A Proposal of the Effective Recognition Method for Low-Resolution Characters from Motion Images

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Abstract

In this paper, we propose a new effective method for low-resolution character recognition from motion images. This method extracts the feature directly from low-resolution images first, and reconstructs the high-resolution feature. Since low-resolution characters of motion images are recognized, a general idea is to reconstruct a high-resolution image first by using these low-resolution images, and it is extracted the feature from that high-resolution image. Feature extraction process of our proposed method has different view of the general idea. Our proposed method has higher accuracy than the general idea in low-resolution characters recognition. We show advantages of it by comparative recognition experiments under the database images and motion images.

1. Introduction

The resolution taken by the digital video camera is often low. Therefore, it is difficult to extract the feature effectively from low-resolution images. In order to solve this problem, the high-resolution image is reconstructed from the low-resolution images. Many researches for reconstructing the high-resolution image are proposed[1][2][3]. These ideas extract the feature from reconstructed that high-resolution image. On the other hand, there is a research that extracts the feature directly from low-resolution images[4], and also the method[5] extracts the four directional feature fields[6] that have a precision of double-resolution without reconstructing a high-resolution image.

In this paper, we propose a new processing method against the general idea; extracting edge features first and restructuring high-resolution four directional feature fields. A comparison method used here was the most basic method[7]; reconstructing the high-resolution image by the sub-pixel method first and extracting four directional feature fields from high-resolution images. To compare between these two methods, we show that our proposed method gives higher accuracy than the comparative method for low-resolution character recognition.

2. Linear problem between two methods

In this section, we explain processes of our proposed method and the comparative method. As described in section 1, processes of two methods have difference extracting method the four directional feature fields. Edge detector filter is used to extract the edge feature. These two methods seem only different in the order of process and if it is same, the linearity is maintained.

Figure 1 is an example of input images consisted of 4x4 resolution. In each image, the center of gravity shifts by 0.5 pixel from the center image E. For example, image D's the center of gravity shifts to the left by 0.5 pixel from image E. To extract features from these images that have sub-pixel shift of the center of gravity, the general idea reconstructs the high-resolution image from these low-resolution images first and extracts the four directional feature

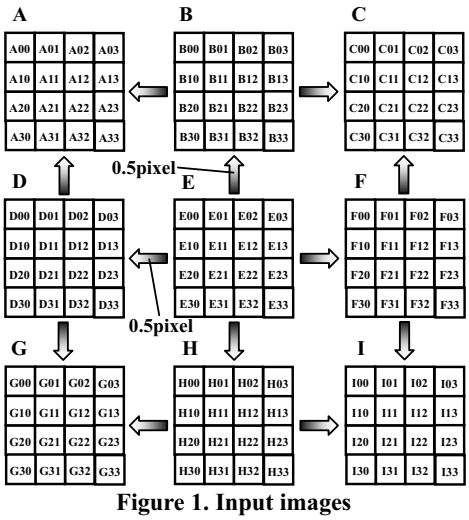

Figure 1. Input images

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fields.

In the 4x4 image of figure 1, "A00" means a pixel value. By correcting to sub-pixel shift of the center of gravity of each image of figure 1, the high-resolution image of 10x10 was reconstructed as shown in figure 2. An equation inside of each frame means the pixel value(eg.(x,y)=(2,0) is G00+H00+I01), it is calculated from figure 1 pixel values. By using this reconstructed image, the existing method extracts the feature. In figure 2, a horizon edge feature in a frame with bolded line(x,y)=(3,3) is expressed by the absolute values of subtraction of pixel values enclosed by the dotted circles by eq.(1).

On the other hand, in our proposed method, the features are extracted from figure 1 images under the low-resolution first. And then, the four directional feature fields is created by superposed these edge features. Figure 3 is a superposed result of horizon edge features. Here, the horizon edge feature in the frame with bolded line(x,y)=(3,3) is expressed by a eq.(2).

Comparing between eq.(1) and eq.(2), there is clearly non-linearity between two methods, since degeneration occurred in the existing method eq.(1) when taking absolute values of subtraction. Our proposed method eq.(2) is constructed only superposed each input image's subtraction edge feature. The degeneration is occurred when extracting the feature after reconstructing the high-resolution image. There is non-linearity problem that occurred by the difference of order of the feature extraction process.

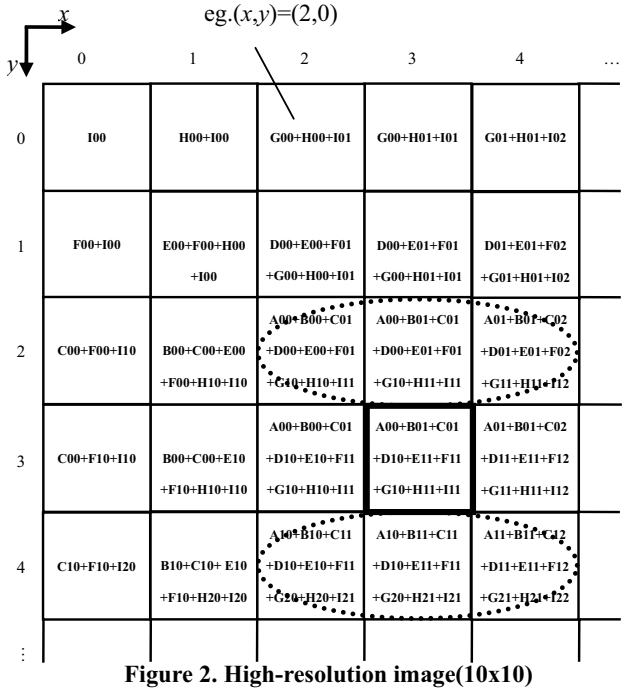

Figure 2. High-resolution image(10x10)

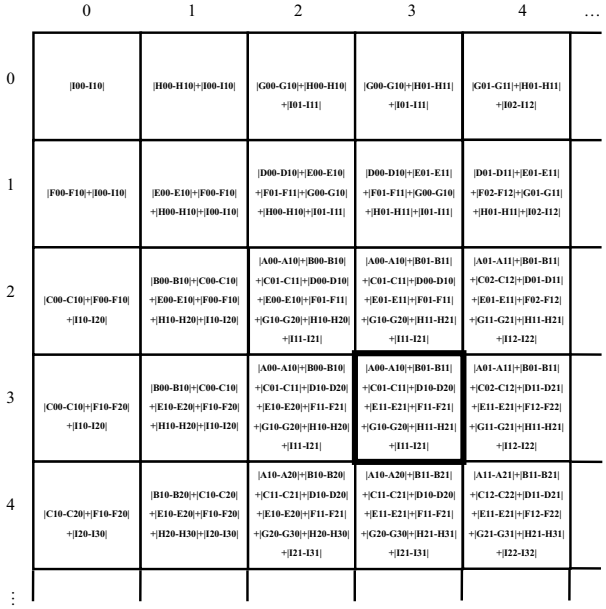

Figure 3. Horizon edge feature of proposed method(8x8)

$$\left|\begin{Bmatrix}|A00+B00+C01+D00+E00+F01+G10+H10+I11|\\+|A00+B01+C01+D00+E01+F01+G10+H11+I11|\\+|A01+B01+C02+D01+E01+F02+G11+H11+I12|\end{Bmatrix}-\begin{Bmatrix}|A10+B10+C11+D10+E10+F11+G20+H20+I21|\\+|A10+B11+C11+D10+E11+F11+G20+H21+I21|\\+|A11+B11+C12+D11+E11+F12+G21+H21+I22|\end{Bmatrix}\right| \quad \textbf{(1)}$$

$$\begin{Bmatrix}|A00-A10|+|B01-B11|+|C01-C11|\\+|D10-D20|+|E11-E21|+|F11-F21|\\+|G10-G20|+|H11-H21|+|I11-I21|\end{Bmatrix} \quad \textbf{(2)}$$

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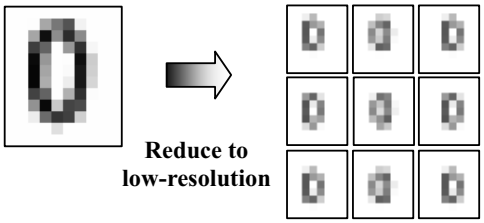

Figure 4. Basis image

Figure 5. Input images

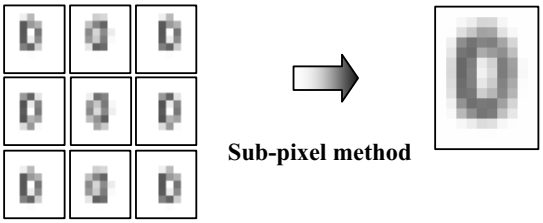

Figure 7. High-resolution image

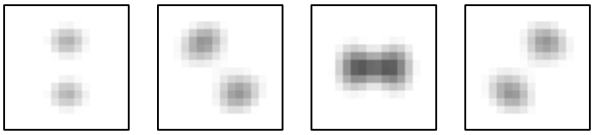

Figure 6. Four directional feature fields of proposed method

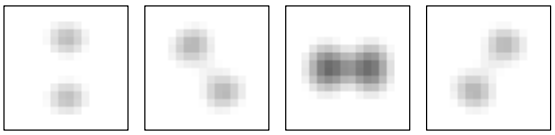

Figure 8. Four directional feature fields of existing method

3. Features extraction method

3.1. Feature extraction method of our proposed method

Our proposed method uses different order of process to the existing method. This method extracts features from low-resolution input images first, and creates the high-resolution feature. It is necessary that an input image sequence has sub-pixel shift of the center of gravity each other. For the basic experiment, we made a basis image by scanning as shown in figure 4. And then, we made eight ideal images from a basis image by shifting 1 pixel and reducing to half-resolution theoretically. Thus we made images as shown in figure 5 that shifted 0.5 pixel to eight directions. Figure 6 is calculated result of the four directional feature fields which is extracted from figure 5.

3.2. Feature extraction method of the existing method

As the comparative method, the existing method in this paper is explained here. First, we reconstructed the high-resolution image as shown in figure 7 with superposing to the sub-pixel shift of the center of gravity of each images from figure 5. Then, the feature is extracted from the high-resolution image. Obtained four directional feature fields is shown in figure 8.

4. Comparative recognition experiment on database images

4.1. Database images and creating dictionary

The database is consisted of 36 character types(the MS Gothic type font of 0 to 9 and A to Z). That is printed to the A4 plain paper with an inkjet printer. We took 200 sets basis images of three patterns (font size 8pt., 10pt. and 12pt.) with a scanner in 100dpi. After reducing to low-resolution and making input images, 100 sets were used for creating dictionary, and other 100 sets were used as input images. Then, we created dictionaries by each method (horizon, upper right, vertical and lower right). These are taken average each direction feature of 100 sets. Figure 9 shows examples of data images.

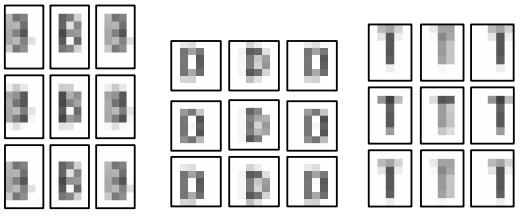

Figure 9. Example of database images (8pt., 100dpi)

4.2. Process of experiment

Input images were operated some preprocessing, removal of back ground, noise reduction and segmentation. After extracting features by several methods, dictionaries were created by normalization operation with the Gaussian filter. The four directional

feature fields are extracted by same process, and characters were recognized.

4.3. Comparative experiment

We experimented comparing between our proposed and the existing method. Results of recognition rate are shown in Table 1 and Figure 10.

From table 1, our proposed method gives higher accuracy than the existing method. That reason why the existing method was influenced by the degeneration of directional vector component by taking the absolute value. In the existing method lost the information of the direction of input images when the high-resolution image is reconstructed. For that reason, directional vector component is not extracted from the high-resolution image. On the other hand, the feature of our proposed method is not influenced by taking the absolute value, because edge feature is made extracting from low-resolution and superposing these. Therefore proposed method gives higher accuracy the edge directional feature better than the existing method.

Table1. Experiment result on database images

	Existing method	Proposed method
12pt	97.36%	97.81%
10pt	96.06%	97.28%
8pt	90.92%	93.17%

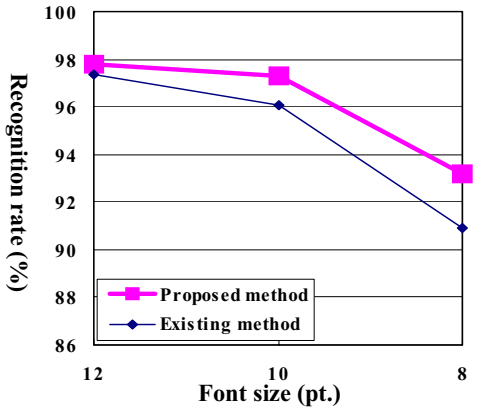

Figure 10. Experiment result on database images

5. Verification for the displacement influence of the center of gravity

To apply our proposed method for actual motion image, it will be important to extract the sub-pixel shift of 0.5 pixel. Therefore, correctly shift of the center of gravity detection is needed. Then, we examined the influence of displacement on the database images.

5.1. Error evaluation by the center of gravity

We verified the error of the center of gravity displacement. Input images shifted the center of gravity by 0.5 pixel were created from 20 sets of scanned basis images (1 set consists of MS Gothic, 0 to 9 and A to Z). When it is actually recognized on the actual motion image, the center of gravity is calculated from segmented each character. We verified the influence of displacement with several values of shifted image. For the result, the average error of the center of gravity in this data base was 0.039 pixels. This error is not problem to recognition.

5.2. Verification on gravity evaluation error and recognition rate

From paragraph 5.1, obtained the center of gravity evaluation error is very minute value. But, to actually extract and recognize features from this database, it is important to know how much this error influences to recognition result. Moreover, when actual motion images are used, there is a possibility that these images can not be acquired with the sifted gravity of 0.5 pixel. Therefore, we performed an experiment to measure how the shift of the center of gravity affects the recognition result when features were extracted by sifted from 0.5 pixels. The dictionary was created with the image group with the shift of the center of gravity by 0.5 pixel. Input images with the sub-pixel shift from 0.3 to 0.7 pixel with 0.02 pixel step were created respectively. The table 2 shows average recognition rate of both methods in 0.5±0.12 pixel range.

Table 2. Recognition rate of shifted the center of gravity

Existing method	Proposed method
96.69%	97.52%

In table 2, our proposed method has higher accuracy recognition rate than the existing method in some range of the sub-pixel shift of the center of gravity. This shows that in the sub-pixel shift margin range within 0.5±0.12 pixel, our proposed method can maintain high recognition rate even if there are no images with the shift of center of gravity by just 0.5 pixel. Because the center of gravity evaluation error at this time was 0.039 pixel in paragraph 5.1, gravity error range doesn't become a factor to decrease the recognition accuracy within 0.38 ~ 0.62 pixel.

6. Experiment result on motion images

We performed an experiment for actual motion images under the verification. As a method of collecting motion images data used for this experiment, we took movie of printed characters (font size 8pt., 10pt. and 12pt.) for a few seconds with a video camera. The object was printed on the A4 plain paper with an inkjet printer (36 character types in total from 0 to 9 and A to Z). At this time, input images were selected within the gravity evaluation range of 0.5±0.08 pixel, in which an especially high recognition rate was maintained in paragraph 5.2. Table 3 and figure 11 are a result of the recognition rate. From the result, our proposed method was superior to the existing method in the selected the sub-pixel shift of the center of gravity range under using actual motion images.

Table 3. Experiment result on motion images

	Existing method	Proposed method
12pt.	96.39%	97.36%
10pt.	91.52%	92.64%
8pt.	87.50%	88.75%

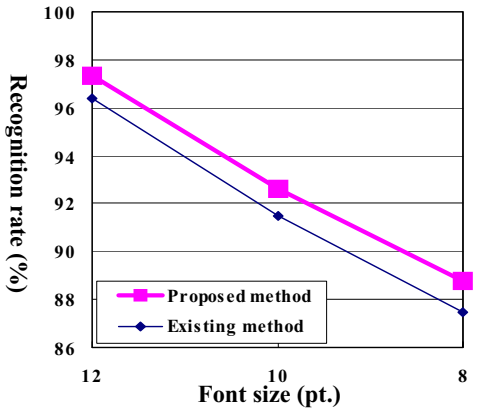

Figure 11. Experiment result on motion images

7. Conclusion

In this paper, we proposed the new effective method for low-resolution character recognition. From the database images and motion images experiment, if each image of motion images has minute sub-pixel shift of the center of gravity, we showed our proposed method is more effective in the recognition. As this reason of the result, our proposed method extracts features first and superposing to features and creating high-resolution features. On the other hand, the existing method reconstructs the high-resolution image first and extracts features from the image. It is thought that our proposed method can avoid the influence of degeneration by using the absolute value of extracting the direction feature. There is non-linearity between two methods which have different order of features extraction process. Also, our proposed method can create features avoiding the smooth of edge information. We showed our proposed method's performance advantage for low-resolution images. Future works; we think an experiment that increases character type.

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