Face Recognition under Variable Illumination Condition Using SIFT Method

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Abstract. Prior research has shown that the performance of face recognition systems in variable illumination condition degrade seriously compared with invariant illumination condition. Face recognition in variable illumination is one of the most challenging problems in this field. The scale invariant feature transform (SIFT) features have been shown to be invariant to image rotation and scale and robust across a substantial range of affine distortion, addition of noise, and change in illumination. In this paper, a method based on SIFT features is used to research on face recognition in variable illumination condition. A professional illumination-variable face database Markus Weber is used to experiment SIFT method. The experiment results show the huge potential of SIFT method in application to face recognition under variable illumination condition.

Keywords: Variable illumination; Face recognition; SIFT feature, match.

1. Introduction

Face recognition has been shown great potential applications in public security, law enforcement and surveillance, access control, digital entertainment, and others. During the past several decades, considerable progress has been made in this field [1]. Now under controlled conditions, face recognition systems perform very well, but when it comes to the variant illumination, pose and expression condition, the performance of systems need to be improved. Among these adverse factors, variable illumination has been proven that, appearance variations caused by illumination are most significant than the inherent differences been individuals [2].There are three main attempts to investigate the problem of face recognition under variable illumination. The first attempt is to reduce the influence of light source or a large amount of training data or some 3D face models whose facial shapes and albedos are obtained in advance, which is not practical for most real word scenarios [3-5].The second is to modeling the illumination variations. [6] Has shown 3D model based illumination modeling methods? The third attempt is to extract the illumination invariant features or descriptors for image representation [7].A same problem of these method is that the computation is not efficient enough.

In this paper, the Scale Invariant Feature Transform (SIFT) is proposed to dealing with above problem. SIFT features are extracted from images to help in reliable match between different views of the same object by SIFT. These features are invariant to scale and orientation, and highly distinctive of the image [8]. Before this, SIFT has already been used for recognizing faces in controlled situations, and performed well [9-11]. This paper proved that SIFT could also perform well under variable illumination situation by some experiments based on a professional illumination-variable face database.

The rest of this paper is organized as follows. Section 2 reviews SIFT method. In Section 3, our approaches are described, to extract SIFT features of illumination-variant faces images. Extensive experiments are conducted and results are analyzed in Section 4. Finally, Analysis and conclusions are presented in Section 5.

2. The Scale-invariant Feature Transform

The scale invariant feature transform, called SIFT descriptor, has been proposed by Lowe[8], and proved to be invariant to image rotation, scaling, translation, projective transform , and partly illumination changes. So the features extracted by SIFT have been shown to be invariant to image rotation and scale and robust across a substantial range of affine distortion, addition of noise, and change in illumination. The basic idea of the SIFT descriptor is detecting feature points efficiently through a staged filtering approach that identifies stable points in the scale space. The approach is efficient on feature extraction and has the ability to identify large numbers of features.

The SIFT features are extracted in four steps [8]. The first step is to construct a Gaussian scale space function from the input image, to compute the locations of potential interest points in the image by detecting the maxima and minima of a set of Difference of Gaussian(DoG) filters applied at different scales all over the image. Then, these locations are localized to sub-pixel accuracy and eliminated if found to be unstable. The third step is to assign an orientation to each key point based on local image features. A histogram of orientations is formed from the gradient orientation at all sample points within a circular window of a feature point. Peaks in this histogram correspond to the dominant directions of each feature point [10]. These orientations, scale and location for each key point enable SIFT to construct a canonical view for the key point that is invariant to similarity transforms [12]. Finally, a local feature descriptor is computed at each key point. This descriptor is based on the local image gradient. Generally, the gradient magnitude and the orientation are smoothed by applying a Gaussian filter and then sampled over a 4×4 grid with 8 orientation planes. Then, each feature is a vector of dimension 128 distinctively identifying the neighborhood around the key point [9].

When it comes to matching feature vectors of two images, a simple Euclidean distance measure is used. A feature is considered matched with another feature when the distance to that feature is less than a specific threshold T of the distance to the next nearest feature. Then, the number of false matches can be reduced.

3. SIFT Features of Illumination-variant faces images

The SIFT descriptor is useful for dealing with illumination-variant face recognition, several noteworthy characteristics are as followed: (1) The features are invariant to image rotation, scaling, translation, partly illumination changes, and projective transform; (2) the information of SIFT features are richness, and they are highly distinctive of images. It is appropriate for processing fast and exact matching in a mass amount of feature database; (3) Large numbers of SIFT vectors can be extracted from a few objects in the image; (4) It can be associated with other methods, and easy to be expanded.

For validating the performance of SIFT descriptors, the professional illumination-variable face database Markus Weber is used [13-14].The database contains 450 images collected in different illumination background, and offered by 27 persons. Fig. 1 shows original images in the database, while figure 2 shows the SIFT features of face images. The length of red arrows represent the scale of key points, the green circles where the starting points of arrows are the location of key points, the direction of arrows represent the gradient orientation of key point corresponding to each scale. Fig. 2 illustrates that a large number of SIFT features could be extracted from face images.

Fig.1 original images in the database

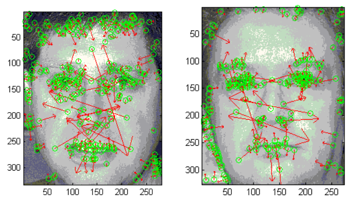

Fig. 2 SIFT features (marked as arrows) of face images

Some matching results of variable illumination (including indoor and outdoor illumination conditions) SIFT features are shown in Fig.3.The blue lines show the right matching points, while the red lines show the wrong matching points.

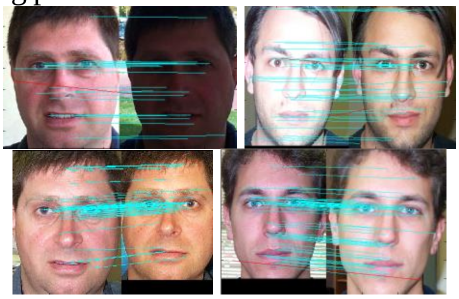

Fig. 3 Matching results for different illumination with threshold T=0.6

4. Recognition Experiments and Results

A recognition experiment is conducted base on Markus Weber database. The database contains 450 images collected in different illumination background, and offered by 27 persons. One image per person is chosen to be sample image, other 423 images are used to test. First, the SIFT features are extracted from all sample images. Then, a test face image is given, the features extracted from this image are compared against the features from each sample image. The sample image with the largest number of matching points is considered the nearest face image, and is used for the classification of the test image. Table 1 shows the False Accept Rate (FAR) with different threshold T, and it clearly shows that the FAR is smaller by decreasing threshold T. We obtain best result with T=0.4. The results also illustrate the SIFT method could recognize faces with variable illumination.

Table 1 Recognition results of illumination-variant face recognition by SIFT

THRESHOLD	T=0.60	T=0.55	T=0.49	T=0.45	T=0.40
FAR	8.27%	6.86%	4.96%	4.73%	4.73%

5. Conclusion

This paper proposes SIFT method for face recognition under variable illumination condition. The advantage of making use of SIFT algorithm is as follows: it can match and recognize face images of differ-size without normalizing face image complicatedly, and the method does not need training process, computing and experimentation are all simple. Several experiments are conducted, and the results show that SIFT could overcome the difference of faces coursed by variable illumination condition and extract more useful features of face. The recognition experimental results, performed on a professional illumination-variant face database, demonstrate the huge potential of SIFT algorithm in application to face recognition with variable illumination.

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