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Comparison and a Neural Network Approach for Iris Localization

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Abstract

This paper presents a fast and reliable approach for the localization of an iris image using neural networks by comparing some of the existing localization methods. Normally any biometric recognition system is used for identification of an individual and verified with the available database to check whether the person is authorized or not. Nowadays, iris recognition systems are considered the best authentication method compared to other biometric systems due to the unique characteristic feature of the human iris. In iris recognition systems, the important and difficult step is to locate or segment the iris from the input eye image which is responsible for success rate of the iris recognition. Hence this paper suggests a efficient approach to locate the iris using neural networks in order to improve the efficiency of recognition systems. Further, the paper compares the existing iris localization methods such as Daugman algorithm, Hough transform and Canny edge detector algorithm. The best localization algorithm is chosen for training a network and simulating for efficient and fast segmentation of irises with good success rate.

Keywords: Iris recognition;Iris localization;integro-differential operator;hough transform;canny edge detector;neural networks;training;

1. Introduction

Biometrics as form of unique identification is one of the subjects of research that more rapidly grow in Computer Science. The advantages of unique identification using biometrics features are numerous, such as fraud prevention and ease of use. Although the current state of art provides reliable automatic recognition of biometric features, the field is not completely researched. Different biometric feature offer different degrees of reliability and performance. The demand for high security has increased nowadays. In every field, there is requirement to preserve the confidential information and authentication is a much needed one in today's environment. It is a necessity for any organization that only the authorized users must be allowed to access the information that is private or local. For providing such security we need to authenticate every user. There may be many millions in this world; among them we have to identity each individual uniquely. There are lots of recognition systems available for this authorization. One of the efficient secured systems is iris recognition biometric system. Every person in this world will have unique iris from each other. So by using this iris recognition we can distinguish the users.

The foremost step in this process is the iris localization. Even though the previous methods may be robust in noisy situation, it takes sometime for the exact location of iris. It may be fast, but under noisy situations it consumes time while finding the location. In our approach, since we train the system for the best localization method using neural networks, it is even more fast and reliable than the other existing methods. There is no complexities and formula in this approach. It will provide the exact and accurate result for any input provided. It is robust even under noise situations. The cost is reduced and the approach is effective when compared to previous works done.

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2. Iris Localization

Iris localization refers to the separation of iris from other parts of the eye. This will help to locate the unique portion of the eye, i.e. iris. The first step in iris localization is to detect pupil which is the black circular part surrounded by iris tissues. The centre of pupil can be used to detect the outer radius of iris patterns. The important steps involved are:

- Pupil Detection
- Outer Iris Localization

In case there are eyelids and eyelashes in the image or eye, there are eliminated by considering only the unique iris portion. There are lot of iris localization algorithms available.

2.1. Integro - differential operator

This is one of the earliest methods for the process of iris localization. This was introduced by Daugman. This was the first technique introduced in the area of iris localization. Daugman was the first person to explore in this area. He used Gaussian filter for smoothing and integration operator along the iris circle. This method tries to find a circle in image with maximum gray level difference with its neighbours. First, inner boundary is localized, due to significant contrast between iris and pupil regions. The outer boundary is detected using same operator with difference radius and parameters. The integro-differential operator equation is

$$max(r,x_0, y_0) \left| G_\sigma(r) * \partial/\partial r \int_{(r,x0,\ y0)} I(x,y)/2\pi r\ ds \right| \tag{1}$$

where: x_0, y_0, r: the center and radius of coarse circle (for each of pupil and iris).$G_\sigma(r)$: Gaussian function. Δ r: the radius range for searching for. I (x, y): the original iris image. $G_\sigma(r)$ is a smoothing function, the smoothed image is then scanned for a circle that has a maximum gradient change, which indicates an edge. The above algorithm is done twice, first to get the iris contour then to get the pupil contour. It worth mentioning here the problem is that the illumination inside the pupil is a perfect circle with very high intensity level (nearly pure white). Therefore, we have a problem of sticking to the illumination as the max gradient circle. So a minimum pupil radius should be set. Another issue here is in determining the pupil boundary the maximum change should occur at the edge between the very dark pupil and the iris, which is relatively darker than the bright spots of the illumination. Hence, while scanning the image one should take care that a very bright spot value could deceive the operator and can result in a maximum gradient [1].

2.2. Hough transform

This is another method for detecting the iris boundaries. This method was proposed by Wildes using the edge detection operator. Wildes used an approach based on consistent measuring optimization. This method has a high computational cost, since it searches among all of the potential candidates. For eyelid detection Wildes used some constraints to locate the true edge points. Hough transform is a standard algorithm for line and circle detection. The main advantage of the Hough transform technique is that it is tolerant of gaps in feature boundary descriptions and is relatively unaffected by image noise, unlike edge detectors.

In theory any kind of curve can be detected if it is expressed as a function of the form

$$f(a1, a2, \ldots, an, x, y) = 0 \tag{2}$$

For example a circle can be represented as

$$(x - a)2 + (y - b)2 - r2 = 0 \tag{3}$$

Then we have a n dimensional parameter space (three dimensional space for a circle). This model has three parameters: two parameters for the centre of the circle and one parameter for the radius of the circle.

2.3. Canny edge transform

Canny edge detector is another method used for iris localization. The Canny edge detector reads the image initially and converts it into the image of class double. Initialize the required value for sigma, minimum and maximum hysteresis threshold which helps to create Gaussian kernels and image deviations for both x and y directions. The gradient magnitude is computed based on the derivatives in x and y. Finally the non-maximum suppression and post hysteresis values are applied to the gradient value. Now the edges are extracted by canny edge detector from the image. It can minimize multiple edges into a single one, and thinning, which reduces width to one pixel. The extracted edges are arranged by connected adjacent edges to make a group for applying the bisection method.

The Canny edge detection operator [2] consists of a gradient computation for each pixel of the image, and construction of a binary edge map by post-processing with non-maxima suppression and hysteresis thresholding. The gradient is computed using a scale-dependent differential geometry operator. We applied the same type of post-processing for binarization to the Gabor energy operator. The two parameters of the canny edge detector are, the standard deviation of a Gaussian smoothing kernel, and, the minimum fraction of edge pixels that have to be retained in the final edge map. The same parameters are used for the Gabor energy operator, where the parameter denotes the standard deviation of the Gaussian factor of the concerned Gabor function. The contour operators have an additional parameter, texture inhibition factor to extract the edges.

3. Iris Normalization

The variant conditions of image capturing can influence the size of iris which must be processed in the system. To compensate the stretching of the iris texture as the pupil changes in size, and have a new model of iris which removes the non-concentricity of the iris and the pupil. A metric called the normalized Hamming distance, which measures the fraction of bits for which two iris codes disagree. A low normalized Hamming distance implies strong similarity of the iris codes. If parts of the irises are occluded, the normalized Hamming distance (4) is the fraction of bits that disagree in the areas that are not occluded on either image. To account for rotation, comparison between a pair of images involves computing the normalized Hamming distance for several different orientations that correspond to circular permutations of the code in the angular coordinate. The minimum computed normalized Hamming distance is assumed to correspond to the correct alignment of the two images.

$$HDnorm = 0.5 - (0.5 - HDraw)\sqrt{9/11} \quad (4)$$

4. Neural Networks

Neural Networks is a very diverse field and many researchers have been investing a great deal of time trying to figure out new ideas and new networks. For the problem in hand, supervised network training and classification, several network models are available, and we've chosen "Feedforward Backpropagation" because it is very well suited for supervised problems, and it is very simple to implement. If data has been properly preprocessed, the classification rate of backpropagation networks is similar to more sophisticated networks, as Radial Basis Function (RBF) networks.Neural Network is a training tool used to train the system to produce an output based on the particular input. It requires various sets of network inputs with the corresponding target outputs. An algorithm or method is selected and used in this process to obtain the training data samples. This will be a reliable approach for locating the iris.

4.1. Training in neural networks

For training in the neural networks, the network input and its corresponding target outputs must be provided before performing the training operation. The training is done for various network inputs and targets repeatedly, so that the system will make adaptive learning. This will help in the simulation to produce the output quickly and exactly. The training is said to be successful only if the goal is met, and a graph is generated during the training.

The training process requires a set of examples of proper network behaviour that includes network inputs and target outputs. During the training, the weights and biases of the network are adjusted iteratively to optimize the network performance function. The performance function for the networks is mean square error (MSE) - the average squared error between the network output and the target output [5].

There are generally five steps in the training process:

Step 1: Generation of Network Inputs and Targets

Step 2: Pre-process the Data

Step 3: Initialize the Weight Values

Step 4: Forward Propagation

Step 5: Adjust Weight Values

The process in the neural network involves training various sets of network inputs and target outputs. In order to perform the training, create a network with certain specifications. Initially create a feed forward propagation network. The minimum and maximum value of the pixels in the network input is found. The size of the image that we have used as network input is 280 x 320(Height x Width).

In order to improve the performance of ANN, four methods are applied. They are described as follows.
- Fast processing
- Selection of number of hidden neurons
- Using adaptive learning rate
- Adding a control loop

Our Neural network architecture for the system is shown in Fig 1. The network specifications required for training our iris localization network are as follows:
- Network type : Feed Forward Network
- Number of hidden layers : 1
- Number of neurons in hidden layer : 6
- Number of neurons in output layer : 280
- Hidden layer transfer function : "tansig"
- Output layer transfer function : "purelin"
- Training function : "traingda"
- Learning rate : 0.05
- Number of epochs : 1000
- Goal to be reached : 10^{-4}

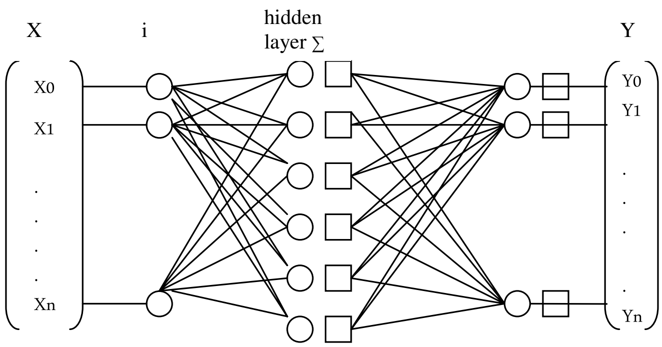

Fig. 1. Neural Network Architecture

4.2. Preprocessing

There are preprocessing methods available. Single Value Decomposition (SVD) is a powerful matrix technique with many useful applications. The main concept behind it is to expose the hidden geometry of the matrix. SVD is utilized in a variety of applications, from least-squares problems to solving of linear equations. We also benefit from SVD using it as a dimension reduction tool. The basic operation of SVD relies on the factorization of an MxN matrix ($M \geq N$).

5. Experimental Results

The iris images for the test are collected from CASIA database. In Daugman method, a gradient level is found to detect the iris using its edges that led to the introduction of circular edge detection operator for iris localization. Gaussian filter is used for smoothing and integration operator along the circle. This method finds a circle in image with maximum gray level difference. Inner boundary and outer boundary are localized based on the pixel grey level.

The other alternative method proposed by Wildes using the edge detection operator for detecting the iris boundaries based on consistent measuring optimization. Hough matrix size is identified and iris is located with radius R. This method has a high computational cost, since it searches among all of the potential candidates. For eyelid detection Wildes used some constraints to locate the true edge points.

Canny edge detection method is used to detect the edges of any given image based on the parameters. The three parameters used in this method are the maximum threshold value for hysteresis, minimum value for hysteresis, and value for generating the Gaussian kernels. Initially the image is read and it is converted into an image of class double. Initialize maximum threshold as 1.5, minimum threshold as 0.05, sigma as 1. Gaussian kernels and the image deviations are created for both x and y directions. The gradient magnitude is computed based on the derivatives in x and y axes. In this method, all the edges are detected apart from the iris. So we have to eliminate the other edges and only the iris must be segmented separately. The input and the localized iris is shown in Fig. 2.

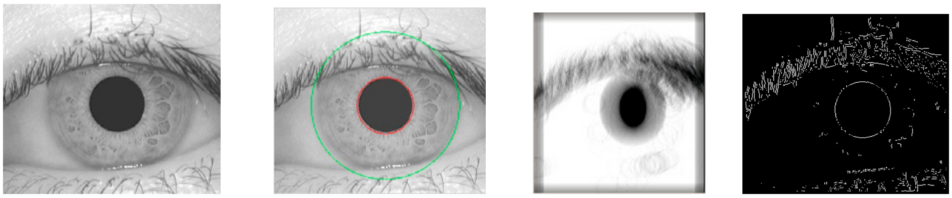

Fig. 2. (a) Input image; (b) Daugman's method; (c) Hough Transform (Wildes method); (d) Canny edge detector

The best method is selected based on the running time and the accuracy of its output. From Table 1, it is clear that among all the existing methods, the integro-differential operator is best suited for training in the neural networks.

From Table 1, based on the accuracy, Daugman method is chosen to train for segmenting the iris. Approximately a set of 87 images are used to train the network and the network is tested with 350 input images which shows excellent efficiency in segmenting the iris from the input images.

The images of the network input and target output are required for the training, the information required to create the network is the number of hidden layers and the number of neurons along with training and transfer functions. Hidden layer is nothing but the layer with some number of nodes, between the input and the output layers. There may be any number of hidden layers and neurons in the network. In this network, only one hidden layer is used to train. The number of neurons in the hidden layer is fixed to 6 and the number of output neurons is 280.

Table 1. Comparison of Localization methods

Method	Running time (in seconds)	Results
Integro-differential Operator	1.1	fast execution, more accuracy, subjected to occlusions
Hough Transformation	6	Inaccurate inner and outer edge detections
Canny Edge Detection	1.0	Flexible to varying inputs

The training becomes more efficient if the number of neurons is fixed to the number of input pixels given for training. The transfer functions used are the 'tansig' and 'purelin', whereas the training function used is 'traingda'. The training parameters such as the learning ratio, number of epochs and the goal are used for effective training. We have assumed the learning rate of the system as 0.05, the number of epochs as 1000 and the goal is fixed to 1e-4. The training is done until the goal is met or till the maximum value of epoch. Simulation is the final step in the neural networks. The network object is loaded into the workspace. Here only the network input is given, and the simulation result is produced after simulation without any target. The training process consumes almost ten minutes for every set of input and target, but in simulation the result is obtained immediately. The trained output with the performance graph is shown in Fig. 3.

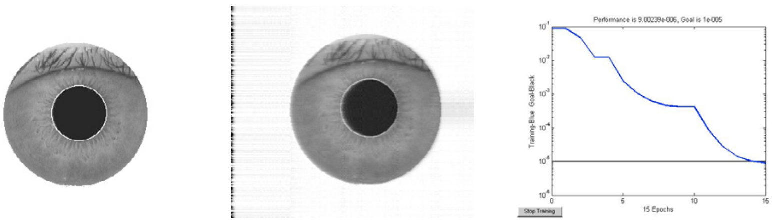

Fig. 3. (a) Target output; (b) Simulation output; (c) Training graph

6. Conclusion

In this paper a Neural Network approach is proposed by training the system for iris localization. There are many existing methods for locating the iris. The best method is selected based on the minimum response time for locating the iris i.e. how fast the iris is located and accuracy level. The integro-differential operator is chosen for training the system based on the required conditions. Especially, neural network has flexible localization even on noisy images. The missing parameter cause big error at classic localization operation thereby making neural network, a good alternative for iris localization. The study of trained output, it shows that the iris locating algorithm based on integro-differential operator suffers from bright spots of the illumination inside the pupil. This problem can be overcome by repeating the training for several times with good resolution input images.

References

[1] John Daugman. How iris recognition works. IEEE Transactions on Circuits and Systems for Video Technology, 14(1):21–30, 2004.

[2] J. F. Canny, "A computational approach to edge detection," IEEE Trans.Pattern Anal. Machine Intel. vol. PAMI-8, no. 6, pp. 679–698, 1986.3. Y. Dimitriev and E. Kashchieva, J.Mater. Sci. 10 (1975) 1419.

[3] Barzegar, N.; Moin, M.S. A New Approach for Iris Localization in Iris Recognition Systems, Computer Systems an Application, 2008. AICCSA 2008. IEEE/ACS International Conference on Volume , Issue ,Digital Object Identifier 10.1109/AICCSA.2008.4493581

[4] 4. ChengzheXu, Tauseef Ali, and Intaek Kim "A Robust Approach to Automatic Iris Localization" Signal Processing Lab, Department of Communication Engineering, Myongji University, Yongin 449-728, Korea Journal of the Optical Society of Korea Vol. 13, No. 1, March 2009, pp. 116-122

[5] T. Camus and R. Wildes, "Reliable and Fast Eye Finding in Close-up images", 16th International Conference on Pattern Recognition, vol. 1, 2002, pp. 389-394.

[6] 6. Lihong Zheng and Xiangjian He "Edge Detection Based on Modified BP Algorithm of ANN" Pan-Sydney Area Workshop on Visual Information Processing (VIP2003), Sydney. Conferences in Research and Practice in Information Technology, Vol. 36.