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Face Illumination and Occlusion based Experimental Research on face Recognition using Artificial Neural Network

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Abstract: ***Face Recognition System is traditional research and development in face detection and tracking are focused on video images or in still images. A face recognition system for classification and authentication using Genetic Algorithm and Optimization Soft Computing Techniques are proposed. The system is framed with three steps. Initially Image pre-processing methods are applied on the input image. Secondly, a neural based algorithm is presented, to detect frontal views of faces. The dimensionality of face image is reduced by the Principal Component Analysis (PCA) and the recognition is done by the Back propagation Neural Network (BPNN). These applications, most existing systems, academic and commercial, are compromised in accuracy by changes in environmental illumination. Thirdly, Gabor feature extraction and feature selection using Genetic Algorithm (GA) is applied in the final step for recognizing the faces. The proposed approaches are tested on a number of face images. Experimental results demonstrate the higher extent performance of these algorithms. Here 200 face images from Yale database are taken and some performance metrics like acceptance ratio and execution time are calculated. Neural based face recognition is better performance of more than 90 % acceptance ratio. In this paper, we present a novel solution for illumination invariant face recognition for indoor, cooperative-user applications.***

Keywords: Biometrics, Face Recognition, Illumination invariant Statically Learning, PCA, Neural Network & Genetic Algorithm

1. Introduction

Face Recognition is a primary modality for biometric authentication has received increasing interest in the recent years. Existing biometric systems are developed for cooperative user applications, such as access control, computer logon, and ATM. In such applications, a user is required to cooperate with the camera to have his/her face image captured properly in order to be permitted some access. In this contrast to more general scenarios, such as face recognition under surveillance, where a person should be recognized without intentional, cooperative effort. Another aspect is that most of the current systems are designed for indoor use. To achieve reliable results, face recognition should be performed based on intrinsic factors of the face only, and mainly related to 3D shape and reflectance of the facial surface. Extrinsic factors, including eyeglasses, hairstyle, expression, posture, and environmental lighting, which make distributions of face data highly complex should be minimized for reliable face recognition. Among several extrinsic factors, problems with uncontrolled environmental lighting are the topmost issue to solve for reliable face-based biometric applications in practice. From the end-user point of view, a biometric system should adapt to the environment, not vice versa.

However, most current face recognition systems, academic and commercial, are based on face images captured in the Visible Light (VL) spectrum; they are compromised in accuracy by changes in environmental illumination, even for co-operative user applications indoors. In an in-depth study on the influence of illumination changes on face recognition, Adini et al. examined several distance measures and several local image operators, including Gabor filters, local directive filters, and edge maps, which were considered to be relatively insensitive to illumination changes for face recognition. Several conclusions are made there: 1) Lighting conditions, and especially light angle, drastically change the appearance of a face. 2) When comparing unprocessed images, the changes between the images of a person under different illumination conditions are larger than those between the images of two people under the same illumination. 3) All of the local filters under study are insufficient by themselves to overcome variations due to changes in illumination direction. The influence of illumination is also shown in the recent Face Recognition Vendor Test. The issues of face detection and tracking have long been studied in the fields of computer vision and pattern recognition. The widespread interests devoted to such research and development, are due in part to increasingly growing performance ratio of computing power and related hardware, and beyond that, due to potential important applications in surveillance, human-computer interaction, retrieval among others.

Many researchers have been attempting to constructing realistic face detection and tracking systems. The face localization is based on skin color segmentation, and tracking is accomplished through Kalman filtering, which estimates the position and face size with the help of eye localization based. This document proposed a method to detect faces in images followed by a neural network approach. Framed in the artificial intelligence field and more specifically in computer vision, face detection is a comparatively new problem in computer science. Long years ago, computers were not able to do real time images processing; it is an important requirement for face detection applications. Face detection has several applications, First it can be used for many task like tracking persons using an automatic camera for security purposes; classifying image databases automatically or improving human-machine interfaces. In the second stage artificial intelligence subject, accurate face detection is a step towards in the generic object identification problem requires extraction of a suitable representation of the face region. The third stage classifies the facial image based on the representation obtained in the previous stage. Finally, compares facial image against database (gallery) and reports a match.

Facial expressions not only to express our emotions, but also to provide important communicative cues during social interaction, such as our level of interest, our desire to take a speaking turn and continuous feedback signaling or understanding of the information conveyed. Support Vector Algorithm is well suited for this task as high dimensionality does not affect the Gabor Representations. The main disadvantage of the system is that it is very expensive to implement and maintain. Any changes to be upgraded in the system needs a change in the algorithm which is very sensitive and difficult; hence our developed system will be the best solution to overcome the above mentioned disadvantages. It is a heuristic method that uses the idea of survival of the fittest.

2. Principal Component Analysis

Principal component analysis (PCA) involves a mathematical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal components. PCA is a popular technique, to derive a set of features for both face recognition.

Any particular face can be (i) Economically represented along the eigen pictures coordinate space, and (ii) Approximately reconstructed using a small collection of Eigen pictures. Face image is projected to several face templates called eigenfaces which can be considered as a set of features that characterize the variation between face images. Once a set of eigenfaces is computed, a face image can be approximately reconstructed using a weighted combination of the eigenfaces.. In new test image is given, the weights are computed by projecting the image onto the eigen- face vectors. The classification is then carried out by comparing the distances between the weight vectors of the test image and the images from the database. Conversely, using all of the eigenfaces extracted from the original images, one can reconstruct the original image from the eigenfaces so that it matches the original image exactly.

2.1 PCA Algorithm

The algorithm used for principal component analysis is as follows.

1) Acquire an initial set of M face images (the training set) & Calculate the Eigen-faces from the training set, keeping only M' eigenfaces that correspond to the highest eigen value.
2) Calculate the corresponding distribution in M'-dimensional weight space for each known individual, and calculate a set of weights based on the input image.
3) Classify the weight pattern as either a known person or as unknown, according to its distance to the closest weight vector of a known person.

2.2 Grayscale Values

Grayscale preprocessing was the most imprecise method. If grayscale testing performance data (averaged from a set of 10 runs with different datasets) for neural networks of 5, 10, 15, 20 and 25 hidden neurons are shown in Table 3. The PCA minimum information percentage that allows the best testing performance is marked with yellow.

Figure 1: Original Image to Gray Scale Conversion

3. Neural Networks and Back Propagation Algorithm

A successful face recognition methodology depends heavily on the particular choice of the features used by the pattern classifier .The Back-Propagation is the best known and widely used learning algorithm in training Multilayer Perceptrons (MLP) [5]. The MLP refer to the network consisting of a set of sensory units (source nodes) that constitute the input layer, one or more hidden layers of computation nodes, and an output layer of computation nodes. The input signal propagates through the network in a forward direction, from left to right and on a layer-by-layer basis. Back propagation is a multi-layer feed forward, supervised learning network based on gradient descent learning rule. This BPNN provides a computationally efficient method for changing the
Weights in feed forward network. Being a gradient descent method it minimizes the total squared error of the output computed by the net. The aim is to train the network to achieve a balance between the ability to respond correctly to the input patterns that are used for training and the ability to provide good response to the input that are similar.

3.1 Back Propagation Neural Networks Algorithm

A typical back propagation network with Multi-layer, feed-forward supervised learning is as shown in the figure. 2. Here learning process in Back propagation requires pairs of input and target vectors. The output vector ‘o ‘is compared with target vector’s ‘. In case of difference of ‘o’ and‘t‘vectors, the weights are adjusted to minimize the difference. Initially random weights and thresholds are assigned to the network. These weights are updated every iteration in order to minimize the mean square error between the output vector and the target vector.

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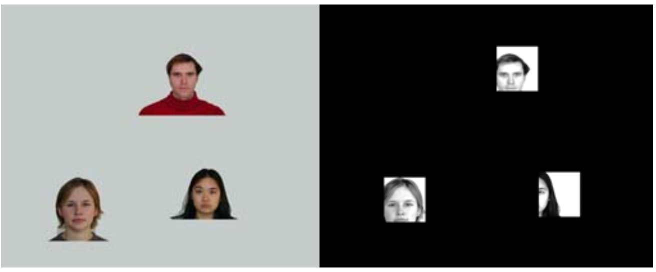


Figure 2: Face detection using Neural Network

Figure 3: Individual image Face detection using Neural Network

Back propagation neural network Input for hidden layer is given by can be supposed that the union dataset of face-like and no face-like patterns is a non-linearly separable set, so a non-linear discriminator function should be used. Artificial neural networks s in general, and a multilayer feed forward perception with back propagation learning rule in particular fit this role. The classifier training process consists of a supervised training. The patterns and the desired output for each pattern are showed to the classifier sequentially. It processes the input pattern and produces an output. If the output is not equal to the desired one, the internal weights that contributed negatively to the output are changed by the back propagation learning rule; it is based on a partial derivates equation where each weight is changed proportionally to its weight in the final output. In this way, the classifier can adapt it neural connections to improve its accuracy from the initial state (random weights) to a final state.

Table 1: The effect on performance of varying the number of hidden neurons

No. hidden neurons	Face detection rate %	Face detection rate %	Total Detection rate
1	99.2	97.5	97.5
10	100.0	99.0	99.4
20	98.3	100.0	99.4
25	99.2	99.5	99.4
30	99.2	98.5	98.8
40	100.0	100.0	100.0
50	100.0	100.0	1000.0

4. Experimental Results

4.1 Multitier Face Detector in Video

Genetic Algorithm is a powerful search and optimization algorithm, which are based on the theory of natural evolution. In Genetic Algorithm, each solution for the problem is called a chromosome and consists of a linear list of codes. The GA sets up a group of imaginary lives having a string of codes for a chromosome on the computer. The GA evolves the group of imaginary lives (referred to as population), and gets and almost optimum solution for the problem. The GA uses three basic operators to evolve the population: selection, crossover, and mutation. Genetic algorithm was developed by John Holland- University of Michigan (1970.s)- to provide efficient techniques for optimization and machine learning applications through application of the principles of evolutionary biology to computer science. It uses a directed search algorithms based on the mechanics of biological evolution such as inheritance, mutation, natural selection, and recombination (or crossover).

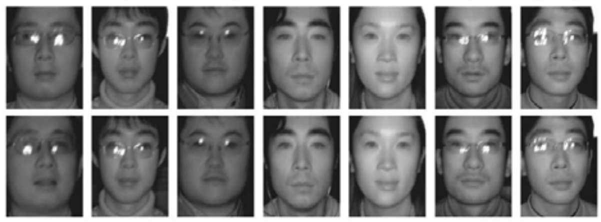
4.2 Illumination Invariant Face Representation

In this section, we first provide an analysis from the Lambert an imaging model to show that such images contain the most relevant, intrinsic information about a face, subject only to a multiplying constant or a monotonic transform due to lighting intensity changes. We then present an LBP-based representation to amend the degree of freedom of the monotonic transform to achieve an illumination invariant representation of faces for indoor face recognition applications.

4.3 Adaptive Lighting Preprocessing

Once the lighting condition of a testing face image has been grouped in a relative manner, facial images will be handled accordingly. For this method, we further propose an adaptive method to perform illumination normalization for each testing face image. By varying the truncation scale, many existing approaches, e.g. the Gaussian smoothing filter used in

Active NIR Light Face Images Taken with Left and Right Lamp Lights



Correlation Coefficients

	Right 1	Right 2	Right 3	Right 4	Right 5	Right 6	Right 7	
Left 1	**0.5467**	0.5407	0.6775	0.6290	0.6503	0.6062	0.5600	Right 1
Left 2	0.5269	**0.9190**	0.5938	0.7091	0.6389	0.6694	0.6257	Right 2
Left 3	0.6628	0.6288	**0.8992**	0.7207	0.7812	0.7044	0.5688	Right 3
Left 4	0.6936	0.6569	0.7321	**0.9684**	0.8040	0.7757	0.6697	Right 4
Left 5	0.7004	0.6426	0.8269	0.7944	**0.9918**	0.8321	0.6864	Right 5
Left 6	0.7610	0.6079	0.7631	0.7991	0.8100	**0.9154**	0.6264	Right 6
Left 7	0.5240	0.6740	0.6042	0.7145	0.7384	0.6536	**0.9090**	Right 7
	Left 1	Left 2	Left 3	Left 4	Left 5	Left 6	Left 7	

Matching Scores

	Right 1	Right 2	Right 3	Right 4	Right 5	Right 6	Right 7	
Left 1	**0.6253**	0.2925	0.3435	0.3268	0.3270	0.3494	0.3158	Right 1
Left 2	0.3035	**0.6709**	0.2201	0.3096	0.3167	0.3081	0.3442	Right 2
Left 3	0.3288	0.2127	**0.6592**	0.2845	0.3389	0.3146	0.2742	Right 3
Left 4	0.3292	0.2929	0.2861	**0.7013**	0.2909	0.3300	0.3845	Right 4
Left 5	0.3618	0.2975	0.3158	0.3003	**0.6914**	0.3620	0.2651	Right 5
Left 6	0.3562	0.3169	0.2981	0.3148	0.3490	**0.6640**	0.2778	Right 6
Left 7	0.3032	0.3224	0.2777	0.3705	0.2711	0.2905	**0.7128**	Right 7
	Left 1	Left 2	Left 3	Left 4	Left 5	Left 6	Left 7	

Figure 4: Face detection using Neural Network

4.4. Facial Aging

Facial-aging process to improve a generic COTS FRS,8 Zhifeng Li, Unsang Park, and Anil Jain developed a specialized FRS to compensate for aging.12 Their approach uses a discriminative aging model to learn a robust face representation. The discriminative model is trained on a set of age separated image pairs using scale-invariant feature transformation (SIFT) and multiscale local binary pattern (MLBP) descriptors as well as random-sampling Linear Discriminant Analysis (LDA) subspace analysis. Combining the discriminative-aging modeling method with the generative preprocessing method we discussed earlier offers significant improvements in identification accuracy. Forensic-Sketch Recognition Automated identification of a subject based on a composite sketch query expands face recognition capabilities to situations where a suspect's face image is not available from the crime scene. In such situations, only a verbal description of a subject, provided by witnesses or victims, is available for use by a forensic sketch artist or a composite software tool to generate a depiction of the subject's facial appearance. Forensic sketches have been successfully used for more than a century in criminal identification. To fill this void, Brendan Klare, Zhifeng Li, and Anil Jain designed a FRS for this task called Local Feature-based Discriminant Analysis (LFDA, .10 LFDA operates by representing both forensic sketches and photographsusing SIFT and MLBP feature descriptors. A column-wise concatenation of these descriptors are used to learn discriminant subspace projections that attempt to maximize the Fisher criterion, where the within-class feature spaces consist of both a sketch and photo from the same subject.

4.5 Filtering

The bigger problem in the training process is to know if plain grayscale images contain enough information by themselves to allow classifier training successfully. everal methods were used to compare performance about this topic: 1) grayscale images, 2) horizontal and vertical derivates filtered images, 3) laplacian filtered images, 4) horizontal and vertical derivates filtered images joined to the laplacian, and 5) horizontal and vertical derivates filtered images joined to the grayscale (Table 1 resumes these methods). These operations over the original image are part of the preprocessing step in the whole face detection process.

Figure 5: Original image Filtering Face detection using Neural Network

4.6 Eye Detection

Detection of eyes in active NIR images is more challenging than in normal visible light images due to likely specular reflections on eyeglasses. On the right of Fig. 6 shows some examples of eyes. At the upper-left corner is an ideal example of eyes which can be easily detected, with a "bright pupil" detector [10], [44], [45] or an appearance-based detector. The other examples are difficult ones. Specular reflection on eyeglasses is the most serious problem. Eyelid occlusion, which happens among people in some ethnic groups and senior people and eye closing due to blinking are among other problems. Eye detection in these situations cannot be done by using a simple eye detector.

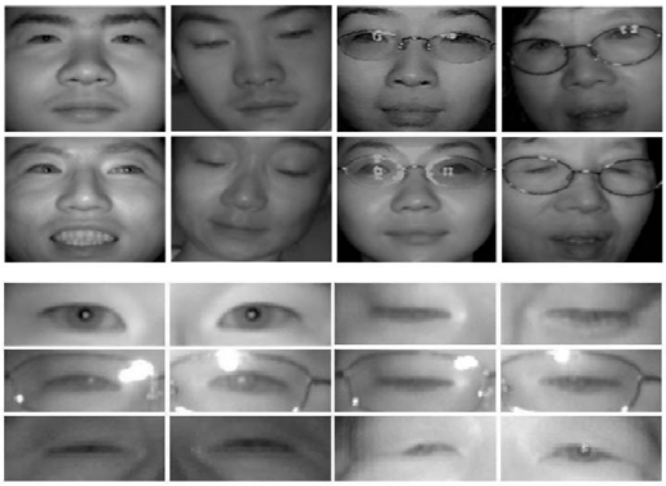


Figure 6: Face detection using Neural Network

The ORL database which contains a set of faces taken between April 1992 and April 1994 at the Olivetti Research Laboratory in Cambridge, UK3. There are 10 different images of 40 distinct subjects. Some of the image subjects were taken at different times. There are variations in facial expression (open/closed eyes, smiling/non-smiling), and facial details (glasses/no glasses). All the images were taken against a dark homogeneous background with the subjects in an up-right, frontal position, with tolerance for some tilting and rotation of up to about 20 degrees. There is some variation in scale of up to about 10%. The images are grayscale with a resolution of given input image.

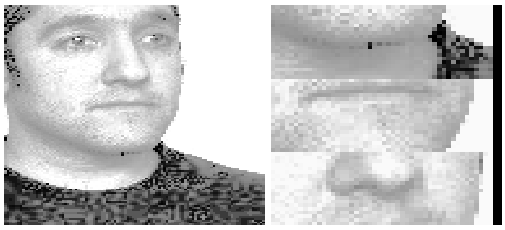


Figure 7: Rectangle features extraction using Neural Network

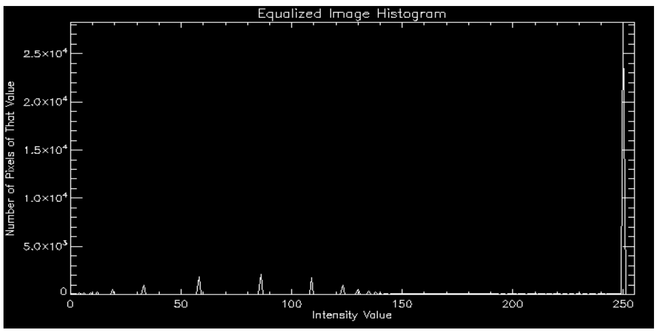


Figure 8: Histogram for Equalize image

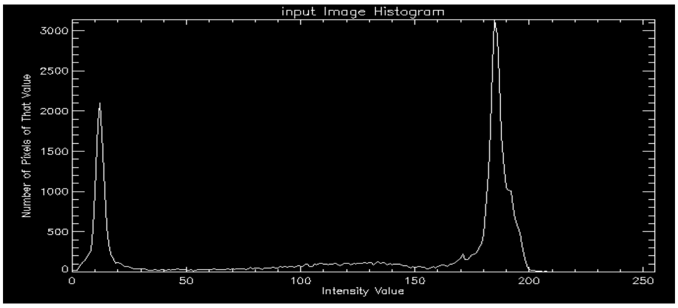


Figure 9: Histogram for input image

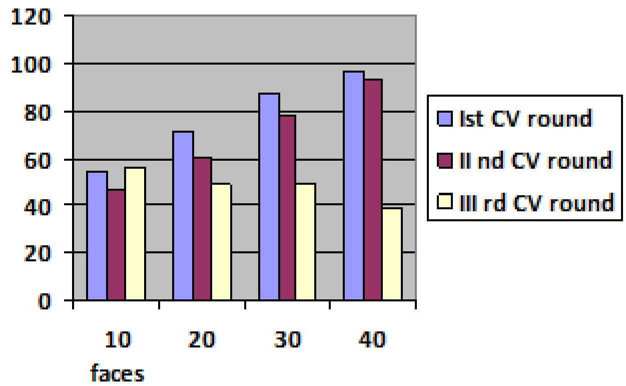


Figure 10: Fitness Measure using Face image

The impact of environmental lighting is much reduced by the present NIR imaging system, as shown by the correlations and scores in Figure. 4. There, the corresponding NIRface images are taken in the same visible light conditions as in Fig. 4 and the explanations of the two tables are similar to those for Fig. 4. The correlation coefficients between NIR images are all positive, regardless of the visible light conditions and person identity. They have mean and variance of 0.8785 and 0.1502 for intrapersonal pairs and 0.6806 and 0.0830 for extra personal pairs. However, the intrapersonal correlation coefficients may not necessarily be higher than the extrapersonal ones, meaning possible recognition errors, even with the NIR images. Therefore, a better matching engine than correlation or PCA is still needed for highly accurate face recognition, even with NIR face images.

5. Conclusions

Face recognition is challenging problems and there is a lot of work that needs to be done in this paper. For the past ten years, face recognition has received substantial attention from researchers in biometrics, pattern recognition, computer vision, and cognitive psychology communities. This common interest in facial recognition technology among researchers working in diverse fields is motivated both by the remarkable ability to recognize people and by the increased attention being devoted to security applications. Applications of face recognition can be found in security, tracking, multimedia, and entertainment domains.

We are taking the number of training samples in the x-axis and recognition rate on the y-axis. In our proposed method compared to the other images for all the eye locations have been correctly and uniquely identified. On the test data set of 10 face images we missed two eye locations only and no false positives were identified.

We have demonstrated how a face recognition system can be designed by artificial neural network. The training process did not consist of a single call to a training function. Instead of the network was trained several times on various input ideal and noisy images of faces. In this case training a network on different sets of noisy images forced the network to learn how to deal with noise, a common problem in the real world.

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