Effective Feature Extraction Using Low-Resolution Images

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Abstract

When character recognition is made from low-resolution characters of motion image, it is the general idea to restructure high-resolution image first by using sequence of the low-resolution images and then extract features from constructed high-resolution image. In this paper, we propose a new method in which the direct extraction of features from the low-resolution images is made first, and then reconstructing high accuracy feature from sequence of feature. We show the advantage of our proposed method for ordinary method in comparative recognition experiment both for ideal database images.

1. Introduction

In recent years, the digital video camera has penetrated to the general people. Images taken by digital video cameras often suffer from a lack of sufficient resolution. Therefore, it is difficult to extract features effectively for the character recognition from these images. There are two competing approaches to solving this problem.

In the first approach, the feature image is extracted from the high-resolution image that is reconstructed from the low-resolution images. The method of the reconstructed high-resolution image has been proposed by many researchers [1]~[4]. The correspondence information (rotation, shift, magnification etc.) between each image is necessary to reconstruct the high-resolution image. However, the method of using the correspondence information to recognize by using reconstructed image is not researched so much.

In the second approach, the feature images are extracted directly from the low-resolution images [5],[6].

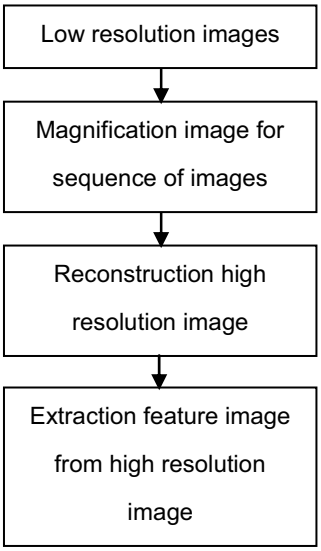
In this paper, we propose a new processing method: extracting edge features first and reconstructing the high-resolution feature images. We test this method against the most ordinary method; reconstructing the high-resolution image by the use of sub-pixels first and extracting feature images from high-resolution image. We show that our proposed method gives higher accuracy than the alternative recognition method for image sequence of low-resolution.

2. Linear problem between two methods

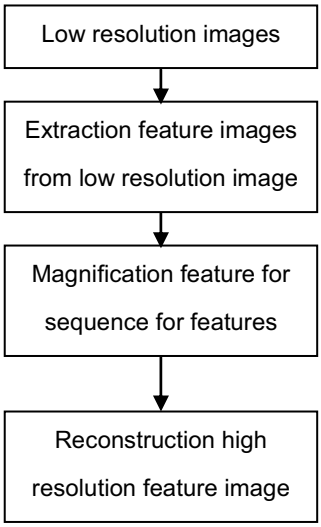
In this section, we explain processes of our proposed method and the ordinary method. Processes of two methods have difference of the stage for extracting features. Figure 1 is shown our proposed method process and the ordinary method process.

Input images of the actual experiment are used two-dimensional images. It is difficult to explain the different phenomenon of each method by the two-dimensional image. The phenomenon on each method appears with the one-dimensional model image. In this paper, these methods are explained for easily by the one-dimensional model images. Figure 2 is an example one-dimensional model of input images consisted of 5×1 resolution. In each image A and C, the center of gravity shifted by 0.5 pixels from the center image B.

For example, image A shifted to the left by 0.5 pixels from image B. By superposing and summing up these images of 0.5 pixels shifted, it can reconstruct a double resolution image. To extract features from these images that have sub-pixel shift, the general idea reconstructs the high-resolution image from these low-resolution images and extracts the four directional feature fields.



(a) The ordinary method on feature extraction from low resolution images



(b) Propose method on feature extraction from low resolution images

Figure 1. The process of feature extraction from sequence for low resolution images

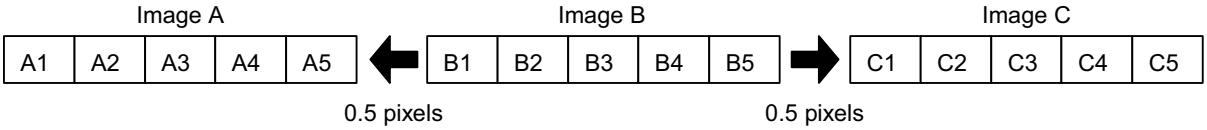


Figure 2. One dimensional model of input images

In the 5×1 image of figure 2, "A1, A2, A3 …", "B1, B2, B3 …", and "C1, C2, C3 …" mean each pixel value. Each image is magnified double size by using nearest neighbourhood method as shown in figure 3. By superposing and summing up each image of figure 3, the high-resolution image of 12×1 is reconstructed as shown in figure 4. An equation inside of each frame means the pixel value. For example when x=5, y=0, value of (x, y) is A2+B3+C3, it is calculated from pixel values of figure 2.

By using this reconstructed image, the existing method extracts the feature through the filter as shown in figure 5. In figure 4, a edge feature in a frame indicated by position (x, y)=(5,0) is expressed by the absolute values of subtraction of pixel values "(x, y)=(4,0) and (x, y)=(6,0)". It is shown by eq.(1).

$$| (A2+B2+C3) - (A3+B3+C4) | \qquad (1)$$

On the other hand, in our proposed method, first, the features are extracted from figure 2 images under the low-resolution through the filter as show in figure 6. After each extracted feature images is magnified double size by using nearest neighbourhood as shown in figure 7. The high resolution feature image is created by superposed these edge features. Here, the summed up equation in the frame indicated by dashed line is expressed by eq.(2).

$$| A2\text{-}A3 | + | B2\text{-}B3 | + | C3\text{-}C4 | \qquad (2)$$

When compare between eq.(1) and eq.(2), there is difference about the stage of the calculation of absolute value. The edge feature is affected by its difference. The edge feature to extract from the reconstructed high resolution image is smoothed to add the pixel value of each low resolution image in equal condition. Therefore, the influence of the edge feature to exist on each low resolution image is reduced in some cases. In the ordinary method, the existence of the edge feature is caused degeneration. The proposed method is constructed only summed up the edge feature that is extracted each low resolution image. The existence of the edge feature isn't caused degeneration.

The influence by these differences is shown to the recognition object of the complex shape, because the degeneration is shown around the pixel of the edge feature. Therefore, our proposed method can create more effective edge feature image which is effective for the recognition than the ordinary method.

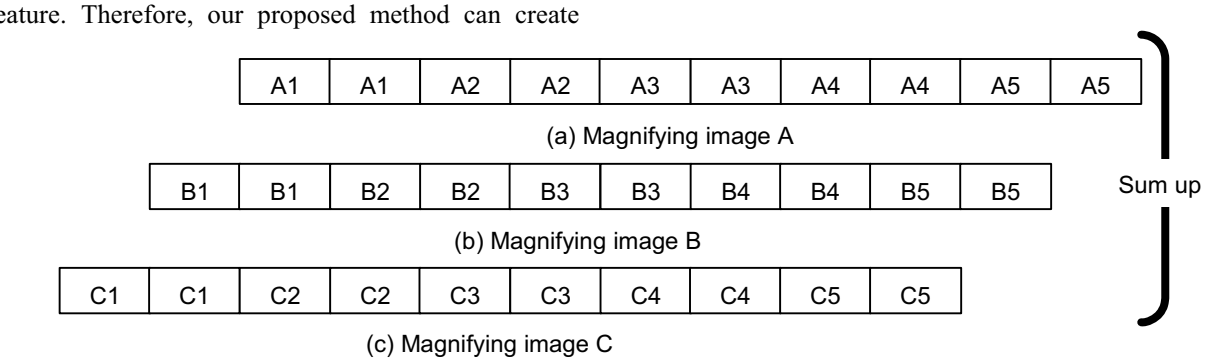


Figure 3. Each magnifying images

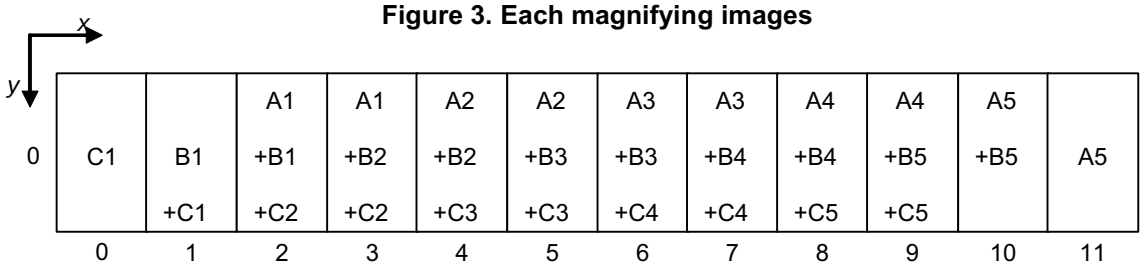


Figure 4. Reconstructed high resolution image

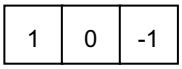


Figure 5. The filter of feature extraction for high resolution image

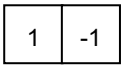


Figure 6. The filter of feature extraction for low resolution image

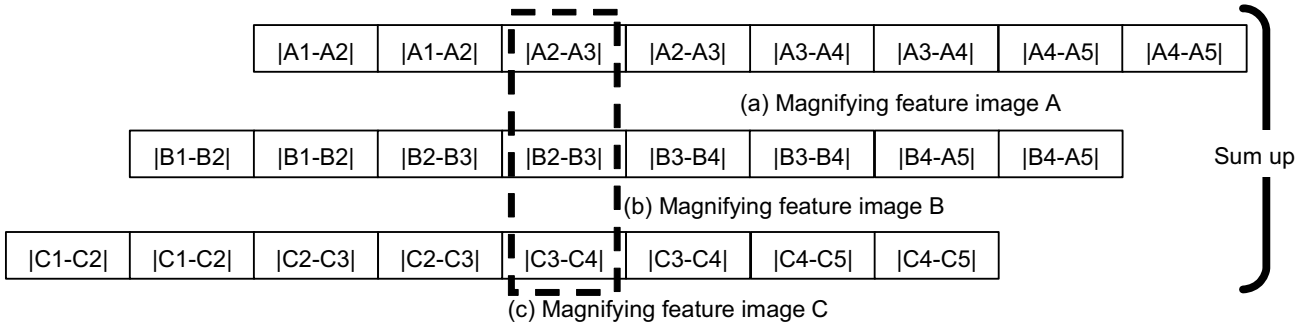


Figure 7. Each magnifying feature images

3. Features extraction method

3-1. Four directional features field

The feature in this paper is used four direction features field [7]. This feature is characterized by four direction edges (horizontal, right-up, vertical and right-down) from the input image. In this paper, the extracted feature from the low resolution image is used 2x2 size filter as shown in figure 8. And, the extracted feature from the high resolution image is used 3x3 size filter as shown in figure 9.

Figure 8. The feature extraction filters through the low resolution image

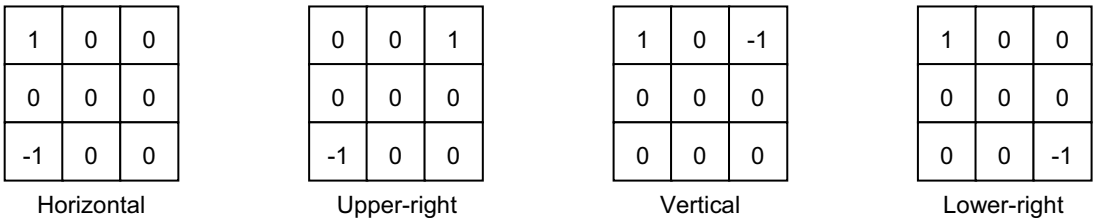


Figure 9. The feature extraction filters through the high resolution image

3-2. Feature extraction method of our proposed method

Our proposed method uses a different order of operations compared to the ordinary method. Our method extracts features from low-resolution input images first, and creates the high-resolution feature. To use this method it is necessary that an input image sequence has sub-pixel shift of the center of gravity. For the ordinary experiment, we made a basis image by scanning as shown in figure 10. And then, we made eight ideal images from the basis image by shifting 1 pixel and reducing to half-resolution theoretically. Thus we made images that shifted 0.5 pixels in eight directions, as shown in figure 11. Figure 12 shows the four directional features field by using our proposed method.

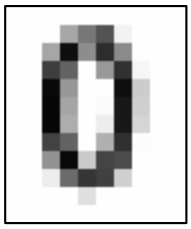


Figure 10. Scanning high resolution

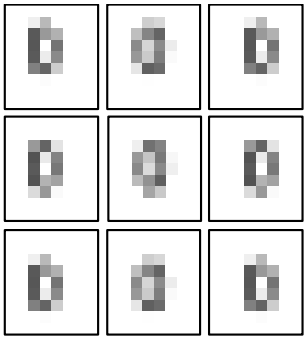


Figure 11. Ideal low resolution images to shift by sub-pixels on eight directions

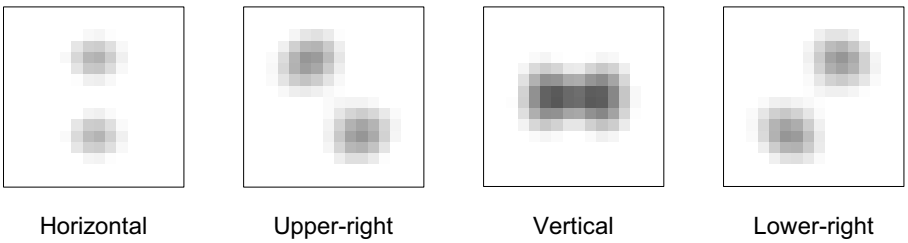


Figure 12. Example of the feature image by using our propose method

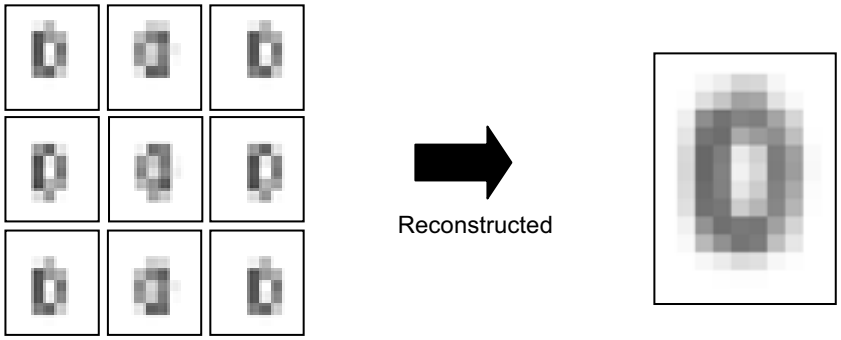


Figure 13. Reconstructed high resolution image from ideal low resolution images

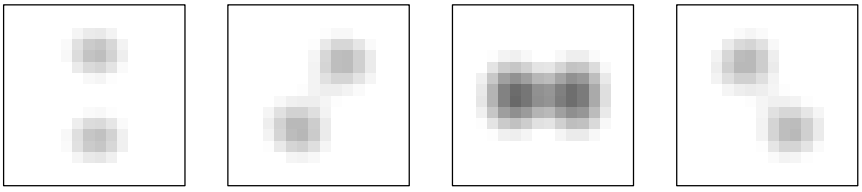


Figure 14. Example of the feature images by using ordinary method

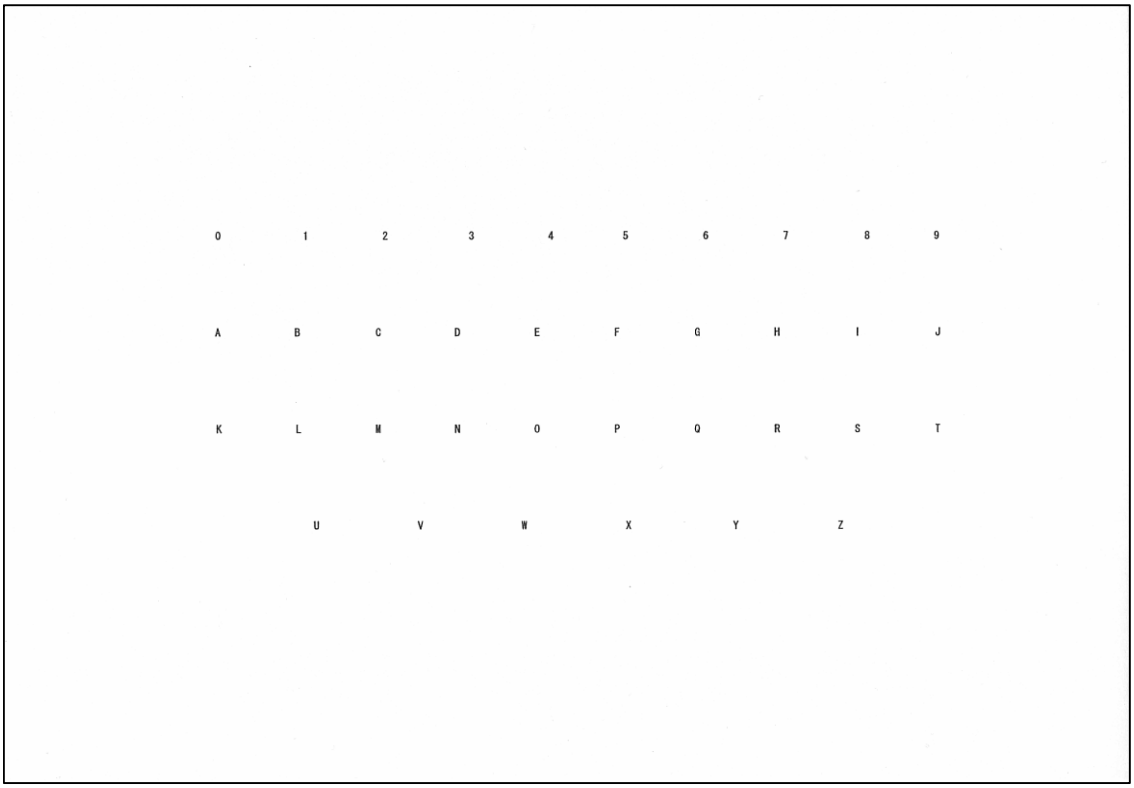


Figure 15. Example of scanning image (8pt, 100dpi)

3-3. Feature extraction method of the ordinary method

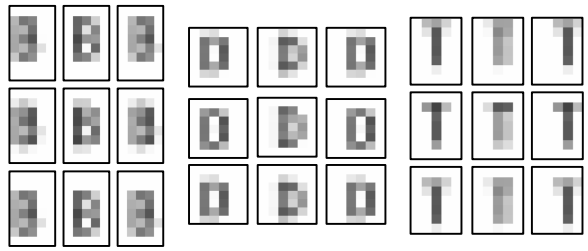
T In the ordinary method, we reconstructed the high-resolution image as shown in figure 13 with superimposing the sub-pixel shift of the center of gravity of each images from ideal low-resolution images as shown figure 11. Then, four directional features field as shown in figure 14 is extracted from the high-resolution image.

When compare between figure 12 and figure 14, there is difference, but difficult to find out exact advantage of our method. Then we need comparative recognition experiment.

4. Comparative recognition experiment on database images

4-1. Database images and creating dictionary

The database consisted of 36 characters (0 through 9 and A through Z in the MS Gothic typeface). These were printed on A4 plain paper with an inkjet printer. We took 200 sets of basis images at three font sizes (8 pt., 10 pt., and 12 pt.) with a scanner in 100dpi. Figure 15 show the example of the scanning image. After reducing to low-resolution and making input images, 100 sets were used for making the dictionary, and other 100 sets were used as unknown input images. Then, we made dictionaries by each method (horizon, upper right, vertical and lower right). These are taken average each direction feature of 100 sets. Figure 16 shows examples of database images.



[B] (5x8 pixels) [D] (6x7 pixels) [T] (5x7 pixels)

Figure 16. Example of database images (8pt, 100dpi)

4-2. Process of experiment

Input images were subjected to some pre-processing, removal of back ground, noise reduction and segmentation. After extracting features by several methods, dictionaries were created by normalization using the Gaussian filter. The four directional features field are extracted by same process, and characters were extracted.

4-3. Experimental result

We experimented comparing between our proposed and the ordinary method. Results of recognition rate are shown in table 1 and figure 17.

Table 1. Experiment result

	Font size		
	12pt	10pt	8pt
Ordinary method (%)	96.08	92.00	87.83
Proposed method (%)	96.94	95.47	90.75

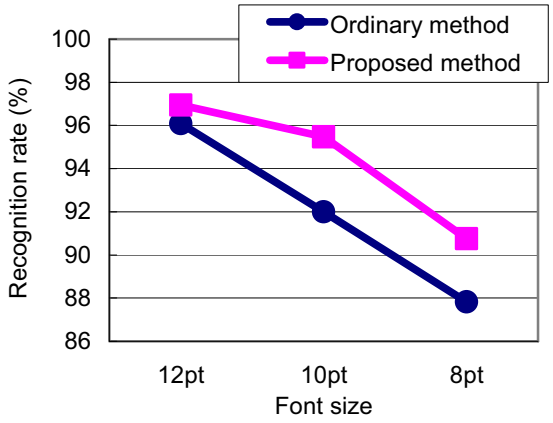


Figure 17. Experiment result on data-base

As show in table 1, our proposed method gives higher accuracy than the ordinary method. That reason why the ordinary method was influenced by the degeneration of the directional vector component by taking the absolute value. In the ordinary method the information in the direction of input images is lost when the high-resolution image is reconstructed. 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 superimposing these images. Therefore the proposed method gives higher accuracy and the edge directional feature extracted is better than that in the ordinary method.

5. Conclusion

We proposed new method of the feature extraction that is effective with low resolution image. It was shown that there is nonlinearity between two methods which inverse order of procedure of derivation and integration. The proposed method is more effective than ordinary method for low resolution character

recognition through experiment for the database images. Our proposed method is less influence of degeneration by using the original value until extracting the feature. We showed the performance of our proposed method for database images. Future works is experiment that increases the number of database and category.

Acknowledgment

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References

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