

3D Measurement System Using Line Laser for Archeological Artifacts

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ABSTRACT

We developed ortho-projection and drawing system for reduction of record work of archeological artifacts. But, in this system, there are lacks of data. They were caused by position of source-light (photography method).

In the place, we examined solution of problems by changing measurement method. As the result, we are able to acquire three dimensions of shape that there are not lacks of data. By this system, we can make development image at same time.

1. INTRODUCTION

Large quantities of remains are discovered currently in all parts of Japan. Archeological artifacts excavated from these remains are enormous number. In Japan, all these artifacts need to record. A record is left unfinished with ortho-projection images (photograph) and edged images.

Shortening of investigation period is pursued in this record work from enormous labor being spent.

At same time, there is a demand to want to leave a three-dimensional shape record of remains. Because, CG technology was became general.

For these demands and in order to reduce work of human power, we investigated ortho-projection and drawing system and the pattern extraction technology that used CCD cameras from 1994.

But, in the ortho-projection system, Shape data of artifacts lacked partially. The part which illumination does not hit is a cause (occlusion).

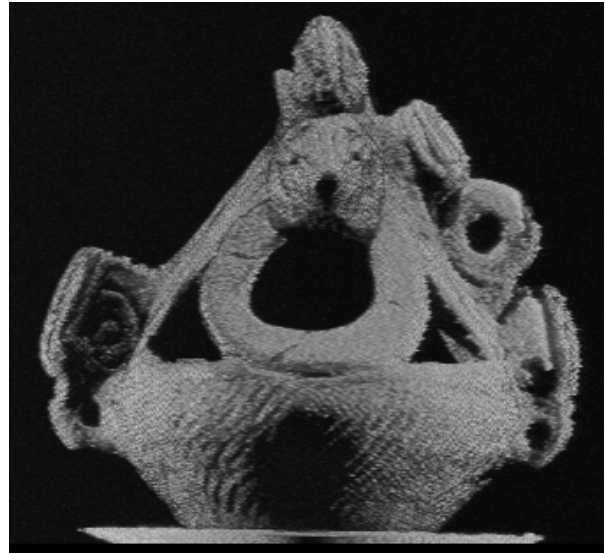
Fig.1 shows a result by ortho projection system. In this way, there are lacks of image (shape data). Occlusion cause these lack of image.

For solution of these lack of images, we developed a measurement system to film using a turntable and source of light from two directions (3D measurement system using line laser-beams).

We examined improvement of image omission that occurred in an ortho projection system using this system.

2. MEASUREMENT SYSTEM

Figure 2 shows the measurement system that developed by this investigation. Table 1 shows experiment components.



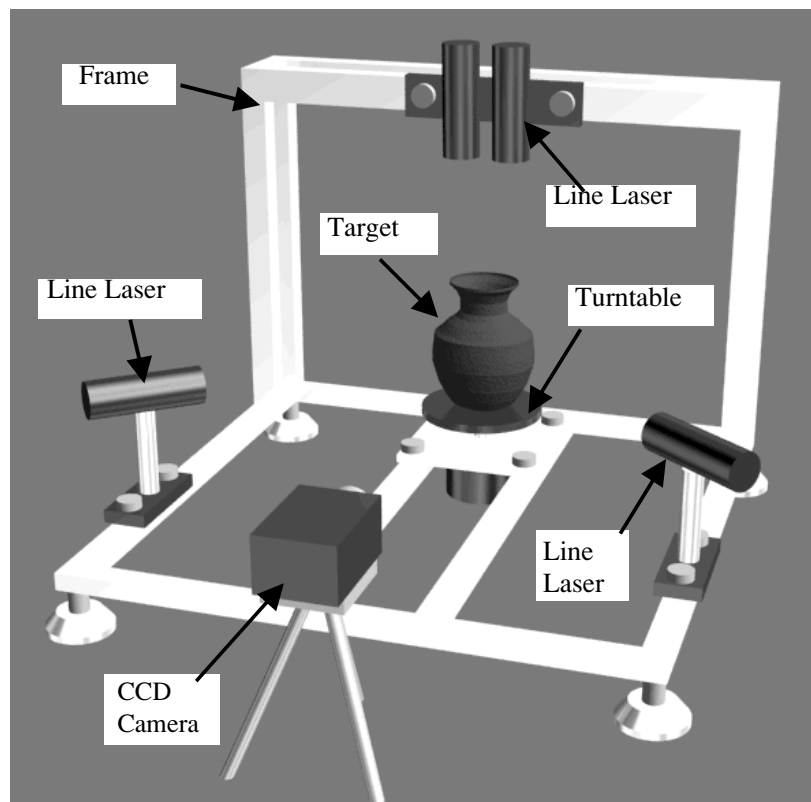


Fig.2 Measurement System

Table 1 Experiment Components

CCD Camera	XC-75 (SONY) CCD: 768pixel(w)*494pixel(h)
Line Laser	SMF-501L-670 (M)-10-30 (MORITEX) Wave Length: 670nm
Turntable (Motor)	UDX-5114 (ORIENTAL MOTOR) Minimum angle of rotation: 0.36deg
PC (CPU & Memory)	CPU: Pentium 133MHz, Memory: 64MB
Image Processing Board	MTAT-CL (Micro Technica) (Use ISA BUS), Image: 512dot*512dot

This measurement system consists of turn table and line lasers, CCD camera, PC for image processing. CCD camera film the measurement target lighted up in being linear with line lasers. CCD camera continues film till the turntable does the 1 circumference. The system grasps three dimensions of shape of target using line-images and angles of rotation degree of these times.

Figure 3 shows position relation of line laser-beams, turntable and CCD camera.

Line lasers are installed so that respect of light intersects at the center of the turntable. As for the respects of these lasers, right and left course each includes 45 deg. of leaning for the line that connected the turn center with CCD camera. In this method, the CCD camera can film line images lighting up the target from positions named objection simultaneously. This is same as the situation that two cameras film one line at a position named objection. It is the point that this method is different from a traditional shooting from the ortho projection system in greatly. In illumination only of a direction, the omission of images may happen from shape of target. This is the reason that adopted illumination method from 2 directions.

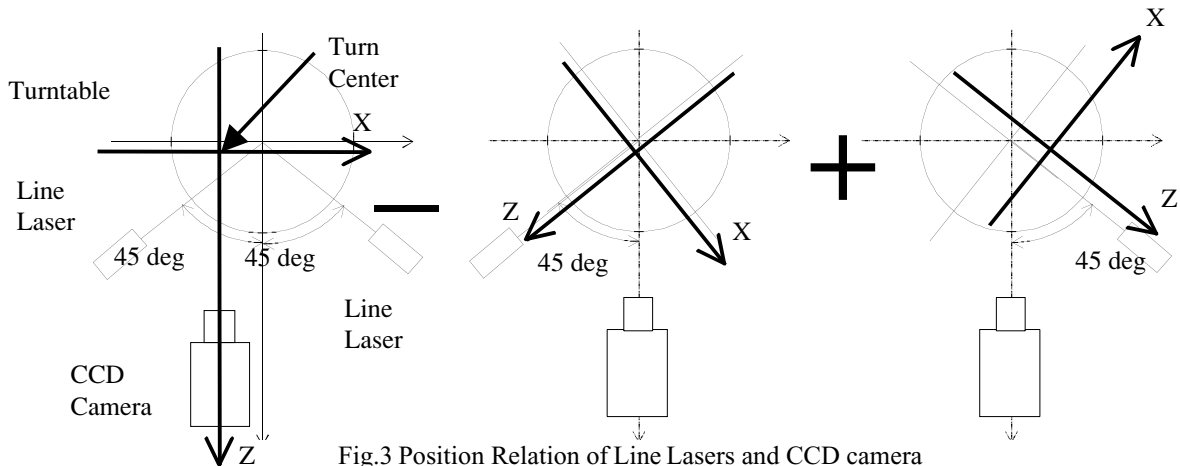


Fig.3 Position Relation of Line Lasers and CCD camera

Fig.4 shows illumination range of line lasers. If we use only one laser, there are omissions of image that measurement target has unevenness shape in the method to light up from a direction. In this investigation, line lasers light up the part that a line laser did not light up with traditional method (1 course type) by lighting it up from 2 directions. CCD camera of the front films two lines appearing on the archeological artifacts surface lighted up with line lasers. The system demand distance from the turn center, height from table base, color information (brightness) of each point about part of archeological artifacts represented with lines. We do measurement (reproduction) of three-dimension shape of target Furthermore by adding angle of rotation degree of turntable. Explains the details of measurement method at later. As a result, we prevented an omission of the image (shape data) that was problems of 1 course type.

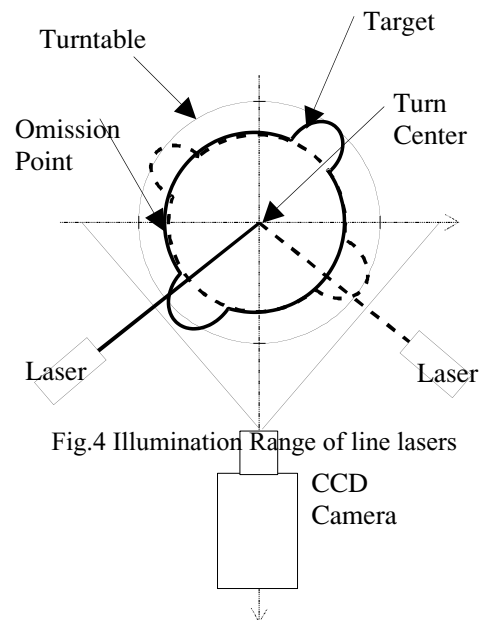


Fig.4 Illumination Range of line lasers

3.MEASUREMENT METHOD

Figure 5 shows flow of new system. In this system, course of coordinate systems become important. Because, we light it up from 2 directions. This system turn front course into the standard and do camera calibration. We calculate a position of CCD camera with each respect as the front (XY plane, Base plane). Then, we calculate the existing turn center to the image. In the image that we filmed of afterward, we divide an image into half to a boundary at the turn center. It is measures not to make a mistake in illumination range of right and left laser. We pull out points to represent external form information of the target (we express it as bright points and lines) from the image that we divided into half. We demand a plane coordinate (distance from the turn center and height from the table base) afterwards. We calculate three dimensions of shape using this plane coordinate and angles of rotation degree of the table. Table 2 shows the numerical formula that we used to demand shape data (three-dimension data). This expression is generally used for three dimensions of coordinate transformation.

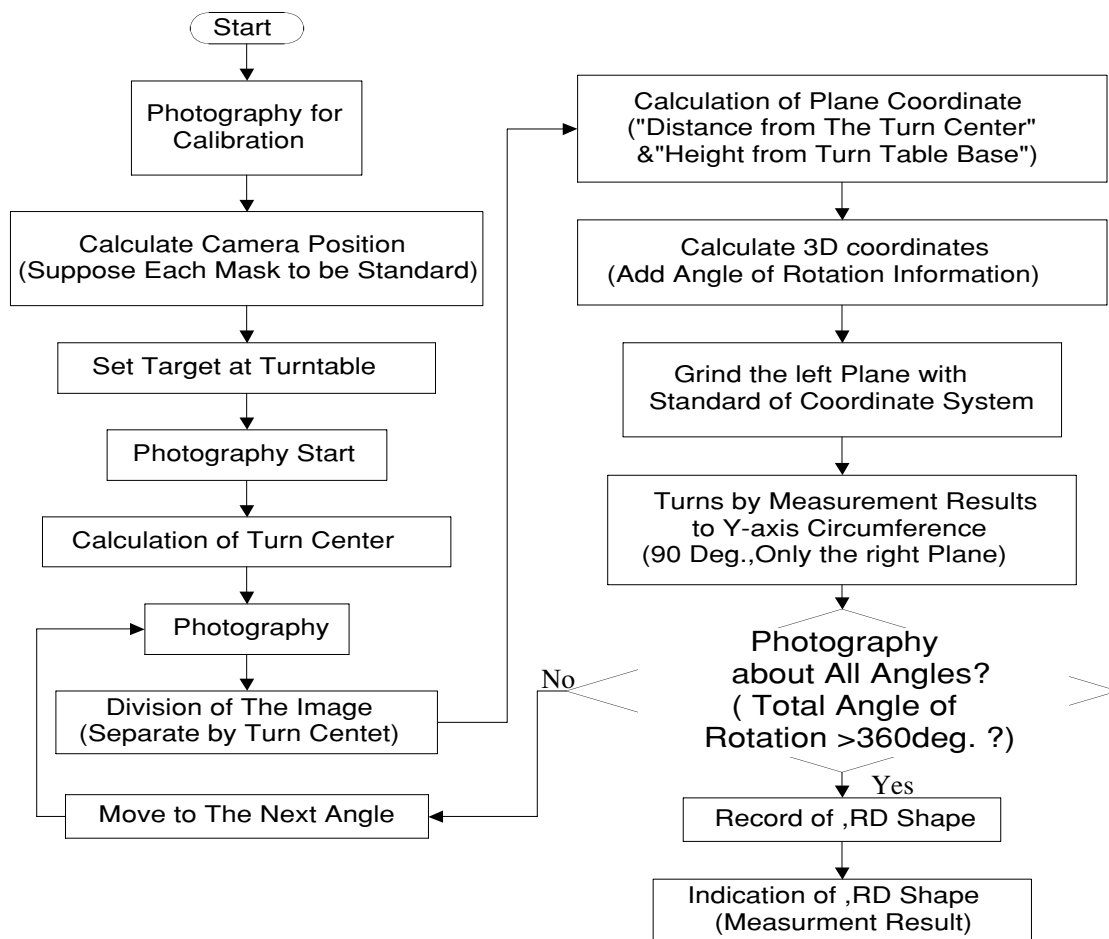


Fig.5 Measurement Flow

Table 2 Turn Conversion Expressions

Coordin	Axi	Y-axis	X-axis	Z-axis
X		$X' = X \cdot \cos_{_} + Z \cdot \sin_{_}$	$X' = X$	$X' = X \cdot \cos_{_} - Y \cdot \sin_{_}$
Y		$Y' = Y$	$Y' = Y \cdot \cos_{_} - Z \cdot \sin_{_}$	$Y' = X \cdot \sin_{_} + Y \cdot \cos_{_}$
Z		$Z' = -X \cdot \sin_{_} + Z \cdot \cos_{_}$	$Z' = Y \cdot \sin_{_} + Z \cdot \cos_{_}$	$Z' = Z$

Here,

(X,Y,Z)= Coordinate Before Conversion, (X'Y',Z')= Coordinate After Conversion, $_ =$ Rotation Angle

We use only the expression of Y-axis circumference when we pursue three dimensions of coordinates from plane coordinate and angle of rotation degree.

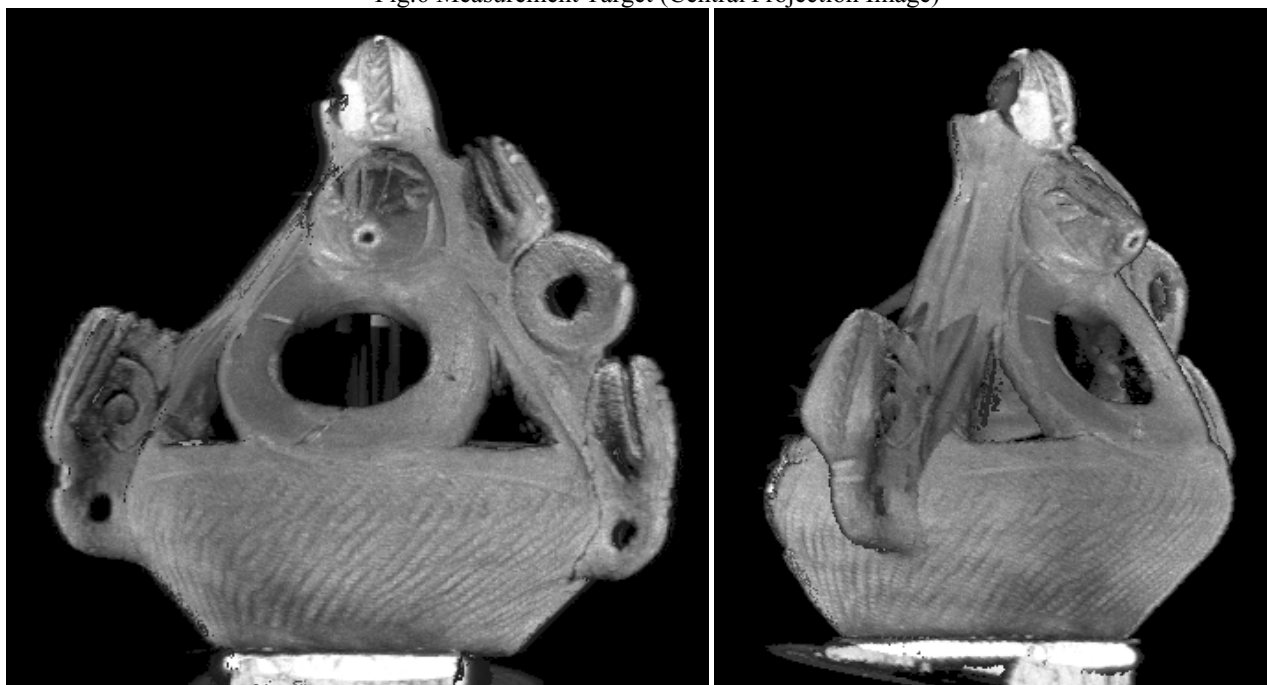
By this system, we summarize a coordinate system in one. Because, two coordinate systems exist. Crossing angle of two base planes is 90 degrees. So, we turn the left plane into standard. We just store three dimensions of information at left plane. As for three dimensions of information of right plane, 90 degree turns to Y-axis circumference. We record the result that turned. Information Systems of two respects is unified hereby. CCD camera films the target (line-images) till 360 degree of it turn.

4. MEASERMENT RESULT

Figure 6 shows the measurement target in this investigation. This is candlestick of Jomon period. Figure 7 shows measurement result by new system. This system needs about 10 minutes by measurement of once, now. Lacks of image (shape data) by occlusion happened to points of artifacts (Show Fig.1). But, by the new system, shapes of three dimensions are pursued.



Fig.6 Measurement Target (Central Projection Image)



(a) Front Image

(b) Another Angle Image

Fig.7 Measurement Result (New System)

This system can acquire development image at same time. Figure 8 shows the development image.

By this system, line lasers hits the part that lacks of images happened with ortho-projection system. So, lacks of image are prevented. And quality of measurement result improves.

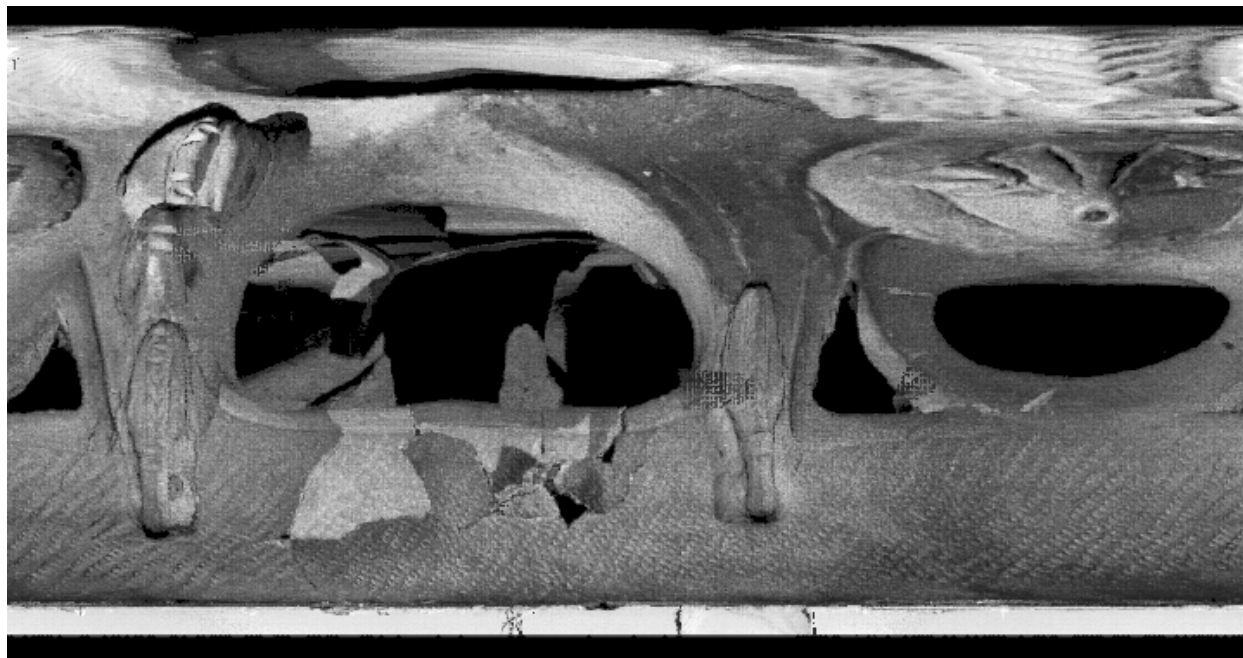


Fig.8 Development Image

5. SUMMARY

The new measurement system is able to solve subjects of ortho projection system. At the same time, it is able to make development image. This system can acquire shape of all around of the target (total image) by one time of measurement with one camera.

The following things are nominated for future subject.

- _Into Color
- _Speed Up(Now, We need about 10 minutes for Photography.)
- _High picture element correspondence

REFERENCE

- 1.H.YOKOYAMA, K.HATANO, H.CHIKATSU, 1996, Ortho Projection and Drawing for Archeological Artifacts of Complicated Form, International Archives of Photogrammetry and Remote Sensing, Vienna, Vol.XXXI, PartB5, pp.95-100
- 2.Devid MARR, 1982, VISION, W.H.Freeman and Company
3. H.YOKOYAMA, H.CHIKATSU, Y.MIYATSUKA, 1996, Ortho Projection and Drawing for Archeological Artifacts using CCD Camera, SPIE Videometrics IV, Vienna, Vol.2598, pp.102-105