A STUDY ON FRAME POSITION DETECTION OF DIGITIZED COMICS IMAGES

Daisuke Ishii and Hiroshi Watanabe

Graduate School of Global Information and Telecommunication Studies
WASEDA University
1011 Nishi-Tomida, Honjo-shi, Saitama 367-0035, Japan

1. INTRODUCTION

Recently, comic is read not only through paper media, but also digital devices i.e. personal computer, cell phone, e-paper reader and etc. Thus, the display environment is quite different at each device. Comic consists of many frames that have text, character and illustrations. Moreover, the reading order of comic is defined by frames. Therefore, in order to provide user centric presentation functions for various types of digital devices, and facilitate the developments of other high level contents application i.e. auto text extraction, copyright protection system and so on, accurate frame shape extraction is needed.

There are many types of document analysis methods which utilized for general documents. For example utilizing histograms, connected components, density of pixels and so on are proposed [1-3]. However, comics have characteristics, which are different from other general document. For instance, unlike regular document structure, comics have free arrangement where some content protrusion from the frame borders is allowable.

Some comic frame separation methods have been proposed. Tanaka et al. have proposed a comic segmentation method by iterative separation [4]. We have extended this iterative separation method utilizing consistency of density gradient, and proposed frame corner detection method [5-6]. However, most of results by frame separation method have redundant blanks. Moreover, results of frame corner detection cannot be used alone for determining frame shapes.

In this paper, we propose a frame position detection method that utilizes the result of frame separation and frame corner detection for comic images.

2. COMIC IMAGE ANALYSIS

2.1. Comic Frame Separation

Comic frame separation method proposed in [4-5] is used in this paper. In this method, the separation step is performed recursively until separation line can be detected. The separation line is detected by a full search method by calculating total gradient of the line. In this step, separation

Figure 1: Result of frame separation and corner detection. The dotted line means border of each frames. The circle is the result of comic corner detection.

line can be detected which align with the one side of a frame line. This method can only obtain the frame shape roughly because redundant blank space is contained in separated frames. The result of this method is illustrated by dotted line in Figure 1. In the figure, all obtained frame contain redundant blank space.

However, the angle of detected separation line is mostly correct. In our preliminary experiment for the total 110 test pages, the angles of detected separation lines of 108 pages were correctly aligns each frame line. For example, in the Figure 1, every detected separation lines are parallel to each frame line.

2.2. Comic Corner Detection

Comic corner detection method [6] is applied in this paper. It consists of three steps. The first step is rough blank detection. General image analysis method cannot obtain good results in comic image, because the analysis is affected by complex elements in frames, for example content protrusion from frame, which was discussed earlier.

Therefore, by this first step preprocessing, many of the effects of these complex elements in frames are removed. In Harris's corner detection. Finally, the corner is determined

Table 1. Experimental result. Total* are decided by Comic Frame Segmentation (that number is same as the total number of the result of proposed method.) Detected frame line is the result lines of proposed method. The proposed method obtained 64-84% of correct frame lines.

Comic	Page	Frame line					Number of frame			
		Ground truth	Correct results	Total*	Recall	Precision	Ground truth	Total*	Four line correct	Three line correct
A	20	388	322	380	0.830	0.847	97	95	56	81
B	30	860	723	888	0.841	0.814	215	222	124	187
C	30	476	305	384	0.641	0.794	119	96	57	72
D	30	608	461	536	0.758	0.860	152	134	84	117

by an "AND" operation from the list. The result of this method is illustrated by circle in Figure 1.

3. FRAME POSITION DETECTION

To detect the frame border with high positional accuracy, we utilize the result of Comic Frame Separation and Comic Corner Detection. Based on the result of 2.1, the angle of frame line is obtained by Comic Frame Separation. Additionally, the possible position where frame line exists can be estimated by corner information obtained from Comic Corner Detection.

The algorithm of our proposed method is as follows. First, image gradient is calculated by Sobel filter. After this process, remaining steps are performed separately in each frame. Next, corner candidates that exists in or neighbor (close) to the frame is selected. Then, assortment list is constructed by shifting each frame lines in parallel. Here, the destination position of a line is limited to passing through the corner candidate, where the corner candidates are limited to the ones close to the frame line. Next, evaluation values of all possible rectangular combinations are calculated, based on the average density of gradient values of the quadrangle that is made by each line and the intersection. If quadrangle includes low gradient pixel, the evaluation value may be decreased to remove blanks effectively. Finally, the combination which gives the biggest evaluation value is selected as the frame.

4. EXPERIMENT

The performance of frame position detection method was evaluated by the experiment. A sample of detection result is shown in Figure 2. In this sample, three frames are detected correctly. Furthermore, out of the existing 20 frame lines, 18 are corrected detected. The only 2 frame lines which were not detected are in the top right and top left frames.

The result of the test sequence that includes 4 comics with a total 110 pages is shown in Table 1. The frame segmentation of preprocessing phase influences the accuracy of our proposal. Our proposal is depending on the number of frame that is obtained using the frame segmentation process. Therefore, the result is deteriorated in the situations of over-segmentation or under-segmentation. As a result, in the case of Comic-C, the accuracy of correct line detection is comparatively low: 64%.

Figure 2: Result of proposed method. Detected border lines are illustrated by dotted line. Three frames in the bottom two and middle right one are detected correctly. Top right and top left frames still have redundant blank in a side (one line is incorrect).

5. CONCLUSION

In this article, a frame position detection method with high positional accuracy is proposed. Our method utilizes the result of Comic Frame Separation and Comic Corner Detection. The proposed method achieves 64-84% of correct frame line detection. The high accuracy frame position will provide basic information for analysis in future on comic image.

6. REFERENCES

[1] S. Mao, A. Rosenfeld, and T. Kanungo, "Document structure analysis algorithms: A literature survey," Proc. SPIE Electronic Imaging, vol. 5010, 2003.

[2] Y. Tsuji, "Document image structure analysis with split detection method," IEICE Trans. Inf. & Syst. (Japanese Edition), vol.J84-D2, no.4, pp. 491-499, April 1991.

[3] K.Y.Wong, R.G. Casey, and F.M. Wahl, "Document analysis systems," IBM J. Res. Dev., vol. 26, no.6, pp. 647-656, November 1982.

[4] T. Tanaka, K. Shoji, F. Toyama, and J. Miyamichi, "Layout analysis of tree-structured scene frames in comic images," Proc. IJCAI-07, pp. 2885-2890, January 2007.

[5] D. Ishii, K. Kawamura, and H. Watanabe, "A study on frame decomposition of comic images," IEICE Trans. Inf. & Syst. (Japanese Edition), vol. J90-D, no.7, pp.1667-1670, March 2007.

[6] D. Ishii, K. Kawamura, and H. Watanabe, "A Study on Frame Corner Detection of Comic Image," IPSJ SIG Technical Report, No.7, June 2010.