DEVELOPMENT AND IMPROVEMENT OF IMAGE PROCESSING SCHEME FOR ARCHIVING INSCRIPTION

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Abstract – This paper shows improvement of image processing scheme for digitally archiving of inscription on stone monuments. The scheme succeeded in speeding up the image processing, and also improved the readability of the inscription text. The method developed in this study is important for the future development of automatic recognition of characters in inscription from photographs.

Keywords – epigraph, inscription, image processing, digital archive, citizen science,

Conference Topics – Designing and Delivering Sustainable Digital Preservation,

I. INTRODUCTION

Numerous stone monuments have been erected across Japan over 1,400 years, since the seventh century. Although it is estimated that the total number of monuments exceeds one million, the actual number remains unknown. Recently, the importance of these stone monuments has been recognized widely. For example, by heeding the warning engraved on a stone monument, "Do not build a house lower than this altitude," indicating where a tsunami had reached in the past, people in that area could escape from the tsunami caused by the Great East Japan Earthquake. The Tohoku Regional Bureau of the Ministry of Land, Infrastructure and Transport released an archive titled, "Tsunami damage and tsunami stone monument information archive" to the public [1]. In fact, there are many stone monuments in the areas affected by the Tokai and Nankai earthquakes in the past, where several earthquakes of magnitudes exceeding that of the Great East Japan Earthquake have occurred. However, most stone monuments exist outdoors and have deteriorated because of weathering. Furthermore, accurate information is no longer available if the stone monuments themselves were lost because of urbanization or road work. Therefore, it is urgently necessary to archive as many stone monuments as possible.

It is difficult to decipher weathered inscription from ordinary photographs. Their surfaces are often covered by moss, and characters on the surface are unclear (Fig. 1). Owing to the ambiguity of the photo images of inscription, researchers have difficulty in the data from photographs of stone monuments. The accuracy of reading the text on the stone monuments from photo images largely depends on the skill of the investigator and field conditions, weather, direction of sunlight, and accessibility to the samples. The quality of the images taken under these different conditions changes largely, making it also decrease the quality of the archive.

In recent year, Software and methods have also been developed to obtain the three-dimensional shape of stone monuments by using Photometric stereo, such as RTI [2]. Furthermore, methods that can restore the shape of stone monuments based on the motion of the camera have dramatically advanced, and it is possible to automatically restore

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the three dimensional shape from a large number of digital photographs [3-4]. However, it was difficult to apply those methods to the fieldwork of the huge number of stone monuments because of time-consuming of image processing.

Figure 1 Sample images of unclear inscriptions.

We are currently developing a new method of digital archiving of inscriptions [5-6]. Our method emphasizes three features, “Speedy”, “Simple”, and “Lightweight” for the fieldwork. In Japan, the investigation of stone monuments is normally undertaken by retired people, who are instructed by the museum curator. For this reason, the photography step should be simple, to facilitate public participation. Another reason is that condition of stone monuments is diverse. Photographic instruments should be made lightweight to make it possible to visit several places with diverse conditions, as shown in the figures. For this reason, we make the photography step as simple as possible.

II. METHOD

In our image processing scheme, we require shadow images of the whole text on the stone monument illuminated by oblique light. A non-shadow image of the surface of the stone monument, called as the background image, is also required. After the acquisition of these images and registration of archive data in our system, the system applies basic image processing to all the images acquired through field work, as a general procedure to prepare for advanced image processing, which aims to automatically extract characters according to a programmed procedure.

The “basic image processing” scheme developed in this study consists of the following steps:

(1) monochromatizing all shadow and non-shadow images into 8-bit grayscale,

(2) subtracting the background image (non-shadow image) from all shadow images to remove non-shadow contrast from the image and to enhance the shadow of characters (Fig.2-(a)),

(3) applying a Gaussian filter to (2) to create a mask image of the area illuminated by oblique light, by blurring the light (Fig.2-(b)),

(4) subtracting (2) from (3) to enhance the shadow of the character and mask the area illuminated by oblique light in (2),

(5) adjusting and unifying the brightness and contrast of images from (4) using the upper and lower limits of gray value derived from the histogram of each image.

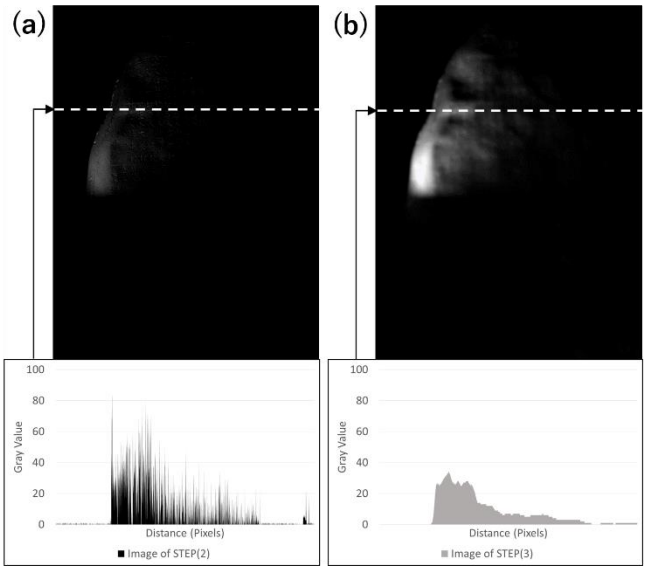

Figure 2 (a): Image of step (2) and a line profile of gray value along the dashed line, (b): Gaussian Blur image of step (3).

Considering steps (3) and (4), there are two purposes of the image processing. First, we aim to enhance the shadow of the character on the stone monument. Second, we aim to mask the image only for the area illuminated by oblique light. Between steps (3) and (4), the contrast of the image was inverted, and a negative contrast image was obtained. If the gray value of a pixel becomes negative during subtraction, we set the gray value to 0.

In Fig. 3, we can clearly see that the contrast of the shade (i.e., contrast of the text) is enhanced compared to surrounding noise. In addition, the intensity of the area outside the illumination by the oblique light is still low. Originally, the "shadow" of

the engraved character on the surface of the monuments and the luminance of the "shade" part outside the irradiation area had similar gray values. However, by reversing the gray value of the shadow by this method, "shade" becomes having much lower gray values than "shadow", and we can create an image in which only the shadow of the character in the irradiation area is present (Fig.3-4). The advantage of this method is that even if we cannot irradiate the entire area of the inscription at once because of larger text area (ROI, Region of Interest) than irradiation area, all of the inscription can be extracted by photographing the stone monuments with changing the irradiation area and combining all images after the acquisition (Fig.5).

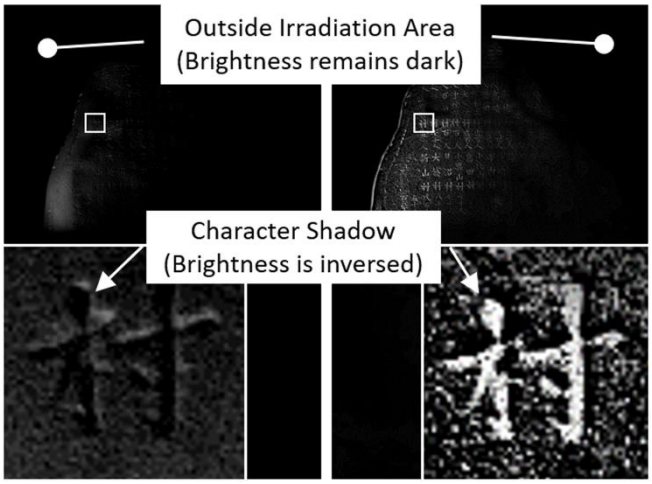

Figure 3 Image in which only the shadow of characters in the irradiation area remains high gray value

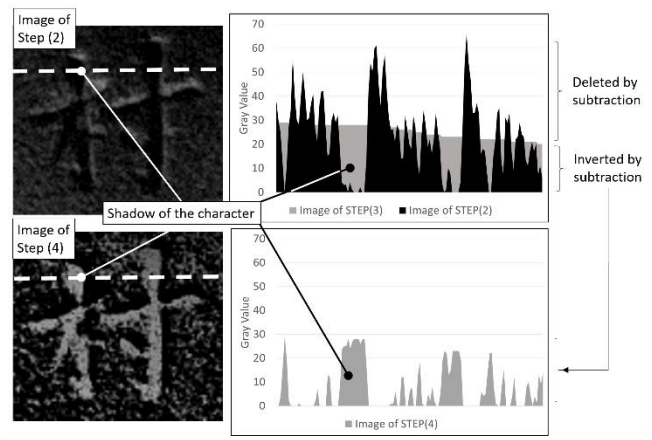

Figure 4 Comparison of images of step (2) (upper left) and step (4) (lower left) around a character. Line profiles along the dashed line are also shown on the right-hand side of the figure.

We had applied a low-pass filter at step (3) in previous studies, but used Gaussian Blur in this study. As a result, we succeeded almost the same result in significantly speeding up the image processing while obtaining the same result (Table I).

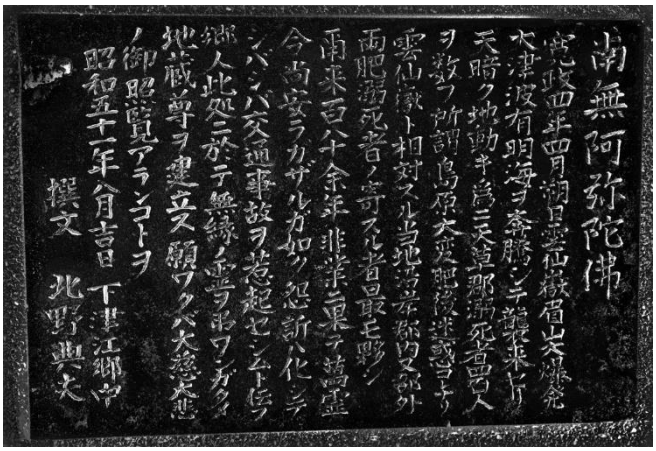

Figure 5 Result of Fig.1

TABLE I
Processing speed comparison

	Number of Image	Image Size	File Format	Processing Time	
				Low-Pass	Gaussian
Sample1 (Fig.3-6)	30	60.9MB	tiff	06'06"67	00'50"68
Sample2	6	60.9MB	tiff	01'31"45	00'10"80
Sample3	27	5.0MB	jpg	03'27"48	01'11"24
Sample4	13	5.8MB	jpg	01'47"73	00'31"01

III. RESULTS

Although we succeeded in increasing the inscription readability significantly, the data are still insufficient for the automatic recognition of the characters on the surface of stone monuments, because of low signal-to-noise ratio of the image in cases of Fig.6.

Figure 6 Original image (left) and combining all images (Right)

Therefore, we applied cluster labeling method to reduce noise level [7]. Cluster labeling is a method in which all adjacent of a pixel those having a specified range of pixel values are regarded as one chunk, i.e. a cluster. After the recognition of all clusters on the

image, gray values of the pixels in a cluster were changed according to the cluster size. Pixels in the largest cluster have gray value 1, and pixels in the second largest cluster have gray value 2. Because gray value of all clusters shows the size of clusters, we can remove small clusters (showing noise) by thresholding the image and extract only large clusters (showing characters) easily (Fig. 7).

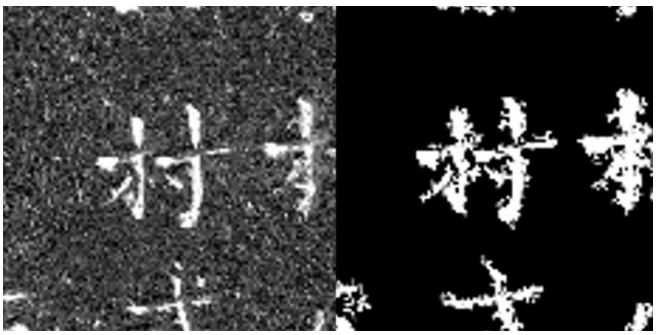

Figure 7 Result of cluster labeling

However, these noise reduction steps cannot be automatically processed with the programmed flow. In future work, we may be able to develop automatic processing of this step by accumulating the result of image processing along with the important parameters of the samples, such as the base material of the stone monument, shape, and tendency in a region, in a database.

IV. DISCUSSION

This report mainly focuses on inscription extraction technology. In future work, we will evaluate the improvement for the efficiency of character recognition quantitatively, by calculating signal to noise ratio and doing an experiment of automatic recognition of inscription by machine learning content using Dataset of PMJT Character Shapes [8]. We will also develop a description schema for inscription with EpiDoc [9]. Furthermore, since this method can acquire images for multiple samples at once, we can obtain a large number of data with considerably small processing time. Figure 10 shows a demonstration for the application of our method to multiple coins those having much faint irregularity compared to inscriptions on stone monuments. Thus, the method can applicable not only inscriptions, but also divers samples of the historical and Archaeological materials, to digitize their surface in speedy.

Figure 8 Result of Coins

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REFERENCES

[1] Tsunami Damage · Tsunami Stone Information Database, Tohoku Regional Bureau of the Ministry of Land, http://www.thr.mlit.go.jp/road/sekihijouhou/archive/top.pdf

[2] G. Palma, M. Corsini, P. Cignoni, R. Scopigno, and M. Mudge, “Dynamic Shading Enhancement for Reflectance Transformation Imaging,” Journal on Computing and Cultural Heritage (JOCCH), 3 (2), September 2010.

[3] A. Koutsoudis, B. Vidmar, G. Ioannakis, F. Arnaoutoglou, G.Pavlis, C. Chamzas : Multi-image 3D reconstruction data evaluation, Journal of Cultural Heritage, 15 (1), pp. 73-79, 2014.

[4] A. Koutsoudis, B. Vidmar, G. Ioannakis, F. Arnaoutoglou, G.Pavlis, C. Chamzas : Development and Disintegration of Maya Political Systems in Response to Climate Change, Science, 09 Nov 2012 338, pp. 788-791, 2012.

[5] H. Uesugi, and M. Uesugi, “Development of the Database for Images of the Text on the Stone Monuments,” Culture and Computing (Culture Computing) 2013 International Conference on, pp. 149-150.

[6] H. Uesugi, and M. Uesugi, “Stone Monument Text Image Database,” Theory and Practice in Modern Computing, 2015, pp. 203-207.

[7] "Slice" -Softwares for basic 3-D analysis-, Slice Home Page, Japan Synchrotron Radiation Research Institute. http://www-bl20.spring8.or.jp/slice/

[8] Dataset of PMJT Character Shapes, http://codh.rois.ac.jp/char-shape/.

[9] S. Orlandi, R. Santucci, F. Mambrini, and PM. Liuzzo, "Digital and Traditional Epigraphy in Context", Proceedings of the EAGLE 2016 International Conference, 2017.