The 12th International Symposium on Virtual Reality, Archaeology and Cultural Heritage VAST (2011)
M. Dellepiane, F. Niccolucci, S. Pena Serna, H. Rushmeier, and L. Van Gool (Editors)

Short and Project Papers

Combining 3D technologies in the field of cultural heritage: three case studies

K. Antlej[1], M. Erič[2], M. Šavnik[3], B. Županek[4], J. Slabe[5] and B. Battestin[6]

[1]IB-PROCADD d.o.o.
[2]Institute for the Protection of Cultural Heritage of Slovenia
[3]National and University Library of Slovenia
[4]Museum and galleries of Ljubljana
[5]National Museum of Slovenia
[6]Virtual Media d.o.o.

Abstract

The advantages of 3D technologies (3D digitisation, visualisation, 3D printing...) are recognised by various professions in the field of cultural heritage (CH). Today these technologies have been technologically improved to the point that allows them to be merged for different purposes. The paper presents projects related to the successful combining of these technologies with regard to CH. In three case studies we discuss processes using 3D technologies for documenting and presenting artefacts, 3D collection by the Digital Library of Slovenia and directly using techology for the restoration of museum object. Although all the examples under discussion show how these tools and processes can be used for different purposes and applications in the area of CH.

Categories and Subject Descriptors (according to ACM CCS): H.3.7 [Information Storage andRetrieval]: Digital Libraries—I.3.5 [Computer Graphics]: Computational Geometry and Object Modeling—I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—J.2. [Physical Science and engineering]: Archaeology—

1. Introduction

3D technologies have recently become so improved that their use in the field of cultural heritage (CH) is no longer in question [PGCS10], [RSZ09] and [TPL08]. However, by themselves these technologies are often insufficient. It is important to complement and combine them through different processes to enable the even wider applicability of 3D technologies. The paper presents three case studies of implementing 3D technologies in different areas of CH. The first example relates to the oldest known carved wooden point that was 3D digitised for the purposes of documentation and presentation. 3D models were made by combining 3D technologies, both virtual (an interactive 3D model and a high-resolution hologram) and physical (a full colour 3D printed tactile model and a 3D picture in glass made by vitrography). The next example presents the Virtual Emona pilot project, a 3D collection of archaeological artefacts from ancient Roman Emona (modern-day Ljubljana), published by the Digital Library of Slovenia – dlib.si, a portal for aggregating Slovenian culture e-contents to the European digital library Europeana. The last case study shows a possible model of restoring ceramic objects with the direct use of plaster-like 3D printed fragments. All of the examples represent some processes that could be applied in other CH projects in the future. All of the projects were realised through interdisciplinary co-operation between engineers and CH professionals.

2. Case study: Virtual and physical presentations of the oldest known carved wooden point

In September 2008 the Underwater Archaeology Workgroup conducted a preventive survey of the Ljubljanica riverbed near Sinja Gorica, close to Ljubljana, the capital of Slovenia. During the underwater archaeological examination, an isolated wooden object apparently unassociated with structures or contemporaneous objects was discovered [GE011]. Intensive archaeological research indicates that the wooden object is a human-made point, probably part of a hunting weapon. The chronological attribution of the object on the

DOI: 10.2312/PE/VAST/VAST11S/001-004

basis of typological characteristics was confirmed by radiometric analyses with the first date showing the wood to be >43,970 BP (Beta-252943) and repeat dating giving us an age of 38,490±330 BP (OxA-19866).

Soon after the point was found and before its important age was known, it was decided to employ all available 3D technologies in the field of CH documentation. There were two reasons for this: the importance of the find for further researches and the extreme fragility of the material from which point was made. It is therefore very difficult to present the delicate artefact. To date, none of the known preservation methods can preserve wooden artefacts for a significant time. The point is 16 cm long and 5.1 cm wide, it has a maximum thickness of 2.5 cm and its symmetry is apparent from all views and cross-sections. The base is damaged at the transition to the tang. Expert determination revealed that the wood is yew (*Taxus sp.*). The first examination by a specialist in prehistoric hunting equipment and techniques showed an amazing analogy between the find's shape and various leaf-shaped stone and bone points from the Late Mousterian of Central Europe [Bos67]. Several lines of evidence indicate that the object was intentionally made and not shaped by natural processes.

2.1. Virtual presentations: an interactive 3D model and a holographic animation; Physical presentations: 3D printing and other applications; Further work on wooden point presentations

First, the wooden point was 3D digitised with a handheld laser scanner. The scanner which we used for the acquisition needs the setting of several markers in the scene. For smaller objects (like point) black plate with markers on was used, so there is no contact with CH object, except on the ground. For larger objects, net with fixed pre-attached scanning targets can be used. By laying of this net over the object the need for adhesive target application is reduced, which is very important for all CH objects. The 3D model was textured using photographs. The scanogram, which was primarily created for the purpose of documentation and scientific research, was also used for conversion into an interactive 3D PDF and for a high-resolution holographic animation that was first shown at an exhibition at the City Museum of Ljubljana in early 2011. The hologram is provided by a Hexquarium, a patented holographic device which enables an autostereoscopic effect of an object using a programming interface which enables a 360 degree viewing angle (Fig. 1). With the software interface developed by Virtual Media, the object can also be enlarged to reveal a more detailed structure of the object on show. From the data obtained by the 3D digitising, a full colour 3D printed copy of the point was also made (Fig. 2). Such a copy can be used as a tactile museographic tool or as a souvenir in the museum shop. Based upon the digitised data, a 3D image (carved with a laser) in a glass cube was also made using a process called 3D vitrography.

It is planned to publish a virtual 3D model on a website which will present all important finds from the Ljubljanica River. We will also continue with the researching and testing of other materials that could be used to make copies for the purpose of museum gifts and souvenirs.

Figure 1: *High-resolution holographic animation of the wooden point. (Virtual media)*

Figure 2: *The original wooden point (left) and the full colour 3D printed copy (right). (IB-PROCADD)*

3. Case study: Virtual Emona, a 3D collection in the Digital Library of Slovenia – dlib.si

In the first decade of the 1st century Romans built their colony of Iulia Emona in the area of what is today the city centre of Ljubljana. The town was the administrative, political, economic and religious centre of the wider area. Emona declined after the 5th century, with the last signs of occupation dating back to the mid-6th century. At the site NUK II many small archaeological artefacts have been found: all types of ceramic and glass ware, coins, as well as chips and dice, namely, frequent finds at Roman baths.

The Virtual Emona project was initiated by the National and University Library of Slovenia (NUK), the owner of the Digital Library of Slovenia – dlib.si and a national aggregator of cultural e-content for Europeana. The collection includes interactive 3D models of Roman artefacts found at an archaeological site called NUK II as a new building of the National and University Library is planned there. During the Roman period NUK II was an area of private houses and public baths near the centre of the Roman colony of Emona, where modern-day Ljubljana is situated. The new NUK will include an archaeological in situ presentation. Until then, a 3D collection of selected artefacts and a model of the site during the archaeological excavation is available to the public at the dlib.si portal, with aims to upgrade it to a virtual exhibition in later years.

3.1. 3D digitisation and data editing; Publishing the collection at dlib.si and Europeana; Further work on Virtual Emona

For the purpose of the virtual collection small artefacts from NUK II and a scale model of the site (scale 1:50) were 3D digitised and prepared for publishing at dlib.si. A model built from pieces from the site was made in 1998 by A. and P. Ogorelec and N. Nemeček. It is kept by the NUK, whereas archaeological objects and site documentation are kept by the Museum and Galleries of Ljubljana [ASZ11]. We 3D digitised 15 archaeological objects: an amphorae fragment with the inscription »cibaria salua« (salted foods), four clay oil lamps, a bronze oil lamp, a weight, an appliqué, an incense burner, a dice, two chips, and a cosmetic spoon.

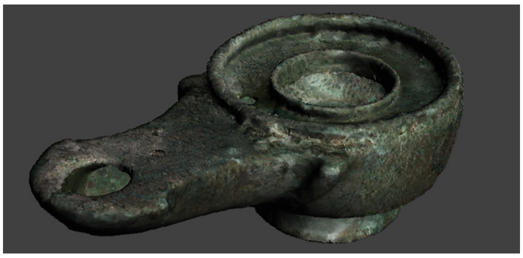

Figure 3: *Roman Bronze oil lamp in 3D PDF file format at Virtual Emona, dlib.si. (National and University Library)*

The Digital Library of Slovenia – dlib.si is a public web portal allowing free access to digital and digitised library materials, and virtual exhibitions. Since our pilot project, 3D objects have also been published at this portal (Fig. 3). 3D scanograms are published as separate digital objects in a reduced (lower resolution) 3D PDF file format together with a metadata description. The PDF format was chosen because it is already used by dlib.si to view 2D documents. The collection also presents a Roman tombstone found at the NUK II archaeological site (digitised earlier). More than 3,000 unique searches by the key words »virtual« and »Emona« were made in a six-month period (September 2010 – March 2011) [Est11]. Objects from Virtual Emona have been in the top 10 searches since they were published. Through dlib.si, this collection will also be accessible via Europeana by the end of 2011. For the purpose of generally promoting and presenting Emonan heritage, full colour 3D printed copies of several artefacts were made.

Research indicates that the town of Emona was completed in the 2nd half of the year 14 / 1st half of year 15 [SW64]. Its 2000th anniversary is approaching and this offers an opportunity to engage the wider public with the heritage of Emona, including with the use of 3D technologies.

4. Case study: Restoration of a museum object - a stemmed fruit bowl using reconstructed 3D printed fragments

3D technologies are widely used in restoration, mostly for documentation purposes. 3D printing is commonly used indirectly to make copies. Since we were interested in the possibility of using 3D printing directly in the restoration of damaged objects, we tested the process on two damaged pieces of a porcelain bowl. The bowls were heavily perforated and therefore making the new missing fragments would require a time-consuming and complicated restoration process. Employing a combination of 3D scanning, 3D reconstruction and 3D printing of unpreserved parts seemed to be an option [ACS11].

The National Museum of Slovenia keeps tableware made by the Royal Vienna Porcelain Manufactory of porcelain in the neo-classicist style of the early 19th century [Neu90]. This ware includes a group of three (two badly damaged) perforated bowls for fruit or candy (height 13.5 cm and a diameter of 21 cm). According to a museological doctrine that we should present the most perfect impression of the past and all diversity of tableware forms, we decided to completely reconstruct the two damaged bowls. Each of them suffered from a variety of major and minor damage.

4.1. 3D digitisation and reconstruction; Restoration; Further restoration work

Reconstruction for the purpose of restoration began with 3D digitising. During the process we documented the condition of the two bowls and their damaged parts. The procedure was carried out with a handheld 3D laser scanner. On the basis of the data acquired, a 3D computer reconstruction of the missing fragments was designed. The virtual reconstructed fragments were translated into a physical form of a plaster-like material with 3D printing. These parts were used directly in supplementing the object.

The restoration of both bowls was similar to a conventional object complementation, which usually occurs by manually copying and casting fragments. In our case, the fragments were acquired by using 3D technologies. During the restoration the 3D printed fragments were adjusted and glued to the bowls. Then the fragments were impregnated with an epoxy resin, coloured and finally coated with another layer of epoxy. We thus achieved the appearance of a glaze (Fig. 4).

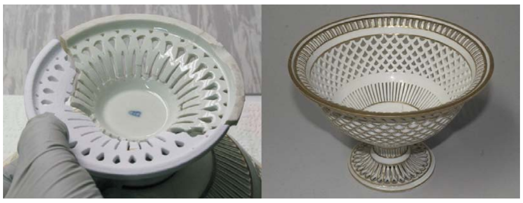

Figure 4: *Restoration of the bowl using 3D printed fragments. (National Museum of Slovenia)*

The procedure is ideal for replacing complex forms or large missing parts on ceramic objects. The only weakness appears when seeking to complement porcelain objects as 3D printed parts are not translucent. This could be overcome by testing other additive manufacturing materials and technologies or by making a silicone mould and moulding from transparent foil in the shape of the 3D printed parts [Lem06]. Missing fragments can then be cast from pure and properly coloured Araldite 2020 Resin [Sla11].

5. Discussion

CH institutions rarely opt for 3D projects because they are unsure exactly which kinds of results they will gain. We have found that what is most important is that engineers are acquainted with the problems of CH institutions, and CH institutions should be acquainted with what engineers can do for them. Engineers must communicate in less technical ways. Engineers must present the realised projects to the CH institution in the simplest manner, without technical details. The institution is primarily interested in the final result and hence technical details (except for safety) of the process do not interest it so much. It is also not enough to show them what kind of technology (SW, HW) is available since the most important information for the institution is what it can gain from it. With a single acquisition a CH institution may acquire many products that it can offer its users. The projects presented here briefly and simply turned out to be an effective way to demonstrate the possibility of technologies to CH institutions. It is also important to give CH professionals some basic technical/engineering education. When they learn to use a basic/simpler technology, they can undertake some projects by themselves; such education would also enable effective communication between CH professionals and engineers, in turn opening pathways to further development. The (partial) sponsored development project of solving a particular smaller problem at a CH institution proved to be a good practice since the CH institution can now recognise the possibilities of 3D technologies. During such a process institutions usually start to understand what 3D technologies enable and start to get the some ideas by themselves.

Acknowledgements

Thanks to: K. Celec, M. Sinani, R. Satošek, G. Grašič, E. Mirtič, D. Ljubič, A. Žužek, Mag. G. Lemajič and many others. Supervision: Prof. Dr. S. Dolinšek, E. Sternad and Doc. Dr. M. Kos. Research programme of the K. Antlej, IB-PROCADD d.o.o. Financed by the EU, European Social Fund. 3D digitised: ZScanner 700 CX, ZScanner 800. Editing and texturized: Geomagic Studio. 3D printing: Magics. Printing: ZPrinter 450. 3D PDF: Rhino. Holography: Virtual media d.o.o.,3D vitrography: Looxis Ljubljana, BTS Company d.o.o. Software: Rhinoceros, Photoshop etc. CH institutions: National and University Library, Museums and galleries of Ljubljana and National Museum of Slovenia.

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