A Method to Improve the Accuracy of Stone Tools Identification with D2 Distribution

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I. Introduction

When a large number of stone tools need to be studied, each stone tool is assigned a unique identification number to distinguish it from the others. Since the current method of stone tool management is entirely manual, identification information may be lost in the process of research. Therefore, a system is required to provide the identification numbers automatically from actual stone tools.

The previous study [1] proposed an identification method that realizes matching using stone tools silhouettes [2] and the ICP algorithm. However, it is difficult to identify stone tools if they are thicker because the matching method is based on two-dimensional approach. In [3], the improvement of performance is achieved by using D2 distribution to narrow down the candidates as a preprocessing step for stone tool matching.

This paper proposes a method that realizes matching using D2 distribution, which enable 3D comparisons, with the methods of the previous study to achieve higher identification accuracy.

II. Related Works

One of the shape similarity comparison methods uses a closed region surrounded by contour lines [2]. It calculates Hu Moment from the closed region to determine the shape similarity. However, it becomes difficult to identify thick stone tools because it does not use object depth.

III. Proposed Method

In our new method, the matching candidate refinement method using Hu Moment [2] is extended to improve the accuracy of candidate selection, so that the number of times of ICP algorithm application is reduced for stone tools identification. In addition, a method that improves the speed of stone tool identification and maintains the accuracy for thicker stone tools is studied.

First, the stone tools are measured with an RGB-D camera to obtain images and depth information. Then, the silhouettes are extracted from the images and matched with those in the database to narrow down the candidates. The database consists of data for all stable postures as in the previous study [1].

Next, a 3D point cloud is generated from the images and depth information, and D2 distribution [4] are calculated. Finally, the candidates are further narrowed down by matching them with the selected database.

Figure 1 shows the constructed measurement environment. The display illuminates stone tools from directly below them. The measurement space is covered with a blackout curtain. This environment prevents reflections caused by the light as much as possible.

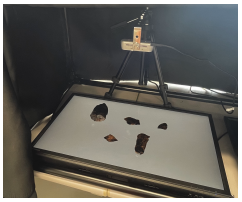

Fig. 1. Constructed measurement environment.

IV. Experimental Results

We use a total of 16 thick and thin stone tools. The experiments are performed with the methods of the previous study [1] and the proposed one. In terms of the percentage by which the correct data becomes the first candidate, the method using only the Hu Moment [2] results in approximately 75%. In contrast, our method which combines the Hu Moment and D2 distribution [4], results in approximately 88%.

V. Conclusion

In this paper, we have proposed a method to improve the accuracy of stone tools matching by combining 2D and 3D approaches.

Acknowledgments

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References

[1] Y. Sawada, T. Kinoshita, R.-O. Amartuvshin, F. Chiba, and K. Konno, "Stone tool identification method based on measured points by rgb-d camera and points of stone tool database," *The Journal of the Society for Art and Science*, vol. 21, no. 4, pp. 213–224, 2022.

[2] T. Batbold, A. Renchin-Ochir, and K. Konno, "Image based 3d posture matching in real time for stone tool assembly," in *2020 Nicograph International (NicoInt)*, 2020, pp. 7–13.

[3] A. Chida, K. Matsuyama, F. Chiba, and K. Konno, "A rapid searching method of adjacent flake surfaces in stone implements by using sets of measured points for generating a joining material," *The Journal of the Society for Art and Science*, vol. 13, no. 2, pp. 107–115, 2014.

[4] R. Osada, T. Funkhouser, B. Chazelle, and D. Dobkin, "Matching 3d models with shape distributions," in *Proceedings International Conference on Shape Modeling and Applications*, 2001, pp. 154–166.