PATTERN RECOGNITION USING NEURAL NETWORKS

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ABSTRACT

Face Recognition has been identified as one of the attracting research areas and it has drawn the attention of many researchers due to its varying applications such as security systems, medical systems, entertainment, etc. Face recognition is the preferred mode of identification by humans: it is natural, robust and non-intrusive. A wide variety of systems requires reliable personal recognition schemes to either confirm or determine the identity of an individual requesting their services. The purpose of such schemes is to ensure that the rendered services are accessed only by a legitimate user and no one else. Examples of such applications include secure access to buildings, computer systems, laptops, cellular phones, and ATMs. In the absence of robust personal recognition schemes, these systems are vulnerable to the wiles of an impostor.

*In this paper we have developed and illustrated a recognition system for human faces using a novel Kohonen self-organizing map (**SOM**) or Self-Organizing Feature Map (**SOFM**) based retrieval system. SOM has good feature extracting property due to its topological ordering. The Facial Analytics results for the 400 images of AT&T database reflects that the face recognition rate using one of the neural network algorithm SOM is 85.5% for 40 persons.*

KEYWORDS

SOM (Self Organizing Mapping), Self-Organizing Feature Map (SOFM), PCA (Principal Component Analysis), ICA (Independent Component Analysis), Neural Network, pattern recognition.

1. INTRODUCTION

Face recognition has the benefit of being a passive, non-intrusive system for verifying personal identity. Many supervised and unsupervised learning techniques have been reported for face recognition. Various algorithms for face recognition have been used which can be broadly divided into two approaches, namely, structure-based (Appearance based) and statistics-based (Feature based). Three different techniques - PCA, ICA & SOM [1],[2] have been used for face recognition. Principal Component Analysis (PCA) [8] is derived from Karhunen-Loeve's transformation. Given an s-dimensional vector representation of each face in a training set of images, PCA tends to find a t-dimensional subspace whose basis vectors correspond to the maximum variance direction in the original image space. This new subspace is normally lower dimensional. If the image elements are considered as random variables, the PCA basis vectors are defined as eigenvectors of the scatter matrix. Independent Component Analysis (ICA) [8] minimizes both second-order and higher-order dependencies in the input data and attempts to find the basis along which the data (when projected onto them) are statistically independent. Bartlett et al. provided 2 architectures of ICA Architecture I - statistically independent basis

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images, and Architecture II - factorial code represent. Facial analytics using SOM gives better results than PCA and ICA techniques, which has been presented in this paper. SOM is an unsupervised learning process that has the property of topology preservation.

Basically there are two types of modes [5]:

- *Supervised*: In supervised learning at each instant of time when the input is applied, the desired response of the system is provided by teacher. This persistent mode is used in many situations of natural learning. A set of input and put patterns called a training set is required for this learning mode.
- *Unsupervised*: Unsupervised learning algorithms use patterns that are typically redundant raw data having no labels regarding their class membership. In this mode of learning, the network must discover for itself any possibly existing patterns, regularities, separating properties etc. While discovering this, the network undergoes change of its parameters, which is called self organization. Unsupervised learning is sometimes called learning without teacher. We are using the neural network based unsupervised learning algorithm known as Self Organizing Map.

2. FACIAL ANALYTICS

Individuals are often recognized by their faces and the recent computing technology has now resulted similar recognition automatically. Initial face recognition algorithms used simple geometric models, but recognition process has matured into a science of sophisticated mathematical representation and matching process.
Recognition algorithms can be divided into two main approaches,

- *Geometric*, which looks at distinguishing features,
- *Photometric*, which is a statistical approach that distill an image into values and comparing the values with templates to eliminate variances. We are using the photometric approach for our facial analysis.

The basic block diagram of face recognition for our project is as shown in Figure 1.

A. Training

B. Mapping

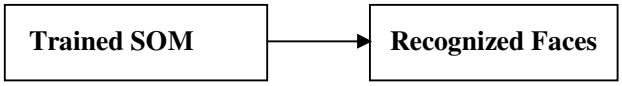

Figure 1. Face Recognition

2.1 Training

2.1.1 Data Base of Faces: There are ten different images of each of 40 distinct persons. For some persons, the images were taken at different times, varying the lighting, facial expressions (open / closed eyes, smiling / not smiling) and facial details (glasses / no glasses). All the images are taken against a dark homogeneous background with the subjects in an upright, frontal position (with tolerance for some side movement). The

files are in PGM format.

2.1.2 Feature Extraction: Feature extraction is a special form of dimensionality reduction. When the input data to an algorithm is too large to be processed and it is suspected to be notoriously redundant (much data, but not much information) then the input data will be transformed into a reduced representation set of features (also named features vector). Transforming the input data into the set of features is called *feature extraction*. If the features extracted are carefully chosen it is expected that the features set will extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full size input.

2.1.3 Training of SOM: The recognition process involves input and target vector. Training a SOM, requires no *target vector*. A SOM learns to classify the training data without any external supervision which results in the formation of different Clusters or Classes. There are various cluster topologies such as grid, hex and random. In our project we are using the *hex topology* as it covers maximum area of the neurons under training.

2.2 Mapping

2.2.1 Trained SOM: The mapping of input image is performed with the trained clusters of the database. This matching is performed by the application of Euclidean distance formula.

2.2.2 Recognized Faces: The best match determined using Euclidean distance formula is the output of this process. The minimum distance between input image and classifiers or clusters is the actual recognized face image.

3. PATTERN RECOGNITION

Face recognition is one of the few biometric methods that possess the merits of both high accuracy and low intrusiveness. Pattern recognition is one of the important steps in Image Processing. Given a pattern, the first step in the pattern recognition is to select a set of features or attributes from the universe of available features that will be used to classify the pattern. Next, the original pattern must be transformed into a representation that can be easily manipulated programmatically. After the data are processed to remove noise, features in the data that are defined as relevant to pattern matching are searched for. In the classification stage, data are classified based on measurements of similarity with other patterns. The pattern recognition process ends when a label is assigned to the data, based on its membership in a class.

In face recognition system, we have database of images stored in the system. Whenever we get a new image, it is compared with the database of images already stored in the system. Initially we experimented with the database of our students. As shown in Figure 2, SOM [4] operates in two modes: training and mapping.

- Training builds the map using input examples. It is a competitive process, also called vector quantization.
- Mapping automatically classifies a new input vector.

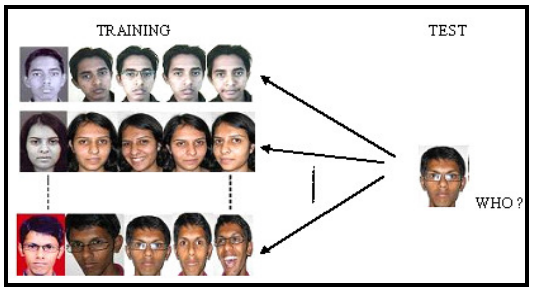

Figure 2. Comparing a new image with the database

4. SELF-ORGANIZED KOHENEN ALGORITHM

The self-organizing map, or SOM [6], introduced by Teuvo Kohonen is an unsupervised learning process which learns the distribution of a set of patterns without any class information. As a neural unsupervised learning algorithm, Kohonen's Self-Organizing Maps (SOM) [9] has been widely utilized in pattern recognition area. Using the SOM as a feature extraction method in face recognition applications is a promising approach, because the learning is unsupervised, no pre-classified image data are needed at all. When high compressed representations of face images or their parts are formed by the SOM, the final classification procedure can be fairly simple, needing only a moderate number of labeled training samples. The SOM is unlike most classification or clustering techniques in that it provides a topological ordering [3] of the classes. Similarity in input patterns is preserved in the output of the process. The topological preservation of the SOM process makes it especially useful in the classification of data which includes a large number of classes.

The algorithm used for our Facial Analytics project consists of following steps:

Step 1 – START.
Step 2 – Initialize the Map for Clustering.
Step 3 – Set $t = 0$ and Repeat the following steps until $t < e$,
where t is the *iteration rate* and e is the *error rate*,
Step 4 – Get the Best Matching Unit.

Step 5 – Scale Neighbours
Step 6 – Increase t by small amount.
Step 7 – END.

- *Initializing*
  There are a number of ways to initialize the weight vectors. The first is just giving each weight vector as shown in Figure 3, random values for its data which lies between 0 and 1. This way, less iterations are required to produce a good map and can save some time making the analysis more efficient.

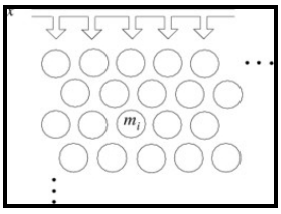

Figure 3. Cell arrangement for map

- *Best Matching Unit*
  This is a very simple step, just go through all the weight vectors and calculate the distance from each weight to the chosen sample vector. The weight with the shortest distance is the winner. If there is more than one with the same distance, then the winning weight is chosen randomly among the weights with the shortest distance. There are a number of different mathematical ways for determining the distance. We are using the Euclidean distance method where the distance formula is given as:

$$\sqrt{\sum_{i=0}^{n} x_i^2}$$

  x_i is the data value at the i[th] data member of a sample and n is the number of dimensions to the sample vectors.

- *Scale Neighbours*
  There are actually two parts to scaling the neighboring weights: determining which weights are considered as neighbors and how much each weight can become more like the sample vector. The second part to scaling the neighbors is the learning function. The winning weight is rewarded with becoming more like the sample vector. The neighbors also become more like the sample vector. An attribute of this learning process is that the farther away the neighbor is from the winning vector, the less it learns. The rate at which the amount a weight can learn decreases and can also be set to whatever you want. So once a weight is determined the winner, the neighbors of that weight are found and each of those neighbors in addition to the winning weight change to become more like the sample vector.

5. EXPERIMENTAL DATASET AND OBSERVATIONS

We used the AT&T database [7] for our face recognition experiments. Here we have experimented with nearly 400 images with variations of 40 persons. A preview image of the Database of Faces is as shown in Figure 6.

Figure 6. Examples of faces in AT&T Dataset

The experimental observations of the experiments performed on datasets are shown in Table 1 as follows:

Table 1. Experimental Observations

Criteria	Values
Training images	30
Testing images	370
Learning coefficient	0.01
Iterations	50
Recognition Rate	85.5%

6. CONCLUSIONS

A novel self-organizing map (SOM) based retrieval system is proposed for performing face matching in large database. The proposed system provides a small subset of faces that are most similar to a given query face, from which user can easily verify the matched images. The architecture of the proposed system consists of two major parts. First, the system provides a generalized integration of multiple feature-sets using multiple self-organizing maps. Second, a SOM is trained to organize all the face images in a database through using the compressed feature vector. Using the organized map, similar faces to a query can be efficiently identified. SOM is statistic-based Face Recognition algorithm.

In this paper an improved SOM method is proposed. The highest average recognition rate of 85.5% is obtained for 40 persons' 400images of AT&T database, where the training is done on 30 images only and tested on remaining images. Thus, the proposed method is an efficient face recognition process.

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