# Real Time Face Detection and Recognition using Haar - Based Cascade Classifier and Principal Component Analysis

Sarala A. Dabhade
PG student M. Tech (Computer Egg)
BVDU's COE Pune

Prof. Mrunal S. Bewoor
Assistant Professor
BVDU's COE Pune

## *Abstract:*

**Face is a complex multidimensional visual model and developing a computational model for face recognition is difficult. The paper presents a methodology for facerecognition based on information theory approach of coding and decoding the face image. Proposed methodology is connection of two stages – Face detection using Haar Based Cascade classifier and recognition using Principle Component analysis. Study of the paper include the system to find the locations of Log-Gabor features with maximal magnitudes at single scale and multiple orientations using sliding window - based search and then use the same feature locations for all other scales. The goal is to implement the system (model) for a particular face and distinguish it from a large number of stored faces with some real-time variations as well.**

***Keywords: Haar Based Cascade Classifier, Principal Component Analysis, Sliding window algorithm, Log-Gabor Filter.***

## I. INTRODUCTIONT

This paper is a step towards developing a real time face recognition system which can recognize static images and can be modified to work with dynamic images. In that case the dynamic images received from the camera can first be converted in to the static ones and then the some procedure can be applied on them [3]. This is to improve the face detection system by using Haar Classifier to get higher accuracy result. Haar Classifier is used for face detection because it can detect the desire image very fast. The main challenge for a face recognition system is of effective feature extraction. In this project we implementing the system to find the locations of Log-Gabor features with maximal magnitudes at single scale and multiple orientations using sliding window -based search and then use the same feature locations for all other scales. For further feature compression we used Principal Component Analysis (PCA) because its simple implementation, fast training. The proposed system utilizes the Eigen face method is information reduction for the images. There is an incredible amount of information present even in a small face image.Each face that we wish to classify can be projected into face-space and then analyzed as a vector. Euclidean distance measure can be used for classification.

## II. FACE DETECTION AND RECOGNITION SYSTEM

This section gives an overview on the major Face detection and recognition system module , There are seven functional block whose responsibility are given below.

### A. *Face detection using HAAR Cascade Classifiers*

The function of this module is to determine where in an image a face is located. The face detection module works by scanning up an image at different scales and looking for some simple patterns that denote the presence of a appears in the centre and presented at a uniform size. Face detection determines where in an image a face is located. The face detection works by scanning up an image at different scales and looking for some simple patterns that identify the presence of a face[5].

The overall algorithm for the face detector is shown in figure

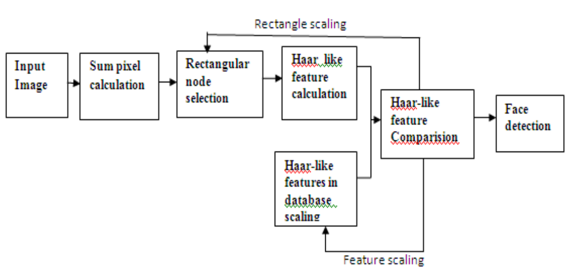


Figure 1.1: Flow diagram of the face detection.

The more window looks like a face, more classifiers to be computed and the longer it takes to Classify that window. Thus, if the window is not a face the classifiers will quickly reject it after considering small fraction of feature in it.

### *B. The pre-processing module*

The aim of the pre-processing phase was to obtain images which have normalized intensity, uniform size and shape. In this module the images are normalized and enhanced to improve the recognition of the system. The preprocessing steps implemented are as follows:

- Conversion of grayscale image
- Image size normalization
- Histogram equalization

### *C. Feature extraction using Log –Gabor Filter*

The Log-Gabor filters were proposed by Field for coding of natural images[1]. Field suggests that natural images are better coded by filters that have Gaussian transfer functions when viewed on the logarithmic frequency scale. Gabor functions have Gaussian transfer functions when viewed on the linear frequency scale The Log-Gabor filter in frequency domain can be constructed in terms of two components, namely the radial filter component G(f) and the angular filter component G(ɵ). In polar coordinates the filter transfer function could be written in the following form

$$G(f,\theta) = G(f).G(\theta) = \exp -\left(\left(\log\left(f/f_0\right)\right)^2 \middle| 2\left(\log(k|f_0)\right)^2\right).\exp\left(\frac{(\theta-\theta_0)^2}{2\sigma_\theta^2}\right)$$

In the above equation following parameter are used$f_0$ – Centre frequency of filter, k – Bandwidth , $\theta_0$ - Orientation angle of the filter , $\sigma_\theta = \Delta\theta / s_\theta$ Where $s_\theta$ – Scaling Factor, Δθ - Orientation spacing between filters.

For face recognition we generated multiple Log-Gabor filters of different scales and orientation using following parameter: $f_0 = 1/\lambda$, $\lambda = \lambda_0 . s_{\lambda}^{(n^s-1)}, k/f_0 = \sigma_f n_s$, Where $n_s = 1, \ldots, N_s$; $\theta_0 = \pi(n_0 - 1)/N_0$, $\Delta\theta = \pi/N_0$, $n_0 = 1, \ldots, N_0$, $\lambda_0$=5 ,here $\lambda_0$ is the wavelength of the smallest scale filter, $s_{\lambda} = 1.6$ where $s_{\lambda}$ is the scaling factor between successive filter scales, $N_s$ is the number of scales, $N_0$ is the number of orientations. Using above Eq. 1 we calculate two dimensional Log-Gabor filter $G_{n_0,n_s}$ in the same as the size of the two dimensional image I that we wish to filter. Then we perform filtering (convolution in Fourier space), magnitude calculation and masking using the following equation:

$$V_{n_0,n_s} = abs\left(IFFT2\left(G_{n_0,n_s} * FFT2(I)\right)\right) * mask$$

(2)

**D.** *Sliding Window algorithm*

The fewer features are selected by Sliding Window algorithm. In order to reduce the number of features and achieve partial face recognition invariance with respect to different facial expressions and minor face detection errors, we use sliding window algorithm

E. *Face recognition using Principal Component Analysis of Log-Gabor feature*

The main idea of using PCA for face recognition is to express the large 1-D vector of pixels constructed from 2-D facial image into the compact principal components of the feature space. This can be called Eigenspace projection. Eigenspace is calculated by identifying the eigenvectors of the covariance matrix derived from a set of facial images(vectors).

**Steps**

A 2-D facial image can be represented as 1-D vector by concatenating each row (or column) into a long thin vector. Let's suppose we have *M* vectors of size *N* (= rows of image *X* columns of image) representing a set of sampled images[2].

1. The first step is to obtain a set S with M face images. In our example M = 16 Each image is transformed into a vector of size N and placed into the set. $S = \{\Gamma_1, \Gamma_2, \Gamma_3, \ldots\ldots, \Gamma_M\}$
2. After you have obtained your set, you will obtain the mean image $\psi$
$$\psi = \frac{1}{M}\sum_{i=1}^{M} \Gamma i$$
3. Then you will find the difference $\Phi$ between the input image and the mean image
$$\Phi_i = \Gamma_i - \psi \quad (I = 1, 2, 3, \ldots\ldots M)$$
4. Next we seek a set of M orthonormal vectors $u_k$, which best describes the distribution of the data. The $k^{th}$ vector, $u_k$, is chosen such that
$$\lambda_k = \frac{1}{M}\sum_{n=1}^{M}\left(u_k^T \Phi_n\right)^2$$
is a maximum, subject to

$$u_k = \delta_{lk} = 1 \quad \text{if } l = k$$
$$= 0 \quad \text{otherwise}$$

Note: $u_k$ and $\lambda_k$ are the eigenvectors and eigenvalues of the covariance matrix C

5. Calculation of the covariance matrix We obtain the covariance matrix C in the following manner

$$C = \frac{1}{M}\sum_{n=1}^{M} \Phi_i \ \Phi_i^T \quad , \Phi = [\Phi 1\ \Phi 2 .... \Phi M]$$

$C = AA^T$, Where A is a column-wise concatenation of all the Φi ' s.

$$A = [\Phi_1, \Phi_2, \Phi_3 ........., \Phi_M]$$

6. Calculation of the Eigenvectors and Eigen values The size of C is $N \times N$ which could be enormous. For example, images of size $64 \times 64$ create the covariance matrix of size $4096 \ X \ 4096$. It is not practical to solve for the eigenvectors of C directly. A common theorem in linear algebra states that the vectors $v_i$ and scalars $\lambda_i$ can be obtained by solving for the eigenvectors and eigenvalues of the M X M matrix. To go through this problem [1] propose the following solution. For an eigenvector $v_i$ associated to an eigenvalue $\lambda_i$ we have:

$$C\, v_i = \lambda i\, v_i.$$

The matrix C has the form $AA^T$. Let us consider the matrix

$L = AA^T$ having the Eigenvectors $u_i$ associated to Eigenvalues $e_i$ $L_i = e_i u_i$

Let $AA^T \ u_i = e_i u_i$

By multiplying by A the left of the two sides of the equality,

we obtain:

$$AA^T \ A\, u_i = A\, e_i u_i$$

And since $C = AA^T$ we can simplify (8):

$$C\, Au_i = A\, e_i u_i$$

$$C\, (Au_i) = e_i (Au_i)$$

According to the definition of the eigenvectors and Eigenvalues of the matrix C we have:

$$v_i = Au_i$$

$$\lambda_i = e_i$$

Then comes the stage of selection of the eigenvectors and Eigenvalues where PCA selects only M' (M' < M) associated to the largest Eigenvalues (those associated to the smallest Eigen values contains only very little useful information). Find the M eigenvector, $v_1$ of L.

7. These vectors ($v_1$) determine linear combinations of the M training set face images to form the eigenfaces $u_1$

$$u_l = \sum_{k=1}^{M} v_{lk} \ \Phi_k \qquad l = 1, 2, ... ...... , M$$

8. Project each of the original images into Eigen space. This gives a vector of weights representing the contribution of each Eigen faces to the reconstruction of the given image.

$$\omega_k = u_k^T (\Gamma - \psi)$$

$$\Omega^T [\omega_1, \omega_2, \omega_3, ... ... ... ..., \omega_M]$$

Where $u_k$ is the $k^{th}$ eigenvector and $\omega_k$ is the $k^{th}$ weight in the vector.

*F. Recognition Procedure*

First, the image $\Gamma_i$ is transformed into its components eigen faces according above formula

$$\Omega_{new}^T = [\omega_1, \omega_2, \omega_3, ... ... ... ..., \omega_{M'}]$$

Then, the class of face providing the best description of $\Gamma_{new}$ is determined by calculating the minimal distance between the vector $\Omega_{new}^{T}$ and those stored in the data base.

The most used metric is the Euclidean distance given by[2]:

$$D(X, Y) = \sqrt{\sum_{i=1}^{n} (x_i - y_i)^2}$$

A face $\Gamma_{new}$ belongs to a class K when the minimum distance between $\Omega_{new}$ and $\Omega_k$(1<K<M) is below a certain threshold θ, otherwise the face is regarded as unknown and can be possibly used to create a new class.

II. RESULT ANALYSIS

The performance of face recognition is commonly evaluated using real time database. Sixteen different poses of 150 individuals are present in the real face database. A database of 150 images of different subjects of size $128 \times 128$ is taken for experimentation. The train image is limited in size (only $128 \times 128$ ). The log Gabor filter based PCA has a face recognition accuracy of 79% for the same test database.

**Table 1 : Test result of recognition rate**

| **Lighting condition(25 Training image each)** | **FRS-PCA +Log-gabor filter** | **Recognision rate** | **Overall recognition rate** |
|---|---|---|---|
| Natural light | 22 | 88 % | |
| Top Up Light | 18 | 72% | |
| Bottom LIght | 19 | 76 % | 74% to 79% |
| Left light | 18 | 72 % | |
| Right light | 19 | 76 % | |

**CONCLUSIONS**

The experiment showed that using proposed face detection is performed by using Haar based cascade classifier, Combination of Log Gabor features and sliding window based feature selection method, Principal Component Analysis and Euclidean-Based distance measure we can achieve very high recognition accuracy(74-79%) and low equal rates(0.3 to o.4% Equal error rates) using real time database. In the future we are going to investigate the possibilities of using decomposed Log-Gabor feature vectors and multiple PCA spaces in order to have the possibility of using this method with an unlimited number of training images. Because the results of all compared methods showed that the accuracy of face recognition is very affected by the lighting conditions, in the future we are going to investigate different lighting normalization methods and test them with the Log-Gabor PCA face recognition method.

References

[1]Vytautas Perlibakas , "Face Recogniton using Principle Component analysis and Log Gabor Filter" Image Processing and Analysis Laboratory, Computational Technologies Centre, Kaunas University of Technology, May 2006

[2] "Simplified and modified approach to face recognition using PCA" by K. J. Karande and S. N. Talbar. IET-UK International Conference on Information and Communication Technology in Electrical Sciences (ICTES 2007),Dr. M.G.R. University, Chennai, Tamil Nadu, India. Dec. 20-22, 2007. pp.523-526.

[3] "Face recognition using Eigenfaces" by Prof. V.P. Kshirsagar, M.R.Baviskar, M.E.Gaikwad, Dept. of CSE,Govt. Engineering College, Aurangabad (MS), India, 978-1-61284-840-2/11/ 2011 IEEE.

[4]"Facial Recognition using Eigenfaces by PCA" by Prof. Y. Vijaya Lata, Chandra Kiran Bharadwaj Tungathurthi, H. Ram Mohan Rao, Dr.A. Govardhan, Dr .L.P. Reddy, International Journal of Recent Trends in Engineering, Vol. 1, No. 1, May 2009.

[5]P. Viola, M. Jones, Rapid object detection using a boosted cascade of simple features, IEEE Conference on Computer Vision and Pattern Recognition, CVPR, Hawaii, 2001