3D data of human skeletal remains acquired by two kinds of laser scanners:

Einscan Pro HD and Creaform HandySCAN BLACK™ | Elite

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Abstracts

3D techniques are becoming increasingly relevant in archaeology and anthropology. As there are several methods for constructing 3D models and there is no assurance that the 3D models produced by each method will have the same qualities, it is necessary to compare the 3D models and examine their qualities. The present study compared 3D models produced by two types of laser scanners, that is, Einscan Pro HD and Creaform HandySCAN BLACK™ | Elite, and concluded that the models are not significantly different and reliable.

Keywords: 3D scanning; human skeletal remains; laser scanner

Introduction

3D techniques have had a greater impact on archaeology and anthropology. They are useful for recording or preserving archaeological remains, including stone tools, pottery, sites, and other educational purposes, as evidenced by several relevant studies (e.g., McCarthy et al. 2019; Morales et al. 2015; Seguchi and Dudzik 2019; Vincent et al. 2017). Furthermore, devices, methods, and software for 3D models are becoming more reasonable and accessible. Many more diverse applications of these techniques will be found in relevant fields.

It should be noted that there are different methods for constructing 3D models, which can potentially cause some problems. For instance, there is no assurance that 3D models obtained by different methods have the same qualities (e.g., Nakamura and Yamaguchi 2017; Ahmad-Yama 2016). Although we have already established that the SfM/MVS (Structure from Motion/Multi-View Stereo) method and Creaform hand-held laser scanners do not construct significantly different models for pottery and human skeletal remains (Kaneda et al. submitted; Nakagawa et al. 2022), further work is required to compare the 3D models obtained from other methods.

The present study employed two types of laser scanners and compared the two types of models obtained by each scanner. The results indicate that they are not significantly different and that deviations among models are not larger than the individual differences found in

traditional measurements of human skeletal remains (e.g., Hanihara et al. 1999).

Material and Methods

This study focused on human skeletal remains primarily because, although our recent projects have measured human skeletal remains in the Japanese archipelago (e.g., Nakagawa et al. 2022), we have not tested how to obtain 3D models of other materials such as stone tools and potteries using the Einscan scanner. We measured human skeletal remains from the Aoyakamijichi site (青谷上寺地遺跡), the Boji site (保地遺跡), the Uto tunnel tombs (宇藤横穴墓群) (see Figure 1 for site locations) and an anatomical model by KYOTO KAGAKU SH-7 (see Table 1 for materials used in this study).

We used the Einscan Pro HD and Creaform HandySCAN BLACK™ | Elite. Although both scanners are hand-held, the Einscan scanner may be mounted on a tripod and can be used to scan objects with an attached turntable (see Figure 2 for the setting of the Einscan scanner and Kaneda et al. (submitted) for the Creaform scanner). When using the Einscan scanner in a fixed manner, we took twenty-four shots from three angles in each material (Figure 3). Finally, the 3D models obtained from the two types of laser scanners were compared using GOM Inspect (https://www.gom-inspect.com/jp/index.php).

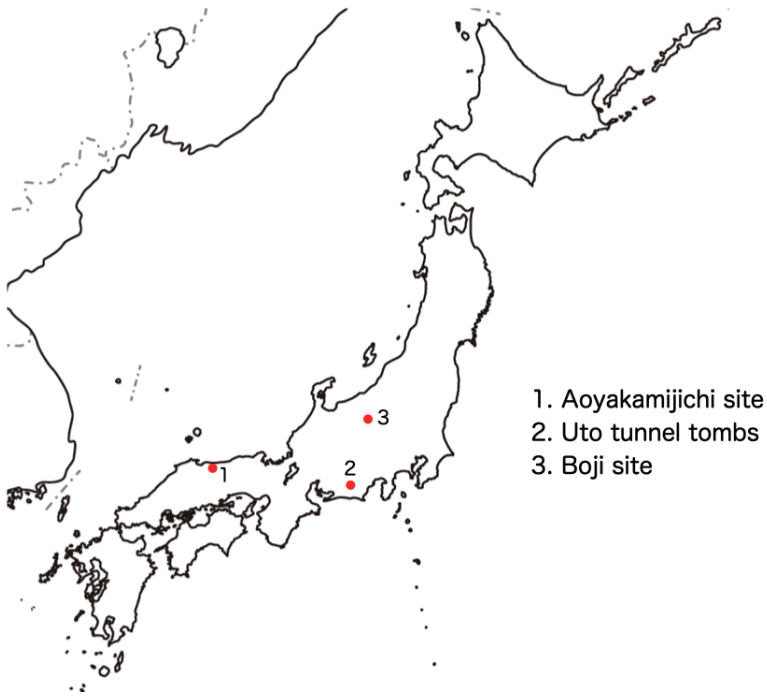

Figure 1. Map of the sites containing human skeletal remains used in the present study.

Table 1. Summary of the materials.

No.	Sites	Bone No.	References
1	Aoyakamijichi	skull 3	Tottori Prefecture Board of Education 2002
2	Aoyakamijichi	skull 7	Tottori Prefecture Board of Education 2002
3	Aoyakamijichi	lowerjaw 7	Tottori Prefecture Board of Education 2002
4	Aoyakamijichi	skull 11	Tottori Prefecture Board of Education 2002
5	Aoyakamijichi	lowerjaw 11	Tottori Prefecture Board of Education 2002
6	Aoyakamijichi	SK156, skull	Tottori Prefecture Board of Education 2002
7	Boji	Grave 6-A, skull	Sakaki Town Board of Education 2002
8	Uto tunnel tombs	No. 7, skull	Shizuoka Prefectural Archaeological Center 2012
9	—	Anatomical model of the human skull (KYOTU KAGAKU SH-7)	—

Figure 2. Settings for 3D scanning for Einscan scanner. The target object is the anatomical model and the angle is 1 and 2 in Figure 3.

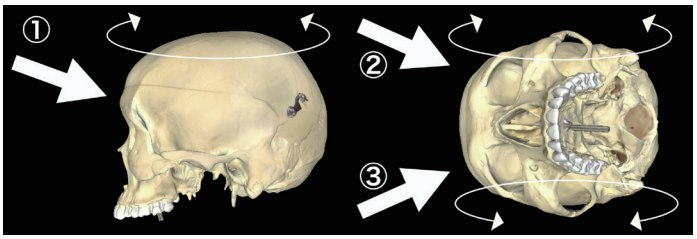

Figure 3. Angles for Einscan scanning. The 3D model is constructed from the anatomical model.

Results

The results of the comparisons are summarized in Figure 4. It shows the deviations between two kinds of 3D models and grayscale bars indicate the degree of deviations. Overall, the deviations of two kinds of models are within 0.3mm, despite some notable differences.

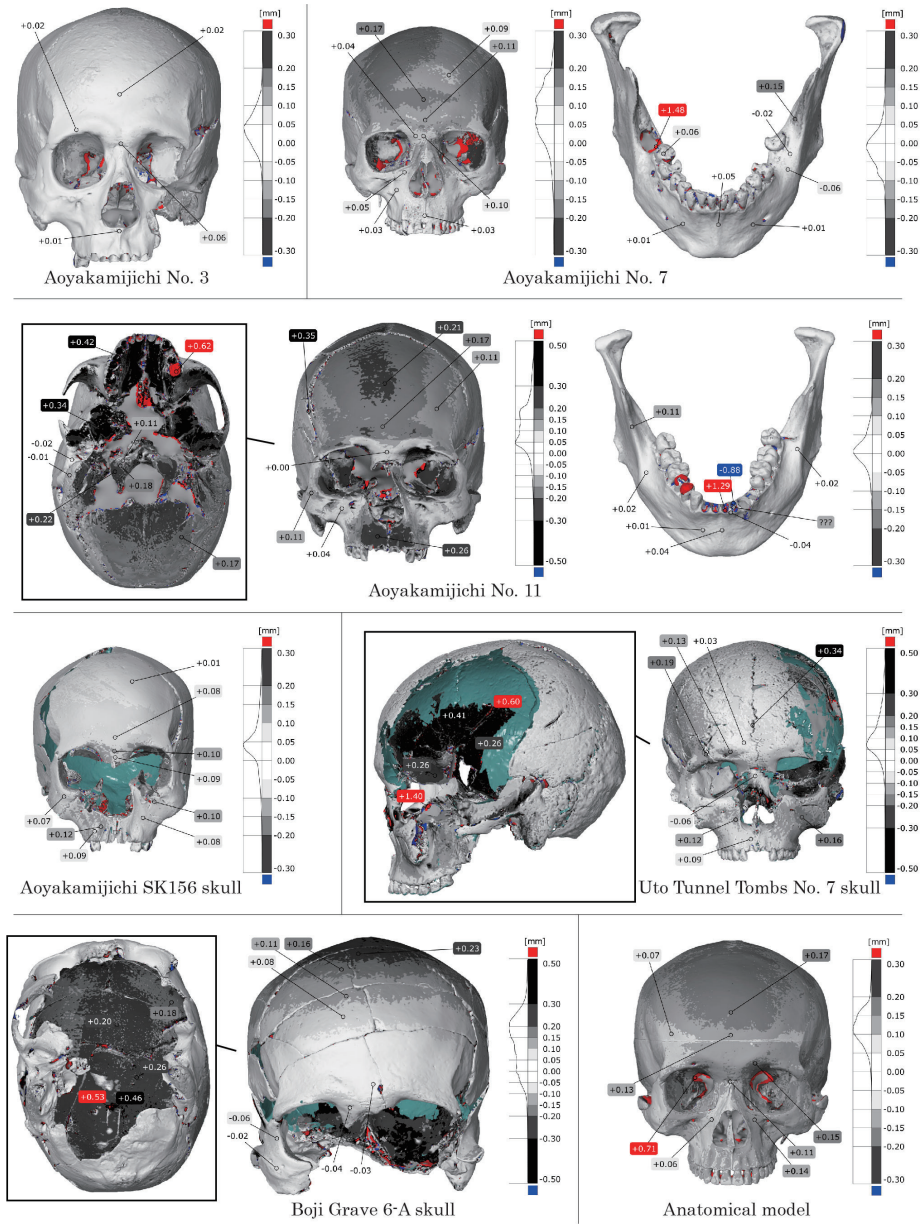

Figure 4. The results of comparisons for each material by GOM Inspect.

Discussion and conclusion

The above results demonstrate that the 3D models created by the two types of laser scanners were not significantly different. Although the largest deviations were found around the teeth or inner parts, which were probably due to the laser reflection caused by the enamel on the teeth, it was more difficult to scan the inner parts using the Einscan laser scanner in a fixed manner, and the deviations of the other parts were almost within 0.3mm. Furthermore, when the above results are combined with the results of Kaneda et al. (submitted), suggesting that the 3D models created by Creaform laser scanners are almost the same as the real objects, we can also argue that the 3D models created by the Einscan scanner are reliable to a large extent. Finally, when the above results were compared with the observations of Hanihara et al. (1999), where individual differences among observers were revealed with the application of traditional measurement methods in physical anthropology, it can be claimed that the deviations between the two types of 3D models are not larger than such individual differences.

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References

Ahmad-Yama, N. 2016. A study on Oketsubo with multiple methods: A case of Sanno, Ota ward. *Bunkazaino-tsubo*, 4：26–27.

Hanihara, T., Dodo, Y., Kondo, O., Nara, T., Doi, N,. and N. Sensui. 1999 Intra-and interobserver errors in facial flatness measurements. *Anthropological Science* 107 (1): 25–39.

Kaneda, A., Nakagawa, T., Tamura, K., Noshita, K., and Nakao, H. submitted. A proposal of a new automated method for SfM/MVS 3D measurement through comparisons of 3D data by SfM/MVS and handheld laser scanners.

McCarthy J. K., Benjamin J., Winton R., van Duivenvoorde W. (Eds.) 2019. *3D recording and interpretation for maritime archaeology*. New York: Springer.

Morales, J. I., Lorenzo, C., Vergès, J. M. 2015. Measuring retouch intensity in lithic tools: A new proposal using 3D scan data. *Journal of Archaeological Method and Theory* 22: 543–558.

Nakamura, A. and Yamaguchi, H. 2017. A comparative investigation of three-dimensional measurement methods of an eaves-tile endpiece. *Bulletin of Nara National Research Institute for Cultural Properties 2017*: 66–67.

Nakagawa, T., Nakao, H., Kaneda, A., and Tamura, K. 2022. A comparative study of the application of SfM and laser scanning to human skeletal remains. *Nabunken Ronso* 3: 39–64.

Sakaki Town Board of Education. 2002. *Kanaihigashi sites: Boji site 2*. Sakaki: Sakaki Town Board of Education.

Seguchi N. and Dudzik B. (eds.) 2019. *3D data acquisition for bioarchaeology, forensic anthropology, and archaeology*. New York: Academic Press.

Shizuoka Prefectural Archaeological Center. 2012. *A family of Oketsubo at Morimachi-enden hills*. Shizuoka: Shizuoka Prefectural Archaeological Center.

Tottori Prefectural Board of Education. 2002. *Aoyakamijichi site 4*. Tottori: Tottori Prefectural Board of Education.

Vincent, M. L., Bendicho, V. M. L-M., Ioannides, M., Levy, T. E. (eds.) 2017. *Heritage and archaeology in the digital age: Acquisition, curation, and dissemination of spatial cultural heritage data*. New York: Springer