Automatic Panel Extraction of Color Comic Images

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Abstract. In this paper, an automatic approach for detecting and extracting panels in a color comic image is proposed. Panel extraction is challenging because the background color, the background pixel locations, the panel shapes and the panel layout are not known in advance. In our approach, uniform color stripes are first identified and used as separators to segment the color comic page image into sub-regions in a recursive manner. Panels are recognized as the sub-regions that cannot be further segmented. The structure of the panels is thus obtained in the extraction process and it contains the layout of the panels as well as the reading order. Panel extraction is useful because: 1) the extracted panels can be better fitted into a handheld device for viewing; and 2) the panels can then be further analyzed to extract features used for content based indexing and retrieval.

Keywords: Comic processing, panel extraction, image analysis, image segmentation.

1 Introduction

Reading comics is a kind of entertainment and there are varieties of comics for readers to choose from. Some comic stories are turned into animations or movies filmed with real actors. In recent years, some comic publishers start to digitize the traditional paper comics and provide the e-comic as an alternative format to enable people to enjoy reading them on a computer. Common forms of comics are comic strips and comic books and they can be in black and white or in color. A comic strip usually contains four panels and a comic book consists of many pages with several panels per page for conveying a story. In Hong Kong, tens of comic books are being published weekly and there is a growing demand to process such comics in digital format.

Several researches have been focused on comic representation and analysis. Shamir *et al.*'s system [1] can extract a sequence of important events from a continuous temporal story line and convert the events into a graphical representation automatically. Tanahashi *et al.* have proposed a comic emotional expression method using an abstract facial model [2]. Kawamura *et al.* have presented a method of

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gradation approximation for vector based compression of comic images [3]. Furthermore, comics are utilized for education in language learning [4]. Comic actors can be used to represent software agents [5]. In [6], cartoon motion capture is performed from a sequence of frames. Cartoon character retrieval is studied in [7][8].

Handheld devices like personal digital assistant (PDA) have gained popularity in these recent years. However, the biggest constraint of handheld devices is the small screen display as mentioned in Qiu *et al*'s study about web interface on small display devices [9]. To solve the problem of Internet surfing in such devices, various researches have been conducted in the areas such as the adaptation of web content [10][11] and dynamic text presentation [12], etc. In this paper, we would like to adapt high-resolution comic images into a small display device.

This paper is focused on processing of color e-comic book consisted of many pages. On each page, panels are put together in a certain layout often with a uniform color background. Some examples of comic page images are shown in Fig. 1. A panel is a small sub-area in a color comic page and represents an instance of the storyline. We are targeting the panel extraction problem in which the panels should be extracted from each color comic page. Panel extraction is useful because: 1) the extracted panels can be better fitted into a handheld device such as PDA for viewing; and 2) the panels can then be further analyzed to extract features used for content based indexing and retrieval.

Fig. 1. Examples of comic page images

Existing software from ComicGURU [13] allows users to perform the panel extraction task and create the e-comic format suitable for viewing in handheld devices. However, these tools require users to specify each panel manually. We would like to develop an automatic approach for panel extraction to relieve the level of human intervention. It is a challenging task because the background color and the background pixel locations are not known in advance and they can vary among different comic pages as illustrated in Fig. 1. Moreover, the shapes of the panels are not always rectangular and the size of the panels can vary across a large range thus the panel layout is also a variable.

Panel extraction can be formulated as a problem in image segmentation [14]. Although Hough Transform [15] can be applied to detect the line segments on the background that can then be used to segment the panels, this method is not suitable for processing comics that can have numerous lines due to the nature of the comic content. Instead, we propose a pixel-based algorithm to handle this problem. In our approach, uniform color stripes are first identified and used as separators to segment the color comic page image into sub-regions in a recursive manner. Panels are recognized as the sub-regions that cannot be further segmented. The structure of the panels is thus obtained in the extraction process and it contains the layout of the panels as well as the reading order. Experiments show that it can provide good accuracy with acceptable speed.

This paper is organized as follows. The panel extraction algorithm is introduced in Section 2. The speed-up strategy is described in Section 3. Experiments and results are given in Section 4. Our implementation of a PDA comic viewer is presented in Section 5. The conclusions and future work are provided in Section 6.

2 Panel Extraction

Fig. 2 illustrates the flow of our panel extraction algorithm. Firstly, stripes formed by consecutive uniform color lines in a particular orientation are recognized. False stripes are removed in the next step. The image region is segmented accordingly to the recognized stripe. This process is repeated recursively until no more stripes are found. The final regions correspond to the extracted panels.

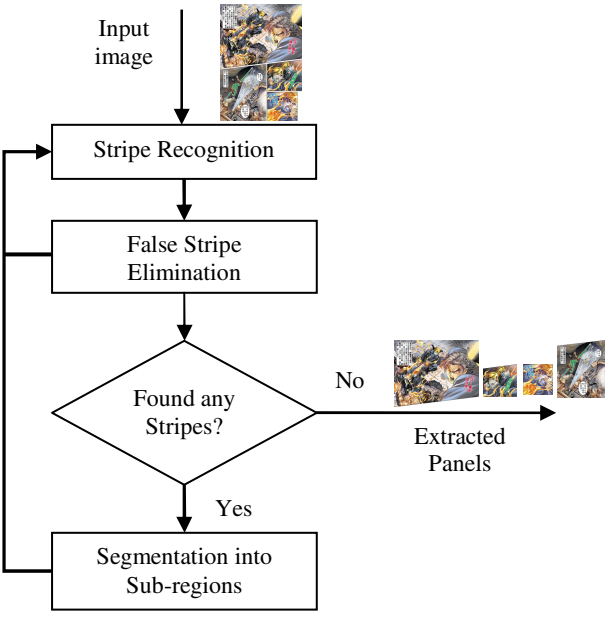


Fig. 2. Flowchart of panel extraction

2.1 Stripe Recognition

A stripe is a set of consecutive lines with uniform color and belongs to the background. The orientation can be horizontal, vertical or tilted as shown in Fig. 3. It can be used as a separator to divide a comic page image into panels.

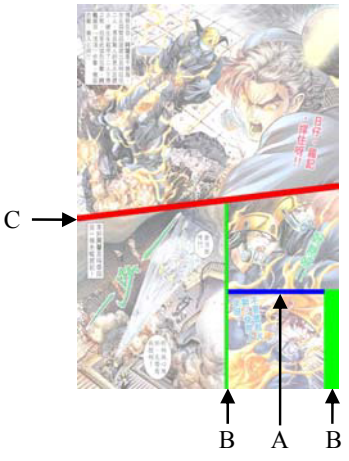
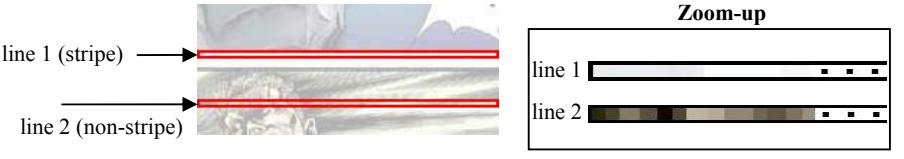
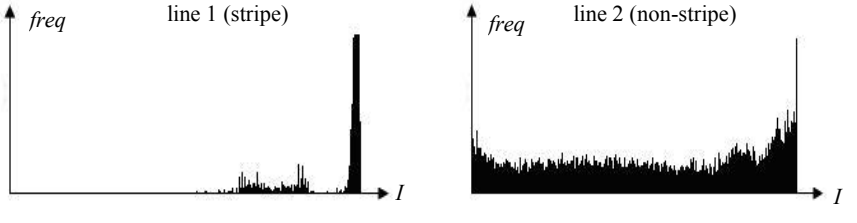


Fig. 3. Examples of stripes (A, B, C are horizontal, vertical and tilted stripes respectively)

Uniform color lines need to be first identified. This can be achieved by checking the intensity histogram of the pixels along each line. We scan each line on an image region according to the line equation $ax+by+c=0$ and compute the intensity histogram. Fig. 4 shows two horizontal lines, one from a stripe and one from a non-stripe, as well as the intensity histograms for each case.



(a) line 1 (stripe) and line 2 (non-stripe)



(b) Intensity histograms of line 1 (stripe) and line 2 (non-stripe)

Fig. 4. Intensity histograms of a stripe line and a non-stripe line

Fig. 4(b) shows that line 1 has uniform color whereas line 2 has larger variations across the intensity levels. Each line is checked to determine if it is a uniform color line by having more than 90% of pixels around the peak in the intensity histogram. Consecutive uniform color lines are then grouped together to form a stripe and this is how a stripe is recognized. The image region is first scanned horizontally, then vertically and then scanned in tilted lines with an angle in every degree. Whenever a stripe is found, it will be further checked if it is a false stripe. The final recognized stripe will be used to divide the image region into sub-regions.

2.2 False Stripe Elimination

It is possible that the stripe recognition is affected by the content of the comic image. As the input region is becoming smaller, the chance of recognizing wrong stripes is getting higher. Fig. 5 shows an example of a false stripe. In this example, a false stripe exists in the panel region that has uniform color. A true stripe should exist in the page background area that has uniform color.

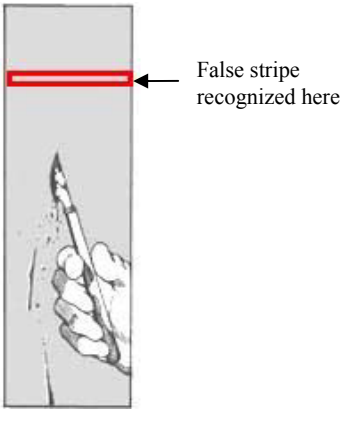


Fig. 5. Example of false stripe

A detected stripe is tested with the following two conditions to determine whether it is a false stripe.

1) False stripes often appear inside small panel regions. This means that at the beginning when the image region to be processed is large, a detected stripe consisted of uniform color lines is most likely a true one. The background color information can be recorded when the first stripe is recognized. The color of subsequent detected stripe can be checked with this background color. If the colors are not the same, then it is a false stripe.

2) A real stripe has a large contrast with the surrounding pixels. A false strip can thus be identified by checking its gradient along the boundary. We have found heuristically that if the percentage of pixels with similar color along the boundary is over 85%, then the detected stripe can be considered as a false stripe.

If a false stripe is identified, it is removed and the input region is further processed to recognize potential stripes. Otherwise, the detected stripe is used to segment the input region into sub-regions in the next step.

2.3 Segmentation into Sub-regions

The input region is divided into sub-regions using the recognized stripe as the separator. Each sub-region is processed recursively until no more stripes are found. The sub-regions can be represented in a tree structure. The reading order of the panels can be acquired by traversing the tree in preorder since the reading order of the comic is from top to bottom and from right to left for Chinese comics. For this paper, we focus on Chinese comics since there are already tens of thousands of Chinese e-comic volumes that are for sale online in Hong Kong.

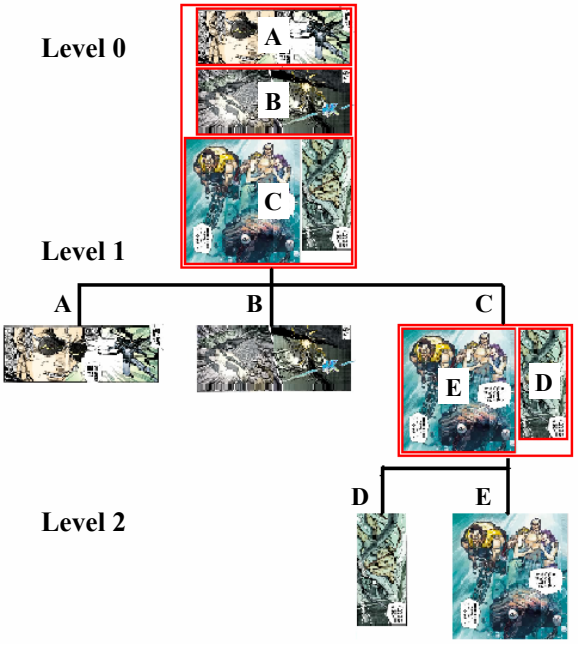


Fig. 6. Tree structure of sub-regions

Fig. 6 illustrates an example of the tree structure of sub-regions. The input comic page image is segmented into 3 sub-regions in level 1. As regions A and B do not contain any stripes, they are identified as panels. A stripe is found in region C thus it is further segmented into regions D and E in level 2. As regions D and E do not have any stripes, they are identified as panels. Furthermore, the reading order of the panels is found to be A, B, D, E using the preorder traversal along the tree.

3 Speed-Up Strategy

In our algorithm, most of the time is spent on checking all the pixels on each line to detect stripes. We present a strategy to accelerate our algorithm while preserving the accuracy of the system. It is observed that the beginning and ending pixels on a true stripe always have the same or similar color. As a result, before checking the histogram, these two pixels can be checked first. If they have different colors, then the line is a non-stripe line and no further checking is necessary. Experiments show that the speed-up strategy increased the speed by 70%. However, this strategy cannot be further applied to all other pixels along the line because there can be variations on the intensities for other pixels on a stripe line as indicated in Fig. 4(b).

4 Experiment and Results

In the experiment, we tested our approach on a comic image database containing 500 pages from 14 comic volumes offered by the Jade Dynasty Group Limited [16][17]. The comic volumes come from 4 different stories and authors. The resolution of each comic page image is around 700×1000 pixels. The experiment is carried out using a Pentium 4 PC with 1.7GHZ and 512M RAM.

The performance of our panel extraction algorithm is given in Table 1. There are altogether 2406 panels from the 500 comic page images. This information is obtained manually and used as the ground truth. On the other hand, we apply our algorithm to detect the panels automatically from these comic page images. As indicated in Table 1, our approach can correctly identify over 83% of panels with 2 seconds per page on average. The number of false panels is about 10%. The result shows that panel extraction can be performed correctly most of the time. Some human intervention may be required to correct the wrong results. With the accuracy of our algorithm, the required manual effort should be much less than if each panel has to be extracted manually.

Table 1. Performance of panel extraction

Total no. of true panels	2406
No. of panels correctly recognized	2016
Accuracy	83.8%
False detection rate	10%

Some examples of comic page images as well as the panel extraction results are shown in Fig. 7. The numbers in the extracted panels indicate the reading order. It can be seen that our algorithm is able to extract panels accurately under variations in panel sizes, shapes and layout.

Some panels cannot be identified mainly because the extended content from a panel causes the stripe recognition to fail so further panels cannot be detected. An example of such case is shown in Fig. 8(a). Sometimes a false stripe cannot be eliminated resulting in false detection. This is because the false stripe also has a large contrast along the boundary due to the panel color content as shown in Fig. 8(b).

Fig. 7. Comic page images and the extracted panels with the reading order

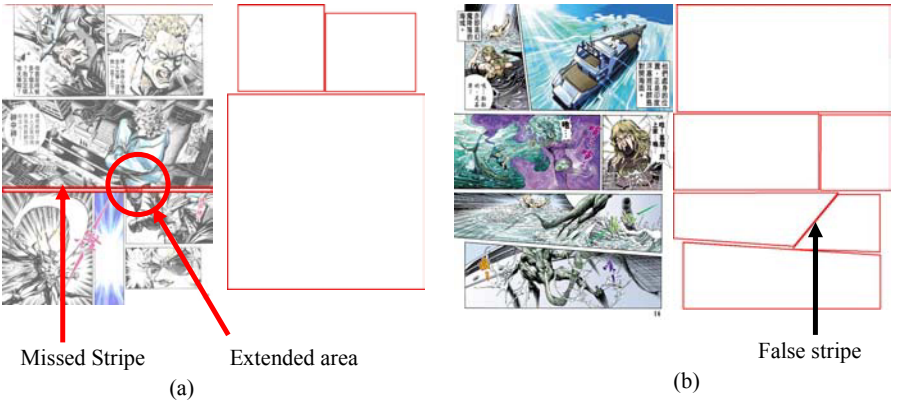


Fig. 8. (a) Missed stripe due to the extended content; (b) False stripe due to the panel color content

5 PDA Comic Viewer

We have developed a PDA comic viewer to read the extracted panels as shown in Fig. 9. It provides a convenient and comfortable way to read comic on a PDA screen. It has common functions such as moving forward, backward or to a specific panel. The panel can be zoomed in different scales or viewed in full-screen mode. The auto-sliding function allows advancing to the next panel automatically after a fixed time interval.

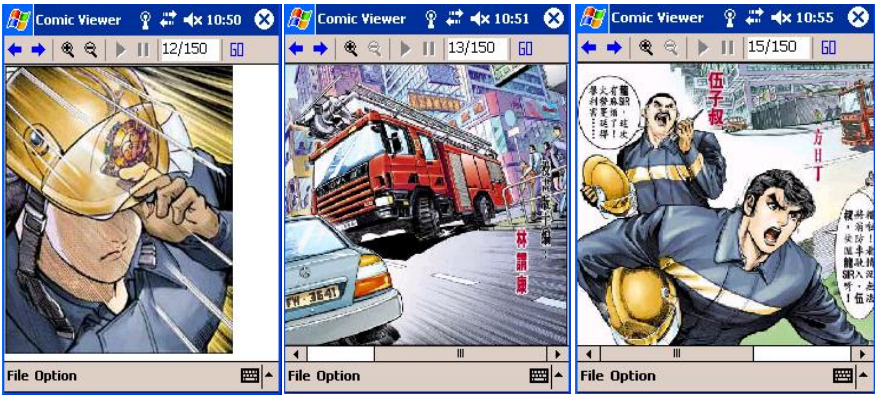


Fig. 9. PDA comic viewer

6 Conclusions and Future Work

This paper proposes an automatic approach for extracting panels in a color comic page image. Given an image region, the stripes are first recognized and false stripes are removed. A recognized stripe is used to divide the image region into sub-regions. This process is repated recursively until no more stripe is found. Experiments show that the panel detection high accuracy with reasonable speed.

As future work, we will detect the text boxes on the panel so that the graphics part and the text part in the panel can be viewed with different scales for better viewing on a small PDA screen. In addition, user behavior will be analyzed to customize parameters such as navigation, zooming and scrolling while reading comics.

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