The PCA-Based Long Distance Face Recognition Using Multiple Distance Training Images for Intelligent Surveillance System

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Abstract. In this paper, PCA-based long distance face recognition algorithm applicable to the environment of intelligent video surveillance system is proposed. While the existing face recognition algorithm uses the short distance images for training images, the proposed algorithm uses face images by distance extracted from 1m to 5m for training images. Face images by distance, which are used for training images and test images, are normalized through bilinear interpolation. The proposed algorithm has improved face recognition performance by 4.8% in short distance and 16.5% in long distance so it is applicable to the intelligent video surveillance system.

Keywords: intelligent surveillance system, image interpolation, long distance face recognition, principal component analysis(PCA)

1 Introduction

Recently, the video surveillance system has been developed to be intelligent, which includes finding criminals automatically or detecting fires by applying the techniques such as image analysis, computer vision or pattern recognition [1]. To satisfy the intelligent surveillance system, the long distance human identification technique applicable to the surveillance camera environment is needed [2]. The studies on long distance human identification using the face are still ongoing [3, 4]. Face recognition in the surveillance camera system should be operated in long distance(3m~5m) as well as short distance(1m~2m). When the existing face recognition algorithm applies to the surveillance camera system as it is, the recognition rate is reduced as the distance between the people and the camera increases. Recently, the technology that recognizes the long distance face using expensive camera which can obtain the high quality image from long distance is being studied [5, 6]. However, in case of face recognition, using expensive camera, it costs a lot to install and manage, making it difficult to use universally. Therefore, it is necessary to develop the long distance face recognition algorithm which can operate in the existing installed surveillance camera environment.

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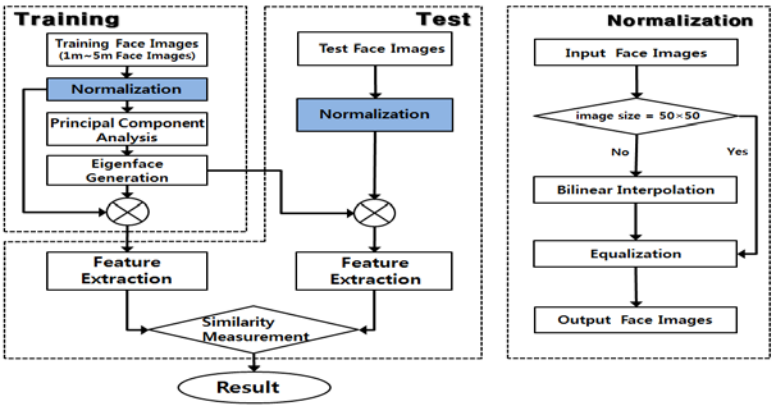
In this paper, PCA-based long distance face recognition algorithm applicable to the environment of surveillance camera is proposed. While single distance face images are used for training images for existing PCA-based face recognition, the proposed method uses face images by distance of 1m to 5m for the user training images. In addition, the size of face images extracted by distance are different for face images by distance of 1m to 5m, and thus the method is used to normalize the face images into the same size by using bilinear interpolation. As a result of experiment, the face recognition rate of existing algorithm was 86.6% in short distance and 48.4% in long distance, but the proposed face recognition algorithm showed 4.8% and 16.4% improved performance for 91.4% from short distance and 64.9% from long distance, respectively. The composition of this paper is as follows. In chapter 2, PCA, which is used in face recognition, and interpolation methods, which is used in normalization of face image size, are introduced. In chapter 3, the proposed long distance face recognition algorithm and experiment results are explained and chapter 4 concludes the paper.

2 Background

In this paper, PCA method which uses feature extraction method using basis vector are used [7]. To express two dimensional face images, face shape and texture information are vectorized. For face shape information, physiographic features like distance and ratio of face elements such as eye, nose and mouth are used. Texture information is expressed as brightness information itself in the face area by arraying the brightness value of two dimensional face images in order, features are extracted by expressing first-dimensional vector. The feature extraction process in face recognition is to find the base vector for linear transition. PCA technique is to find the eigenvector for covariance matrix as basis vector. PCA uses face images as a feature vector for face recognition by reflecting the face images to basis vector.

In case of long distance face recognition using PCA, the size of recognition images should be normalized fitting to the data size of training images. In general, since images taken from long distance are smaller than images taken from short distance, interpolation should be used to normalize the image size [8]. The nearest neighbor interpolation is the simplest method among interpolations and it refers to the pixel of nearest original images from the location that the output pixel is to be produced. Bilinear interpolation is a technique to produce the pixel to be interpolated using adjacent four pixels. The interpolated pixel is determined by the sum of four pixels multiplied by weighted value. At this time, weighted values are determined linearly and are inversely proportional to the distance from each of the adjacent pixels. Interpolation using higher-order polynomial equation defines the function of weighted value and is a method to calculate the pixel values by adding all values of neighboring pixel values of original images multiplied by weighted values. The representative method using higher-order polynomial equation includes cubic convolution interpolation. Bicubic convolution interpolation produces new interpolated pixels using 16 pixels of original images.



(a) (b)

Fig. 1. Face recognition flowchart using PCA. (a) The flowchart of proposed long distance face recognition algorithm. (b) Flowchart of face image normalization

3 Proposed Long Distance Face Recognition and Experimental Results

Fig. 1 is the flowchart of proposed PCA-based long distance face recognition. The overall flow of face recognition algorithm is same as existing PCA-based face recognition [7]. However, it has a difference in that proposed algorithm uses face images by distance of 1m to 5m as training images and adds the normalization process for face images by distance. Since PCA-based face recognition must use the difference of each face images and average face images, the size of images to be used in face recognition should be the same through the normalization. In this experiment, the size of face images was set as 50×50. 50×50 is the average size of face images extracted from 1m distance. The normaliz.ation process is shown in Fig. 1(b).

Face recognition algorithm is divided into training area and test area. Once the face images for training are entered, the size of input face images is judged. If the size of image is 50×50, the next step which is equalization will be conducted, but if the size is smaller than 50×50, the equalization will be conducted after enlarging the size to 50×50 through bilinear interpolation. All face images entered through this process will be normalized into 50×50 image size. Using normalized face images, the average face is produced in training images and by projecting each training image to the average face, the feature points unique to each face image are extracted. In test area like in training area, the input face images are normalized through interpolation and equalization. By comparing the feature points extracted from input face images to test area and feature points of face registered in training area, find the face images with the most similar values and classify.

Since the face recognition experimented in this paper needs face images by distance, the experiments in this paper used the ETRI face database [8] composed of face images by distance. ETRI face database obtained 500 face images (1m~5m: 100 im-

ages for each) per person from 10 people considering various lighting environment and distance change. The obtained face images were obtained through various lighting environment and 1m to 5m of distance change. To check whether the proposed method in this experiment is suitable for long distance face recognition situation, the experiment was conducted under the assumption that all of the face is extracted from input images by distance of 1m to 5m.

In this experiment, to select the appropriate interpolation for the normalization process of face images, 1m face images were used as training images and the face images by distance of 1m to 5m were used for test images. At this time, for normalization of face image size by distance of 1m to 5m, the nearest neighbor, bilinear, bicubic convolution and lanczos3 interpolations were used [10]. The original face image extracted from person 1 according to the distance change of 1m to 5m. The sizes of extracted face images are 50×50, 30×30, 20×20, 16×16 and 12×12 from 1m to 5m, respectively. The face images extracted by distance are normalized by four kinds of interpolation.

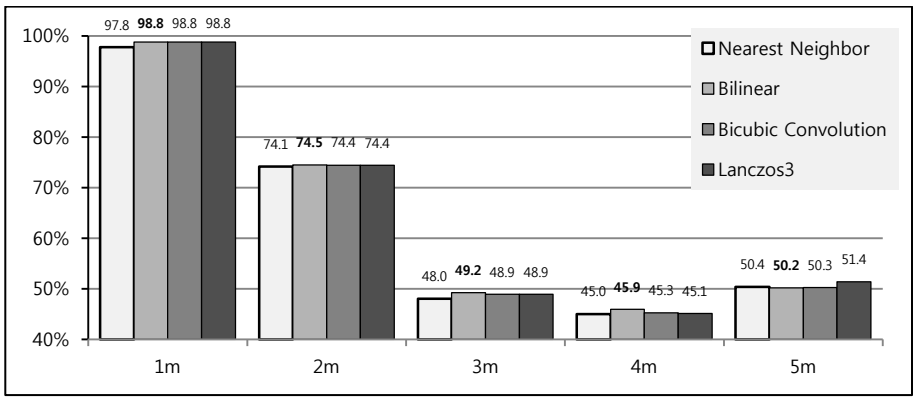


Fig. 1. Face recognition rate by distance according to interpolation.

For training images per one person, 20 images of 1m face image were used and 80 images of face image by distance of 1m to 5m were used for test images. Fig. 2 shows the change of face recognition rate by distance according to interpolation in the same training and test condition. As a result of experiment, for short distance, when bilinear interpolation was used, the short distance face (1m to 2m) had the best recognition performance which is 86.6%. When the nearest neighbor interpolation, bilinear, bicubic convolution and lanczos3 interpolations were used, the long distance (3m to 5m) showed similar performances which were 47.8%, 48.4%, 48.2% and 48.5%, respectively. Therefore, the bilinear interpolation was used in PCA-based face recognition considering the complexity of computation, execution time and performance.

The existing face recognition algorithm has only used the single distance face images for training images, but the proposed algorithm improves the face recognition rate using the face images by distance for training images. Table 1 is the experimental condition to compare the recognition rate when using single distance face images and face images by distance for training images. In CASE 1, only images taken at 1m were made up for training images and the number of training images per person used

as 20 images. In CASE 2, the number of entire training images per person was 20 images which is same as CASE 1, but instead of using 1m face images, total of 20 images with 4 images each by distance of 1m to 5m were used. Fig. 3 shows the change of face recognition rate according to construction of training images. The experiment was conducted under the same condition that the number of training images per person was 20 images. When using single distance for training images, the performance was shown for 86.6% in short distance and for 48.4% in long distance. However, when using face images by distance of 1m to 5m, the short distance had better performance for 91.4% than when using single distance for training images which is 64.9%.

Table 1. Face recognition experiment according training images

CASE	Training Condition		
1	Training image per person	-1m	: 20 images
	Test image per person	-1m~5m	: 80 images each
2	Training image per person	-1m~5m	: 4 images each
	Test image per person	-1m~5m	: 80 images each

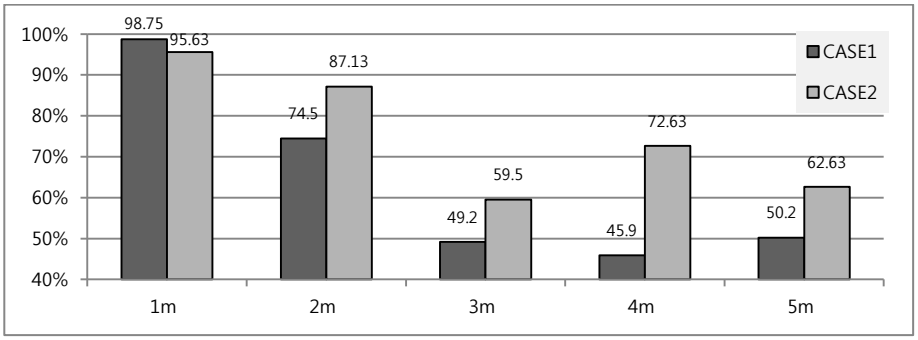


Fig. 2. Face recognition rate by distance according construction of training images.

4 Conclusions

As various incidents are frequently occurred recently, the interest in long distance human identification technology is also increasing with the development of intelligent video surveillance camera. The PCA-based face recognition which has used the existing single distance face images as training images has disadvantage of lowering the recognition rate as the distance between surveillance camera and the user increases. In this paper, PCA-based long distance face recognition algorithm that is applicable to the environment of surveillance camera is proposed. The proposed face recognition algorithm uses face images by distance of 1m to 5m for training images and the bilinear interpolation is used for normalization of input face images by various distances. As a result of experiment, the proposed face recognition algorithm had improved face recognition rate by 4.8% in short distance and by 16.5% in long distance.

In the future, to improve the inconvenience of registering face images by distance of 1m to 5m by the user, the study to produce the various face images by distance automatically will be conducted using single distance images.

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