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ScienceDirect
Pattern Recognition 41 (2008) 2253–2262
PATTERN RECOGNITION
THE JOURNAL OF THE PATTERN RECOGNITION SOCIETY
www.elsevier.com/locate/pr

Recognition of camera-captured low-quality characters using motion blur information

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Received 11 August 2006; received in revised form 9 January 2008; accepted 10 January 2008

Abstract

Camera-based character recognition has gained attention with the growing use of camera-equipped portable devices. One of the most challenging problems in recognizing characters with hand-held cameras is that captured images undergo motion blur due to the vibration of the hand. Since it is difficult to remove the motion blur from small characters via image restoration, we propose a recognition method without de-blurring. The proposed method includes a generative learning method in the training step to simulate blurred images by controlling blur parameters. The method consists of two steps. The first step recognizes the blurred characters based on the subspace method, and the second one reclassifies structurally similar characters using blur parameters estimated from the camera motion. We have experimentally proved that the effective use of motion blur improves the recognition accuracy of camera-captured characters.

Keywords: Motion blur; Digital camera; Low-quality character; Character recognition; Generative learning method

1. Introduction

Character recognition technologies using portable digital cameras have gained attention in recent years in proportion to the diffusion of portable digital imaging devices [1]. However, even with the improvement of the devices, the quality of captured images is still not sufficient for recognizing characters in many practical cases. For example, characters in such images tend to be small and blurred even from a slight vibration of the hand holding the camera. This problem becomes more serious when the photographer backs the camera away from the target document, trying to capture a larger part of it. In this paper, an approach to recognize low-quality characters in such blurred image is presented.

As described above, image degradation is an unavoidable problem peculiar to camera-based character recognition. One of the main approaches to cope with such degradation is image restoration [2]. Various attempts have been made for image restoration. In Ref. [3], Hobby proposed a super-resolution method for small characters, and in Ref. [4], Li et al. used multiple images to create super-resolution image, while in Ref. [5], Mancas-Thillou et al. used a Teager filter to enhance low-resolution text. The PSF (point spread function) can also be applied to remove optical blur. The compound method proposed by Tsunashima et al. [6] is a simple but effective way to obtain the optical blur PSF because it allows us to estimate it by simply averaging multiple captured images. Another form of degradation to be removed is motion blur, which requires the identification of blur parameters [7]. Ben-Ezra et al. proposed a method for de-blurring motion blurred images using PSF [8].

In practical applications, however, restoring an image is not always effective for character recognition because small characters are difficult to de-blur. This paper proposes a recognition method that does not need any restoration. It instead, copes with the degradations by learning artificially degraded images and using estimated motion blur information.

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0031-3203/$30.00
doi:10.1016/j.patcog.2008.01.009

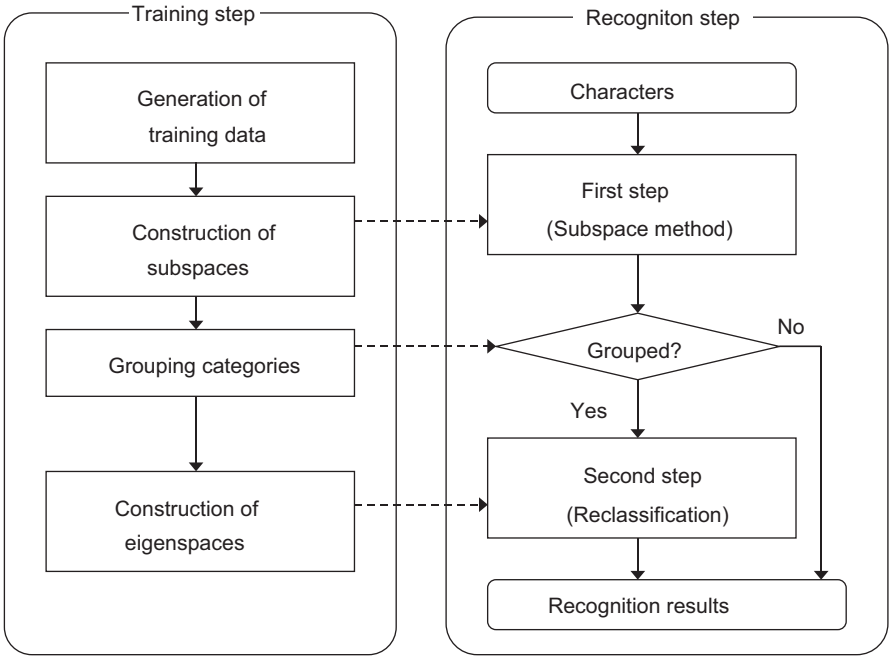

Fig. 1. Flow of the proposed camera-based character recognition.

In our previous papers [9,10], models for generating such images were presented and used for constructing subspaces. However, the use of generation models was limited to obtaining training sets. Once the subspaces were constructed in the training step, test images were compared only with them regardless to the individual training images with various degradation parameters. The proposed method also uses the subspace in the first step of recognition, but in the second step, the test images are directly compared with the generated images by means of eigenspace method [11] in order to correct the misclassifications in the earlier step.

Fig. 1 illustrates the flow of the proposed method. The training step is based on the generative learning method [9,10], where training images undergoing various speeds and orientations of motion blur are generated. The recognition method consists of two steps. The first employs the subspace method [12], whose effectiveness for low-resolution character recognition is demonstrated in Ref. [13]. However, the subspace method constructs a single subspace from the training images with various speeds and orientations of blur, which often yields the misclassification among structurally similar characters. The eigenspace method [11] is more effective for such characters, since the similarity to each training image is evaluated. A reclassification based on the eigenspace method is then introduced as the second step to improve the recognition accuracy of such characters. This second step reclassifies characters by effective use of the motion blur. For this purpose, motion blur parameters are estimated from camera motion; the similarity between the characters and training images simulated with the motion blur parameters is evaluated in the recognition step.

This paper is organized as follows: Section 2 explains the generation process of the training images which are used in all stages of the recognition. The parameters used both for the image generation and for the recognition are also introduced first in this section. Section 3 describes the first step of the recognition using the subspace method. Section 4 details the second step of the recognition using the eigenspace method and estimated blur parameters. Section 5 demonstrates the performance of the method through an experiment, and Section 6 concludes this paper.

2. Generation of training images

The generative learning method was developed to generate degraded patterns by simulating actual degradation. Traditionally, this synthesis-based approach has often been used for learning distorted characters in handwritten character recognition [14,15]. We have been applying a generative learning method to camera-based character recognition, and have so far investigated the effectiveness of an optical blur model and a motion blur model in Refs. [9,10], respectively. Also, the effectiveness of using a resolution transformation model to simulate low-resolution characters has been demonstrated by Sun in Ref. [16]. In contrast with the collection-based approach such as that introduced in Ref. [17], the generative learning method eliminates the exhaustive collection of training images. It enables us to acquire parametrically degraded character images in accordance with the actual degradations.

2.1. Generation models

To simulate various degradations, four generation models are defined along with parameters that control the degradation degree of images. The generation models used for this work are listed below.