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REAL TIME FACE RECOGNITION USING ARTIFICIAL NEURAL NETWORKS: A SECURE PERSONNEL IDENTIFICATION SYSTEM

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ABSTRACT

This paper presents the development technique of an automated face recognition system as a biometrically based technology for personal identification and verification where recognition phase is being implemented by artificial neural network. The motivation for this endeavor stems from the observation that the human face provides a particularly interesting structure on which identical biometric assessment can be performed. Face images are being acquiesced by digital camera and then scaled using the digital image processing techniques. Scaled forms of images are then filtered with highpass filtering or edge detection technique. Finally, the features are extracted from the edge detected form of images and the extracted image features are fed to the neural network for learning. The recognition of unknown face image is performed by comparing this special pattern to the pattern for which an image module has already been built.

1. INTERODUCTION

Access control by face recognition has the following advantages in comparison with other biometrics systems. There are no requirements for expensive or specialized equipment; a system may be built using a simple video camera and a personal computer. The system is passive. There is no need to touch something by fingers or palm, no need to say any word or lean eye to a detector. Any person just may walk or stay before the camera, and the system performs recognition. It is especially useful in everyday usage. Also it has advantages in different external or non-standard situations, where it is impossible or inconvenient to deploy other systems.

The subsequent discussion of face recognition system has been organized into four major sections. Section two gives a brief introduction of the face recognition system. Then implementation of face recognition system using neural network technique has been discussed in section three. Section four describes the results of performance analysis and finally, section five includes the conclusion and observations.

2. WORKING PRNCIPLE OF FACE RECOGNITION SYSTEM

Face recognition system works by first obtaining an image of a person. This process is usually accomplished by a video camera with at least 320x240 resolutions and at 3-5 frames per second. High quality cameras will of course produce more accurate results. Then, the computer software analyzes certain features of that image through different techniques, or a combination of techniques. Finally, verification of a person's identity is accomplished by comparing and matching his face image features to the features of other images stored in a database [1]. The analysis process has moved away over the years from the use of simple geometry of key facial points to the use of more complex mathematical techniques [2].

3. IMPLEMENTATION OF THE FACE RECOGNITION SYSTEM

There are many techniques to recognize the image pattern such as Hidden Markov Model, Statistical Pattern Recognition Technique, Genetic Algorithm, Neural Network etc. For face image recognition, Neural Network Technique has been used in this work [3]. Artificial neural network is one of the most interesting and active areas of computer science. It is a modern technology in the field of applied computing. The implementation of this

system depends mainly on the image processing technique with neural networks [4].

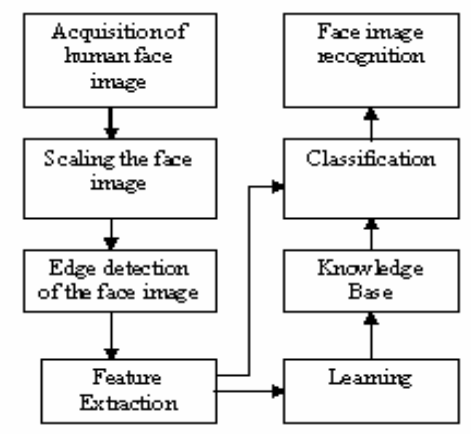

Fig.1 Block diagram of the face recognition system

Each individual subsections of image processing are being discussed in the following parts:

Image Processing of the Face Recognition System

3.1 Image Acquisition

The first step in image processing is image acquisition; that is to acquire a digital face image. To do so, an imaging sensor along with signal digitization capability is required so that captured image can be converted to digital form directly. Digital camera is being used to capture image and to get the digital form of face images. Better digital camera must be used for good face image [4]. Fig. 2 represents a sample of face image which was being obtained using digital camera.

3.2 Image Scaling

After acquisition of face image, it was being scaled. In this work, scaling on the face image was being done to get the actual shape of face from its original image. It was observed that the background color of the original form of face image was black or like shadow and the original shape of face (i.e. foreground color) was not actually black which means there was some dissimilarity between the foreground and background color. So, using scaling technique, we removed the background color from the original image and obtained the actual shape of face image.

Fig. 2: Sample face image

Algorithm for detecting the starting point of top-left and top-up is given below:

Step1: Set X = first window width
Step2: Set Y=first window height
Step3: For j=0 to Y
Step4: For i=0 to X
Step5: If (colorvalue[i][j] != BLACK or GRAY) then
Step6: Set StartX1 = I and StartY1 = j
Step7: Exit from For loops
Step8: End of if
Step9: End of For loops
Step10: End of For
Step11: For i=0; to X
Step12: For j=0; to Y
Step13: if (colorvalue[i][j]! = BLACK or GRAY) then
Step14: Set StartX2 = I and StartY2=j;
Step15: Exit from For loops
Step16: End if
Step17: End of for loop
Step18: End of loops
Step19: Set StartX = Minimum (StartX1, StartX2)
Step20: Set StartY = Minimum (StartY1, StartY2)

Algorithm for detecting the ending point of bottom-right and bottom-down is given below,

Step1: Set X = first window width
Step2: Set Y = first window height
Step3: For j = Y to 0
Step4: For i = X to 0
Step5: if (colorvalue[i][j] != BLACK or GRAY) then
Step6: Set EndX1= i and EndY1 = j
Step7: Exit from for loops
Step8: End of if
Step9: End of For
Step10: End of For
Step11: For i = X to 0:
Step12: For j = Y to 0
Step13: if (colorvalue[i][j] != BLACK or GRAY) then

Step14: Set EndX = i and EndY = j
Step15: Exit from for loops
Step16 End of if
Step17: End of for
Step18: End of For
Step19: Set Endx=Minimum (EndX1, EndX2)
Step20: Set EndY = Minimum (EndY1, EndY2)

After applying this algorithm, we get the starting and ending point of face. This gives a frame of face image by subtracting extra portion of the image. This is necessary because only the part of the image that contains the face is to be considered in the system. Scaling technique is applied on this resized image and finally the following scaled form of the face image is obtained (Fig. 3).

Fig. 3: Scaled face image

3.3 Filtering or Edge Detection

Different edge detection technique can be used for detecting the edge of a face image. For this specific case, Highpass filtering or edge detection technique was being applied on the experimental face images. Regarding performance, Edge detection technique was observed better and is considered as the best for the face recognition system. As a mask of the edge detection technique, 'Quick Mask' (Fig. 4) was used. The reason for choosing quick mask is that the processing time for quick mask is less than any other mask such as Sobel, Prewitt and Kirsch masks. Quick mask is applied in only one direction for an image; on the other hand, masks like Sobel, Prewitt and Kirsch are applied from eight direction of an image [6]. This makes the operation of quick mask eight times faster than other masks [5]. The result of applying a 3X3 quick mask on the scaled image (Fig. 3) is shown at Fig. 5.

$$\frac{1}{9} X \begin{bmatrix} -1 & 0 & -1 \\ 0 & 4 & 0 \\ -1 & 0 & -1 \end{bmatrix}$$

Fig. 4: 3X3 Quick mask

Fig. 5: Edge detection from the scaled image

3.4 Feature Extraction of the face image

Feature extraction means extracting the recognizable properties of an image. For performing feature extraction of an image, segmentation is required. Segmentation process partitions an input image into its constituent parts or objects. To extract the feature of face images, we divided them into an 18X18 matrix. The algorithm for this feature extraction process is given below,

Step1: Set X = image width
Step2: Set Y= image height
Step3: Set Width = X / N1
Step4: Set Height = Y / N2
Step5: Set Total_pixel = Width × Height
Step6: For i = 1 to N1
Step7: For j= 1 to N2
Step8: Weighted_sum = 0
Step 9: For m = (i-1) × Height To (i × Height)
Step10: For n = (i-1) × Width To (j × Width)
Step11: Weighted_sum = Weighted_sum +
(color_value[n][m] / maxcolor)
Step 12: End of loop n
Step 13: End of loop m
Step 14: Threshold = Weighted_sum / Total_pixel
Step15: End of loop j
Step 16: End of loop i
Step 17: End

Features extraction process provides us with feature matrixes containing the recognizable features of the face images. Image processing for face recognition ends here. These feature matrixes are used in the subsequent phases related with neural network training and recognition.

Neural Networks of Face Recognition Systems

3.5 Learning of the face Recognition System

The face recognition part of the secure personnel identification system has been developed with a 3-layer Back Propagation Neural Network (BPNN).

Feature matrixes are used to train the neural network using Gradient Descent learning algorithm. After learning is complete, adapted weight vector and threshold values are stored in the knowledge base and these values are used for enabling the system to recognize any test face image in future.

3.6 Recognition of Face Image

When we go for testing the system, an image of human face is captured with digital camera. This image is then scaled and is resized in both horizontal and vertical direction to obtain only the part of the image that contains the structure of human face. Edge detection and feature extraction operation is then performed on this scaled image. The extracted feature matrix is then fed for recognition into the 3-layer trained neural network with adapted weight vector for hidden and output layer. Output of the hidden layer is calculated by comparing the weighted sum of each node to the corresponding threshold value. These outputs are then used for calculating the weighted sum for the output layer. Actual output of the output layer is obtained by comparing this weighted sum with the threshold values of each output node. For every pattern that we have used for training the system, a corresponding binary target output was used for calculating error. When a face pattern is presented to the system, their deviations with other patterns were calculated using the following equation.

$$Error_{a} = 0.5 \sum (t_{ak} - o_{ak})^2$$

Here 'a' is the input pattern, t_{ak} is the target output and o_{ak} is the actual output. Input pattern will generate the least amount of deviation (error) with the target output, which actually represents the input face image.

4. PERFORMANCE ANALYSIS

For performance analysis, the system was first trained with 30 different non-distorted face images. During the training session, gain factor of the neural network was set as: $\eta_1 = \eta_2 = 0.9$. Used spread factor (network constant) was $k_1 = k_2 = 0.15$ and tolerable error rate was fixed to 0.001%. After completion of training, these 30 face images were used to test the system in a random order. For analyzing the capability of the system in recognizing distorted face image, noise was added to this image in different rate by changing several entry of the feature matrix of each image. These distorted images were then provided to the network for recognition. Complete result is shown in table 1.

Table 1: Results of Performance Analysis

No. of Image	% of Noise	No. of Success	No. of Failure	Efficiency
30	0%	28	2	93.33%
30	5%	25	5	83.33%
30	10%	23	7	76.67%
30	15%	20	10	66.67%

5. CONCLUTION AND OBSERVATIONS

As shown in table 1, recognition capability of the system decreases as the amount of noised added to the input image increases. So, to obtain better performance from the system, the captured image should be kept noise and distortion free. Higher quality image capturing device might be a potential solution to this problem. Changing the internal structure of neural network can increase the performance of the system to a great amount. For example, number of nodes in the hidden layer for the neural network that was used in this system was 100. Increasing this number can improve the efficiency over 93.33%. But this will obviously increase the learning time in a large amount. Optimization of weight for the neural network using Genetic Algorithm may improve the system performance and reduce the learning time considerably.

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