EXPLORING GABOR FILTER & NEURAL NETWORKS IN FACE DETECTION & RECOGNITION

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Abstract

Pattern recognition and matching consists of classifying, processing the input and matching it with a known pattern. Face Detection and Recognition is a very complex form of pattern recognition with highly ambiguous input signals, using multiple dimensions and matching them with the known 'signals'. Face recognition can be applied for a wide variety of problems like image and film processing, human-computer interaction, criminal identification, public security, law enforcement and commerce, such as mug-shot database matching ,identity authentication for credit card or driver license, access control, information security, and video surveillance etc.

Different approaches to the problems of face detection and face recognition were evaluated, and implemented using the Matlab technical computing language. The model developed is simple, fast and accurate in constrained environments. The goal is to implement the model for a particular face and distinguish it from a large number of stored faces with some real-time variations as well finding an effective means to reduce the dimensionality is the first step in face recognition. Considering the face to be a matrix of values reduces the dimensions to single dimensions. In the implemented face detection systems face detection was achieved using a Gabor filter, Eigen face and ANN based on image invariants. Successful results were obtained for automated face detection and for automated face recognition.

Keywords: Pattern recognition, Face Detection & Recognitio, Matlab, Gabor filter, Eigen face, ANN

1. INTRODUCTION

A face recognition system is a computer-driven application for verifying or recognizing a person either from a still image or video. It performs this by comparing selected facial features within the live image and a facial database Face recognition technique tries to find a face within a large database, where the system returns a possible list of faces from the database. Every face has numerous, distinguishable landmarks. The different peaks and valleys that make up facial features are known as nodal points. Once the nodal points are extracted it is easy to highlight respective face.

2. GABOR FILTERS

Gabor Filters are defined as class of linear filters used in image processing based on multi resolution properties. The main characteristics of Gabor wavelet correspond to extract different frequency orientations of the image. This involves use of coefficient matrices. These are highly robust against changes in illumination levels together with noise. A family of Gabor

kernel is the product of a Gaussian envelope and a plane wave. Gabor kernels are characterized for selective orientation based on localized approach. A 2D Gabor filter is expressed as a Gaussian modulated sinusoid when operating in the spatial domain. However, it is represented as shifted Gaussian in the frequency domain. The Gabor wavelet representation helps in preserving larger information for spatial relations. This is given by following expression,

$$\mathbf{P_k(\bar{x}) = k^2/\ \sigma^2\ exp(-k^2/\ 2\sigma^2\ \bar{x}^2\ )\ (exp(ik\bar{x}) - exp(\ -\sigma^2/2))} \qquad \mathbf{(1)}$$

Where (x, y) is the variable in spatial domain and k is the frequency vector which determines the scale and direction of Gabor functions. (kx, ky) = (kv cosθw, kv sin θw) and kv = (0, 1, 2, 3, 4) is the discrete set of different frequencies and w= (0, 1, 2...7) is the orientation.

The multiplicative factor ensures that filters tuned to different spatial frequency bands have approximately equal energies. The term exp is subtracted to render the filters insensitive to illumination. In our application, f= √ 2, k = Π /2 and θw= Π w/8, and σ = Π, the standard deviation of the Gaussian envelope. A well designed Gabor filter bank can capture the relevant frequency image of Gabor filter can be written as a correlation of input image I(x) with Gabor Kernel. The feature vector consists of all useful information extracted from different frequencies, orientations and from all locations, and hence is very useful for expression recognition. But, in the practical application, evaluating all 40 filters to convolve the face image is quite time consuming. The real part of Gabor feature vectors with eight orientations and five frequencies is given in Fig.1.

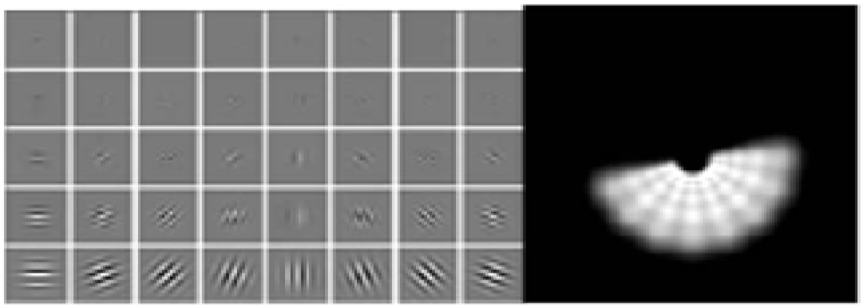

Fig. 1 Gabor Filter real part and orientations

An average of five images is taken. To reduce the computational complexity of using 40 Gabor filter bank, we propose a new technique to represent Gabor features. The outputs generated by convolving the image with the sum of Gabor functions over eight directions with the fixed scale. Thus we have five set of different outputs for the representation.

The outputs generated by convolving the image with the sum of Gabor functions over five frequencies with a fixed direction. Here eight sets of outputs can be represented. Take the average of all eight images. The extracted information is considered as feature vectors to a Support Vector Machine (SVM) for classification. SVM are a set of related supervised learning methods used for classification and regression. It shows better classification accuracy than Neural Networks if the data set is small. SVM rearranges the data points according to a mathematical function or kernels and transforms it into a feature space, which allows the classification. One of the popular kernel is the Radial Basis Function (RBF) Kernel, defined as k (x, y) = exp, where σ is the Gaussian width and x and y are the feature vectors in input space. Facial expression analysis requires multiclass SVM for classification. One–against–all approach constructs M binary SVM classifiers, each of which separates one class from others. The two average images, one for fixed scale and another for fixed orientation are divided in to 'k' sub blocks. The mean and standard deviation is calculated for each sub block.

A face recognition system comprises basically two stages training and testing. In practical applications, the small number of available training face images and complicated facial variations during the testing stage are the most difficult problems for current face recognition systems.

A novel approach using Independent Gabor Features (IGF) is considered to predict novelty in approach. Here two factors are implemented (a) Derivation of Gabor features in Feature Extraction stage, (b) Probabilistic Reasoning Model (PRM) for classification in the pattern recognition stage. Thus derivative of Gabor feature vector is identified from a set of sampled representations of face images. Thereafter dimensionality of faces is reduced using Principal Component Analysis (PCA). Lastly technique to conclude facial marks uses Independent Component Analysis (ICA).

The independence property of Gabor features facilitates the application of the PRM method for classification. The rationale integrating the Gabor and ICA is accountable for two actions. On the one hand, the Gabor highlights spatial and frequency characteristics. ICA reduces redundancy and transforms independent features completely. These images are most useful for subsequent pattern discrimination and facial extraction.

Since the face is not isolated in the image, variations in the clothing, hairstyle or the background would adversely effects recognition performance. This can be manipulated from Fig. 2.

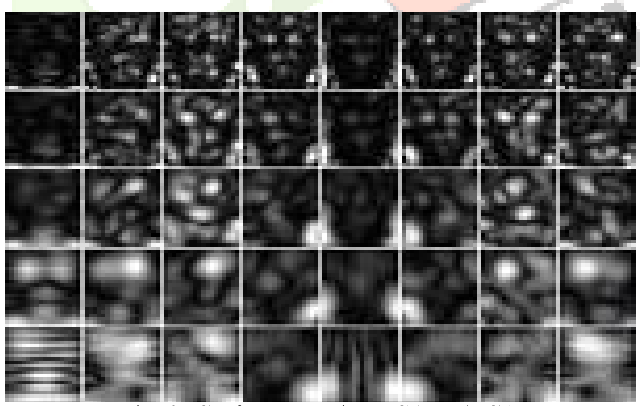

Fig. 2 IGF features using PCA and ICA

The pose invariant face database and testing images gathered in this thesis were obtained under highly controlled by using Artificial Neural Networks.

3. NEURAL NETWORK THEORY

Neural Networks are chain of simple neural processors forming networks. These are arranged and interconnected in parallel. Neural Networks are based on our current level of knowledge related to human brain. Based on weights computation ANN attracts interest from both engineers and scientists who can use them for understanding of human brain. The speed processing ability together with solution of computational problems in back box strategy is continuously increasing use of ANN in stages of development. However there occurs major concern related to susceptibility of noise. Sometimes they appear to be too dependent on the training sets used, but these effects can be minimized through careful design. Neural Nets can be used to construct systems that are able to classify data into a given set or class. For face detection generally set of images containing one or more face together with set of images containing no faces is used. Fig. 3 shows an example of a single neural processor, or neuron.

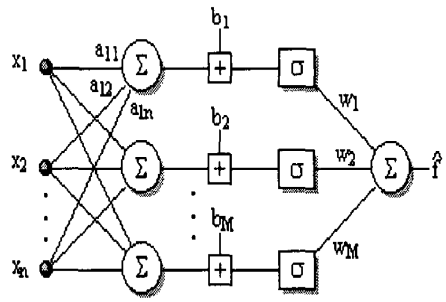

Fig. 3 Neural Network

Neurons have many weighted inputs, that is to say each input (p1, p2, p3… pm) has a related weighting (w1, w2, w3… wm) according to its importance. Each of these inputs is a scalar, representing the data. In the case of face detection, the shade of GRAY of each pixel could be presented to the neuron in parallel (thus for a 10x10 pixel image, there would be 100 input lines p1 to p100, with respective weightings w1 to w100, corresponding to the 100 pixels in the input image). Complex problems can be realized by adding more neurons, forming multiple layers of several neurons, interconnected via a weighted matrix. Additional layers of neurons not connected directly to the inputs or the outputs are called hidden layers (layers 1 and 2).

The work done through simulations operates in two stages. Firstly it applies a set of neural network based filters to an image. Secondly uses an arbitrator to combine the outputs. The filters examine each location in the image at several scales, looking for locations that might contain a face. The arbitrator then merges detections from individual filters and eliminates overlapping detections using summations given by equation as below,

$$\mathbf{F(x) = \sum wi\ \sigma\ (a_i^T x + bi)} \qquad (2)$$

4. SIMULATION AND RESULTS

The system is designed in MATLAB by programming for Gabor filter. Thereafter Neural Network system is presented using GUI. The filter receives as input a 20x20 pixel region of the image, and generates an output ranging from 1 to -1, signifying the presence or absence of a face. Filter is used to extract every location and determine changes. To detect faces larger than the window size, the input image is repeatedly reduced in size (By sub sampling), and the filter is applied at reduced size.

The invariance statistics correspond to number of scales prior to position. The amount of invariance determines the number of scales and positions at which it must be applied. For the work presented here, we apply the filter at every pixel position in the image, and scale the image down by a factor of 1.2 for each step in the pyramid.

MATLAB CODE & FIGURES

```
%~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
face_folder = 'face\'; %LOCATION OF FACE IMAGES
non_face_folder = 'non-face\'; %LOCATION OF NON-   FACE IMAGES
file_ext = 'face.png';
out_max = 0.9;  % DESIRED OUTPUT FOR DETECTING A FACE
out_min = -0.9; % DESIRED OUTPUT FOR NOT DETECTING A FACE
%~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

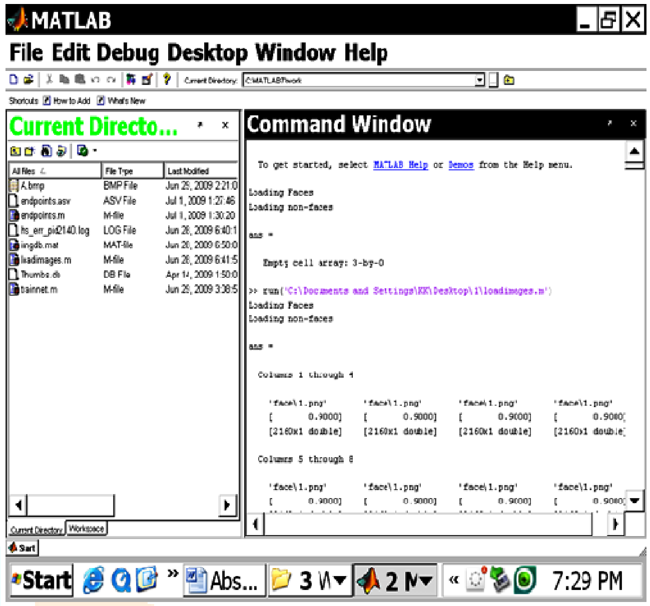

Fig. 4 Simulation of Matlab Program

The GUI returns a menu for calculation of face extraction after using features of Gabor. It results in display of square window around the face manipulating all selected features as in Fig. 5.

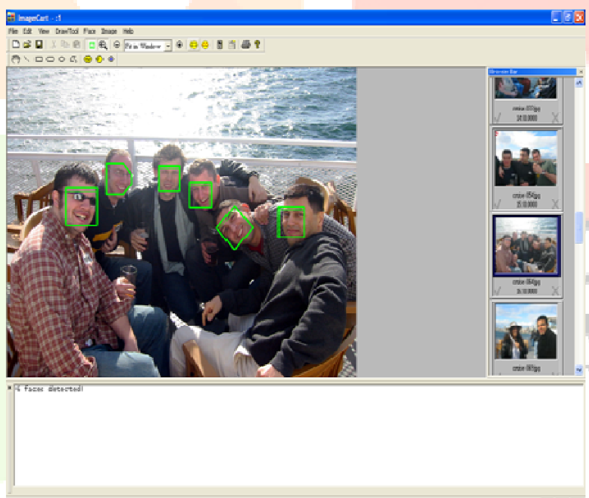

Fig. 5 Window highlighting faces

5. CONCLUSIONS

The limitations of 2D facial recognition have been known for some time and were confirmed in the recent Face Recognition. The results are really not too surprising, given the fact that existing algorithms are trying to identify a 3D object the face. The study identified that while facial recognition is improving, it is still not robust enough to stand on its own. In fact, a combination of facial recognition and fingerprints is the best biometric performance available today. Much can be done to improve the performance of existing 2D facial recognition well before true 3D arrives. Rather than force the infrastructure to change by purchasing all-new surveillance cameras and software, the goal is to improve 2D facial recognition sufficiently so that its performance can be significantly enhanced using existing 2D infrastructure.

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