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Review of Face Recognition Systems Using Different Artificial Neural Network Algorithms

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ABSTRACT

Face recognition is one of the most relevant applications of image processing and biometric systems. Artificial neural networks (ANN) have been used in the field of image processing and pattern recognition. In the past few years, face recognition has received a significant attention and regarded as one of the most successful applications in the field of image analysis. The human faces represent complex, multidimensional, meaningful visual stimulant. Developing a computational model for face recognition is difficult. Face detection can be regarded as fundamental part of face recognition systems according to its ability to focus computational resources on the part of an image containing a face. The process of face detection in images is complex because of variability present across human faces such as: pose; expression; position and orientation; skin color ; presence of glasses or facial hair; differences in camera gain; lighting conditions; and image resolution . The analysis of facial expression was primarily a research field for psychologists in the past years. At the same time, advances in many domains such as: face detection; tracking; and recognition; pattern recognition; and image processing contributed significantly to research in automatic facial expression recognition. Therefore, this research includes a general review of face recognition studies and systems, which based on different ANN approaches and algorithms

Keywords: Biometric system, ANN, Image processing, Pattern recognition.

I. INTRODUCTION

Face recognition has become an important issue in many applications such as security systems, credit card Verification, criminal identification etc. [1]. Even the ability to merely detect faces, as opposed to recognizing them, can be important. Although it is clear that people are good at face recognition, it is not at all obvious how faces are encoded or decoded by a human brain. Human face recognition has been studied for more than twenty years. Developing a computational model of face recognition is quite difficult, because faces are complex, multidimensional visual stimuli. Therefore, face recognition is a very high-level computer vision task, in which many early vision techniques can be involved. For face identification, the starting step involves extraction of the relevant features from facial images [2]. In face recognition we mostly use the Neural networks because of its Adaptive learning: an ability to learn how to do tasks [3,4]. Next one is Self Organisation: An ANN can create its own organization. Third one is it has a remarkable ability to derive meaning from complicated or imprecise data A neural network is a powerful data modelling tool that is able to capture and represent complex input/output relationships. In the broader sense, a neural network is a collection of mathematical models that emulate some of the observed properties of biological nervous systems and draw on the analogies of adaptive biological learning [5]. It is composed of a large number of

highly interconnected processing elements that are analogous to neurons and are tied together with weighted connections that are analogous to synapses [6]. An artificial neural network is a computing system made of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external input. Motivated right from its inception by the recognition. A machine that is designed to model the way in which the brain performs a particular task. A massively parallel distributed processor. Resembles the brain in two respects, one is Knowledge is acquired through a learning process. Second is Synaptic weights, are used to store the acquired knowledge [7]. Neural network architecture is divided into three networks. One is Single layer feed forward network. Second, one is Multilayer feed forward network and third one is recurrent network [8].

II. RECOGNITION TECHNIQUES

A. Recognition Using DCT and Neural Networks

One approach to the problem of face recognition is based on DCT (Discrete Cosine Transform) and neural networks[9]. The DCT is used to extract features from high dimensional facial data two different neural networks are used. The standard back propagation neural network is used in an 'network per person' implementation, while the counter propagation network is used in a database implementation. After the image is captured and normalized, a 2-D DCT is applied to the image [10]. This is the initial data reduction step. Certain lower frequency coefficients are chosen in accordance with a variance distribution of the transformed image, while others are discarded. These coefficients form the features that are used as inputs to the neural networks. In the problem of face recognition, there are two distinct aspects: determining whether someone is known (determining database membership) and identifying the person (determining identity). The back propagation network. With momentum is used for determining identity, while the counter propagation network was used for determining database membership [11].

Linages on their own are highly correlated, and it is this property, which allows them to be effectively compressed by large factors and recovered with small errors. Theoretically, if an array has redundancy, it is possible to give the same information with less numbers. The DCT develops a set of numbers whose values are uncorrelated (i.e. each number in the array gives new information not given by the other members). Since the same information content is to be represented in the original and transformed arrays, some numbers in the transformed array give little or no information about the image and can be discarded. The definition of DCT for N x N image is given as

$$F(u,v) = \frac{2}{N} C(u)C(v)\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} f(x,y)\cos\left[\frac{(2x+1)u\pi}{2N}\right]\cos\left[\frac{(2y+1)v\pi}{2N}\right]$$

where

u ,v = discrete frequency variables (0,1 ,2...N-I)

f [x ,y] = N x N image pixels (0,1,2,... N-I)

F [u, v] = DCT result.

The 2-D DCT can be implemented via I-D DCTs along the rows and columns of the 2-D matrix, respectively [12].

Since the trace of the auto-covariance matrix in the transform domain for any unitary transform is invariant, one can judge the performance of a discrete transform by its variance distribution. They elaborate that since the variances represent the energy or information content of the corresponding transform coefficients, the transform coefficients with larger variances are candidates containing significant features in a pattern recognition application.

Say coefficient k, which resides at row m and column n does not change over a set of images, then it does not convey much information, and should thus be discarded. Conversely, if a coefficient has high variance over the set, then it should not be discarded.

B. Recognition Using PCA And BPNN

A face recognition system can be implemented using Principal Component Analysis (PCA) with Back Propagation Neural Networks (BPNN) [13, 14] .A neural based algorithm is presented to recognize the frontal views of faces. The multi-variate data set of face image is reduced using the PCA technique. BPNN is used for training and learning, leading to efficient and robust face recognition [15].

Experiments and testing were conducted over (ORL) Face database. Results indicate that PCA based execution is faster while the recognition accuracy suffers and vice versa for BPNN, thus suggesting a system incorporating both techniques is preferred [16].

In the high-dimensional spaces, data become extremely sparse and far apart from each other .It has been experimentally shown that in this situation once the number of features increases linearly, the size of the data set for learning exponentially increases. This phenomenon is known as the curse of dimensionality. Dimensionality reduction is an effective solution to the problem of curse of dimensionality. While considering high-resolution images, dimensionality reduction is a must for real time face recognition.

Principal component analysis (PCA) is one of the most popular methods of dimensionality reduction. It incorporates a mathematical method called orthogonal transformation to transform a number of possibly correlated variables into a smaller number of linearly uncorrelated variables called principal components.

Mathematically, it can be detailed as the orthogonal linear transformation of data onto a new coordinate system such that the greatest variance lies on the first coordinate (called the first principal component), the second greatest variance on the second coordinate, and so on.

(1). Principal Component Analysis Algorithm

The algorithm proceeds as follows:

1). Acquire an initial set of M face images from the training set and calculate the Eigen faces.

2). Only the Eigen faces that correspond to the highest eigenvalue (M') are considered.

3). Calculate a set of weights for each image in the training set based on the input image

4). Calculate the Euclidian Distance between the input image and the train mages. The image corresponding to the shortest distance is the equivalent image.

5). Classify the weight pattern either as a known person or as unknown, according to its distance to the closest weight vector of a known person.

(2). Back propagation neural networks

The success of a face recognition system depends on its ability to learn real-world data. The ability to learn real world data depends on the pattern classifier being implemented. Back Propagation Algorithm (BPNN) is a very widely used and well-known learning algorithm in training Multilayer Perceptron's (MLP) [2]. The MLP network is composed by a set of sensory mathematical units, which form the input layer, hidden layer(s) and a single output layer. The input signal follows a unidirectional flow, from left to right, through the multiple layers of the network

BPNN is a multi-layer feed-forward, supervised learning algorithm that incorporates the gradient descent-learning rule [17]. The primary concern when implementing BPNN is to ensure that there is a balance between quick responses and accurate responses

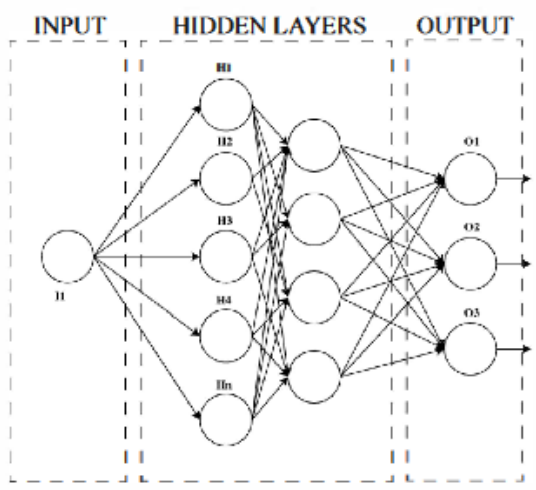

Figure 1. Representation of the three layers in a Multilayer Perceptron (MLP): input, hidden and output layer.

During training of a neural network (BPNN) appropriate values have to be assigned to parameters such as weights, learning rate, number of hidden layers etc. to obtain satisfactory results [18].

Thus the systems implementing both PCA and an artificial neural network classifier (in this case BPNN) have slower execution time but the trade-off is made in return for greater accuracy in recognition. The Euclidean distance computed on an image that has not been pre-processed is greater when compared to a pre-processed image. This is because pre-processing

accounts for uncontrolled lighting and other variations in the subject image. Hence, to finally conclude, the study indicates that a system incorporating the technique of PCA along with ANN is preferred for more accurate detection of faces

C. Recognition by Probabilistic Decision-Based Neural Network

The PDBNN face recognition system consists of three modules: First, a face detector finds the location of a human face in an image. Then an eye localizer determines the positions of both eyes in order to generate meaningful feature vectors. The facial region proposed contains eyebrows, eyes, and nose, but excluding mouth. (Eyeglasses will be allowed.) Lastly, the third module is a face recognizer [19]. The PDBNN can be effectively applied to all the three modules. It adopts a hierarchical network structures with nonlinear basis functions and a competitive credit-assignment scheme [20].

Two features of the PDBNN make itself suitable implementation for not only the face recognition system, but also other biometric identification systems. These features are:

(1)Architectural Feature:

The PDBNN inherits the modular structure from its predecessor, Decision Based Neural Network (DBNN). For each person to be recognized, PDBNN devotes one of its subnets to the representation of that particular person. This kind of structure is beneficial not only for training/recognition performance, but also for hardware implementation. More specifically, we have the following.

1) The system will be easy to maintain. Take company security system as an example. The updating of a PDBNN-based security system is relatively straightforward. An addition or deletion of one or more subnets (using localized training process) is sufficient to take care of any change of personnel. A centralized system, in contrast, would have to involve a global updating.

2) A distributed computing principle is adopted. When the number of persons increases, the computing hardware will become more demanding. Due to its modular architecture, a PDBNN-based biometric identification system is relatively easy to implement on parallel computer.

3) It leads to a portable ID device. It is possible to implement a PDBNN-based biometric identification system on a wallet-size magnet card system. The user may carry a “smart card”, which need to record only the parameters of the subnet in the PDBNN corresponding to the user him/herself.

(2). Performance Feature:

The discriminant function of PDBNN is in a form of probability density. This yields low false acceptance and false rejection rates, . This characteristic is very critical in preventing illegal entrance by an intruder.

PDBNN is a probabilistic variant of its predecessor, DBNN (Decision Based Neural Network). DBNN is an efficient classification neural network [21]. It has a modular network structure. One subnet is designated to represent one object class. PDBNN inherits this structural property. For the face detection problem, since the “non”-face class can be considered as the complement of face class, PDBNN detector uses only one, instead of using two, subnet [22]. This subnet is used to represent the face class. There are two properties of the DBNN learning rules [23]. The first one is decision based learning rules. Unlike the approximation neural networks, where exact target values are required, the teacher in DBNN only tells the correctness of the classification for each training pattern. Based on the teacher information, DBNN performs a distributed and localized updating rule.

The second property of the DBNN learning rules is

Hybrid locally unsupervised and globally supervised learning. The training scheme of DBNN is based on the so-called LUGS (Locally Unsupervised Globally Supervised) learning.

PDBNN follows the principles of these learning properties [24]. In the LU phase, PDBNN uses the positive training patterns to adjust the subnet parameters by some unsupervised learning algorithm, and in the GS phase, it only uses the misclassified patterns for reinforced and anti-reinforced learning. The negative patterns are only used for the anti-reinforced training of the subnet. A threshold, which can also be trained by reinforced, determines the decision boundaries and anti-reinforced learning.

III. COMPARISON BETWEEN DIFERENT ANN APPROACHES

Literature studies based on ANN for building face detection systems were described in this study. Each one of these studies was based on special architecture of ANN for face detection. Many of these studies were based on one architecture of ANN such as : Multilayer Perceptron (MLP); Back Propagation Neural Networks (BPNN) , Probabilistic decision based neural network (PDBNN); . Other studies were based on ANN on combination with other techniques and methods such as Principal Component Analysis with ANN (PCA & ANN).

All of these studies were based on ANN. Each one of these studies includes its own experiments and based on different database for training and testing images. Many of these studies take detection rate as performance measure; other studies take error rate as performance measure and so on.

IV. RECOMMENDATIONS FOR FACE DETECTION SYSTEM

The following recommendations must be taken in our consideration when we suggest building a strong face detection system such as:

- Try to design a real time face detection system that is based on video taken in real time camera.
- Give sufficient details about the exactly used database for system training and testing.
- Give sufficient details about performance measures and equations used for face detection.
- ANN can be adopted in combination with other algorithms to obtain better results for face detection. At the same time, we must focus on how to simplify the combined algorithms steps to reduce the memory required and processing time.
- Try to use other ANN architectures: self-organizing map, PatternNet, FitNet and Fast BPNN.
- Try to use different optimization ANN training algorithms such as: Levenberg-Marquardt (TRAINLM); TRAINBFG; Bayesian regularization (TRAINBR); TRAINCGF algorithm; Gradient descent (TRAINGD); and Gradient descent with momentum (TRAINGDM) [25] to obtain best results for face detection system.
- Try to use genetic algorithm (GA) as an optimization algorithm to obtain the best values of ANN algorithm parameters that result to optimal results .

IV. CONCLUSION

This paper includes a summary review of literature studies related to face detection systems based on ANNs. Different architecture, approach, programming language, processor and memory requirements, database for training/testing images and performance measure of face detection system were used in each study. Each study has its own strengths and limitations.

In future work, a face detection system will be suggested based on using Pattern Net and Back propagation neural network (BPNN) with many hidden layers. Different network architectures and parameters' values of BPNN and Pattern Net will be adopted to determine Pattern Net architecture that will result in best performance values of face detection system.

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