VEAAR – Virtual Environment for Archaeological Artefacts Restoration

Jiří Chmelík
Masaryk University
Brno, Czech Republic
jchmelik@mail.muni.cz

Mikoláš Jurda
Masaryk University
Brno, Czech Republic
jurda@sci.muni.cz

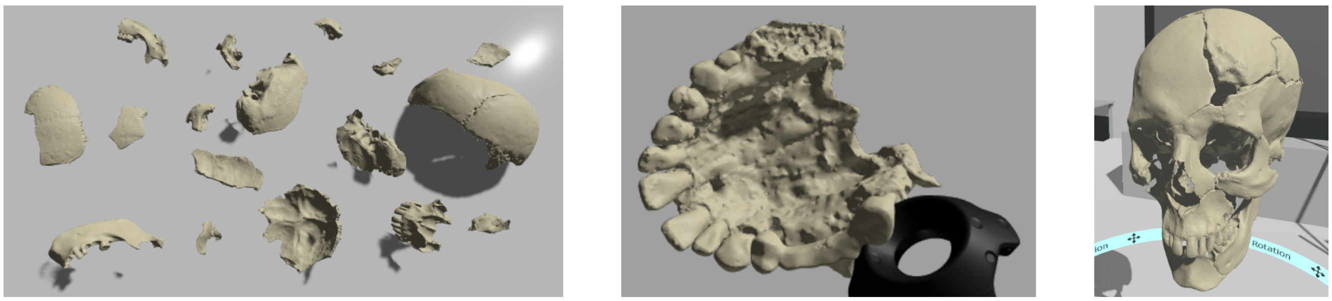

Figure 1: Stages of the restoration process in virtual environment. Left: the initial state of restoration – 17 fragments placed randomly on a table. Middle: the user is holding and inspecting one fragment. Right: Restoration result.

ABSTRACT

This demo presents a virtual environment for assembling archaeological artefacts from 3D scanned fragments. We have implemented a set of interaction techniques tailored to this specific task, allowing users to examine, manipulate and assemble fragments to obtain the original shape of the object. The tool is developed and continuously tested by domain experts from the field of anthropology. The presented pilot user study confirms our initial expectation that the restoration process using a virtual environments can be significantly faster than restoration done in a desktop environment keeping the same level of assembly precision.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; **Empirical studies in HCI**; • **Applied computing** → *Anthropology*;

KEYWORDS

virtual environment, interaction techniques, object restoration, archeology, user study

ACM Reference format:
Jiří Chmelík and Mikoláš Jurda. 2017. VEAAR – Virtual Environment for Archaeological Artefacts Restoration. In *Proceedings of VRST '17, Gothenburg, Sweden, November 8–10, 2017,* 2 pages.
https://doi.org/10.1145/3139131.3141780

VRST '17, November 8–10, 2017, Gothenburg, Sweden

ACM ISBN 978-1-4503-5548-3/17/11.
https://doi.org/10.1145/3139131.3141780

1 INTRODUCTION

Recent technological advancements in scanning devices are resulting in an increasing number of archaeological artefacts being digitized by 3D scanning technology. Frequently, only partially or severely damaged fragments are discovered and digitized instead of the whole objects. To reveal the original shape and dimensions of an artefact, individual fragments have to be assembled (this process is also referred to as restoration).

For the digital restoration, common 3D software tools like Blender or 3ds Max are commonly used by the domain experts. The restoration of one artefact can take up to several hours in case of a large number of fragments. Our work is based on the assumption that utilizing of an immersive virtual environment with spatial input and output and tailored interaction techniques should decrease the restoration time, while maintaining the same level of precision of fragments placement.

2 VIRTUAL ENVIRONMENT

Our virtual environment uses a head-mounted display (HMD) and a pair of wireless hand-held controllers. Therefore, the user can freely look around, walk in a given space and manipulate virtual fragments. The supplementary video showcases the usage of this environment.

The restoration itself is done by the progressive placement of fragments in 3D space by the user. In the center of our VE, there is a cylindrically-shaped "working area", with no gravity force acting on fragments and no collisions between fragments. Therefore, the user can simply place fragments into the mid-air and manipulate them freely without collision-based constrains. Outside the working area, the "common laws of physics"[1] are applied to the fragments to increase the level of realism and immersion.

[1]This consists of gravity force, inertia force, and collisions between fragments and other objects in the virtual environment.

2.1 Interaction Techniques

The crucial interaction task in scope of the restoration process is placing individual fragments in 3D space. Various techniques for improving precision and speed of the "direct manipulation" technique were proposed, based on the concept of spatial widgets (gizmos) or "scaled" manipulation, such as the PRISM technique [Frees et al. 2007]. A comparison of spatial manipulation techniques can be found in work of Mendes et al. [Mendes et al. 2016], concluding that direct manipulation is well suited for coarse manipulations, while the widget-based interaction leads to more precise results, although the interaction is more time-consuming.

In our system, the user can use the direct manipulation technique as well as spatial gizmos with limited degrees of freedom. The visual style and functionality of gizmos was adapted from commonly used desktop 3D modelling applications. Therefore it is already familiar to the domain experts. To further increase the precision of manipulation, we have implemented an adjustable precision of gizmos, see video for details.

Besides the manipulation of individual fragments, the user can also manipulate the whole content of the working area – translate, rotate, and scale all fragments. This allows very fast and intuitive inspection of already placed fragments. The user can also connect selected fragments to color-coded groups and change the level of transparency of individual fragments via a control panel attached to the virtual controller.

2.2 Data-sets

Our main focus is on the restoration of archaeological objects, but our system is general enough to work with arbitrary models, as far as the input data is properly formatted. The size of the whole data-set is limited mainly by the rendering capabilities of the used hardware.[2]

After loading the selected files, the system performs an automatic pre-processing of the data, including the computation of collision hulls of fragments and initial placement of fragments in the environment.

Finally, fragments can be exported in the restored positions as OBJ files for further processing by the domain experts.

3 PILOT USER STUDY

We have conducted a pilot user study with ten participants involving both the university students of anthropology without any experience with restoration tasks and the skilled domain experts. Digital scans of human skulls fragmented into three, six and seventeen pieces were used as input data sets (see Figure 1). Each participant performed the restoration of all three data-sets using both the desktop and the virtual environment. The restoration time and the precision of fragments placement were measured. Here we summarize the main results and the feedback from participants.

While there were only minor differences in the precision of the fragments placement, there were significant improvements in VE regarding the assembling time. We observed that the more complex dataset, the more significant time decrease when using VE. Figure 2 depicts the results of ten participants restoring the skull model

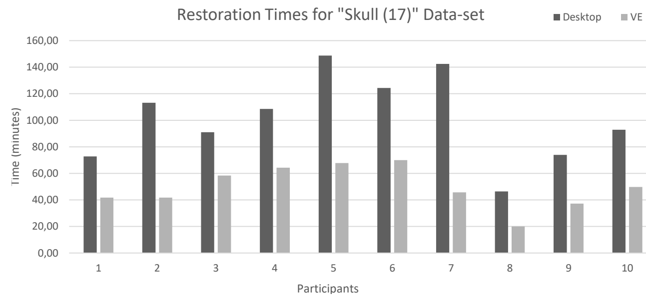

Figure 2: Comparison of restoration times for the "Skull" data-set (17 fragments).

from 17 fragments. The median of time saving for the restoration process in VE is over 43 minutes.

The users found our VE easy to learn and use. As the main advantage of VE, the users reported better spatial orientation and more direct control of fragments placement in 3D space. Despite rather long VR sessions, not a single case of motion sickness was recorded during the user study. Insufficient resolution of the HMD was reported as a drawback by several users – VR rendering was noted as "*less sharp*" or even "*blurry*" compared to 2D screen rendering.

4 DEMO

The presented demo will show our tool in action. It will demonstrate the fact that a virtual environment with tailored interaction scheme can outperform common desktop applications in domain-specific tasks. Users will be able to test the process of object restoration in virtual environments using the above-described interaction techniques. The demo will provide six different data-sets to test.

The demo contains the explanation of basic controls directly in the virtual environment. Therefore, even the users without any previous experience with VR can easily learn and use the controls.

5 CONCLUSION

We presented a new virtual environment for restoration of objects from digitized fragments. Our VE provides an easy-to-use and precise manipulation scheme. The conducted pilot user study confirms that the restoration task can be solved in the virtual environment faster than using a common desktop environment, while keeping the same placement precision.

ACKNOWLEDGMENTS

This work was supported by the GAMU 'MUNI/M/0846/2015' and H2020 '727153' projects.

REFERENCES

Scott Frees, G. Drew Kessler, and Edwin Kay. 2007. PRISM Interaction for Enhancing Control in Immersive Virtual Environments. *ACM Trans. Comput.-Hum. Interact.* 14, 1, Article 2 (May 2007). https://doi.org/10.1145/1229855.1229857

Daniel Mendes, Filipe Relvas, Alfredo Ferreira, and Joaquim Jorge. 2016. The Benefits of DOF Separation in Mid-air 3D Object Manipulation. In *Proceedings of the 22Nd ACM Conference on Virtual Reality Software and Technology (VRST '16)*. ACM, New York, NY, USA, 261–268. https://doi.org/10.1145/2993369.2993396

[2] Currently, our solution is able to work with data-sets consisting of millions of triangles and still keep the rendering refresh rate above 75 FPS.