RADON TRANSFORM FOR FACE RECOGNITION

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Abstract

Face recognition is an important biometric because of its potential applications in many fields, such as access control, surveillance, and human-computer interface. In this paper, an investigation of the effect of the step size for both the angle and vector of the Radon transform on the performance of a face recognition system based on Principal Component Analysis (PCA) and Euclidean distance is carried out. It was found out the change of either the vector or the angle step size affects the performance of the system. However, the best equal error rate is achieved when the step size for both angle and vector is set to 1.

1. Introduction

Over the past two decades face recognition has received considerable interest as it is a widely accepted biometric because of its potential applications in many fields, such as access control, surveillance, human-computer interface, and so on. Several methods are available to extract and represent the facial features. One of the widely used representations of the face region is Eigenfaces [1], which are based on principal component analysis (PCA). The goal of the Eigenface method is to linearly project the image space to a feature space of a lower dimension.

Chunming et al. [2] proposed a face recognition method called Statistical PCA. The improved PCA algorithm is used to compute the eigenvectors and eigenvalues of the face. Then, Bayesian rule is used to design the classification rule. The experimental result shows that the method introduced has the advantages of simple computation and high recognition rate up to 95.08%.

Jamikaliza et al. [3] presented a face recognition system based on Eigenfaces as feature extractor and Fuzzy ArtMap (FAM) neural network as classifier. The motivation of using FAM as a classifier is due to its unique solution to the stability-plasticity dilemma, where it has the ability to preserve previously learned knowledge and the potential to adapt to new patterns indefinitely. They reported recognition rate of 97.22% using local dataset and 98% using ORL dataset.

Jadhao and Holambe [4] described a new technique for face recognition which uses Radon transform and Fourier transform to derive the directional spatial frequency features. The Radon transform is used for the line integral of features and the DFT is used to enhance the features. They used FERET and ORL databases and achieved recognition rates 99.133% and 97.33%, respectively.

Dabbah et al [5] presented a novel method to face biometric. They proposed randomized Radon signature (RRS) to overcome the natural limitations of biometric. They used the Eigenface algorithm for evaluation. The results have shown 81.99% accuracy.

1.1 Radon transform

The Radon transform is one of the techniques used to detect features within an image. The Radon transform defined as:

$$R(\theta,\rho) = \int_{\infty}^{\infty} A(\rho cos\theta - sin\theta, \rho sin\theta + s cos\theta)ds \qquad (1)$$

where S is defined as an integral line in the image and ρ is defined as the distance of the line from the origin and θ is the angel from the horizontal as shown in Figure 1.

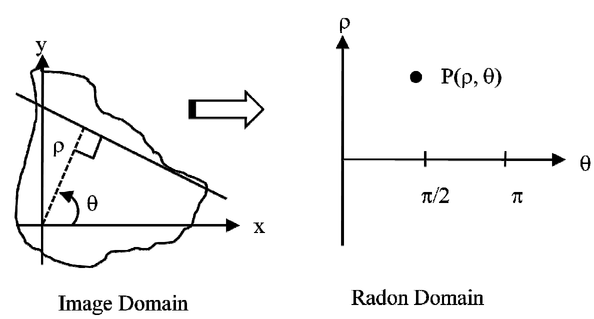

Figure 1. Image domain and Radon domain [7].

The Radon transform is a mapping from the Cartesian rectangular coordinate (x, y) to a distance and angel (ρ, θ) also known as the polar coordinate [6, 7].

2. Face databases

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A total of 500 images with frontal face of a person were selected from the FERET database. They

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represent 200 different individuals. 100 individuals are used for training & testing, and the other 100 different individuals are used for testing only. All the 500 selected FERET images were cropped to get only the desired face part of a person (from forehead to the chin). All images have been adjusted so that both eyes of an individual are aligned in the same horizontal line.

2.1 Training database

Each of the 100 persons in the training and testing database (Known Database) has four images. Up to three images will be used for training and 1 image will be used for testing. Figure 2 shows an example of training and testing database. The four images are of the same person. The three images on the left will be used for training while the image on the right will be used for testing. Thus, three training databases were created. These are (i) one image per person (1p1i), (ii) two images per person (1p2i), and (iii) three images per person (1p3i). Figure 3 shows a sample image of each of these databases.

(a) (b)
Figure 2. An example of the known database.

(a) (b) (c)

Figure 3. Examples of the training databases (a) 1p1i, (b) 1p2i, (c) 1p3i.

2.2 Testing database

Two testing databases were created. The first database, known test database, has 100 images of the 100 persons in the training database. This database will be used to test the recall capability of the face recognition system. The second database, unknown test database, has also 100 images of 100 different persons. This database will be used to test the rejection capability of the system.

3. Results and discussion

3.1 System block diagram

Figure 4 shows the block diagram of the system. The system has training and a testing stage. The Radon transform will be applied on the image to compute its 2-D projection image along angles varying from 0 to 180°. The result of the projection is the sum of the intensities of the pixels in each direction. All the projections of the image are concatenated to form 1-D radon transform's vector. The 1-D radon transform's vectors for all training images are computed. PCA is then applied on the collection of 1-D radon transform's vector to produce a low-dimensional features vector.

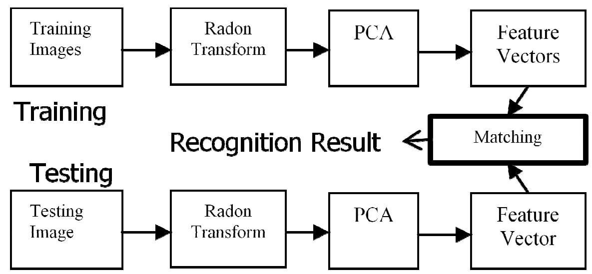

Figure 4. Block diagram of the system

For the classification task, the Euclidean distance measure is used. If the Euclidean distance between test image y and image x in the training database d(x,y) is smaller than a given threshold t then images y and x are assumed to be of the same person. The threshold t is the largest Euclidean distance between any two face images in the training database, divided by a threshold tuning value (Tcpara) as given in Equation 1.

$$t = \frac{[\, max\,\{\|\Omega j - \Omega k\|\}\,]}{Tcpara} \tag{1}$$

where j, k = 1, 2 … M. M is the total number of training images, and Ω is the reduced dimension images.

To measure the performance of the system, several performance metrics are used. These are:

- For Recall
  - ***Correct Classification***. If a test image $\mathbf{y_i}$ is correctly matched to an image $\mathbf{x_i}$ of the same person in the training database.
  - ***False Acceptance.*** If test image $\mathbf{y_i}$ is incorrectly matched with image $\mathbf{x_j}$, where ***i*** and ***j*** are not the same person
  - ***False Rejection.*** If image $\mathbf{y_i}$ is of a person ***i*** in the training database but rejected by the system.
- For Reject
  - ***Correct Classification***. If $\mathbf{y_i}$, from the unknown test database is rejected by the program

- ***False Acceptance***. If image $\mathbf{y_i}$ is accepted by the program.

3.2 Setting the Threshold Tuning Parameter

The value of the threshold tuning parameter can be used to tune the performance of the system to have either high correct recall with high false acceptance rate for application such as boarder monitoring or high correct rejection rate for unknown persons for application such as access control. For this work, the threshold tuning parameter was set so that the system has equal correct recall rate and correct rejection rate. Figure 5 shows the correct recall and rejection rates for different values of the threshold tuning parameter when the number of images per person used for training is (i) one image per person (ii) two images per person and (iii) three images per person. As can be seen from Figure 5, the equal error rate (EER) for 1p1i is 58%, 84.5% when using 1p2i, and 89% when using 1p3i training database. The value of the threshold tuning parameter (Tcpara) that gives an equal error rate depends on the number of images per person used for training. For the training database 1p3i it is 4.34. This value will be used on all subsequent investigation

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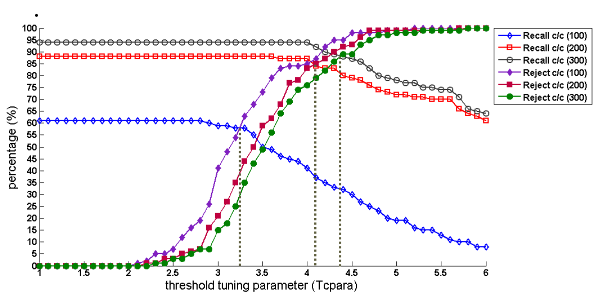


Figure 5. The effect of the threshold tuning parameter on the correct classification

3.3 The effect of the angle θ step size

We have investigated the effect of changing the angle step size on the performance of the system. The angle step size was increased by 1(default), 2, 3, …,10. As can be seen from Figure 6, the correct recall rate is constant for all step sizes of the angle. However, the correct reject rate is different for different values of step size but on average is decreasing. The highest equal error rate of 89% is achieved when the angle step size of 1.

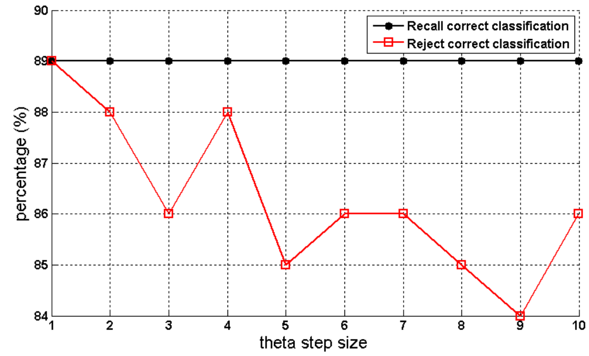


Figure 6. The effect of the angle θ step size on correct classification

3.4 The effect of the vector ρ step size

We have also investigated the effect of changing the vector (ρ) step size on the performance of the system. The vector step size was increased by 1(default), 2, 3, …,10. As can be seen from Figure 7, for step size of 3 and below the correct recall rate is higher that the correct rejection rate. However, for step size larger than 3 the reverse is true. Thus, in general the correct recall and reject rates tend to change in opposite directions as the step size increase. The step size that gives the highest equal error rate of 89% is still 1.

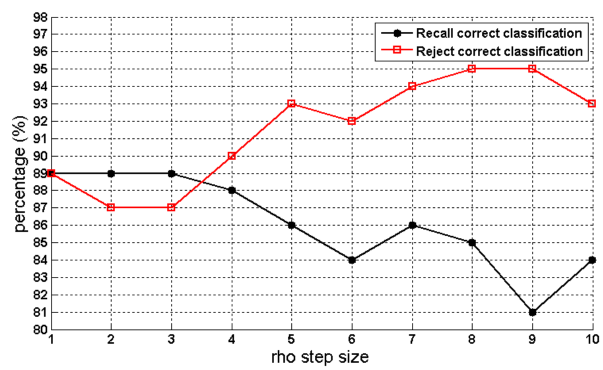
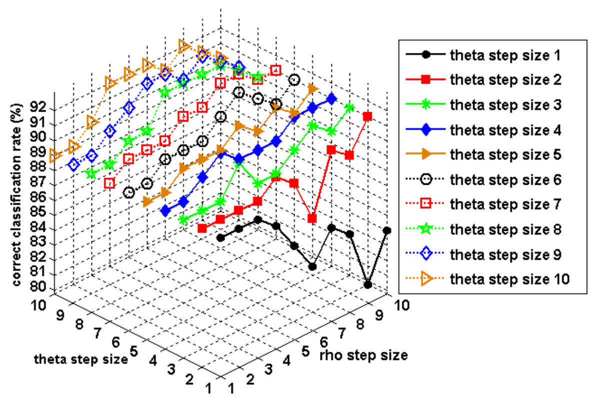


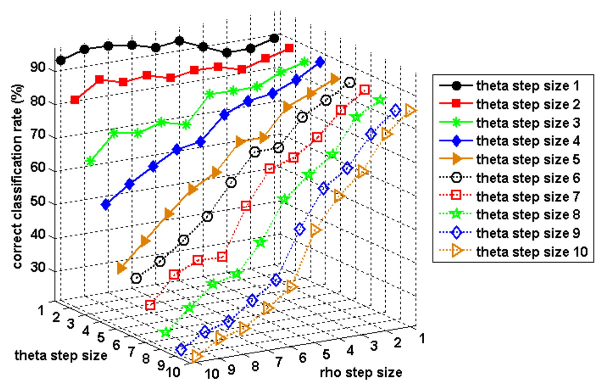
Figure 7. The effect of the vector ρ step size on correct classification

3.5 The effect of the vector and angle step sizes

We have also investigated the effect of changing both the vector (ρ) step size and the angle step size on the performance of the system. The vector and angle step sizes were increased by 1(default), 2, 3, …,10. As can be seen from Figure 8(a), for any value of the step size greater than 1 for the angle θ, the correct recall rate, on average, increases as the step size for the vector ρ increases. On the other hand, the correct reject decreases as the as the step size for the vector ρ increases as can be seen in Figure 8(b). Thus, it is possible to use step sizes of ρ and θ to select the required performance of the system. For example, the combination of step size 1 for the angle θ and step size 8 for the vector ρ gives a correct recall rate of 86% and a correct reject rate of 95%.



a. Correct recall rate



b. Correct reject rate

Figure 8. The effect of changing both the angle θ and vector ρ step size on (a) the correct recall and (b) correct reject rates

4. Conclusion

In this paper, an investigation of the effect of the step size for both the angle and vector of the Radon transform on the performance of a face recognition system based on Principal Component Analysis (PCA) and Euclidean distance is carried out. It was found out that changing either the angle θ step size or the vector ρ step size affect the performance of the system. Thus, these can be used to tune the performance of the system in addition to the Euclidean distance tuning parameter. The work carried out so far was on an image size of 60 by 60 pixels, thus, we intend to investigate the effect of having larger image sizes.

5. References

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