Techniques of Image Processing for Decoding Mokkans

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Abstract This paper presents several results of investigations to find effective image processing methods for decoding *mokkans*. *Mokkans* are wooden tablets with handwritten characters excavated from ruins of ancient cities in Japan. Historical *mokkans* are important cultural properties. Several image processing methods have possibilities to support reading the *mokkans* damaged heavily. For example, "Gaussian blurring" is effective when used in conjunction with contrast enhancement in the HSV space. We have also identified several techniques that allow convenient extraction of character strokes in *mokkan* images. Constructing image processing systems to aid archaeologists and historians is our future work.

Key words image processing, historical documents, *mokkan*

1. Introduction

"*Mokkan*" is a Japanese generic name for every wooden tablet on which text is written in Indian ink. Over 320,000 *mokkans* made and used in and around the 8th century have been excavated at the ruins of ancient cities in Japan: *Heijyo* (in Nara prefecture) and *Dazai-fu* (in Fukuoka prefecture) are the most famous ruins of them. Many of the *mokkans* were used for luggage tags of gifts, commodities, goods for tax, and so on. Therefore, decoding the *mokkans* is important work to find the flow of materials, the relations among regions and the condition of economy at the period (Figure 1).

Decoding the *mokkans* is difficult even for archaeologists and historians. Unfortunately, the color of ink has been faded, the surfaces of the *mokkans* have been scratched and the wooden tablets have been broken during the time over 1,200 years.

Some researches to support reading old paper documents have been proposed binarizing methods to extract text and figures in the digital document images [1-5]. In the image processing of the historical *mokkans*, employing such binalizaion is difficult because of the complex texture and the variable degradation of the surfaces of the *mokkans*. For the reason, we set our goal of expanding the human-viewability of the historical *mokkans*.

In this paper, we show examples of image processing to enhance the historical *mokkan* images. The results provide efficient choices of the image processing to the archaeologists and historians. Also, we propose an interactive image processing to extract ink parts on the *mokkans*.

Figure 1 *Mokkans* from the ruin of the Heijo palace site.

2. Methods to enhance readability

2.1 Contrast enhancement

Contrast enhancement is an image processing method to expand the contrast between the foreground and background pixels in an image. Our technique presented in this paper uses this method in each channel of RGB or HSV color space.

Figure 2 shows the experimental results in which the contrast enhancement is applied to three images. In the

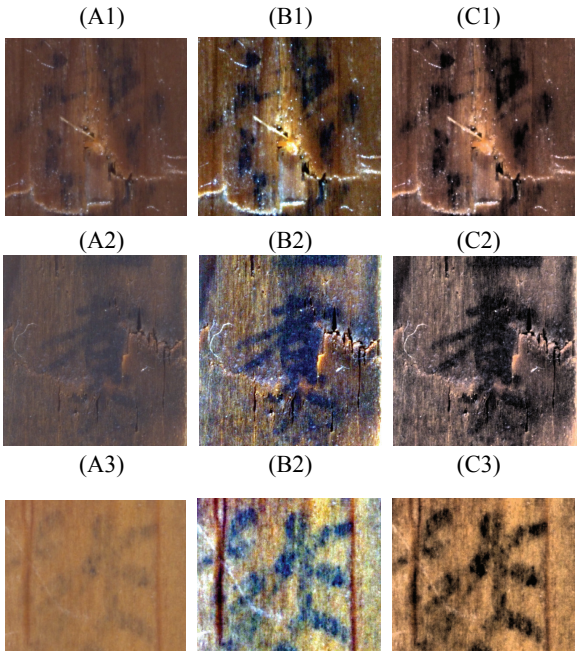

Figure 2 (A1-A3) original images (B1-B3) after contrast enhancement in RGB space (C1-C3) after contrast enhancement in HSV space.

examples using HSV space, only the V channel is enhanced to prevent the extreme change in appearance of wooden tablets and ink. According to the limited enhancement, we obtained fine images: (C1)-(C3).

In contrast, the results using RGB space is not fine. Since most of the *mokkan* images consist of only ink and wooden parts, the pixels in the images compose narrow Gaussian distribution in each channel of RGB. In such images, we need other technique to expand the contrast between the foreground and background pixels.

2.2 Using a set of Gaussian filters

In order to emphasize particular frequency elements in mokkan images, we employ Gaussian filters with different window sizes. Each window size specifies the frequency elements that the Gaussian filter extracts from the image. By overlapping the extracted elements with weighting factors, we obtain a new image in which the frequency elements with large weight have been emphasized.

In this research, we prepare Gaussian filters with eleven different window sizes (3,5,7,…,23 pixels). Also, we preset 2 sets of weighting factors to extract high and low frequency. One for high frequency follows the function f_{high}, the other for low frequency follows the function f_{low} in Figure 3. Then we obtain two images I_{high} and I_{low}. Afterword, we obtain the weighting sum of I_{high} and I_{low} for easy operation. Figure 4 shows the example of this technique.

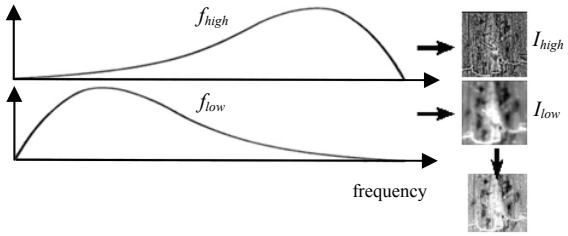

Figure 3 Noise reduction using a set of Gaussian filters

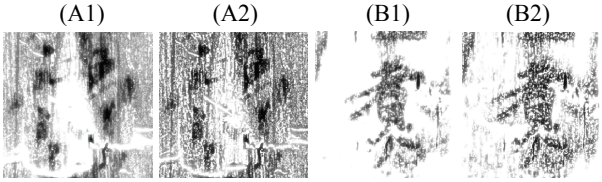

Figure 4 Images obtained from overlapping multiple Gaussian filters: (A1) 0.3H+1.55L on Figure 2 (C1); (A2) 0.6H+1.05L on Figure 2 (C1); (B1) 0.3H+2.13L on Figure 2 (C2); (B2) 0.6H+1.55L on Figure 2 (C2).

3. Selection based on pixel similarity

This technique provides simple and interactive user interface of pixel selection. At the start point of the technique, an archaeologist or a historian selects pixels that consist of ink part of a *mokkan* image. The archaeologist or the historian can use pen or mouse devices to select the pixels. Then the technique calculates distances between each of the selected pixel and the other pixels in the image. Each of the distance is the sum total of the differences in each channel of RGB, HSV or LAB space. Finally, the technique selects every pixel of which the distance is smaller than 10 (Figure 5).

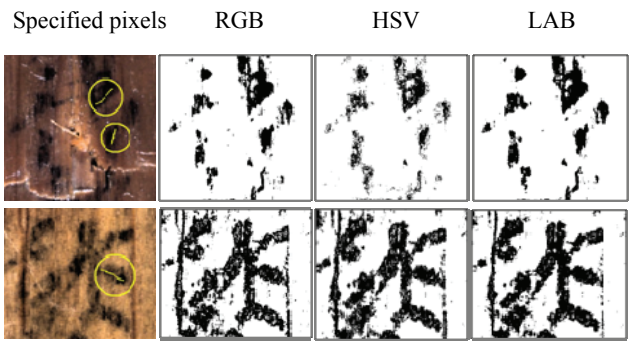

Figure 5 Selected pixels in RGB, HSV and LAB spaces corresponding to the specified pixels, on respectively the images from (C1) and (C3) in Figure 2.

4. Conclusion

This paper presented several techniques to support decoding historical *mokkans*. Enhancement only in the V channel in the HSV space seems effective while preventing extreme change in appearance of wooden tablets and ink. Constructing image processing systems to aid archaeologists and historians is our future work. Also, evaluating other image processing methods is another important work for us.

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