

Recognition of Characters Distorted by Camera Angle

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Abstract

At present, many researches of the character recognition have been proposed. Most of them treat non-distortion characters, but characters taken by a camera are often distorted by the camera angle. In this paper, we propose the recognition method of characters distorted by the camera angle. We will show the effectiveness of our method. We used the reverse perspective transformation to recover the distortion. The recovering parameters are determined by using the similarity that is calculated by the character recognition. The recovering parameters that have the high similarity are regarded as the correct parameters. In this method, we treated the distortion of characters in the scene taken by a camera and we supposed that characters written on the plane. We made experiments with the virtual and the real images and confirmed the effectiveness of our method.

1. Introduction

In recent years, the digital camera and digital video camera have widely spread. And the opportunity of handling the image taken by a camera has increased. So, the character recognition of the scene taken by a camera has been required. At present, many researches of the character recognition have been proposed, especially the recognition of characters in the text. Researches of the characters in the image taken by a camera are actively proposed, but most of them are the research of the character segmentation^{[1][2]}, not the recognition of characters. Therefore it is not known whether these segmented characters can be recognized.

When characters taken by a camera are recognized, the distortion of the character by the position of the viewpoint is a problem. Many conventional character recognitions suppose that characters are not distorted. However, actual characters are distorted by the positional relationship between the viewpoint and the character location. It is conceivable to depend on the supplementary information except characters, such as frame and camera parameter to correct these distortions^{[3][4][5][6]}. In the case that the supplementary information was not obtained precisely, these methods

are not effective. Therefore, in order to recognize the character without giving the information except characters, we propose a method, which recovers and recognizes the distorted character automatically by using information only of the character.

The purpose of this work is to recognize the character in the real images taken by a camera. In this paper, we paid attention to the distortion of the character. The recovering and recognition of distorted characters written horizontally on the plane are mainly described.

We can make the distorted character image written on the plane by using perspective transformation. So the reverse perspective transformation can recover the distortion.

In this case, the problem is the decision method of the recovering parameter. We used the similarity of the character to decide the recovering parameter. This similarity is obtained as the result of the character recognition. In the case that the character was recovered correctly, the similarity is high while it is low if the character was not recovered correctly. When the parameter searching started, we had no information of the similarity. Therefore, we searched the recovering parameter that has high similarity based on this theory.

In chapter 2, we describe the searching method of the recovering parameters. In chapter 3, we summarize the constitution of the recognition system. In chapter 4, we show the results of the experiments using synthesized image. In chapter 5, we show the result of the recognition experiment for the image taken by a camera. In section 6, the effectiveness of our system and future works are discussed.

2. The searching method of the reverse perspective transformation parameters

We describe the searching method for the recovering parameter. Fig.1 shows the flow of the searching process. The recovering parameters used in the reverse perspective transformation are the rotation angle of x , y and z -axis from the vertical point on the plane. Fig.2 shows the definition of the space.

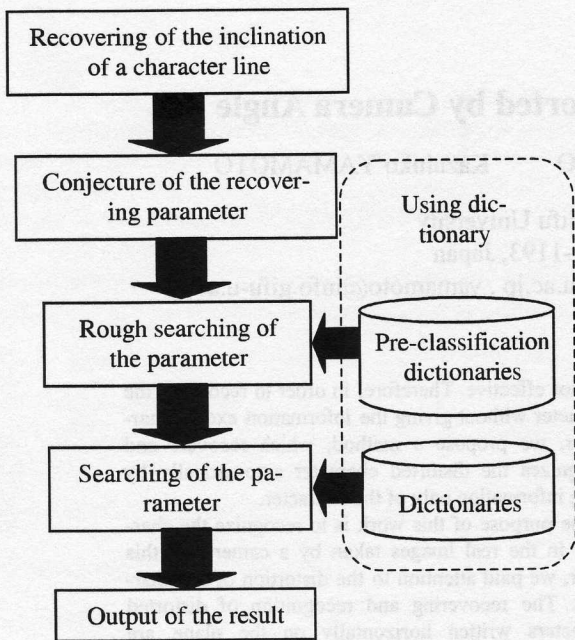


Fig. 1: Flowchart of the searching of the recovering parameter

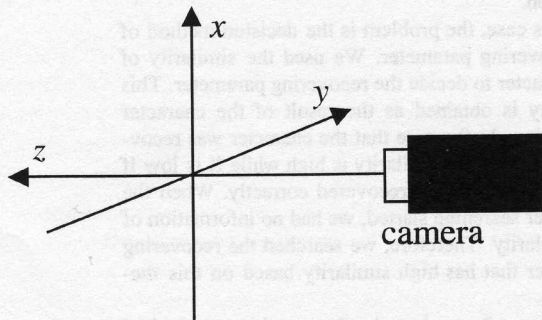


Fig. 2: Definition of the space

2.1 Recovering the inclination of the character line

We recovered the inclination of the character line first, since the z parameter can be calculated easily and precisely by using only the shape information of the character line, and it can be treated independently. In this paper, we treated the character line, written laterally. In this case, the width of character line is longer than its height. Therefore, the correct inclination is recovered by rotating the character line so that the height becomes the minimum, as shown in Fig. 3.

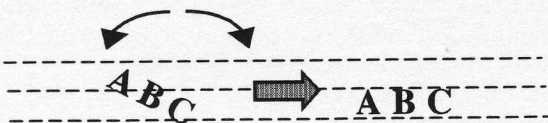


Fig. 3: Recovering the inclinations of the character line

Usually a character line of the lateral writing is not taken by a camera inversely or lengthwise. Therefore, we suppose that the inclination of the character line is in the range of ± 70 degrees. The character line is rotated from $+70$ degrees to -70 degrees at intervals of 10 degrees around the z -axis to find the angle that gives the minimum height of the character line. Next, the character line is rotated around the z -axis from $+20$ degrees to -20 degrees at intervals of 5 degrees across the angle obtained in the previous step.

2.2 Conjecture of the recover parameter by using shape information

The shape of the distorted character line is decided by the position of the viewpoint shown in Fig. 4. The shape is either like a trapezoid or a parallelogram. The distortion will be same, as shown in Fig. 4, even if the sign of the parameter reverses. On the basis of these, therefore, it is possible to conjecture the parameter by using the shape information of the character line.

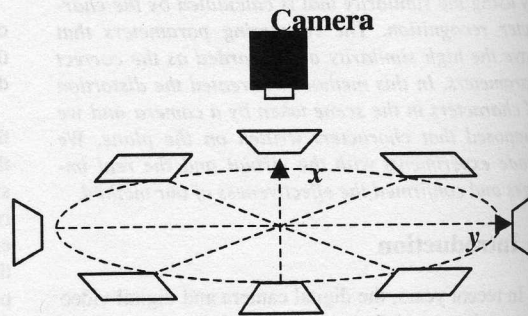


Fig. 4: Relation between the distortion and the viewpoint

This time a judgement method that uses shape information was adopted to estimate the recovering parameter^[7]. In this method, a character is cut in parallel in the direction of the inclination θ to the character image, and the dispersion value of the fragment length of the character is calculated. The calculated value is used as the feature.

In learning the dispersion, the images were distorted by the computer with the changing the parameters at intervals of 10 degrees. The distance between the dispersion of the input image and the dispersion of the learning image was calculated, and the parameter of the smallest distance was output. In this case, it contains the parameter that has a reversed sign.

2.3 Searching the recovering parameter by using the similarity of characters

We recover distortion by using 2 sets of parameters that are obtained as the result of estimation. Character recognition was performed to the recovered image.

The set of the parameters that had the higher similarity is adopted as the starting point of the search using the pre-classification dictionary. After the starting point is calculated, we searched the area around this point with intervals of 10 degrees. The mean similarity is used to search. First, the similarities of each character in the image were calculated. The mean similarity was calculated based on these. In the searching process, the mean similarity of characters of 8 neighboring points of the attention point were compared, and the point with the highest mean similarity in the 8 neighboring points is selected as the next attention point.

This process will be repeated until the mean similarity becomes greater than the threshold to obtain the recognition result. In the case that the mean similarity is not greater than the threshold, the searching process is repeated until the searching process count becomes greater than the fixed count. Characters are recovered and recognized by using the parameter of the highest mean similarity.

3. Constitution of the character recognition part

The constitution of the character recognition part is as follows.

1 Reverse perspective transformation

Input image is transformed by using reverse perspective transformation.

2 Segmentation of the character

The character line is extracted from the image by the histogram of y -axis projection. The character is segmented for the character line by the histogram of x -axis projection.

3 Calculation of parameters of the four directional patterns^[8]

The nonlinear normalization parameter and outlines of characters are calculated by segmented character^[9].

4 Making the four directional patterns of 20x20 for the dictionary

The four directional patterns for the dictionary are made, on the basis of the calculated parameter, and the nonlinear normalization is applied.

5 Making the four directional patterns of 8x8 for the pre-classification

The four directional patterns for pre-classification dictionary are made, based on the four directional patterns for the dictionary.

6 The four directional pattern matching

The four directional pattern matching is used to the pattern of the character in the input image. First, the pre-classification is used, and then the classification is used with the 100 high score candidacies as the result of the pre-classification.

7 Determination of the completion condition using the similarity

The four directional pattern matching is used with each character in the input image, and the mean value of the similarity of all the characters in the input image is used to determine the completion of the searching process. If this value is not less than the threshold, the searching process is finished and the result is output. If it is less than the threshold, the searching process is continued.

4. The recognition experiment using virtual images

We experimented with synthesized images before real images. We used images including characters written in Gothic, and we used mainly Gothic in the database of JEIDA FUJI (Japanese character database) to make the dictionary^[10]. The examples of the image used in this experiment are shown in Fig.5. As shown in Fig.5, we put space between the characters for easy segmentation. The total number of images is 304 sheets. The total number of characters is 1045 characters.

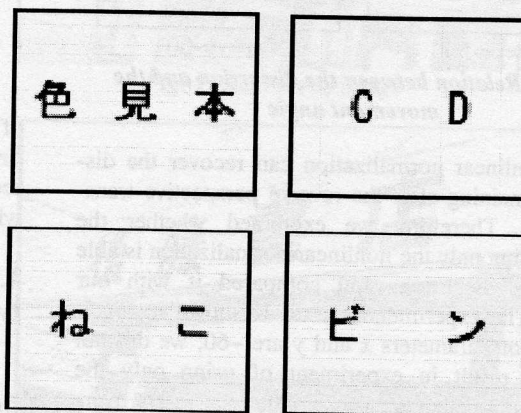


Fig. 5: The examples of the image used in the comparison experiment

These images were distorted by the perspective transformation on the computer and used for the recognition experiment. The parameter z of perspective transformation was 0. The parameters x, y of perspective transformation were $-10, -20, -30, -40, -50$ and -60 . The examples of the distorted image are shown in Fig.6.

4.1 The experiment using only nonlinear normalization for comparison

We used the four directional pattern matching method to recognize the character. When the four directional patterns were made, the nonlinear normalization was applied.

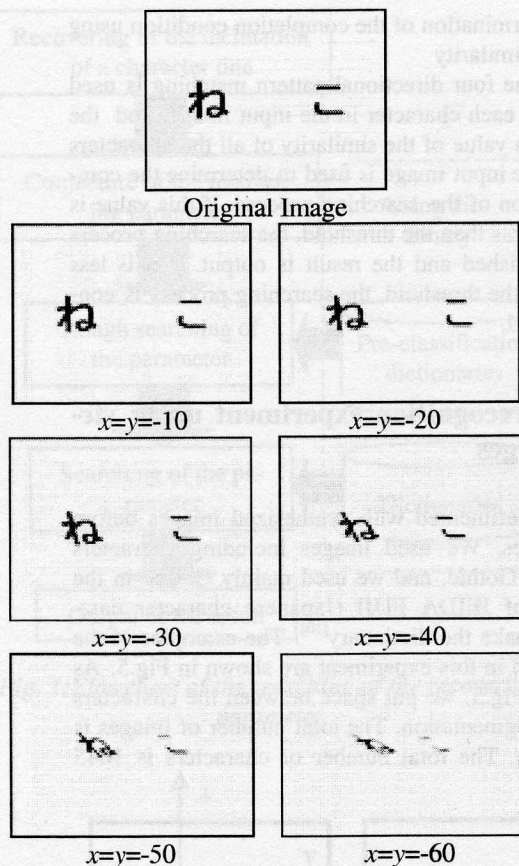


Fig. 6: Relation between the distortion and the movement angle

The nonlinear normalization can recover the distortion remaining after the reverse perspective transformation. Therefore, we examined whether the method using only the nonlinear normalization is able to recover distortion, and compared it with our method. The experimental result is shown in Fig. 7. The case of parameters x and y are -60 , we did not get good result in experiment of using only the nonlinear normalization because the characters overlapped, and the character was not segmented correctly.

The recognition rate using only nonlinear normalization was high when the distortion was light. But, its recognition rate decreased rapidly when the distortion was heavy. In contrast to this, the decreasing of the recognition rate using our method was small even when the distortion was heavy.

The reason is that the four directional patterns used in the character recognition were changed by the big distortion. The nonlinear normalization recovers mainly the difference of the location of the stroke. Therefore, the nonlinear normalization is unable to recover the feature which was changed by the distortion. In contrast to this, our method that uses reverse perspective transformation can recover the heavy distortion to the character.

By this result, we understand that it is possible to recover the light distortion by using only the nonlinear normalization. In the case using our method,

heavy distortion is recovered by the reverse perspective transformation, and light distortion is recovered by the nonlinear normalization. Therefore, combining reverse perspective transformation and nonlinear normalization is effective to distorted characters.

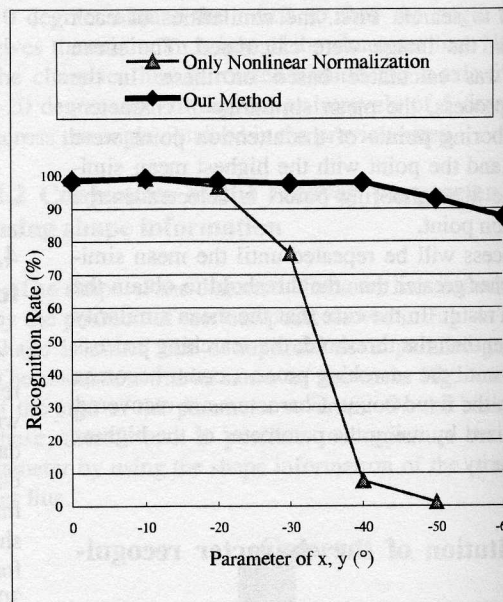


Fig. 7: The result of comparison experiment on case of using only nonlinear normalization and our method

The major cause of a miss-recognition was the blur of characters when the distortion was heavy. At this time, the blur of characters remains even after the recovery of distortion by using the correct parameter, which causes the wrong results.

4.2 The experiment of comparison using two kind of normalizations

We made experiments in order to examine the influence of the blur on the nonlinear normalization. The nonlinear normalization is based on stroke density. Therefore, the nonlinear normalization is affected by the blur of the character stroke. On the other hand, the linear normalization is not affected by the blur. Thereupon, we compared the case of applying the nonlinear normalization and the case of applying linear normalization. The experimental result is shown in Fig. 8.

By this result, it is understood that the blur affects the nonlinear normalization. But, recognition rate of the nonlinear normalization is higher than that of the linear normalization.

The recognition rate decreased when the parameter was 0. This was caused by the miss-conjecture. In this time, the searching point was started from the wrong parameter. And there was the character which had the high similarity even if it was recovered by wrong parameter. This raised the mean similarity and the miss-recognized character was output.

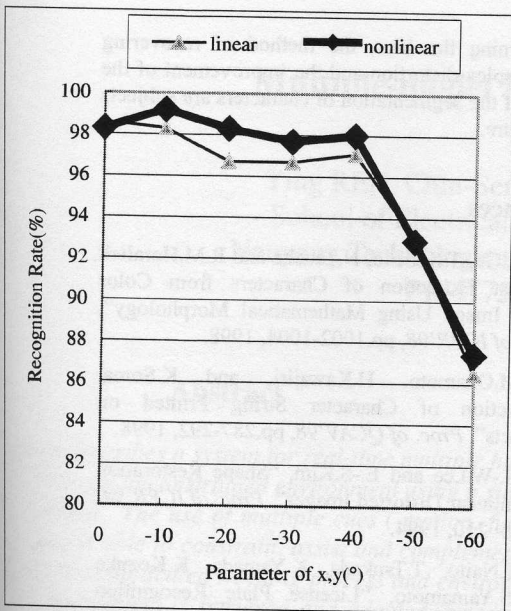


Fig. 8: The result of the comparison experiment on the case of applying nonlinear normalization and applying linear normalization

5. Recognition experiment using real images

Our final purpose is the recognition of characters in the real scene image, so we experimented using real scene images.

5.1 The extraction of the character line

In the case of using real scene images, characters must be extracted from the scene image properly. Therefore, we extracted characters from scene images.

Since the main purpose of this paper is to treat the distortion of the character, we used images from which characters can be extracted easily with a simple. We used the assumption that black pixels are characters and white is a background, and characters are surrounded by white pixels. Therefore, we used the method which is shown below.

1 Transformation of the image to the binary image

The input image is transformed to the binary image. An example of the input image is shown in Fig.9. An example of the binary image is shown in Fig.10.

2 Resizing to low-resolution

To remove a detail of the image, the binary image is resized to the low-resolution. An example of the low-resolution image is shown in Fig.11.

3 Removing the part which adjoins the outside frame

The part which adjoins the outside frame is removed by the assumption that characters are surrounded by white pixels.

4 Removing of the isolated point in a low resolution image

Characters are not constructed one pixel, but some pixels in the low-resolution image. Therefore, the isolated point is removed so that the part except characters is not extracted.

5 Extraction of the black pixels in the binary image that connects to the black pixels remained

The black pixels that are connecting to the remaining black pixels in the low-resolution image are extracted in the binary image. An example of the result image is shown in Fig.12.



Fig. 9: Real scene image



Fig. 10: Binary image

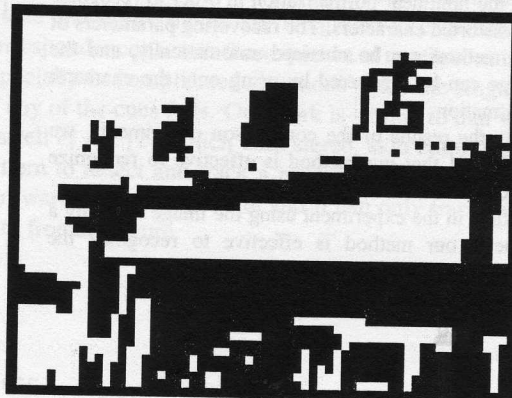


Fig. 11: Low-resolution image

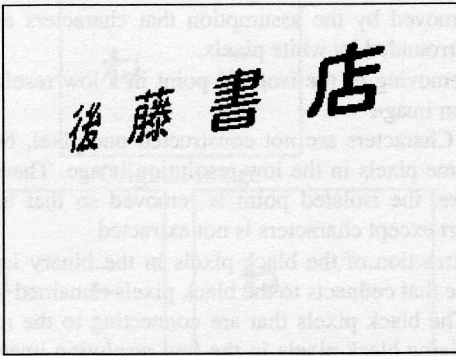


Fig. 12: Image of extracted characters

5.2 Recognition of extracted characters

We made experiments using the image that succeeded in the segmentation. The number of the images that succeeded in the segmentation is 52. The number of the extracted characters is 243. We used the same dictionary as in section 4.

As the result of the experiment of the real image, we obtained the recognition rate of 84.0%. An example of the recovered image is shown in Fig.13.

The major cause of the miss-recognition is blurring of the recovered character.

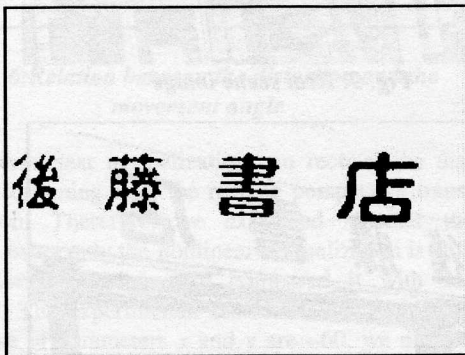


Fig.13: Recovered image

6. Summary

We proposed the recognition method with the combination of reverse perspective transformation and the nonlinear normalization in order to recognize the distorted characters. The recovering parameters of this method can be obtained automatically, and the image can be recovered by using only the character information.

By the results of the comparison experiments, we confirmed that our method is effective to recognize the character with the heavy distortion.

Also, in the experiment using the image taken by a camera, our method is effective to recognize the character in the real scene image.

Concerning the blur, the method of recovering more complex distortion and the improvement of the method of the segmentation of characters are subjects in the future.

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