DRAWING FOR ARCHEOLOGICAL ARTIFACT USING MULTIPLE EDGE DETECTION TECHNIQUES

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ABSTRACT

In order to save the labor for the drawing work of archeological artifacts, an edge detection method was examined aiming at making a high definitional image based on an ortho projection image. An edge detection method, but not the conventional filtering process, was applied to the edge detection work of earthenware taking into account the influence of noise which can be read from multiple edge detection techniques . The result has revealed that an image with greatly-reduced noise can be assured compared with the traditional method.

1. INTRODUCTION

In Japan, there are lots of archeological sites discovered every year and an enormous quantity of artifacts are being dug out of these archeological sites. For example , more than I0,000 archeological sites, large and small were discovered in 1996. These artifacts are all measured and to be recorded as an ortho projection image and a detailed drawing (edge detection) wherein the pattern of artifact has been recorded and for the work, quite much a hard labor is being spent. In view of such facts, there are request advanced to shorten the term of investigation and simplify the method investigation.

To meet these requirements, the authors have been conducting the research on the ortho projection and drawing using CCD camera since 1994. And as the result, it has become possible to make an ortho projection image with the same definition and besides in a short time (reduced to about 1/10) compared with the conventional method using a still camera. However, viewed from that in the drawing (edge detection) result which is a final result, noise generated in the photo-graphing image is included, there was a room for improvement (H.YOKOYAMA et al.,1996).

In this investigation, aiming at making a high definition edge image to cope with the problem, an examination was made in regard to an edge technique using multiple edge detection techniques .

2. SUMMARY OF ORTHO PROJECTION SYSTEM

The ortho projection and drawing system used in our study substantially comprises; CCD camera, personal computer (PC), actuator and line-lasers. Ortho projection image and DEM(Digital Elevation model, Depth) image can also be made.

At this system, there are any problems which are edge detection method and luck of image with hollow shape. In this investigation, the authors will show about high performance edge detection method.

Figure 1 is showing about the targets to use edge detection in this investigation(central projection image).

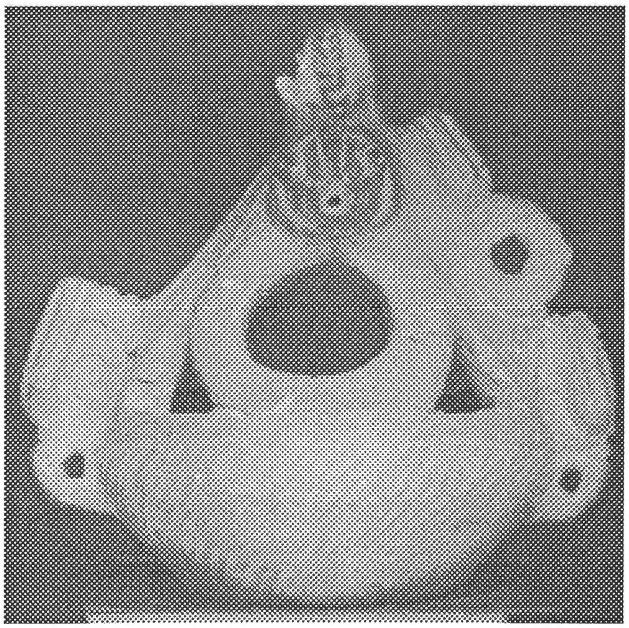

Figure 1(a) Target.1(central projection image)

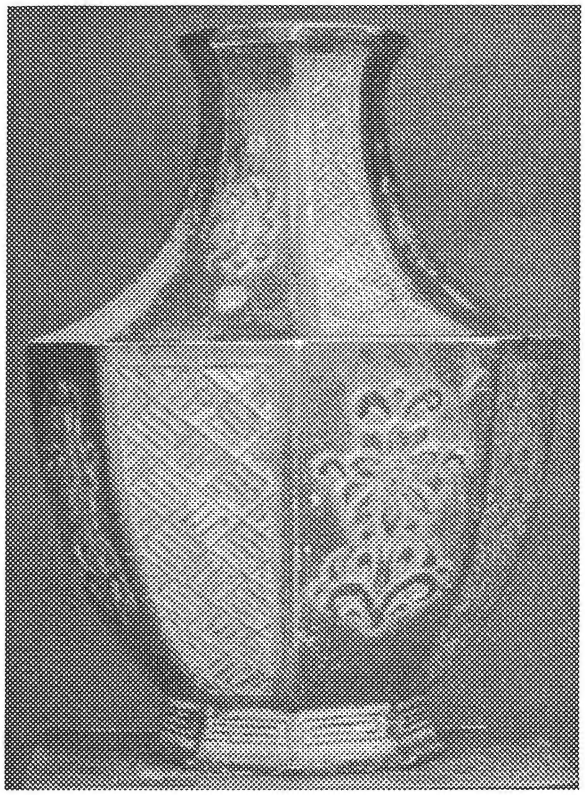

Figure 1(b) Target 2(central projection image)

3. EDGE DETECTION METHOD

3.1 EDGE DETECTION IN FILTERING METHOD AND PROBLEMATICAL POINTS

An edge detection images are important data for straw-rope pattern pottery(e.g. archeological artifacts at Jomon period) because of being used when an archaeologist does a chronological classification referring to the direction of bonds attached to the surface. The authors, with the purpose of reducing a tracing time have been developing so far with the automatic making of edged image as one function of the system by using a filtering technology.
Figure 2 shows edged images obtained relative to the images in Figure 1. Table 1 shows a parameter of Laplasian Gausian Filter(size:5 × 5)

Table 1 Parameter of Laplasian Gausian Filter(size: 5 × 5)

-1	-5	-7	-5	-1
-5	-9	8	-9	-5
-7	8	78	8	-7
-5	-9	8	-9	-5
-1	-5	-7	-5	-1

These edged images have been made by a Laplasian Gausian (LG) filter which is known as a filter having no directionality among many filtering techniques available currently(D.MARR,1982). Moreover, the filter size in this case is a minimum size of 5×5 for the LG filter because of being taken up to a fine point of the edge. However, since even up to noise are detected as edges in the edged images obtained by using the filter. It is difficult to judge which part is a true edge and how is the shape of pattern or feature even if taking a look at only the edged image directly.

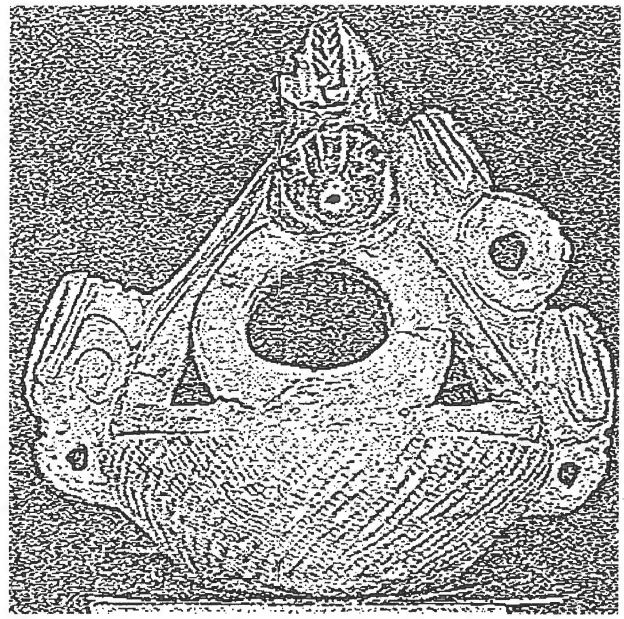

Figure2(a) Edged image(Target 1,LG filter)

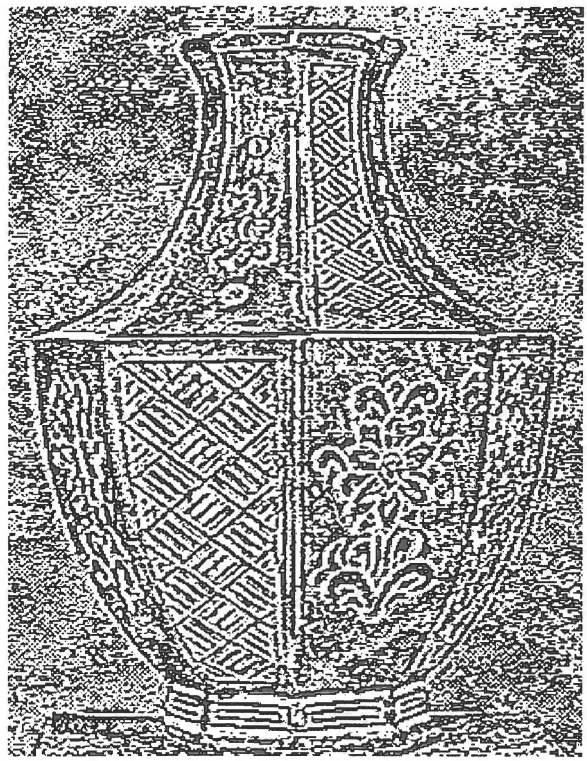

Figure2(b) Edged image(Target.2,LG filter)

The archaeologists are collecting the scientific data including the supposition of years and classification of cultural systems by checking to see a general shape of the artifact, the shape of pattern and the directionality of pattern from the ortho projection image and drawn (edged) image which is made of the image and they have formed a conclusion saying that an extra information of a noise included in the image is unnecessary.

Thus, in the present situation, the edged image obtained by using the filtering technique is handled by characterizing it generally as a thing used as a reference given immediately after photographing or for drawing by a manpower.

Therefore, in this investigation, it has been decided to employ an edge analysis technique using a reliability for making an edged image having even higher definition than the result obtained by using the conventional LG filter.

3.2 EDGE METHOD USING RELIABILITY

The edge detection, broadly classified, is composed of 3 processes

(1) detection of features of edge from image, (2) judgment of whether extracted features are on edge and (3) connection of edged points, and the detection of the features of the edge is greatly significant in this work.

Mr. Sugiyama et al. have proposed a method for extracting the features by setting 2 threshold limit values relative to 2 components called the height and reliability of edge and the elements obtained from these components (T.SUGIYAMA et al.,1995) .

This height of edge is a variation obtained from a relation of brightness with the periphery at a point of attention and the reliability is an index representing the scale of influence of noise .

The height of edge(edge variation, h (x,y)) can be obtained by applying an expression(1) shown below to an image becoming an object, which is representing the variation of edge at the periphery of the point of attention. Moreover, σ in the expression(1) denotes dispersion of a weight function (w(r)) and it is obtained from a relation with a size (WS) of window (calculation region) set at a time of calculation. And, it has been set as WS = 2 σ .

$$h(x,y) = \sqrt{h_x^2(x,y) + h_y^2(x,y)} \quad \cdots(1)$$

Where;

$$h_x(x,y) = \int_{-\pi}^{\pi}\int_{0}^{\infty} f(x + r\cos\theta, y + r\sin\theta) w(r)\cos\theta dr d\theta$$

$$h_y(x,y) = \int_{-\pi}^{\pi}\int_{0}^{\infty} f(x + r\cos\theta, y + r\sin\theta) w(r)\sin\theta dr d\theta$$

$$w(r) = -\frac{r}{2\sigma^2}\exp\left(-\frac{r^2}{2\sigma^2}\right)$$

$f(x,y)$: Brightness value at (x, y)

At the same time, the reliability (degree of noise influence, r(x,y)) can be obtained from an expression(2) shown below and it is handled as the scale of noise influence and obtained at a range of 0 to 1.

$$r(x,y) = \frac{h(x,y)}{2\sigma_0(x,y)} \quad \cdots(2)$$

Where;

$$\sigma_2^2(x,y) = \int_0^{\infty}\int_{-\pi}^{\pi} f(x + r\cos\theta, y + r\sin\theta)^2 w(r) dr d\theta$$

$$-\left(\int_0^{\infty}\int_{-\pi}^{\pi} f(x + r\cos\theta, y + r\sin\theta)\, w(r) dr d\theta\right)^2$$

For detecting the features of edge, it makes it a rule to judge whether the edge height (h (x,y)) at each point fulfills an expression(3) (shown below) represented by using the above expressions(1) and (2) and preserve only an edge height fulfilling the condition as the edge. As a threshold (ht') in this case, the following two ones have been set and a threshold corresponding to either condition is preserved as the edge and a threshold not corresponding is deleted. Moreover, the threshold for the height of edge and reliability set in this case is set manually by the operator based on the result of edged image which is an output result.

$$h_t' < h(x,y) r(x,y) \exp\left(\frac{1}{2\sigma^2}\right) \quad \cdots(3)$$

Conditions :

(1) Edge detected by high threshold (htu)
(2) Edge detected by low threshold (htl) and having reliability(RelyLim) which is higher than threshold

4. EDGED RESULT

Figure 3 shows a height images, Figure 4, an image of reliability and Figure 5 shows edged images, respectively. The height images are obtained by imaging the results brought by applying the expression(h(x,y)) used for obtaining, the height of edge shown in the foregoing expression(1) to the image given in Figure 2.

Consequently, an image in which a pattern of such an image including noise as that made by the conventional filtering technique has been acquired. The image of reliability is obtained by imaging the result brought by increasing the result obtained by the expression (r(x,y))

used for obtaining the reliability shown in the foregoing expression (2) by 255 times.
They are because that the reliability is obtained at a range of 0 to 1 and in the condition as it is, it is impossible to display as a gray-scale image.
From these images, a part extracted originally as an edge can be confirmed clearly and a part judged to be a noise is confirmed to be displayed darkly.
From these images, it is to be understand that any edge part was deleted with noise part at this method.

Moreover, these thresholds have been set taking the result of edged image into account. There are many noise part, yet. The authors used following process to delete noise part.
The edged result in Figure 5 has been obtained by providing the aforesaid conditions with each threshold set as follows;

Threshold:
(1) Figure 5(a)
Htu = 20, Htl = 5 and RelyLim = 0.4
(2)Figure 5(b)
Htu = 15, Htl = 5 and RelyLim = 0.9

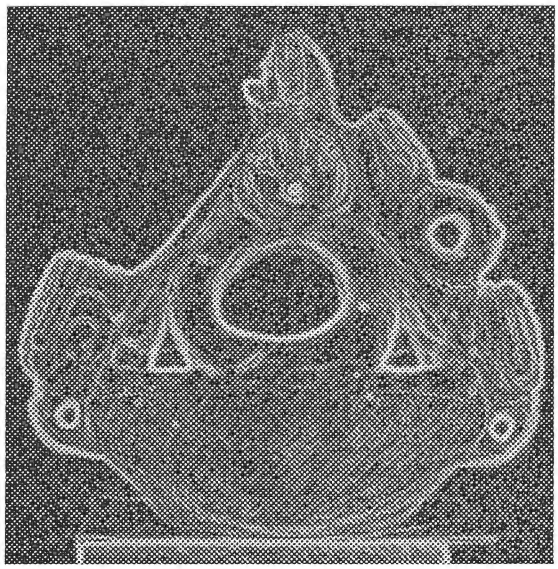

Figure3(a) Height Image(h(x,y), Target 1)

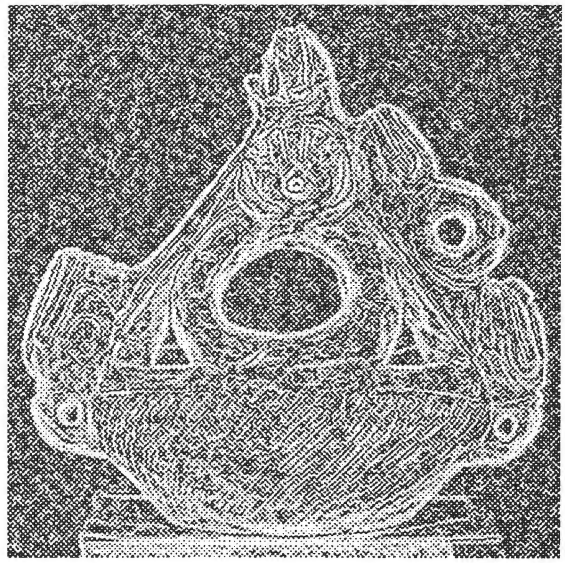

Figure4(a) Reliability Image(r(x,y) × 255,Ttarget 1)

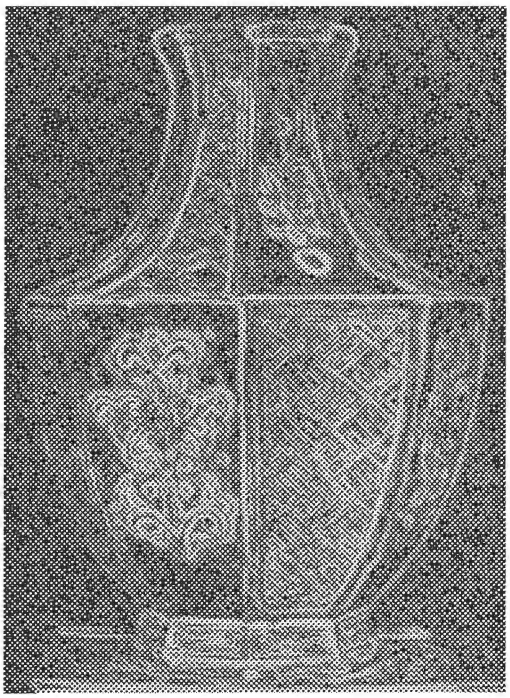

Figure3(b) Height Image(h(x,y), Target 2)

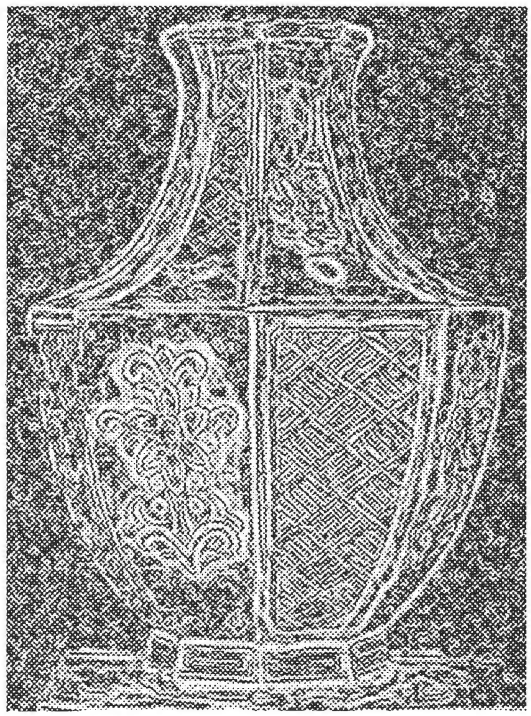

Figure4(b) Reliability Image(r(x,y) × 255,Ttarget 2)

Process(New Process):

① Use LG filter to original image.
(For reduction of noise and emphasis of edge)

② Use reliability method to edged image by LG filter(First detection)

③ Calculation for height and reliability with original image.(Second detection)

④ Comparison of image data between first work image and second work image.

(At edge part, if a edge part fulfils height thresholds and reliability thresholds, they will save as edge data either one will delete as noise)

Figure 6 show the edged images which made by new process.

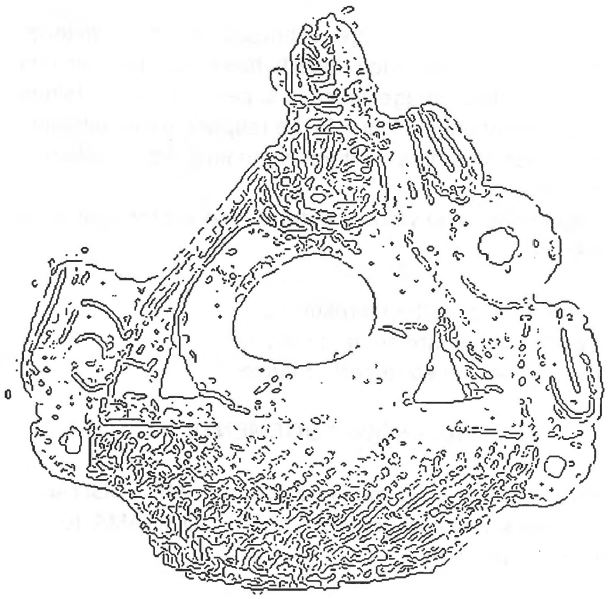

Figure 5(a) Edged image obtained by taking reliability into account(Target 1)

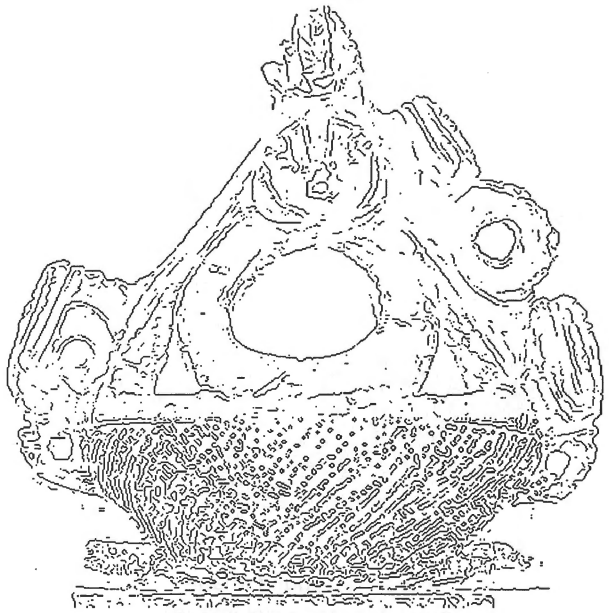

Figure 6(a) Edged image obtained by new process (Target 1)

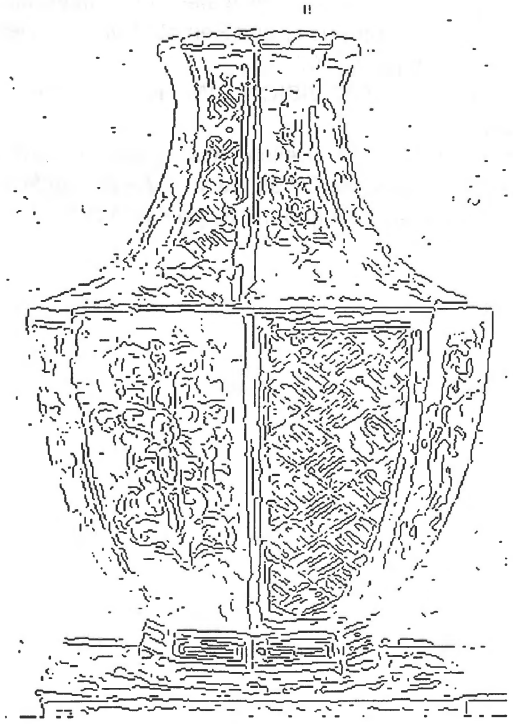

Figure 5(b) Edged image obtained by taking reliability into account(Target 2)

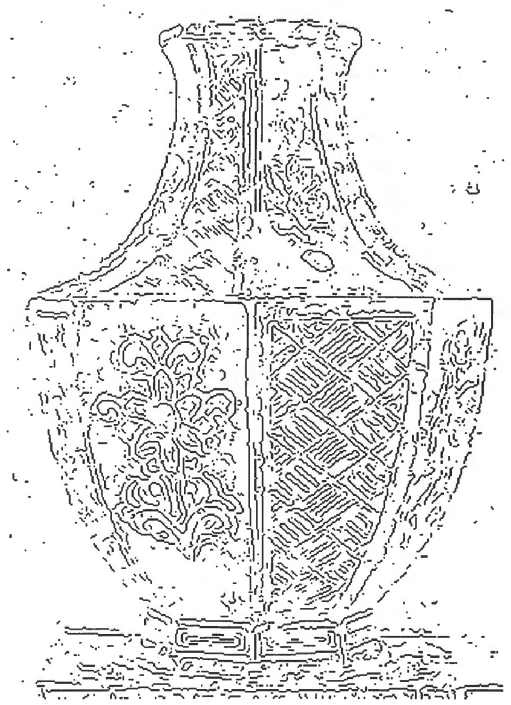

Figure 6(b) Edged image obtained by new process (Target 2)

From these result, we can find high definition images more than Figure 5
Figure 1 was taken by a CCD camera which has 400,000 pixels. At this investigation, the authors used new method to use a image which taken by mega-pixel CCD camera (using 1,000,000 pixel CCD, mega-pixel image).
Figure 7 shows edged result with mega-pixel image.

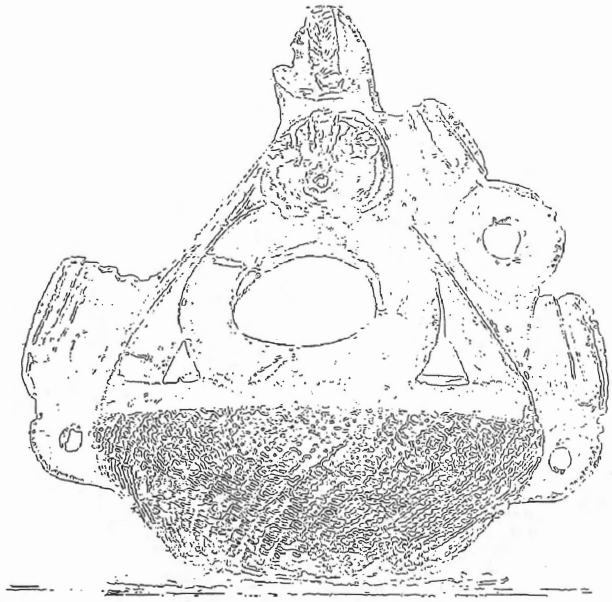

Figure 7(a) Edged image
(Target 1, mega-pixel image)

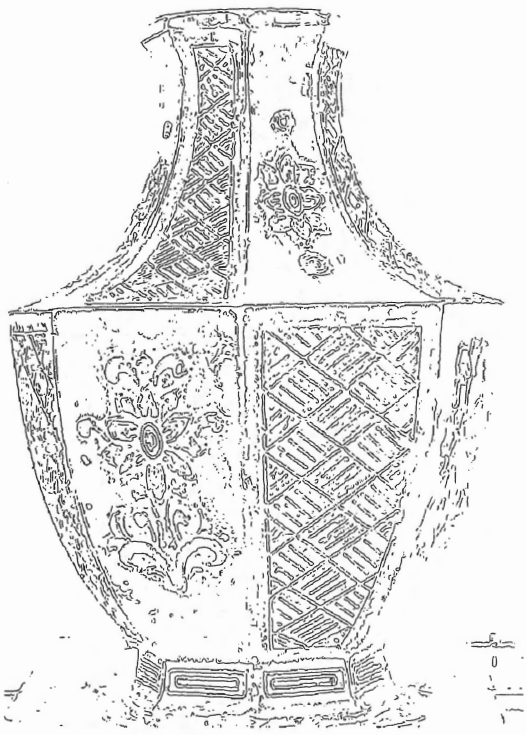

Figure 7(b) Edged image
(Target 2, mega-pixel image)

From these results, it is to be understood that though such an edge as to have been extracted even by the filtering technique is seen only in the height image, a noise part has been reduced greatly by taking account of a relation with the reliability and a better edged result than the conventional one has been secured.
Especially, if we use high resolution image, we can get more minuteness edged image.

5. CONCLUSION

The employment of an edge technique (reliability method) using an edge height and reliability has made it possible to acquire an edged image which is superior to that obtained by the conventional LG filter in the respect of the detection performance of edge by enhancing mainly the reduction of noise in the image.
The questions to be worked out in future are thought to be as follows:

a. Automation of setting thresholds
(At present, they are set manually.)
b. Improvement in edge performance

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