

Book Cover Identification by Using Four Directional Features Filed for a Small-scale Library System

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Abstract

This paper describes the identification method for the book cover images. It is used in a novel library system using images of books and borrower's faces. A returned book is identified from lent books by processing the images of the book cover. Four directional features field in the low resolution are used to identify of books. This feature can be compatible with computation time and performance. To identify books of series which are similar but different in small area, the partial area matching is used. The experiments shows the effectiveness of proposal methods.

1. Introduction

We are developing a novel library system[1] which uses the images of books and borrower's face. This system assume the small scale library, such as a reference room of a laboratory[2]. Administration of lending and returning is based on the identification of the book images and the face images of returning with these images of lending. The system can automate the administration of borrowing and returning in cooperation with the user. In this paper, we improve the method of identification of the book cover images.

books.

Distinction among the serial books is difficult, because the difference between these books is only a volume number. In this case, one solution is reading of the volume number using character recognition. Many character extraction method from book cover image have been presented[6][7]. The cover images of books have many colors and different kinds of layouts. The characters of the book covers include designed fonts and symbols. These diversities of the book covers are disadvantages for segmentation and recognition of the characters, but these are advantages for our method that uses partial area matching.

Partial area matching is a detailed distinction method which does not use a character recognition. First, the book images are divided on some parts. The similarities between the each parts of lent book and returned book are calculated by shifted correlation. If some parts have low similarity, these parts have important information to distinguish the book from the similar ones. Thus the obtained parts have the important information to identify the detail of the books of a series.

2. Four directional features field for book identification

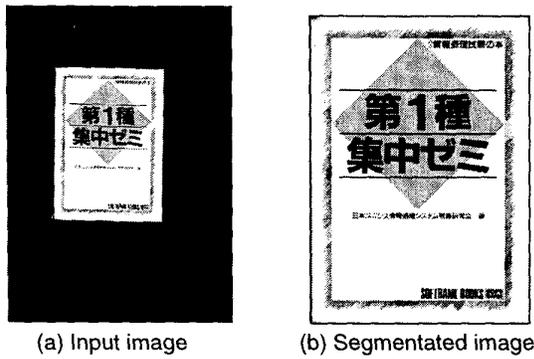


Figure 1. Segmentation

First, the book area is segmented from the input image using Hough transform as shown in figure 1(b).

The size of the book obtained by the above process is useful for rough classification. Another rough classification is made by color information. RGB color histogram is extracted from book image.

2.2. Feature extraction

The main component of book recognition is the four directional feature in low resolution. The feature has a good performance and a fast processing speed. We will compare two features; edge feature and four directional feature, for book identification in the experiments.

A horizontal, vertical, upper right and upper left edge image are extracted from book image. Figure 2(a) are four directional features field of the book of figure 1(b). The four directional feature in low resolution is shown by figure 2(b). The resolution 16x23 pixel is used. Aspect ratio of feature is about $\sqrt{2}:1$ because aspect ratio of many books is $\sqrt{2}:1$.

Four directional features field in low resolution improves performance, because noises, position gaps and small incline taken by low resolution. Further, computation time can be improved by them.

The correlation between a book to be lent and a book being returned is obtained by formula (1)

$$C = \frac{\sum_{n=1}^N F_L(n)F_R(n)}{\sqrt{\sum_{n=1}^N \{F_L(n)\}^2} \sqrt{\sum_{n=1}^N \{F_R(n)\}^2}} \quad (1)$$

where $F_L(n)$ and $F_R(n)$ are the feature of the lent and returned book, and N is a dimension of feature.

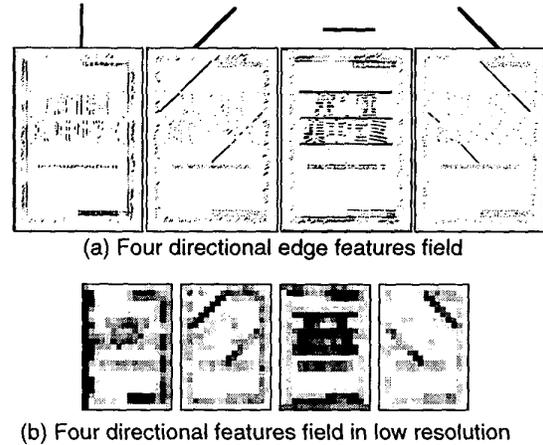


Figure 2. Feature extraction

3. Partial area matching

Using the low resolution feature, the difference between two books of series is not noticed. These are very similar and the differences are in a small area such as the volume number as shown in figure 3. To distinguish these books, we use high resolution feature and partial area matching.

This method is used four directional features fields in high resolution which are divided into $X \times Y_s$ mesh as shown as figure 4. The difference area is detected by shifted correlation. Partial area matching is the pattern matching method using the shifted correlation of the obtained difference area.

Two similar lending books are defined as L_1 and L_2 . Four directional features fields in high resolution I_{L1} and I_{L2} are divided into $X \times Y_s$ parts. Resolutions of these features x_p, y_p are the quarter resolution of input images. Features of parts P_{L1}^{xy} and P_{L2}^{xy} are written as formula (2) and (3).

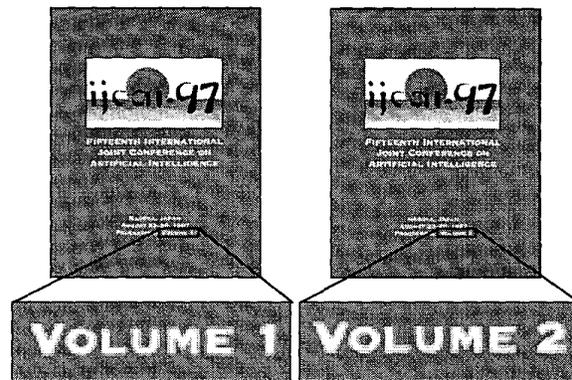


Figure 3. Series books

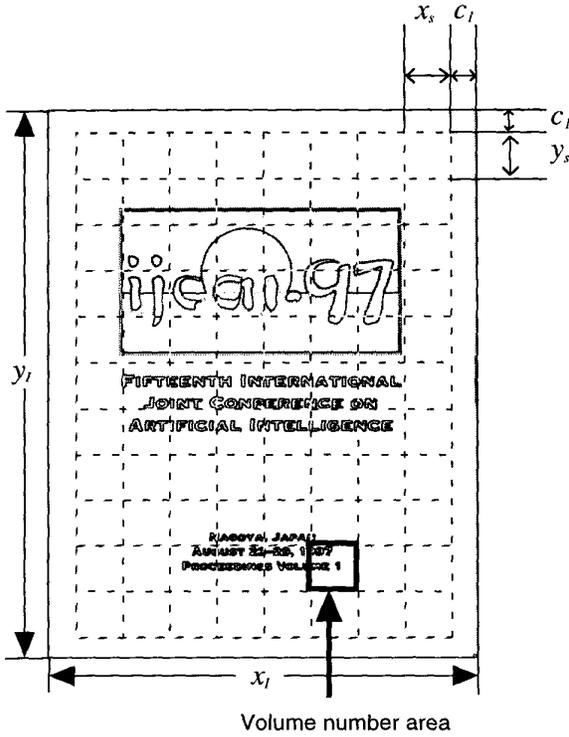


Figure 4. Divided feature field

$$X_s \times Y_s = 8 \times 11$$

$$P_{L1}^{XY}(x, y, d) = I_1(x_s X + x + c_1, y_s Y + y + c_1, d) \quad (2)$$

$$P_{L2}^{XY}(x, y, d) = I_2(x_s X + x + c_1, y_s Y + y + c_1, d) \quad (3)$$

where x and y are the coordinates, d is the direction which is 1 to 4, X and Y are the coordinates of parts, c_1 is the area size which ignores peripheral of the book cover, x_s, y_s are the sizes of parts which are obtained by formula (4)(5).

$$x_s = \frac{x_l - 2c_1}{X_s} \quad (4)$$

$$y_s = \frac{y_l - 2c_1}{Y_s} \quad (5)$$

The outlines of these parameters are shown by figure 4.

High resolution feature is sensitive to the positional shift if the simple correlation such as formula (1) was used. Therefore, the comparison is made by using the shifted correlation in which the one side feature is actively shifted. The correlation between the parts P_{L1}^{XY} and P_{L2}^{XY} is obtained by formula (6).

$$C_{L1L2}^{XY} = \max_{x_c = -z}^z \max_{y_c = -z}^z \frac{\sum_{x=1}^{X_s} \sum_{y=1}^{Y_s} \sum_{d=1}^4 P_{L1}^{XY}(x, y, d) P_{L2}^{XY}(x + x_c, y + y_c, d)}{\sqrt{\sum_{x=1}^{X_s} \sum_{y=1}^{Y_s} \sum_{d=1}^4 \{P_{L1}^{XY}(x, y, d)\}^2} \sqrt{\sum_{x=1}^{X_s} \sum_{y=1}^{Y_s} \sum_{d=1}^4 \{P_{L2}^{XY}(x + x_c, y + y_c, d)\}^2}} \quad (6)$$

where z is limit of shift. The shifted correlation is maximum value of the correlation between a feature P_{L1}^{XY} and the features P_{L2}^{XY} where these position parameter x and y are actively shifted from $-z$ to z .

Figure 5 is the map of the shifted correlation between the volume 1 and 2 in figure 3. The white express high correlation, the black express low correlation. The size of ignore area $c_1=5$ and division $X_s \times Y_s = 8 \times 11$ are used. In figure 5(a), $z=0$ is used and that means simple correlation. It can not extract the volume number. In figure 5(b), shifted correlation is used with $z=5$. It can extract the difference area which includes volume number clearly.

Positions of parts which have correlation C_{L1L2}^{XY} smaller than c_2 , are the important parts to discriminate between the volume numbers of similar books. These parts are used for the comparison of the return book. If all parts have a large correlation, book L_1 and book L_2 are regarded as the same books.

C_p is the similarity between a lent book and a returned book based on partial area matching. It is defined as formula (7).

$$C_p = \frac{\sum_{X=1}^{X_s} \sum_{Y=1}^{Y_s} w_{XY} C_{LR}^{XY}}{\sum_{X=1}^{X_s} \sum_{Y=1}^{Y_s} w_{XY}} \quad (7)$$

where:

$$w_{XY} = \begin{cases} 0 & (C_{L1L2}^{XY} > c_2) \\ c_2 - C_{L1L2}^{XY} & (C_{L1L2}^{XY} \leq c_2) \end{cases} \quad (8)$$

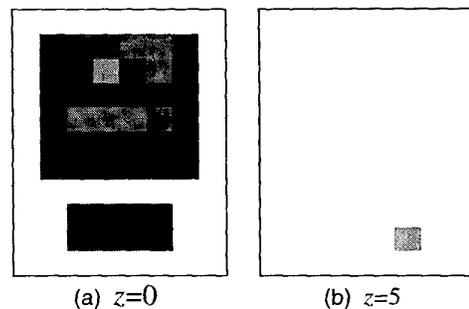
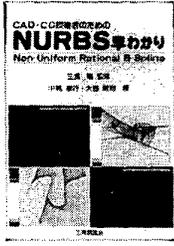
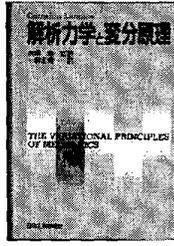
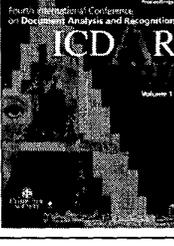
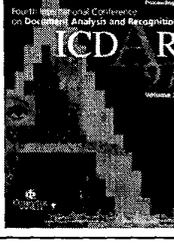


Figure 5. Shifted correlation

Table 1. Experimental data

Subset 1 209 books	 
Subset 2 493 books	 
Subset 3 106 books	 

C_{LR}^{xy} is the shifted correlation between the feature of the lent book and the feature of the returned book. In the experiments, we use $c_1=5$, $z=5$ and $c_2=0.95$ which are obtained by basic experiments.

4. Experiments of book identification

4.1. Experimental data

Experimental data consist of the images of 808 books. These were captured by the image scanner. Every book is captured two times; an image of lent and an image of returned. These images are RGB color, A3 size and 75 dpi. The data includes three types of books as shown as table 1. Subset 1 contains 209 books of various kinds. Subset 2 contains 493 books from the series, but these are not very similar. Subset 3 contains 106 books that look same, but are different in a small area, as shown in figure 3.

Because these books have various sizes, book sizes are usable in rough classification. In the experiments, rough classification was not used to evaluate the availability of the proposal method.

4.2. Experiments of feature extraction

Two types of feature which are edge feature and four directional features field are compared. Table 2 shows the ratio of the correct book decided by the highest correlation. The results of subset 1 are 100%, because identification is easy for subset 1 which is various books. Using the edge feature, the results of subset 2 was good, but result of subset 3 which are books of series were poor. Four directional features field improved the result of subset 3 and total. This result shows that the four directional features field is useful for book identification.

Figure 6 shows the changes of the correct answer rate for subset 3 by the difference of resolution. Four directional features field in resolution 32x45 has best performance, but its computation time is too long. In edge

Table 2. Correct answer rate comparing the type of feature

Feature	Subset 1	Subset 2	Subset 3	Total
Edge	100%	99.59%	87.74%	98.14%
Four direct.	100%	99.80%	97.17%	99.01%

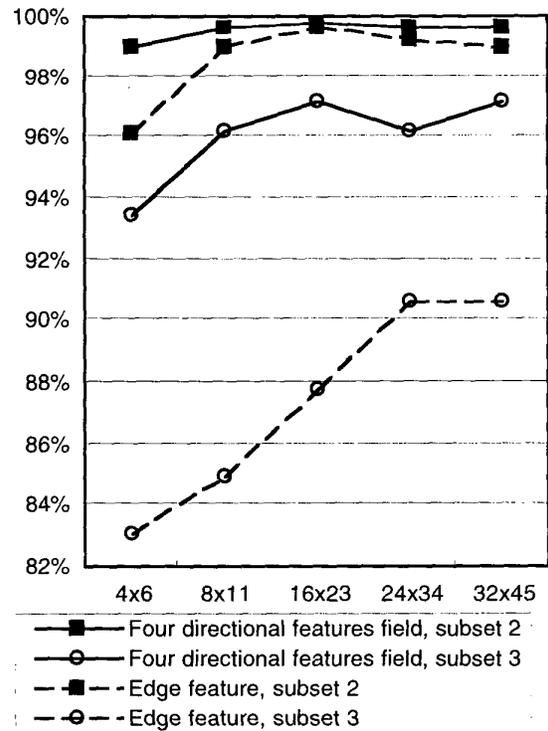


Figure 6. Results by changing the resolution

feature, performance suddenly falls whenever it lowers resolution, but performance down is small in four directional features field. These results shows that four directional features field can improve computation time when much performance does not lose by low resolution.

Suitable resolution is 16x23 by considering computation time and performance. To get a good result than these results, partial area matching is necessary.

4.3. Experiments of similar detection

For a series book, performance is not sufficient with four directional features field in low resolution. Because the computation time of the partial area matching on high resolution feature is too long, four directional features field in low resolution was used for candidate election. For provided candidate, the book covers are distinguished with four directional features field in high resolution and partial area matching in detail.

Figure 7 shows correct answer rates by using four directional features fields in low resolution with general matching and high resolution feature with partial area matching. This result shows that the partial area matching can discriminate between similar books of a series.

The books failed to be discriminated are damaged. Identification of these books is difficult, but the correct book is among the books with higher similarity.

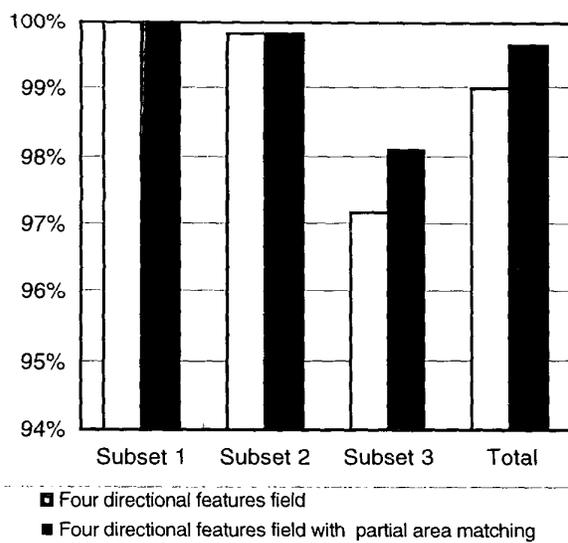


Figure 7. Experimental results by using partial area matching

5. Conclusion

We presented the methods of the identification of book cover images for a library system using images. The methods are four directional features field and partial area matching.

In the experiments, the features of book identification was compared. It was shown that four directional features field in low resolution has good performance. Four directional features field can improve the computation time by low resolution and does not lose much performance.

To identify the series of books in detail, four directional features field in high resolution and partial area matching was effective.

In our future work, we will construct friendly and useful interfaces of the library system using this method.

Acknowledgement

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