FACE RECOGNITION USING GABOR WAVELET AND SOM (SELF ORGANIZING MAP)

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Abstract- Face recognition plays a vital role in our daily life which perform routinely and effortlessly. Nowadays, efforts are being put to incorporate our brains inherent capability of recognizing faces into computer because of which face recognition has evolved as one of the efficient biometric systems. Face recognition is becoming more and more popular for authentication purpose in organization as compared to conventional systems such as ID, SSN. These type of biometric systems face (Pose Illumination Expressions)PIE problems. To resolve these problems, several methods have already being proposed. In this research work, our focus is on local feature detection, extraction and classification which are the basic phases of (Face Recognition System)FRS. For this purpose, Gabor Wavelet along with (Self Organizing Map)SOM is used over (Olivetti Research Laboratory)ORL face database.

Keywords: Face Recognition: Gabor Wavelet, Face Bunch Graph Matching, Self Organizing Maps (SOM) , ORL (Olivetti Research Laboratory) Database.

I. INTRODUCTION

Face Recognition has always been an area of intensive research. It is a challenging biometric technique of identifying individuals by facial features. People in computer vision and pattern recognition have been working on automatic face recognition of human faces for the last two decades and it is attracting much more attention. The main reason for the attraction of many researchers towards this has been the variety of practical applications. It is an ideal application for security, such as, to limit employee access to sensitive data in private companies, to limit the physicians to have an access to their patient records in hospitals and the others like airport security, criminal identification, video surveillance etc. A face recognition system compares the current image with the images in the database. In recent years face recognition has received substantial attention from researchers in biometrics, pattern recognition, and computer vision communities. The machine learning and computer graphics communities are also increasingly involved in face recognition. This common interest among researchers working in diverse fields is motivated by our remarkable ability to recognize people and the fact that human activity is a primary concern both in everyday life and in cyberspace. Besides, there are a large number of commercial, security, and forensic applications requiring the use of face recognition technologies[7]. There are basically three approaches for face recognition[2] : Feature base approach, Holistic approach and Hybrid approach.

It’s a true challenge to build an automated system which equals human ability to recognize faces. Although humans are quite good identifying known faces, but are not very skilled when deal with a large amount of unknown faces. The computers, with an almost limitless memory and computational speed, overcome humans limitations[3]. In this research paper following steps are taken:

1. Preprocess the input image
2. Detection and Extraction of the local features from the image by using the Gabor Wavelet
3. Then Classify images by using the SOM algorithm.

Also, ORL database is used for face recognition methods which tested for different number of images per person as training set images and then analysis the performance of the algorithm.
The face recognition technique mainly work in three steps such as:

1. **Preprocessing:** The first step of image preprocessing is detection of face in the image. Because of variability of illumination, scale, orientation and pose, face detection is a challenging task and done by various filter method. Second, is convert the input facial images into the appropriate format such as-Converting the RBG image into a grayscale image, resize the image if size is too large and also detecting the location of face in arbitrary images.

2. **Feature Extraction:** The second stage requires extraction of pertinent features from the localized image obtained in the first stage by using Gabor Wavelet.

3. **Classification:** It is done by using SOM. The training is done using the extracted feature i.e. Gabor Filter, is given as input to the SOM classifier and the output is checked for the correctness.

II. **GABOR WAVELET**

Gabor wavelet is a complex Gaussian sinusoid. It yields a more stable representation of face features. The Gabor wavelet, which captures the properties of orientation selectivity, spatial localization and optimally localized in the space and frequency domains, has been extensively and successfully used in face recognition[5]. Gabor wavelet is expressed as [f]:

\[
g(x, y; \lambda, \theta, \psi, \sigma, \gamma) = \exp \left( -\frac{x'^2 + y'^2}{2\sigma^2} \right) \exp \left( i \left( \frac{2\pi x'}{\lambda} + \psi \right) \right)
\]

(1)

where,
\[
x' = x \cos \Theta + y \sin \Theta
\]
\[
y' = -x \cos \Theta + y \sin \Theta
\]

\(\lambda\) represents the wavelength of the sinusoidal factor, \(\theta\) represents the orientation of the normal to the parallel stripes of a Gabor function, \(\psi\) is the phase offset, \(\sigma\) is the sigma/standard deviation of the Gaussian envelope and \(\gamma\) is the spatial aspect ratio, and specifies the ellipticity of the support of the Gabor function.

An image can be represented by the Gabor wavelet transform allowing the description of both the spatial frequency structure and spatial relations. Convolving the image with complex Gabor
filters with 5 spatial frequency ($v = 0, \ldots, 4$) and 8 orientation ($f = 0, \ldots, 7$) captures the whole
frequency spectrum, both amplitude and phase as shown in figure 2[6]. The parameter $\sigma$ of the Gaussian
envelope is set equal to the wavelength $\lambda$. The total number of orientations and frequency parameters
leads to 40 real (odd) and 40 imaginary (even) Gabor wavelets, which are separately applied over the
face images. To make Gabor wavelet illumination invariant a DC factor, $\exp (\sigma^2/2)$ is deducted from
the cosine part of Eqn. (1)[5].

The imaginary (even) part of the Gabor wavelet is expressed as:

$$g(x, y; \lambda, \theta, \psi, \sigma, \gamma) = \exp \left( -\frac{x^2 + \gamma^2 y^2}{2\sigma^2} \right) \sin \left( \frac{2\pi x'}{\lambda} + \psi \right)$$

(2)

Figure 2: Gabor Filter Bank showing 80 Gabor wavelet masks including real and imaginary part of
Gabor filter

III. SELF ORGANIZING MAP(SOM)

Self Organizing Map also known as Kohonen Map, is a neural network model of the
unsupervised learning .It has the property of clustering the data that preserves the topology of the input
data with the minor changes gets clustered in closer zones.SOM ordinary mapping of an input high
dimensional space in much lower dimensional space. As it compresses information while preserving the
most important topological and metric relationships of the primary data items, it can be thought to
produce some kind of abstractions of information[9]. It consists of two layers of neurons: an input layer
and competition layer. The weights of the connections of the input neurons to a single neuron in the
competition layer are interpreted as a reference vector in the input space.

A self-organizing map is trained using competition learning. There is a competition among the
neurons to be activated or fired. When an input pattern is presented to the network, the neuron in the
competition layer is determined; the reference vector of which is closest to the input pattern. The neuron
is called the winner-takes-all neuron. Its weights are changed. The changes are made in such a way that
the reference vector represented by these weights is moved closer to the input pattern. The weights of
the neighboring neurons are also changed[7]. The algorithm is summarized as follows[4]:

1. Assume the input vector $X_i=(x_1, x_2, \ldots, x_n)$ from the input space with certain probability.
2. Initialize the weights $W_{ij}=(w_{ij}, w_{2j}, \ldots, w_{nj})$ to small random values.
3. Set the initial radius of the neighbor around node from input space with certain probability.
4. Choose the closest distance by using Euclidean distance method, which is between the input data
   (vector) with weights and nodes that have the minimum distance between the data input node weights
   declared as the winner neuron.
where:
\[ d_j = \sum_{i=1}^{n} (X_i(t) - W_{ij})^2 \]

5. Finally perform the weights updation, node weights winner will then be updated with this function,
\[ W_{ij}(t + 1) = W_{ij}(t) + \alpha(t) \cdot (X_i(t) - W_{ij}(t)) \]

\[ j \in \mathcal{N}_c \, , \, 0 < \alpha(t) < 1 \]  

where:
\( X_i \) = Input data
\( W_{ij} \) = Weight
\( \mathcal{N}_c \) = Neighborhood value
\( t \) = Time
\( i \) = Input index node
\( j \) = Output index node
\( \alpha \) = Alpha learning rate

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**Figure 3**: Model of SOM Algorithm

**IV. GABOR WAVELET AND SOM**

In this section, proposed algorithm is summarized as follows[1]:

**Stage1: Form face template**

The face bunch graph of different users are formed from the features extracted using the method Gabor Wavelet. These face templates formed from training images are called Model graph for that particular class of face image. A single face template (FBG) is formed for every single face image, i.e. for every single subject face image features are extracted. The number of model graphs formed equals as
many samples and users for which the closed-set identification is to be performed. The procedure for forming the model graphs of different face classes is explained in Fig. 4.

**Stage 2: Form FBG for novel images**

After forming all the face templates, i.e. model graphs, FBG for novel images are created by using Gabor Wavelet. The procedure followed for FBG creation for novel images is depicted in the flowchart of Fig.5.

**Stage 3: Identification and Classification**

The novel images and template face graph from database are compared by using SOM. The comparison result is classified by using the SOM as described in section III. Finally the output achieved as the winning neuron by using SOM algorithm.

![Flowchart](image1)

**Figure 4:** Model for creating and storing face templates for training images.

![Flowchart](image2)

**Figure 5:** Model of creating face bunch graphs for novel images.
EXPERIMENTAL ANALYSIS

The face recognition system, combined with Gabor Wavelet and SOM was developed, trained, and tested using MATLAB™ R2012A. The ORL (Olivetti Research Laboratory) face database has been used which basically contains 10 different images of 40 distinct subjects [12]. The image set of ORL face database is divided into two sets: Training and testing image set which is used for creating and analyzing the face set. A comparison of the performance of other well known algorithm with recognition rate such as SOM is eighty five percent [11], Gabor wavelet with PCA has ninety two percent accuracy [10], PCA with SOM has seventy seven percent recognition rate along with ten number of classes, also it varies as the number of classes change [7]. In proposed method, test set images obtained a good detection and extraction with hundred percentage of rate and face classification gives eighty six percentage of rate.

VI. CONCLUSION

The proposed method is effective on face images having variation in expression, illumination and pose and it is applicable only for frontal images and show some minor changes in classification. So, this could be extended over different images with different database and also the factors of the Gabor Wavelet will be increases. The algorithm performance show that the individual techniques SOM and Gabor Wavelet itself give excellent performance but the combination of these two approaches can also be utilized for other face techniques.

REFERENCES


