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Analysis of Faces Using Supervised and Unsupervised Neural Network for 3D Face Recognition

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Abstract: ***Soft computing based different methods are largely being applied in diverse areas of the research world. Face recognition being one of the major streams of Biometrics is going through huge research around the globe. In this paper, the experimental results for the comparative investigation of the performance of supervised and unsupervised learning based two classifiers have been put forward. The two methods Support-Vector Machine (SVM), which are supervised learning models with associated learning algorithms that analyze data and recognize patterns, used for classification and regression analysis. The basic SVM takes a set of input data and predicts, for each given input, which of two possible classes forms the output, making it a non-probabilistic binary linear classifier and Self-Organizing Map (SOM), is a type of artificial neural network (ANN) that is trained using unsupervised learning to produce a low-dimensional (typically two-dimensional), discretized representation of the input space of the training samples, called a map. Self-organizing maps are different from other artificial neural networks in the sense that they use a neighborhood function to preserve the topological properties of the input space belonging to supervised and unsupervised approach respectively have been used against two distinct 3D facial datasets. The recognition rates have been calculated using LDA technique and results have been calculated to serve the purpose of determining a most prominent of the ANN based two main classifiers used for efficient 3D Face recognition system.***

Keywords: 3D Face recognition, LDA, ANN, SVM, SOM Etc.

I. INTRODUCTION

The main advantage of the 3D based approaches is that the 3D model retains all the information about the face geometry. The 3D facial representation seems to be a promising tool coping many of the human face variations. There has been increasing interest in using artificial neural networks (ANN) for pattern recognition. A classifier is considered to be good or not according to its ability to generalize. The investigation of sample size problem for neural network classifiers leads the conclusion that the generalization error decreases as the training sample size increases. However, in contrast to statistical pattern recognition, neural networks have a good behavior regarding small size problem. In this paper, a comparative study has been represented for 3D Face recognition.

Following two classifiers have been used to bring out the recognition rates. First classification tool used in this paper and present in ANN theory is, Support Vector Machine (SVM). It is the supervised learning based approach. The standard SVM takes a set of input data and predicts, for each given input, which of two possible classes the input is a member of, which makes the SVM non-probabilistic binary linear classifiers. Since an SVM is a classifier, then given a set of training examples, each marked as belonging to one of two categories, an SVM training algorithm builds a model that predicts whether a new example falls into one category or the other. The second technique, Self-Organizing Map (SOM) (also called Kohonen network) is an artificial unsupervised neural network characterized by the fact that the neurons become specifically tuned to various classes of patterns through a competitive, unsupervised or self organizing learning. The spatial location of a neuron in the network (given

by its co-ordinates) corresponds to a particular input vector pattern. Similar input vectors correspond to the same neuron or to neighbor neurons. The paper has been organized in the form of sections. The section 2 gives the details regarding the datasets used for experiment, section 3 describes the experimental framework, section 4 shows the recognition rates and experimental results, conclusions have been drawn in Section 5 and the section 6 contains the final summary and discussion.

II. DATASETS

The two methods Support-Vector Machine (SVM) and Self-Organizing Map (SOM) belonging to supervised and unsupervised approach respectively have been used against two distinct 3D facial datasets, First dataset is made locally for the collection of randomly taken own images later processed to 3D model. It has been specifically made with own efforts and is being entitled as SPRING dataset in this entire article. The images in this dataset are taken with varying expressions, background conditions, age, illumination and partial occlusion. The images have been captured into different time periods of the year. People differ based on gender, age, hair style, culture and complexion. The devices used for capturing the images are differing, such that, the different camera models used for the collection purpose are: COOLPIX L550 and COOLPIX L21 few have been taken using the standard cameras of Motorola L6 and Karbon K500 cellular handsets. Some random 3D images from SPRING dataset are:

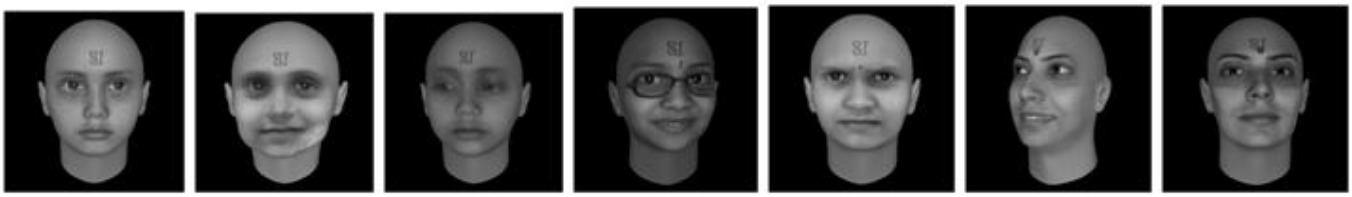

Figure 1 Sample Images from Local dataset SPRING

Another one is GavabDB dataset, developed by GAVA B research group, Universidad Rey Juan Carlos, Spain which is a 3D face database containing 549 three-dimensional images of facial surfaces. The database provides systematic variations with respect to the pose and the facial expression. In particular, the 9 images corresponding to each individual are: 2 frontal views with neutral expression, 2 x-rotated views with neutral expression, 2 y-rotated views with neutral expression and 3 frontal gesture images. Each image is given by a mesh of connected 3D points of the facial surface without texture. These meshes correspond to 61 different individuals. Some random images from GavabDB dataset are as follows:

Figure 2 Sample Images from standard dataset GavabDB

III. EXPERIMENTAL FRAMEWORK

3.1. IMPLEMENTING LDA

Standard Linear-Discriminant Analysis technique has been used for deriving the set of three most prominent of nearest neighbors of the set of training images. The set of input images is sampled for generating the eigenfaces, the average face is calculated from the train images, the lambda strength is derived and as the sum of the tests, top three nearest neighbors' are projected.

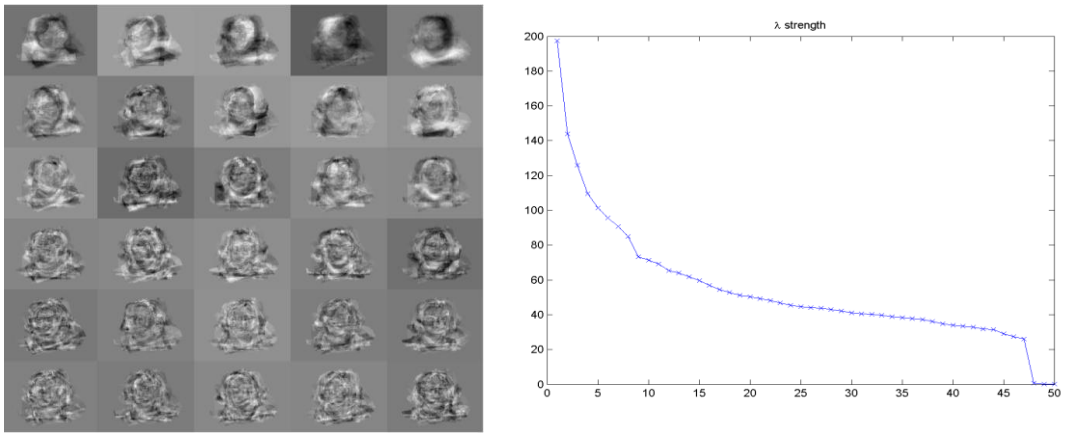

Figure 3 Eigenfaces for GavabDB dataset images and corresponding Eigenvalue strength.

The images in the training set are divided into the corresponding classes. LDA then finds a set of vectors *WLDA* such that Fisher Discriminant Criterion is maximized, where *SB* is the between class scatter matrix and *SW* is the within-class scatter matrix,

$$W_{LDA} = \arg\max_{W} \frac{W^T \cdot S_B \cdot W}{W^T \cdot S_W \cdot W}$$

After the eigenvectors have been found (and only the ones corresponding to largest eigenvalues have been kept), the original images are projected onto them by calculating the dot product of the image with each of the eigenvectors. Recognition is again done by calculating the distance of the projected input image to all the training images projections, and the nearest neighbor is the match. Both PCA and ICA do not use face class (category) information. The training data is taken as a whole. Linear Discriminant Analysis (LDA) finds an efficient way to represent the face vector space by exploiting the class information. It differentiates individual faces but recognizes faces of the same individual. LDA is often referred to as a Fisher's Linear Discriminant (FLD).

3.2. BASIC NEURAL NETWORK ARCHITECTURE

The proposed neural network architecture has been given by following figure. The preprocessed images have been given as input to the neural network; each neuron takes a single image. These are being given as inputs to the functions at the hidden layer, the functions of the hidden layer calculate the mean image, reconstructed images and eigenfaces, at last the output layer generates the set of recognized images.

The finally generated set of reconstructed images is being fed to the actual classifiers, namely, SVM and SOM based next ANN, i.e. ANN-2 as shown in the Figure 3. This is in order to bring forth the final correct and false recognition rates for each dataset. SVM and SOM then further analyze the similarity factor between the reconstructed test images provided by the previous network, results given by the output nodes of ANN-2 are treated as the final conclusions for this comparative study of two classifiers.

IV. RESULTS

For the experimentation purpose randomly chosen 100 images have been taken from a collection of own images, the sample images are shown in the figure 2. All the experiments have been performed in MATLAB 6.5.1 computing environment. The set of reconstructed images obtained from the first neural network is then fed to the next network. For derivation of the comparison of recognition rates, both the classifiers have been tested. These rates have been estimated based on the percentages of recognized images for these two techniques, SVM and SOM respectively. The standard Linear Discriminant Analysis (LDA)

method is closely related to linear regression analysis and hence has been used for facial feature extraction and recognition. Following table shows the summary of results obtained through the experimental work:

Data Distribution			Rate Obtained (%)			
LDA Subspace	No. of classes	Purely separated cluster	SPRING Dataset		GavabDB Dataset	
			SVM	SOM	SVM	SOM
20	1	2	85.50	76.00	83.6	76.20
40	2	4	82.30	73.80	83.20	73.50
60	3	6	82.00	72.40	80.30	70.60
80	4	8	80.40	71.50	75.80	69.00
100	5	10	78.90	69.20	70.00	67.80

TABLE I RESULTS OBTAINED FOR EACH CLASSIFIER ON TWO 3D FACIAL DATASETS

All the recognition rates have been extracted using the same subspace analysis method for the better judgment of relative efficiency of the ANN classifiers. Results show that for both the classification modes, recognition rate decreases as the size of LDA subspace increases. The clusters have been created of the main collection of images; each cluster contains ten images of a single subject, therefore, the purely separated clusters are increased by two at each testing experiment. In the main clustering operation, the cluster containing images of a single individual has been treated as a single cluster. The following table demonstrates the average of the results obtained from both the supervised and unsupervised learning based classification tools on two different 3D facial datasets. Average has been calculated by the formula R= sum(Cr)/n, where R is the average recognition rate, sum(Cr) is the summation of recognition rates calculated with a single classifier and n is the number of classes.

DATASET	(%) SVM (Supervised Learning)		(%) SOM (Unsupervised Learning)	
	False	Correct	False	Correct
Local Database Spring	13.47	86.53	34.57	65.43
GavabDB	10.62	89.38	28.90	71.10

TABLE II AVERAGE RECOGNITION RATES

V. Conclusion

The set of results obtained by the experiments carried out using Linear Discriminant Analysis (LDA) method on two different 3D facial datasets encourages to draw two conclusions: First is that the unsupervised learning method expects us not to be aware with the final output to be produced, this may be the reason because of which regressive analysis approach of LDA does not perform well with unsupervised learning based classification tool, which is Self-Organizing Map(SOM), as compared to the Support-Vector Machine (SVM) i.e. Supervised learning based paradigm. Second conclusion can be made according to the numeric results obtained in the process. SVM performed well in the entire experiment, nevertheless, similar to SOM, the recognition rates for SVM decrease as the size of LDA subspace increases in the test.

VI. Summary & Discussion

Through this paper, an attempt of comparative analysis of the neural network based two classification algorithms has been put forward. One of which belongs to supervised learning paradigm and another is the unsupervised learning based method. Experimental results have been drawn using two different 3D facial datasets, for the better analysis of comparative outcome. Results have shown that, unsupervised learning based classification tool did not perform well with the standard linear regression subspace analysis method of Face recognition i.e. LDA. Being a supervised learning based method SVM performed relatively

well on both datasets, but the false rate associated with it started to increase along with the size of LDA subspace. Moreover, the further interrogation of whether both the classification methods give the same results if used along with other two conventional subspace analysis methods (PCA ICA) is left to the further analysis of the same.

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