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Face Recognition Using ANN With Reduce Feature by PCA in Wavelet Domain

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Abstract— Face recognition is an active research area in various streams such as pattern recognition, image processing. The Strong need of Face Recognition is personal identification and recognition without the cooperation of the participants. This paper presents face recognition using wavelet transform. A face recognition system follow these steps image decomposition, detection, feature extraction, and matching. For face detection haar wavelet is used to form the coefficient matrix and PCA is used for extracting features. These features are used to train the classifier based on artificial neural networks. The performance of the classifier is determined in terms of recognition rate for different training and testing data set.

Keywords— Haar, WT, PCA , DWT, Neural Network etc.

I. Introduction

Face recognition from still images and video sequence has been an active research area due to both its scientific challenges and wide range of potential applications such as biometric identity authentication, human-computer interaction, and video surveillance. Within the past two decades, numerous face recognition algorithms have been proposed as reviewed in the literature survey. Even though we human beings can detect and identify faces in a cluttered scene with little effort, building an automated system that accomplishes such objective is very challenging. The challenges mainly come from the large variations in the visual stimulus due to illumination conditions, viewing directions, facial expressions, aging, and disguises such as facial hair, glasses, or cosmetics [1].

Face Recognition focuses on recognizing the identity of a person from a database of known individuals. Face Recognition will find countless unobtrusive applications such as airport security and access control, building surveillance and monitoring Human-Computer Intelligent interaction and perceptual interfaces and Smart Environments at home, office and cars [2]. Within the last decade, face recognition (FR) has found a wide range of applications, from identity authentication, access control, and face-based video indexing/browsing, to human-computer interaction/communication. Two issues are central to all these algorithms:

1) Feature selection for face representation

2) Classification of a new face image based on the chosen feature representation.

Face Recognition Technology involves analysis of facial Characteristics. It Stores the features in a database. These database are used them to identify users. For this process sensors are used to capture an image or feature extraction. As the time passes construction of face recognition system is facing the problems because the faces have a lot of changes in the environment. For these reasons the recognition of faces is a challenging task due to Head pose, illumination, hair, aging problem, facial expression, occlusion e.g. glass so we have to select exact properties to represent a face under various environmental changes. In image verification, comparison between single images is done. In image identification, comparison between one too many image is done and matching process is performed using different algorithms. The various applications of face recognition is voter verification, residential security, banking, counter terrorism.

Wavelet Transform is based on wavelets. A wavelet is a small wave. The amplitude of wave starts at zero increases and then decreases back to zero.

The wavelet transform is used to analyze a signal or image into different frequency components at different resolution scales. It does not give the information about spectrum at particular time instant while it provides the spectrum information between two time periods. Wavelet transform is very effective tool for data analysis, numerical analysis and image processing.

II WAVELET TRANSFORM

There are two types of wavelet transforms named as Continuous wavelet transforms (CWT) and Discrete wavelet transforms (DWT).

A. *Continuous wavelet transforms (CWT)*

This transform works when we use a continuous wavelet function to find the detailed coefficient of a continuous signal. We define a mother wavelet function $\psi(t) \in L^2(R)$, which is limited in time domain. That is, $\psi(t)$ has values in a certain range and zeros elsewhere. Another property of mother wavelet is zero-mean. The other property is that the mother wavelet is normalized. Mathematically, they are

$$\int_{-\infty}^{\infty} \psi(t)dt = 0 \qquad (1)$$

$$\|\psi(t)\|^2 = \int_{-\infty}^{\infty} \psi(t)\psi^*(t)dt=1 \qquad (2)$$

As the dilation and translation property states, the mother wavelet can form a basis set denoted by

$$\{\psi_{s,u}(t)=\frac{1}{\sqrt{s}}\psi(\frac{t-u}{s})\}|_{u\in R, s\in R^+}$$

u is the translating parameter, indicating which region we concern. s is the scaling parameter greater than zero because negative scaling is undefined. The multi resolution property ensures the obtained set $\{\psi_{u,s}(t)\}$ is orthogonal. Conceptually, the continuous wavelet transform is the coefficient of the basis $\{\psi_{u,s(t)}\}$. It is

$$Wf(s; u) = < f(t),\psi_{s.u} >$$

$$= \int_{-\infty}^{\infty} f(t)\psi^*_{s,u}(t)dt \qquad (3)$$

$$= \int_{-\infty}^{\infty} f(t)\frac{1}{\sqrt{s}}\psi^*(\frac{t-u}{s})dt \qquad (4)$$

Via this transform, one can map an one-dimensional signal f(t) to a two-dimensional coefficients Wf(s; u). The two variables can perform the time frequency analysis. We can tell locate a particular frequency (parameter s) at a certain time instant (parameter u). If the f(t) is a L2(R) function. The inverse wavelet transform is

$$f(t)=\frac{1}{C_\psi}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} Wf(s,u)\frac{1}{\sqrt{s}}\psi(\frac{t-u}{s})du\frac{ds}{s^2}$$

Where Cψ is defined as

$$C_\psi=\int_0^{\infty} |\Psi(\omega)|^2 d\omega< \infty \qquad (5)$$

Ψ(ω) is the Fourier transform of the mother wavelet ψ(t). This equation is also called the admissibility condition.

The wavelet transform can be used to create smaller and accurate images, which results in a Multi-resolution Analysis. The discrete wavelet transform (DWT) is an implementation of the wavelet transform. It uses a discrete set of the wavelet scales. In other words, this transform decomposes the signal into mutually orthogonal set of wavelets, which is the main difference from the continuous wavelet transform (CWT), or its implementation for the discrete time series sometimes called discrete-time continuous wavelet transform (DT-CWT). Alfred Haar is a Hungarian mathematician invented the first DWT. The input in Haar wavelet is represented by a list of 2^n numbers. In Haar Wavelet transform firstly input is paired up, difference is stored and passing the sum. The whole process is repeated many times or repeatedly. Then the pairing of sum is done to provide the next scale finally resulting in 2^n-1 differences and one final sum.

B. *Discrete Haar Wavelet Transform*

An outstanding property of the Haar functions is that except function haar(0, t), the i–th Haar function can be generated by the restriction of the (j − 1)–th function to be half of the interval where it is different from zero, by multiplication with p2 and scaling over the interval [0, 1]. These properties give considerable interest of the Haar function, since they closely relate them to the wavelet theory. In this setting, the first two Haar functions are called the global functions, while all the others are denoted as the local functions. Hence, the Haar function, which is an odd rectangular pulse pair, is the simplest and oldest wavelet. The motivation for using the discrete wavelet transform is to obtain information that is more discriminating by providing a different resolution at different parts of the time–frequency plane. The wavelet transforms allow the partitioning of the time-frequency domain into non uniform tiles in connection with the time–spectral contents of the signal. The wavelet methods are strongly connected with classical basis of the Haar functions; scaling and dilation of a basic wavelet can generate the basis Haar functions.

Let :R ! R, the Haar wavelet function is defined by the formula

$$\Psi(t)=\begin{cases} 1 & for\ t \in [0,\frac{1}{2}] \\ -1 & for\ t \in [\frac{1}{2},1] \\ 0 & otherwise \end{cases}$$

The Haar wavelet uses both low pass filter and high pass filters. It uses filters for image decomposition first in image columns and then in image rows independently. Four sub-bands are produced as the output of the first level Haar wavelet. The four sub-band named as LL1,HL1,LH1and HH1.The low frequency sub-band LL1 Can be further decomposed into four sub-bands LL2,HL2,LH2 and HH2.The other three sub-bands are the high frequency parts in the vertical, horizontal and diagonal directions.

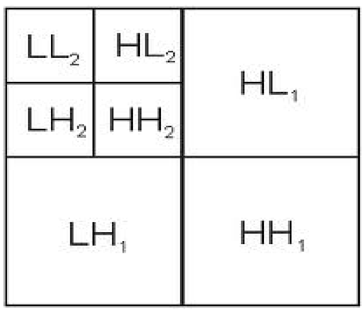

Figure.1-Wavelet Decomposition

The discrete wavelet transform has a huge number of applications in science, engineering, and mathematics and computer science. Mostly, it is used for signal coding, to represent a discrete signal in a more redundant form, data compression. Practical applications can also be found in signal

processing of accelerations for gain analysis, in digital communications and many others.
It is shown that discrete wavelet transform is successfully implemented as analog filter bank in biomedical signal processing for design of low-power pacemakers and also in ultra-wideband (UWB) wireless communications.

The Haar Transform is real and orthogonal. Therefore

Hr = Hr*

Hr^-1 = Hr ^T

figure.2- Wavelet decomposition of face image

The Haar wavelet transform has a number of advantages:

- It is conceptually simple.
- It is memory efficient, since it can be calculated in place without a temporary array.
- It is exactly reversible without the edge effects that are a problem with other wavelet transforms.
- It is fast.

III. Principal Component Analysis

Principal Component Analysis (PCA) based face recognition method was proposed in Turkey and became very popular. In pattern recognition and image processing this is one of the successful methods. The goal of PCA is to reduce the dimensionality of the data while retaining as much as possible of the variation present in the dataset. PCA is an orthogonal transformation of the coordinate system in which the pixels are described. The eigenvector with the highest Eigen value is the principle component of the data set. Face space is comprised of Eigen faces, which are the eigenvectors of the set of the faces. PCA is performed by projecting a new image into the subspace called face space spanned by the Eigen faces and then classifying the face by comparing its position in face space with the positions of known individuals. PCA aims to extract a subspace where the variance is maximized. PCA derives only the most expressive features which are related to actual face recognition, and in order to improve performance additional discriminate analysis is needed. PCA based face reorganization system consists two major part first is database preparation and second is calculation of distance of a test image with database for face recognition. The reduction of dimension is important factor in face recognition system. The time taken to recognize the face image in wavelet transform is high but the sizes of feature matrix or data occupy less space. Face recognition is the application of wavelet transform.

Figure.3- Eigen faces in wavelet domain

Assume that we start with a data set that is represented in terms of an m × n matrix, X where the n columns are the samples (e.g. observations) and the m rows are the variables. We wish to linearly transform this matrix, X into another matrix, Y, also of dimension m × n, so that for some m × m matrix, P,

$$Y = PX$$

This equation represents a change of basis. If we consider the rows of P to be the row vectors p1, p2, . . . , pm, and the columns of X to be the column vectors x1, x2, . . . , xn, then(3) can be interpreted in the following way.

PX =(Px1 Px2...Pxn)

$$PX = \begin{pmatrix} p1.x1 & p1.x2 \ldots p1.x_n \\ p2.x1 & p2.x2 \ldots p2.x_n \\ . & . & . \\ . & . & . \\ . & . & . \\ p_m.x1 & p_m.x2 & p_m.x_n \end{pmatrix} = Y$$

Note that p_i, xj ∈ R^m, and so pi.xj is just the standard Euclidean inner (dot) product. This tells us that the original data, X is being projected on to the columns of P. Thus, the rows of P, {p1, p2, . . . , pm} are a new basis for representing the columns of X. The rows of P will later become our principal component directions.

IV. NEURAL NETWORK

Neural Network is an interconnected assembly of simple processing elements, units or nodes, whose functionality is loosely based on the neuron. The processing ability of the network is stored in the inter-unit connection strengths, or weights, obtained by a process of adaptation to, or learning from, a set of training patterns. It resembles the brain in two aspects. Knowledge is acquired by the network through a learning process. Interneuron connection strengths known as synaptic weights are used to store the knowledge.

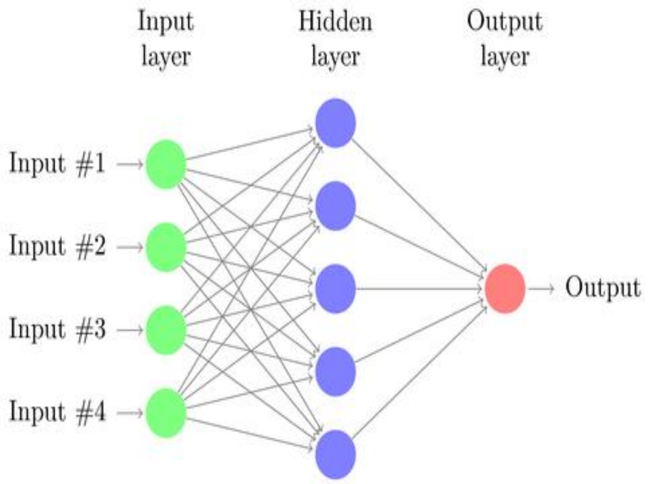

Figure.4-Neural Network

LAYER PROPERTIES

Input Layer: Each input unit may be designated by an attribute value possessed by the instance.

Hidden Layer: Not directly observable provides nonlinearities for the network.

Output Layer: Encodes possible values.

V. FACE RECOGNITION SYSTEM

The proposed face recognition system is described as in the following stages:

a) *Pre-processing*: We have taken Olivetti and oracle research laboratory (ORL) face database from internet. The RGB face image is converted into gray scale image.

b) *DWT Feature Extraction:* This stage is extracting DWT features from the image obtained in stage 2 by applying Haar DWT on this image. The approximation part only considered for feature extraction.

c) *PCA Feature Extraction*: In this stage, PCA is applied on approximation (LL) features obtained in the previous stage.

d) *Recognition Process*: In this process face is recognized from ANN train by available feature matrix of database shown in figure -5.

Figure.5- Oracle database for simulation

The flowchart of processes is given below,

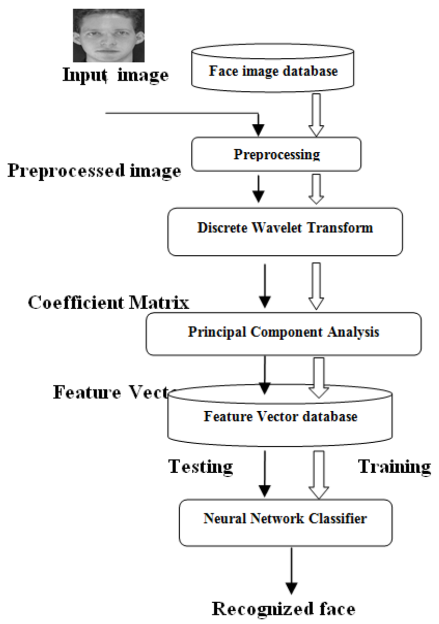

fig.6-The proposed face recognition system

IV. RESULTS AND DISCUSSIONS

Simulation was carried out in MATLAB environment. The face image database used in our experiment is oracle research laboratory (ORL) face database, in which different images of 40 persons are available. Each person has 10 different types of images. So total available face images are 400.These face images varies in facial expression and illumination. The classifier employed in this experiment is Neural Network. The training of the classifier is shown in the figure below . The Mean Square Error (MSE) reduces with the iteration for weight and bias optimization for Neural Network .

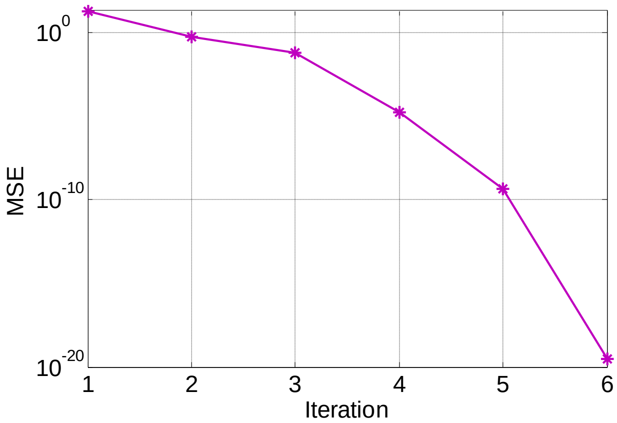

Figure:7 Neural network training

Classifier used the feature set for determining the recognition rate accuracy. The Training and testing sets used different faces from available database & results are given below in table.

TABLEI

Training	Testing	Recognition accuracy	Training accuracy
1	9	81.11	70
2	8	80	85
3	7	78.57	86.66
4	6	76.66	85
5	5	76	86

k- fold testing

The dataset are break in to parts for the testing. This testing is called k-fold testing. The k-1 parts used for training and remaining 1 part used for testing. The effect of different value of K shown in figure below.

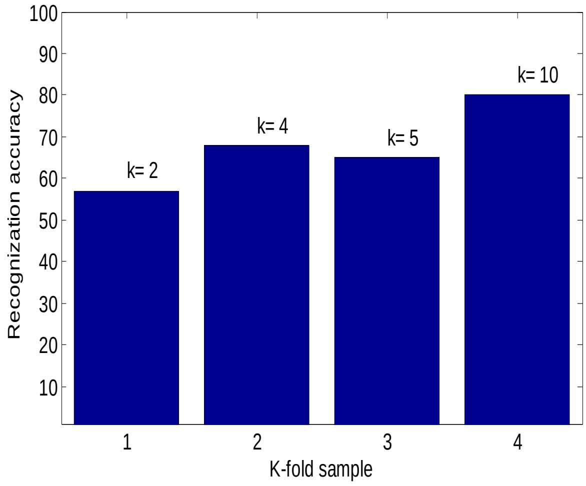

Figure :8 Recognization rate with K folding

VI. Conclusions

The simulation results indicate that the accuracy of ANN is not getting poor due to the compression by the wavelet transform. By the k-fold testing it is observed that the increase in training image result better.

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