifying and/or recognize the person with across poses.

Executions of pose invariant face recognition system as follows. Initially, face is being detected from input image given to the system using face detection method. After this, normalization takes place by removing the noise from the detected face, followed by feature extraction which deals with the facial feature extraction such as length of nose, width of the mouth and eyes etc are extracted and stored it in the database. Finally, recognize the person and labelling the class.

This paper organized as follows: In section 2 survey provided on pose invariant face recognition system. Issues and challenges of face recognition system are discussed in section 3. Problem definition and aim of the work is defined in section 4. In section 5 described the proposed approach with design and implementations. Experimental results have shown in the section 6. Finally, conclusion and future work are given in section VII.

2. Literature Survey

The face recognition systems have developed by many researchers using different approaches. Some of them are discussed below.

The author proposed application for the classroom attendance in order to track the proxy attendance in [1]. Here they make use Radio frequency identification to provide unique identification to student. FEI database used to store the images of the student and Fast Adapter Neural network classifier is used to check whether every student is present in the class or not. If the student couldn’t classify then it gives the result as proxy attendance and achieved result is 98%.

The authors explained the feature progressing method in [2]. The facial features will change whenever the pose changes. The model finds the frequently changing features when the pose changes and it plots to that person. To detect the face components, Active appearance model has been used frequently and achieved the result 91.2%.

The authors have used shape descriptor called Affine moment invariants to address the issue of pose variations in [3], where technique divides the entire face in to non-overlapping components. Here, they have taken five images for each person with different like 0 degree, 45 degrees, 90 degree, 135 and 180 degree and result achieved is 95%.

In [4] authors make use of Local Binary Histogram through which every pixel information has obtained by identifying labels in histogram. For the whole image, global binary histogram is developed by concatenating all these local binary histograms & achieved the recognition rate 81.65%.

Authors defined reference-based descriptor in [5] for image by taking the resemblance among a face image and a set of reference individuals. Identification of the individual is performed by using the reference-based descriptors of probe and gallery images. The result obtained is 84.7%.

In [6] Hidden Markov Models are fused with Support Vector Machine to detect face very quickly. Authors created frontal face by using Markov Random Fields and high value of Eigen values are extracted as features. By using SVM classifier results are classified and accuracy obtained is 99.617%.

In [7] authors summarize the application of face recognition and feature are extraction based on facial features and holistic features. Facial features are extracted from nose, eyes, mouth and holistic features are extracted from the entire face. Facial Recognition Technology database and the Sheffield face database are used and recognition rate obtained is 91.2%.

In [8] authors proposed method contains three steps: Weber face has been used for image normalization, feature extraction where Daubechies discrete wavelets transform and lower order pseudo Zernike moments are combined and classification is done by using KNN classifier. AT&T and Yale database are used and results obtained are 97% and 98% respectively. Future works includes analysis on performance, such as recognition of ear, palmprint etc.

In [9] face is captured and normalized in to 119x92 pixels. Applying the curvelet features on the normalized face and selecting those sub bands which are invariant to pose. Feature vectors are formed from curvelet invariant features and these feature are given as input curvelet neural network classifier and used FERET, LFW and CMU-PIE database and recognition rate are 89.9%, 63.9%, 90.23% respectively.

In order to calculate the pose a multi view face detection method proposed by authors in [10]. To detect the face image, they have used the combination of Eigen face method and SVM. By making use of irises information input face image is normalized to frontal view. For the face alignment of input pose
image to frontal view Affine Transformation parameters have been used. CAS-PEAL face database has used and 93% recognition rate is obtained for the same.

The NP complete optimization problem proposed by authors in [11]. In a two-level dynamic programming procedure, serially optimizing image columns the complexity can be handled. For each column set of hypothesis computed locally and best hypothesis is computed by globally and achieved recognition accuracy is 94.6%.

In [12] authors presented a method for reconstructing the frontal view virtually from a given non frontal view face image by using Markov random fields. Here Scale invariant feature transform features are extracted and to classify the results the SVM has been used. Used the database like FERET, CMU-PIE and obtained the result 95.5% and 98.5% respectively.

To produce the frontal view virtually from non-frontal view authors in [13] presented locally kernel-based nonlinear regression method. Then the images are converted in to front images and those are classified and recognition rate obtained is 95%

In [14] authors presented method to detect the twelve landmark component which contain pose related characteristics and anatomy. The region of interest is detected by PittPatt face detector. The cascaded classifier used to classify the by making use of Bag of words. Multi-PIE database have been used and result obtained is 82.6% and in [15], authors applied fusion techniques on voice and face by implementing multimodal biometric system to authenticate the person.

In [16] authors used probability distribute functions and to differentiate image from background they used the technique called successive mean equalization transform for preprocessing purposes. Classification is performed by measuring Kullback Leibler distance between the PDFs of a given face and a set of database images. The recognition rate for database FERET =98% is obtained and in [17], authors have discussed methods used to authenticate the face.

3. Issues and Challenges in Face Recognition

After performing literature survey of several papers some issues are identified and described below.

- The main challenge is pose variations of the face, when the user sees camera with different angle or orientation then system can extract information of face region which is visible to the camera and stored in database. If different pose or orientation of the same person comes then system has to be capable of identifying that person by matching the features with the database.
- Illumination is also challenge, if there is no proper illumination or intensity of the light on face region then there would not be proper facial features extraction. The facial feature extraction plays very important role while classifying or identifying the person face and it is difficult get the better accuracy rate.
- Distance of the camera is also plays crucial part, if camera is far away from the user or person then quality of the image will not be good, in which information of the face might lost. So that it will affect the performance of the system.
- Some people or user comes with occlusion, where some regions of the face are occluded with sunglasses, scarf, and hats. In these cases, some parts of face regions cannot be obtained and may fail to extract the facial features like nose, mouth, forehead and eyes.
- Expression is also one of the challenging issue, whenever the expressions changes it’s going to affect the information about facial features.

4. Problem Definition

In Face recognition, authentication of the user under the facial pose variation is a major challenge for the research community. Hence there is a scope to develop new algorithm/method to address the issue of pose variation. The proposed system aim is to design and develop the efficient model for Pose invariant face recognition method which helps for identifying the person across the pose.

5. Proposed Approach

5.1. Block Diagram

Fig 1 is the representation of the proposed method. The diagram mainly consists two important phase: Training and Testing phase
In the training phase, first step is input images with possible pose variation are given to system. Second step is pre-processing which in turn consists of face detection and gray scale image conversion of image. Face detection done by using the Viola Jones method, where it will identify only face from image and it subtracts the rest of the part as a background and the detected face image is converted into gray scale image to remove the noise. Next step is feature extraction, where the log gabor feature are extracted and finally it stored in the database. Once the training is done, testing phase will resume where those images will be given to system as input images which have not trained during the training process. After performing the pre-processing and feature extraction these values will be matched with same person of the database values and classified using the K-NN classifier. Finally, recognition of the person with labelled class name.

5.2. Image acquisition
The database collection plays very important role while during the registration and to store images needed during the identification. In this work, have used the own database and while collection of images of the individual we have used the 14.1 megapixels’ camera. Images are taken against homogenous background and each individual the following poses are included: looking left, looking right, looking front, looking up and looking down. The RGB colour space is constructed of 50 users with size of 640x480 pixel resolutions. Fig 2 shows the collection of own database.
5.3. Face Detection and Face Alignment
Object detection is very important in the most of the biometrics applications including the surveillance. Hence object is needed, to identify the face location in the image. In this work, we used the Viola Jones technique to detect the face from image.

The face image captured from the camera is size of 640x480 pixel resolution. Alignment is process of detecting the region of interest. Here the bounded region by bounding box i.e face is resized into 128x128 pixel resolution. After this resized, image is converted into a gray image to remove the complexity or noise from the image.
5.4. Feature Extraction and Classifier

The feature extraction plays very important role in pose very important. Where, need to select those features which are invariant even though the pose changes. In this work, we used the Log Gabor features. The log Gabor feature has very good in encoding of natural images. In this phase log Gabor feature extraction from gray image is proposed i.e. Gabor wavelet features. Gabor wavelet is function for computing Gabor features of gray-scale image. A one dimensional Log-Gabor function has the frequency response as shown in equation 1.

$$G(f) = \exp\left(\frac{-(\log(f/f_0))^2}{2(\log(\sigma/f_0))^2}\right)$$  \hspace{1cm} (1)

Where \(f_0\) and \(\sigma\) are the parameters of the filter. \(f_0\) will give the center frequency of the filter. \(\sigma\) affects the bandwidth of the filter. This function calculates the mean squared energy for scale and mean amplitude for orientation, it returns the values as feature vector and the size is 1x160 for each person.

The classifier is the one which helps for identification of the person In this work, we are using K-nearest neighbour (KNN) classifier with 1 nearest neighbour to classify the results. This computes pair wise Euclidean distance for each training instances versus testing instance. For classification purpose, some sample images are trained and some other sample images are tested against trained images to authenticate the face of the person under labelled class.

6. Experimental Results

6.1. System Performance Evaluation

The developed method is tested for own created face database, by considering two images of each user with variation in poses. The performance calculated by taking three parameters namely Accuracy, FAR (false acceptance rate) and FRR (false rejection rate). Accuracy is the ratio of total number of correctly identified users multiplied by 100 to the total number of users attempted and stated as below equation 2.

$$\text{Accuracy} = \frac{\text{Number of correctly identified Users}}{\text{Total Number of Attempts}} \times 100$$  \hspace{1cm} (2)

FAR is the ratio of number of wrongly identified users multiplied by 100 to the total number of users attempted and stated in below equation 3.

$$\text{FAR} = \frac{\text{Number of Wrongly Identified Users}}{\text{Total Number of Attempts}} \times 100$$  \hspace{1cm} (3)

FRR is the ratio of number of wrongly rejected users multiplied by 100 to the total number of users attempted and stated in below equation 4.

$$\text{FRR} = \frac{\text{Number of Wrongly Rejected Users}}{\text{Total Number of Attempts}} \times 100$$  \hspace{1cm} (4)

6.2. System Performance Analysis

The experiment has been conducted for different number of users to analyze how the system works, as well as how the training phase impacts the accuracy rate. The performance calculated by taking three parameters namely Accuracy, false acceptance rate and false rejection rate. Here, we have tested system for 5, 10, 15, 20, 40 and 50 users.

The performance of the system analyzed as below.

- **3 images for training and 2 images for testing:** The experimental results are tabulated in Table I. The performance analysis of designed system is plotted in fig 5.
Table 1. Performance of Pose Invariant Face Recognition System

| Sl. No | Number of persons | Number of persons taken for training | Number of persons taken for testing | Number of correctly identified persons | Number of wrongly identified persons | Accuracy % | FRR % | FAR % |
|--------|--------------------|-------------------------------------|-------------------------------------|---------------------------------------|-------------------------------------|------------|-------|-------|
| 1      | 5                  | 15                                  | 10                                  | 0                                     | 100                                 | 100        | 0     | 0     |
| 2      | 10                 | 30                                  | 20                                  | 0                                     | 100                                 | 100        | 0     | 0     |
| 3      | 15                 | 45                                  | 30                                  | 27                                    | 3                                   | 90         | 10    | 0.34  |
| 4      | 20                 | 60                                  | 40                                  | 31                                    | 9                                   | 78         | 22    | 0.57  |
| 5      | 40                 | 120                                 | 80                                  | 53                                    | 27                                  | 66.25      | 33.75 | 0.42  |
| 6      | 50                 | 150                                 | 100                                 | 60                                    | 40                                  | 60         | 40    | 0.40  |

Figure 5. Performance Analysis

- 4 images for training and 5 images for testing: In this work, tested system for 5,10,15,20 users. The experimental results are tabulated in Table II. The performance analysis of the designed system is plotted in fig 6.

Table 2. Performance of Pose Invariant Face Recognition System

| Sl. No | Number of persons | Number of persons taken for training | Number of persons taken for testing | Number of correctly identified persons | Number of wrongly identified persons | Accuracy % | FRR % | FAR % |
|--------|--------------------|-------------------------------------|-------------------------------------|---------------------------------------|-------------------------------------|------------|-------|-------|
| 1      | 5                  | 20                                  | 25                                  | 25                                    | 0                                   | 100        | 0     | 0     |
| 2      | 10                 | 40                                  | 50                                  | 50                                    | 0                                   | 100        | 0     | 0     |
| 3      | 15                 | 60                                  | 75                                  | 75                                    | 0                                   | 100        | 0     | 0     |
| 4      | 20                 | 80                                  | 100                                 | 100                                   | 0                                   | 100        | 0     | 0     |
8 images for training and 5 images for testing: In this project, tested system for 5, 10, 15, 20 users. The experimental results are tabulated in Table III and performance analysis is plotted in fig 7.

Table 3. Performance of Pose Invariant Face Recognition System

| Sl. No | Number of persons taken for training | Number of persons taken for testing | Number of correctly identified persons | Number of wrongly identified persons | Accuracy | FRR | FAR |
|--------|--------------------------------------|------------------------------------|--------------------------------------|------------------------------------|----------|-----|-----|
| 1      | 5                                    | 15                                 | 25                                   | 25                                 | 100      | 0   | 0   |
| 2      | 10                                   | 30                                 | 50                                   | 50                                 | 100      | 0   | 0   |
| 3      | 15                                   | 45                                 | 75                                   | 72                                 | 96       | 4   | 0.05|
| 4      | 20                                   | 60                                 | 100                                  | 91                                 | 91       | 9   | 0.09|

Figure 6. Performance Analysis

Figure 7. Performance Analysis
• **2 images for training and 5 images for testing**: In this project, tested system for 5, 10, 15, 20 users. Experimental results are tabulated in Table IV and performance analysis is plotted in fig 8.

### Table 4. Performance of Pose Invariant Face Recognition System

| Sl. No | Number of persons | Number of persons taken for training | Number of persons taken for testing | Number of correctly identified persons | Number of wrongly identified persons | Accuracy % | FRR % | FAR % |
|--------|-------------------|-------------------------------------|-----------------------------------|----------------------------------------|------------------------------------|------------|-------|-------|
| 1      | 5                 | 10                                  | 25                                | 25                                     | 0                                  | 100        | 0     | 0     |
| 2      | 10                | 20                                  | 50                                | 49                                     | 1                                  | 98         | 2     | 0.04  |
| 3      | 15                | 30                                  | 75                                | 72                                     | 3                                  | 96         | 4     | 0.05  |
| 4      | 20                | 40                                  | 100                               | 89                                     | 11                                 | 89         | 11    | 0.11  |

![Figure 8. Performance Analysis](image)

• **1 image for training and 5 images for testing**: In this work, tested system for 5, 10, 15, 20 users. Experimental results are tabulated in Table V. The performance analysis of the designed system is plotted in fig 9.

### Table 5. Performance of Pose Invariant Face Recognition System

| Sl. No | Number of persons | Number of persons taken for training | Number of persons taken for testing | Number of correctly identified persons | Number of wrongly identified persons | Accuracy % | FRR % | FAR % |
|--------|-------------------|-------------------------------------|-----------------------------------|----------------------------------------|------------------------------------|------------|-------|-------|
| 1      | 5                 | 5                                   | 25                                | 21                                     | 4                                  | 84         | 16    | 0.66  |
| 2      | 10                | 10                                  | 50                                | 41                                     | 9                                  | 82         | 14    | 0.36  |
| 3      | 15                | 15                                  | 75                                | 63                                     | 12                                 | 84         | 16    | 0.21  |
| 4      | 20                | 20                                  | 100                               | 76                                     | 24                                 | 76         | 24    | 0.24  |
7. Conclusion
Face recognition systems are widely used as authentication purposes as it is process of non-contact, which is the important aspect in the securities field. After performing the around seventeen research articles/papers many issues were identified like illumination, expression, occlusion. But, the major challenge is pose variation of the user which has grabbed every ones’ attentions in the research community. The proposed system focuses on pose variation problem due to its scope in recognition systems and thus to achieve the better recognition rate by developing efficient model. In the proposed system, have used Viola Jones method to detect the only face of the user and used the image processing techniques for the pre-processing of image. The Log Gabor features are extracted which helps for the improvement in terms of performance of the system and KNN classifier has been used for identification of the person. In future, the system has to handle other challenges like illumination; expression and occlusion are to be address.

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References
[1] Pss S and Bhaskar M 2016 RFID and pose invariant face verification based automated classroom attendance system Int. Conf. on Microelectronics, Computing and Communications (MicroCom) 1-6
[2] Si J, Li W 2016 Pose-invariant face recognition using feature progressing model IEEE Int. Symp. on Circuits and Systems (ISCAS) 586-589
[3] Zaeri N 2016 Pose invariant thermal face recognition using AMI moments UKSim-AMSS 18th Int. Conf. on Computer Modelling and Simulation (UKSim) 60-64
[4] Panchal P, Patel P, Thakkar V, Gupta R 2015 Pose illumination and expression invariant face recognition using laplacian of Gaussian and Local Binary Pattern 5th Nirma University International Conference on Engineering (NUiCONE) 1-6
[5] Kafai M, Eshghi K, An L, Bhanu B 2015 A reference-based framework for pose invariant face recognition 11th IEEE International Conference and Workshops on Automatic Face and Gesture Recognition (FG) 2 1-8
[6] Indumathi R, Palanivel N 2014 Pose invariant face recognition using HMM and SVM using PCA for dimensionality reduction Int. Conf. on Information Communication and Embedded Systems (ICICES2014) 1-6

[7] Osocos GC, Khoshgoftaar TM, Wald R 2014 Rotation invariant face recognition survey Proc. of the 15th International Conference on Information Reuse and Integration (IEEE IRI 2014) 835-840

[8] Sultana M, Gavrilova M, Yanushkevich S 2014 Expression, pose, and illumination invariant face recognition using lower order pseudo Zernike moments International Conference on Computer Vision Theory and Applications (VISAPP) 1 216-221

[9] Sharma P, Yadav RN, Arya KV 2014 Pose-Invariant Face Recognition Using Curvelet Neural Network The Institution of Engineering and Technology Biometrics 3 128-138

[10] Muruganantham S 2013 Pose invariant face recognition—a new technique International Journal of Computer Science Engineering and Information Technology Research 3 135-40

[11] Hanselmann H, Ney H, Dreuw P 2013 Pose-invariant face recognition with a two-level dynamic programming algorithm Iberian Conf. on Pattern Recognition and Image Analysis 11-20 Springer, Berlin, Heidelberg

[12] Ho HT and Chellappa R 2013 Pose-Invariant Face Recognition Using Markov Random Fields IEEE Transactions on Image Processing 22 1573-1584

[13] Arianpour Y, Ghofrani S, Amindavar H 2012 Locally Nonlinear Regression Based on Kernel for Pose-Invariant Face Recognition The 11th Int. Conf. on Information Sciences, Signal Processing and their Application 401-406

[14] Efraty B, Papadakis M, Profitt A, Shah S and Kakadiaris IA 2011 Pose Invariant Facial Component-Landmark Detection 18th IEEE Int. Conf. on Image Processing 569-572

[15] Poornima B and Hatture SM 2017 A Fusion Model for Multimodal Biometric System International Journal of Engineering Research & Technology (IJERT) 5

[16] Demirel H and Anbarjafari G 2008 Pose Invariant Face Recognition Using Probability Distribution Functions in Different Color Channels IEEE Signal Processing Letters 15 537-540

[17] Madhura S and Hatture SM 2017 A Model for Unconstrained Face Recognition System International Journal of Engineering Research & Technology (IJERT) 5