RELICS MODELING AND VISUALIZATION IN VIRTUAL ENVIRONMENT

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ABSTRACT

The authors have been concentrating on developing a real-time ortho imaging, drawing and modeling system for a recording system of relics using a CCD camera and line lasers. An ortho projection image can be acquired in real-time by synthesizing line images since line images which show only an outline of relics can be taken while a relic is slowly moving perpendicular to a CCD camera and with line lasers being applied from above and both sides. Fitting a band pass filter, line images for relics can be taken without a dark space.
There are still, however, some issues which need to be resolved before this system may become operational. These problems include imaging for shadow areas occurring in hollow areas on complicated relics or faint areas at the top of columnar relics and lack of an exquisiteness for an edged image for a drawing.
This paper describes an imaging approach for these shadow and faint areas synthesizing an ortho and a central projection image which are taken using a color CCD camera. The most remarkable points of this approach are its ability to obtain a color ortho projection image and a color 3D model. As for further additional results of this system, visualization of relics from several view points can be achieved on the computer using an animation technique. Some virtual archeological examples are demonstrated in this paper.

1. INTRODUCTION

Many archeological sites are being excavated every year in Japan. Figure 1 shows the excavation number for the last decade. The excavation number has been increasing yearly and an abundance of relics have been recovered from over 10,000 archeological sites. These relics have to be drawn by archeologists for archival records taking a great deal of time, labor and skill.
Generally, an orthophoto is used for a drawing. An orthophoto is taken from a continuous photo which is taken with the shutter opened while a relic is slowly moved in a dark space. Slit lights are applied from both sides. But it has weak points such as developing, enlargement and tracing.
According to the news paper (Nihon Keizai Shimbun) on the 4th of April 1997, the Japan government adopted a policy to reduce costs for public works projections by at least 10 percent over the next three years. The remarkable point in this guideline is that rapid acceleration of investigation of deposited cultural assets was planned as one of the ways of achieving this goal.
With these motives, the authors have been concentrating on developing a real-time ortho imaging, drawing and modeling system for a recording system using a CCD camera and line lasers. The effectiveness of this system

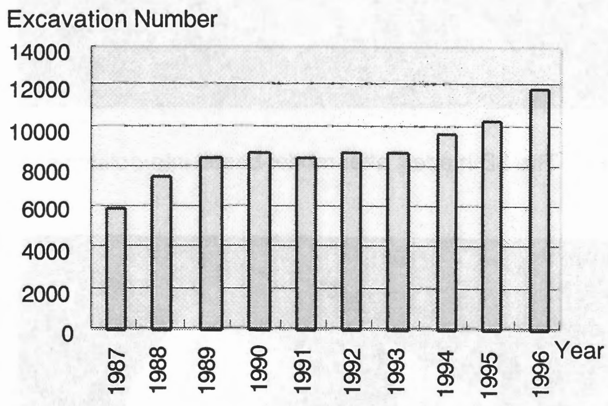

Figure 1: The Excavation Number for the Last Decade

has been demonstrated by the authors(Chikatsu and et al.,1997a,1997b). However, imaging for shadow areas occurs in hollow areas on complicated relics, or faint areas at the top areas of columnar relics, have become an issue since these areas cause insufficient clarity of images in ortho projection image and depth image.
After describing the real-time ortho imaging and modeling system developed by the authors, a new imaging approach for shadow areas or faint areas on relics are described and some virtual archeological examples are shown in this paper.

2. ORTHO IMAGING AND MODELING SYSTEM

2.1 Ortho Imaging

An ortho projection image can be acquired by synthesizing line images since line images which show only an outline of relics can be taken while a relic is slowly moving perpendicular to a CCD camera and with line lasers being applied from above and both sides.
Fitting a band pass filter which can pass 670 ± 5nm to a lens of a CCD camera, a line image for relics can be taken in a room without dark space since the wavelength of the line laser is 670 ± 10nm.
Figure 2 shows the system configuration. An ortho projection image for the front and back side can be acquired using two color CCD cameras.

Figure 3 shows the color CCD camera with a 1/3" sensor (768H × 494V, 6.00H × 4.96Vmm) and 16mm lens.

Figure 3: Color CCD Camera (SONY, XC-003)

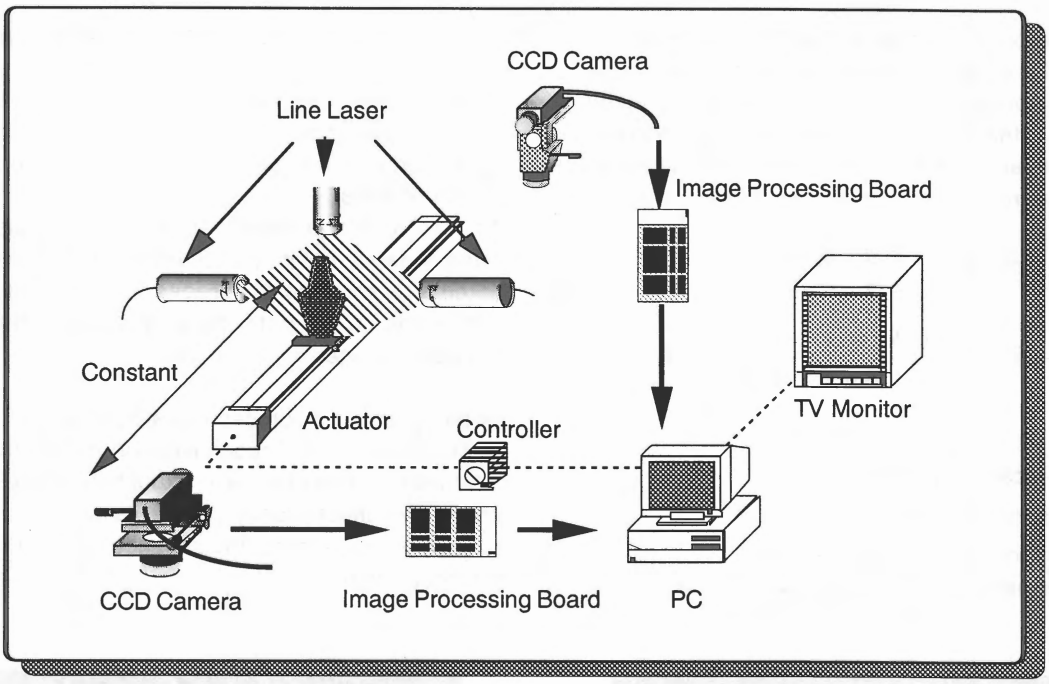

Figure 2: System Configuration

Figure 4: Ortho Projection Image

Figure 5: Depth Image

Figure 4 shows the ortho projection image on the front side of the relic as a result of synthesizing the line image at 1mm intervals.

2.2 Depth Image

In the process of synthesizing the line image, the Z-coordinate(mm) for the line image is given since the changing values of the actuator are then controlled by a personal computer.
Consequently, a depth image can be acquired in real-time similar to an ortho projection image. Figure 5 shows the depth image on the front which was acquired by the difference between the maximum and the minimum value of the Z-coordinate divided into 256 gray levels.

2.3 Modeling

If camera calibration was performed previously, the image coordinate for each line image can be transformed into a 2D object coordinate from the following equation. A Z-coordinate that equals(=0) was given in equation(1) since the distance between the CCD camera and the line images are constant.

$$X = (Z - Z_0)\frac{a_{11}\,u + a_{21}\,v - a_{31}\,f}{a_{13}\,u + a_{23}\,v - a_{33}\,f} + X_0$$

$$Y = (Z - Z_0)\frac{a_{12}\,u + a_{22}\,v - a_{32}\,f}{a_{13}\,u + a_{23}\,v - a_{33}\,f} + Y_0 \qquad (1)$$

where:

(X_0, Y_0, Z_0); camera position,

X, Y, Z ; ground coordinate,

u, v ; image coordinate, f; focal length,

a_{ij} ; rotation matrix with three parameters, ω, ϕ, κ.

In order to get a common coordinate system for the two CCD cameras, control points were set on a transparent acrylic board, and calibration for the two CCD cameras were performed using the height for 4 common control points and the length between the control points (Chikatsu and et al., 1996). 3D data for the front and the back side of the relic can be calculated from equation (1) utilizing the calibration results.
The 3D surface model is achieved in semi real-time using both depth images and the Z buffer method since the depth images have a common 3D coordinate.
Figure 6 shows the 3D surface model. Similarly, the 3D texture model is achieved in semi real-time using both ortho projection images since the pixel values on the ortho projection images correspond to the depth images. Figure 7 shows the 3D texture model.

3. NEW ORTHO IMAGING APPROACH

Since the line laser beams travel straight, insufficiently clear images occur in shadow areas in hollow areas of complicated relics or faint areas in upper areas of columnar relics.
To resolve this problem, an approach synthesizing an ortho and a central projection image which was previously taken is used since the images for the shadow and the faint areas on the ortho image are taken on the central projection image.

Detail synthesizing procedures are as follows:
1. The absence of Z-coordinates on the depth image are interpolated using the Spline function or the TIN model since the insufficiently clear images on the ortho projection image mean the absence of Z-coordinates on the depth image.

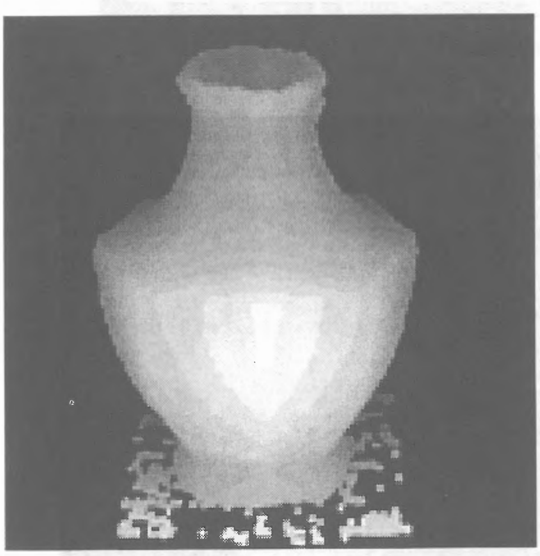

Figure 6: 3D Surface Model

Figure 7: 3D Texture Model

1.1 The Spline interpolation is used for the areas where the shapes around the absence of Z-coordinates can be obtained.

1.2 The TIN model is utilized for the areas where the shapes around the absence of Z-coordinates can not be obtained.

The TIN model is generated on the ortho and central projection image using the same feature points. The feature points on the ortho image can be transformed into the center projection image using the collinearity equation since the 3D coordinates and calibration parameters were given. After the affine transportation for each triangular mesh, an imaging for the insufficiently clear area on the ortho projection image is achieved.

The 2D coordinates for some edged points on the interpolated area can be calculated using equation (1).

The Z-coordinates corresponding to these points can be calculated using pixel values of the central projection image and calibration results. Here, the shapes around the insufficiently clear area become possible to obtain. Then the Spline function is applied.

2. The interpolated depth image is transformed into a central projection mode as a central depth image using 3D coordinates and calibration results.

3. Textures on the central projection image are automatically mapped to the central depth image since pixel values in both images coincide with each other.

4. The texture mapped central depth image is automatically retransformed into the ortho mode as an ortho projection image since the relation for the pixel values between the depth image and the central depth image are known.

Figure 8 and 9 show the ortho projection image and the depth image for the front side of complicated and columnar relics. The previously noted insufficiently clear images and absence of Z-coordinates are exposed in these figures. Figure 10 shows the interpolated depth image. The ortho projection image is a mono color image

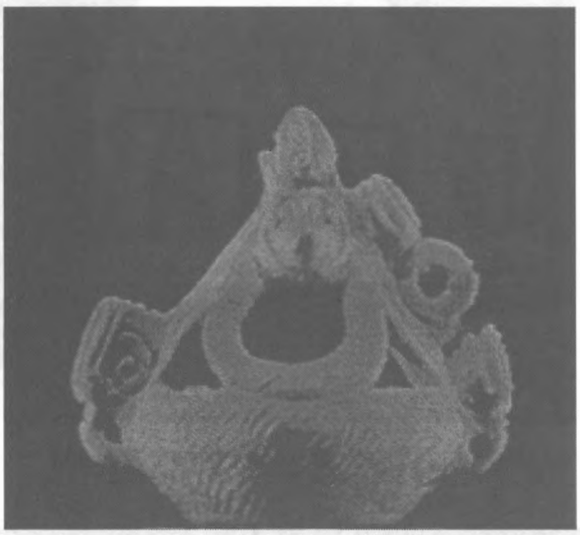

Figure 8: Ortho Projection Image

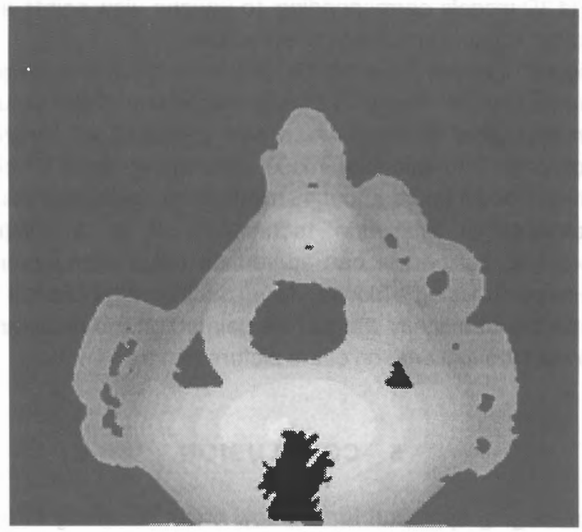

Figure 9: Depth Image

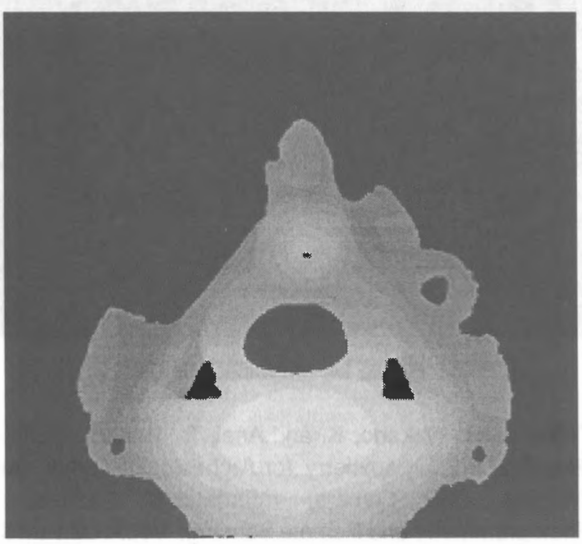

Figure 10: Interpolated Depth Image

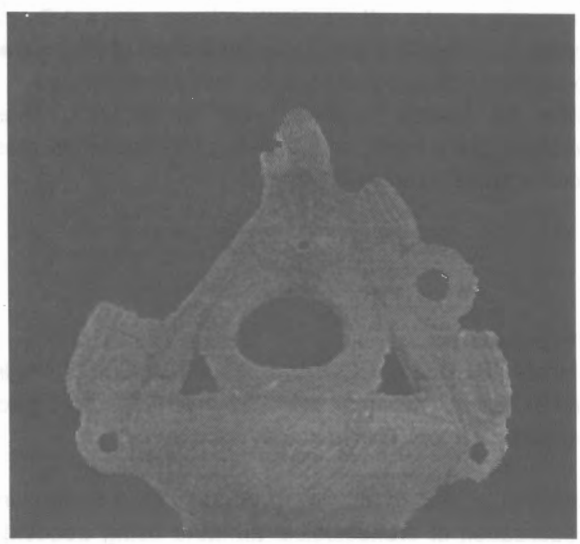

Figure 11: Interpolated Ortho Projection Image

even using a color CCD camera, but as an additional point in this approach, coloring for the ortho projection image is accomplished since the central projection image is a color image. Figure 11 shows the color ortho projection image and indicates that the imaging problems are resolved.

4. VIRTUAL ARCHEOLOGY

Virtual Archeology has recently received more attention from a possibility that people can appreciate or experience the archeological objects or historical space and art through the computer at any time and without going to the museum.

In order to construct a virtual archeological museum, 3D relics models corresponding to several view points should be generated. Color modeling is needed to create this reality. The ortho imaging and modeling system using color CCD cameras described in this paper is available for this purpose since the color 3D texture model is acquired and 3D models corresponding to various view points are obtained using an animation technique.

Figure 12 shows the color 3D texture model from a certain view angle and Figure 13 shows one scene of the virtual archeological museum which was produced by graphic software. One animation model consists of about 27 cell images and it takes about 45 minutes for one model using conventional animation techniques. It is a simple example, but people can appreciate relics from several view points using a mouse. As an additional function, it is possible to magnify the picture painted on the relics and to read the explanation of the picture (Figure 14).

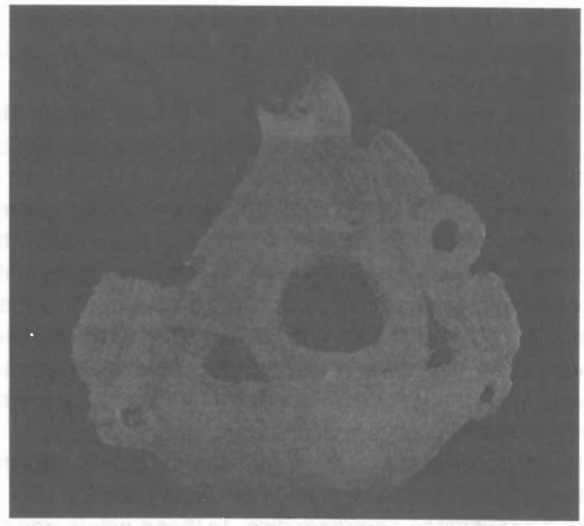

Figure 12: Color 3D Texture Model in Virtual Museum

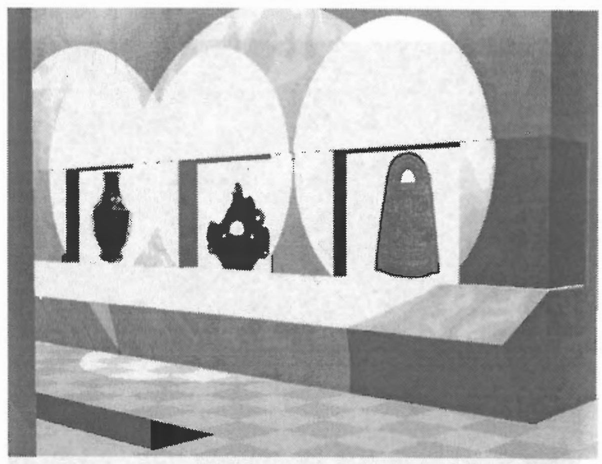

Figure 13: One Scene of the Virtual Museum

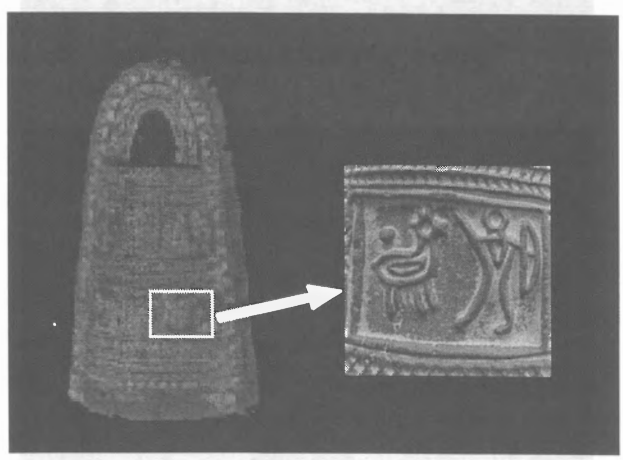

Figure 14: Magnified Picture

5. CONCLUSION

An imaging approach for shadow areas occurring in the hollow areas on complicated relics and faint areas on the top of columnar relics were described. The remarkable points as additional results of this approach are its ability to acquire a color ortho projection image and a 3 D color model. The effectiveness as an application of this system to a virtual archeological museum was demonstrated.

There are issues, however, for further work. These problems are imaging and modeling for occlusion areas occurring in side areas on relics.

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