A Binarization Approach for Ukiyo-e Rakkan Extraction

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***Abstract*—Rakkan is a Japanese word for the signature and/or seal of the artist for a completed painting. In this paper, we present a binarization scheme for ukiyo-e Rakkan extraction. The Rakkan characters are extracted based on both lightness and color information in $L^*a^*b^*$ color space using k-means clustering. Different thresholding and noise removal methods are applied to different types of Rakkan images according to the extraction results. This approach can be adopted to the ukiyo-e authorship identification system for ukiyo-e study and archiving.**

Keywords-binarization; historical documents; character extraction; digital archives

I. Introduction

Ukiyo-e, an artistic genre of Japanese woodblock prints and paintings produced between the Edo period (1603–1868) and the Meiji period (1868–1912), is one of the most famous Japanese cultural heritages. The collections of ukiyo-e have over one million art works in the world. Researches of ukiyo-e not only contribute to the aspect of art, but also provide useful information sources for studying the culture and history. However, many ukiyo-e prints are collected without archiving. The motivation of our research is to identify artist information and make automatic archiving of ukiyo-e prints using *Rakkan* information.

In our previous research, we tried to build an experimental ukiyo-e authorship identificatio system [1]. However, conventional binarization methods sometimes could not provide satisfactory output. In order to improve the overall performance of the authorship identificatio system, in this paper, we propose a binarization approach for ukiyo-e Rakkan extraction.

II. Features of Rakkan

Ukiyo-e Rakkan has some unique features which make it difficul to be binarized using conventional binarization methods: (1) Ukiyo-e Rakkan characters were printed from handwritten characters that varies in style, size, shape, and alignment. (2) The Rakkan characters were printed on backgrounds of various colors, thus the color of Rakkan is affected by the background color instead of pure black. It's difficul to extract the characters only using color information. (3) Seals, decorative patterns, and ornament frames may be depicted on the background. The characters may be overwritten on the painting contents which is a big challenge for threshholding methods. (4) Since ukiyo-e were produced by woodblock printing, the Rakkan characters are often faded, and sometimes blurred or corrupted with age.

Some examples of ukiyo-e and typical Rakkan images are shown in Figs. 1 and 2.

Figure 1. Examples of ukiyo-e and Rakkan.

(a) normal (c) blurred (d) faded (b) dark background (e) uneven background (f) painted background (g) with ornament (h) seal on background

Figure 2. Typical Rakkan images.

III. Our Approach

We propose a binarization approach for extracting Rakkan from background. The processing procedure is illustrated in Fig. 3.

A. $L^*a^*b^*$ color space

To separately handle lightness and color information for thresholding and clustering, we transform the input Rakkan image into $L^*a^*b^*$ color space, in which L represents lightness, a and b represent the color-opponent dimensions.

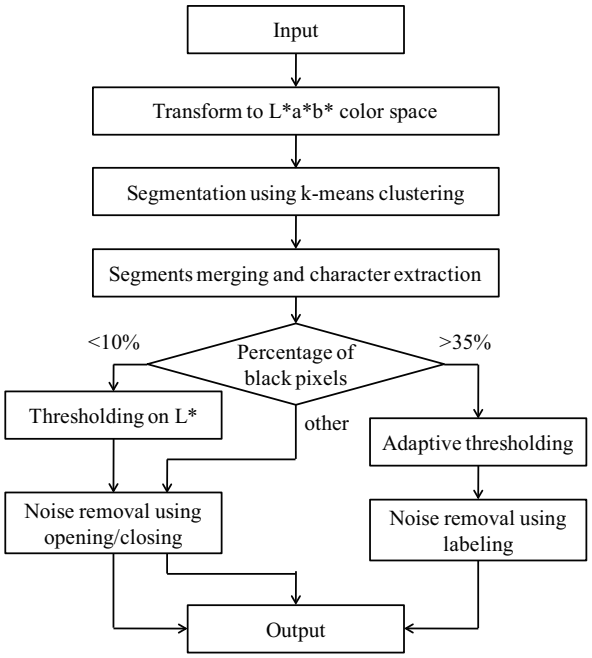

Figure 3. Flow of processing.

B. Character area extraction

In $L^*a^*b^*$ color space, we apply k-means clustering to segment the character areas according to the lightness and color information. In this research, we set k to 4 based on our prior experiments. We pick up the cluster with least lightness value as the basis of character area, and merge it with similar clusters within a threshold as the output character area. We calculate Euclidian distance of each cluster to the basic cluster in $L^*a^*b^*$ color space by CIE 1976 $L^*a^*b^*$ color difference formula. If the distance of a given cluster is less than 40% of the greatest distance, the cluster is considered as the character area (Fig. 4).

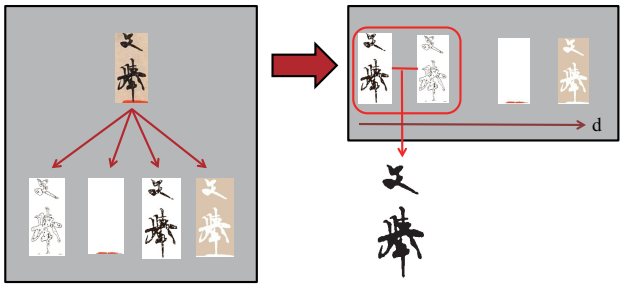

Figure 4. Segmenting and merging character areas.

C. Thresholding and noise removal

Due to the Rakkan features we addressed before, the extraction quality varies with different types of Rakkan images. We carry out different thresholding and noise removal methods for different Rakkan types. First, we binarize the extracted character area using Otsu's global thresholding method [2]. Then, we calculate the percentage of black pixels in (1) whole image area; (2) upper part of the image; (3) center part of the image; (4) lower part of the image. If any of the percentages greater than 35%, we consider the character area is affected by uneven background, and carry out adaptive thresholding [3]. If any of the percentages less than 10%, we consider the character area is blurred or faded, and carry out thresholding in L^* dimension. Otherwise, we consider the extracted character area is correct and directly go to noise removal.

In noise removal step, we carry out labeling and morphological opening and closing methods. The threshold for labeling method was set to 100 pixels. The structuring element used for opening and closing was a 3×3 square.

IV. Results and Discussion

In the experiments, we manually cut out Rakkan areas from 400 ukiyo-e images of 12 artists in Ritsumeikan University ARC Ukiyo-e Database. The size of each Rakkan image is around 150×250. The experimental results of the output Rakkan images is shown in Fig. 5. The proposed approach automatically extracted the character areas from different types of Rakkan images. Based on the results of 400 testing images, the extraction accuracy is over 90%.

To remove the ornament frame around the Rakkan characters and automatically cut out the Rakkan area are our future works.

(a) Original Rakkan images

(b) Output binarized images

Figure 5. Experimental results.

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