Virtual Archaeology Review

Deploying 3D technologies for the documentation of tangible cultural heritage

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Resumen

Cada vez más, los visitantes y profesionistas del patrimonio cultural esperan más de las tecnologías 3D. Es por esto que el proyecto 3D-COFORM pretende hacer que la tecnología 3D sea una realidad para el sector. El proyecto está desarrollando herramientas dirigidas a diversos tipos de usuarios y a la vez investigando sobre las cuestiones prácticas para su implementación en organizaciones de patrimonio. En esta comunicación se describe la metodología para lograr esto, así como diferentes tipos de pruebas llevadas a cabo por el proyecto. También propone tres modelos para la implementación de las tecnologías 3D y describe una de ellas con más detalle. Aunque estos resultados son preliminares, se espera que contribuyan a que el sector vea la implementación de tecnologías 3D como una opción sustentable.

Palabras Clave: *TECNOLOGIAS 3D, MODELS DE IMPLEMENTACION, PRUEBAS*

Abstract

Increasingly, visitors and cultural heritage professionals expect more from 3D technologies. The 3D-COFORM project aims to make 3D technology a practical proposition for use in the cultural heritage sector. While developing state of the art tools targeted to a diverse group of users, the project is also researching on the practical issues for the technologies' implementation on heritage organisations. This paper describes the methodology to achieve this; as well as different types of testing conducted by the project. Moreover, it proposes three deployment models and describes one of them in more detail. Although, these results are preliminary they are expected to contribute towards the sector considering 3D technologies as a sustainable option.

Key words: *3D TECHNOLOGIES, DEPLOYMENT MODELS, TESTING*

1. Introduction

Increasingly, 3D technologies are becoming well known to the public by the introduction of user experiences, such as 3D TVs and 3D cinema. Hence, visitors to museums and other cultural heritage organisations are beginning to expect more quality in the cultural content which they access before, during and after their visit. Moreover, cultural heritage professionals are increasingly aware of these technologies and thinking of different kinds of uses they could give to this new richer type of information for conservation, preservation and dissemination purposes.

Nevertheless, the use of 3D technology remains challenging to use on a day-to-day basis as expertise is still scarce and technologies are difficult and expensive to use; while they do not always meet the expectations of the cultural heritage organisation. In order to address some of these challenges, the 3D-COFORM project aims making 3D technology a practical proposition to the cultural heritage sector. The project focuses on the 3D digitisation, processing, documentation and presentation of tangible cultural heritage. This type of heritage refers to all of the cultural assets found in museums as well as town and cities, ranging from tiny artefacts to sculptures, monuments and archaeological sites. The project is funded by the European Commission in the framework programme 7, and will run until November 2012. The project includes an ambitious research programme on the different aspects of 3D technology. Critically, it is linked to research on the practical issues for the technologies' implementation on the heritage sector. These include deployment issues, such as testing and training.

This paper discusses the first findings of this practical aspect of the research and its implications to the sector. The paper first introduces a 3D pipeline for the 3D documentation of heritage assets, including tools and their users. The paper then describes the methodology used to understand deployment issues of these technologies. It then presents different deployment models used during the project. Finally it presents conclusions.

2. Pipeline for the use of 3D technologies to document tangible Cultural Heritage

The 3D-COFORM project proposes that a critical aspect of 3D technology is that metadata is essential to the 3D documentation of cultural assets. This metadata includes both the information regarding the digitisation of the cultural asset and processing of the digital assets as well as the information associated to the history of such assets. For example, metadata could include the date of its creation, the author, information on its location, shape and size among others.

Based on the premise that metadata is generated throughout all the process of documentation of tangible cultural heritage, the following pipeline is used:

1. *Acquisition and processing*: includes the acquisition of data and the additional processing of this set of data.

2. *Searching and browsing*: includes accessing the data. The query formulation process is a recursive process where the user starts with an initial query which will be refined based on search results he/she will browse through.
3. *Viewing and annotating*: includes visualising the 3D content and adding annotations to the models.
4. *Modelling and presenting*: includes the modelling of virtual artefacts which might accompany or not the acquired digital assets in presentations both for heritage professionals and the wider public.

All of these steps are supported by a Repository Infrastructure which supports the ingestion, retrieving and querying of data within all of these steps.

2.1 Tools

Within each of the steps of the 3D pipeline different tools can be used to support users to document tangible cultural heritage. These tools can be hardware or software technologies which are intended to be used in "toolchains" or combination of tools where the output of one tool can be used as the input of another tool until a final result is achieved that fulfils the user's documentation needs. An outcome of the 3D-COFORM project is an infrastructure of tools which are underpinned by a Repository Infrastructure for the documentation of 3D digital assets and their associated metadata.

A 3D documentation campaign might draw on some of these tools, but of course is not limited to them, as many other tools are available in the market to support 3D digitisation. However, an important advantage of the 3D-COFORM tools is that they share a semantic language to document the 3D assets' metadata. These tools include tools for creating 3D reconstructions, for processing 3D meshes, for reasoning and structuring 3D meshes, for querying a semantic network, for visualizing 3D scenes, for generating procedural 3D models or for enabling the authorship of presentation applications.

2.2 Users

One of the main questions when discussing practical aspects of deployment of 3D technologies is who are the users of these tools? As such, different user's communities have been identified, including:

1. *Cultural heritage professionals*: this user normally has a background related to art history, archaeology, archival science, conservation, museology, librarianship, etc. They have in depth knowledge of some areas or areas of Cultural Heritage, the associated objects and their environments.
2. *Technical users*: those users that have the technical background to produce, test and modify the tools required to produce scientific data. They can be engineers but also those who manage the system like the database or system administrators.
3. *Commissioners*: they can be entrepreneurs, SMEs or the Cultural Heritage institutions themselves. They are usually interested in an overview of the whole system, practical information about the environment, thematic information and anything that can be exploited, for example, by the tourism industry.
4. *Citizens*: this includes everybody who has an interest in cultural heritage.

In reality, it is expected that all of these communities will be interested in using the tools, but the specialised skills required by their use will constrain who will be able to use them. Because of the innovative concepts involved in using the tools, it is expected that these skills will need to be taught to potential users which are drawn from these communities. This will lead to the development of a new professional profile in the arena which includes a mixture of heritage background and technical skills.

3. Methodology

In order to explore a set of deployment models for 3D documentation, research was undertaken in the area of practical aspects of the technology resulting from the 3D-COFORM project.

This research uses a V-model for the technology development process, where each of the steps of the technology development is matched by an activity which aims to understand how the developed technology is being deployed by the different communities of users (see figure 1). Hence, the different types of testing include component testing, interface testing, system testing, acceptance testing, and release testing.

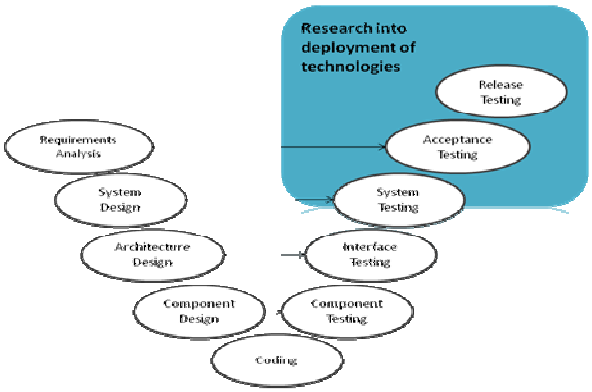

Fig. 1: The V-model for technology development

Two main types of testing analyse the issues surrounding the deployment of technologies. Acceptance testing is a validation step to check developers are building the right tool which addresses the user's needs. End users from different user communities perform these tests, as they know what is required from the system to achieve value in the business and are the only person qualified to make that assessment. Release testing is about seeing how the new or changed system will work in the existing business environment, including testing the business processes (training, operational protocols) which have been designed as part of the deployment environment. This type of testing is done mainly by users from the cultural heritage professional communities, as they understand the existent business environment.

3.1 Acceptance testing

Two complementary mechanisms are being used to understand how tools meet user requirements. The first one included a

testing workshop focusing mainly on those non-mature tools, where developers support the testing of their tools under controlled conditions. An example of this, was a testing workshop during 2010, which was attended by a mixture of professionals in cultural heritage, service providers and academic users. During the workshop users interacted with the tools structured in three different scenarios: 3D capture and documentation of tangible heritage, enriching multilingual textual heritage documents using CIDOC-CRM and 3D procedural modelling of a heritage site.

Testers spent around 45 minutes testing each scenario in groups of 4 or 5 using 2 or 3 PCs in each testing area (see Figure 2). Each session included an explanation by the developer of a test case using the tools and testing by users.

Fig. 2: Testing workshop part of the methodology

Feedback was collected via quantitative and qualitative methods, by video recording the conversations from each session, through round table discussion to gather overall impressions on the scenarios, and by questionnaires. Questions varied according to each scenario to cover the different tools used, but generally covered user background, their opinion on several aspects of the scenario including the tool's user interface, the tool's functionalities, the tool's intended user and other potential uses for the scenario.

Feedback from the workshop focused on wanting to know more about the capabilities of the tool, making suggestions and queries of whether other additional functionalities were possible, commenting on the user interface and functionalities of the tools as well as the envisaged uses for these tools.

The second mechanism involves testing the tools remotely. This testing makes use of testing packages to enable users to test specific functionalities with the minimum amount of training. The testing package provided with each released tool, include a set of instructions for testing the functionalities that developers are interested in getting feedback about, a dataset to support the test, instructions to download the software, and a questionnaire with relevant questions.

In previous testing using this mechanism, users usually provide useful comments on a range of additional features they would like to see in each of the tools and many of these related to easier to use dialogue boxes, clearer user options and improved support materials, such as on-line tutorials and user manuals. In particular users were looking for speed and reliability.

3.2 Release testing

In order to complement the acceptance testing, during the course of the project a range of deployment experiments have been undertaken by Cultural Heritage partners. Experiments have tested the capabilities and limitations of 3D acquisition hardware and software against a range of different object types, materials, textures, colours and sizes (see Figure 3). The experiments involved using acquisition tools, such as 3D scanners and photogrammetry, and some combined different methodologies to enhance results. In all cases, the experiments attempt to answer those questions of how to make 3D technologies a day-to-day option for the cultural heritage sector. For instance, issues that are being considered include project management during documentation campaigns, acquisition of digitisation capacity, workflow processes, training requirements, usability of tools, throughput, quality monitoring, copyright, potential exploitation strategies, analysis of the investment and potential returns and socio-economic impact evaluation.

Fig. 3: 3D acquisition deployment experiment at V&A museum in the UK

Examples of these issues, for instance, are the questions of how much time is needed to produce a 3D model of an artefact as well as its cost per item. These issues relate to the cost/benefit of having a 3D model compared to any other type of content which museums currently use. It is also thought important to understand the accuracy of the technology and the support required in selecting the most suitable tools for the job, progressing towards guidelines for selection and use for accurate results.

4. Deployment Models

The testing activities implemented during the project have highlighted three potential deployment models for other cultural heritage organisations who would like to use 3D technologies to document their collections. These proposed models take into account where the expertise to deploy the technologies resides. These are:

- **In-sourcing**: when a CH organisation sees the use of 3D technology as part of the organisation's strategy and invests in acquiring in-house expertise and equipment.
- **Out-sourcing:** when a CH organisation prefers to delegate the implementation of 3D technology to an external expert or company; being interested only on the result of such implementation.
- **Crowdsourcing:** when a CH organisation delegates tasks involved in the use of 3D technology to a larger crowd loosely or not associated with the organisation (e.g. museum's visitors, general public).

These models have different requirements for organisations as well as those processes involved in using the technologies. The following section will briefly describe the crowdsourcing deployment model as an example of issues involved.

4.1 Crowdsourcing: large scale content acquisition

This model is based on the basic premise of crowdsourcing, which is outsourcing a task to the crowd. Although this trend was first observed in the open source software movement, more recently this concept has been applied to all kinds of tasks, from taking photographs to providing technical support (Howe 2006).

The suitability of the crowdsourcing model for the cultural heritage sector is currently being tested within the 3D-COFORM project in an experiment that documents the sculptures and monuments of Sussex in the United Kingdom.

The two tools which were selected to support the 3D digitisation of the public monuments and sculptures were Arc3D (KU Leuven ESAT-PSI 2011) and Meshlab (Visual Computing Lab of ISTI-CNR 2011). Arc3D is a tool which produces a 3D reconstruction using a set of digital images using photogrammetry. It requires a user to photograph an object while walking with the camera in an arc around the object. MeshLab is a tool for processing and editing unstructured 3D triangular meshes, which supports cleaning and producing a simpler version of the 3D model generated by Arc3D.

The protocol for volunteers performing the digitisation involves photographing the object, uploading the pictures to Arc3D, receiving the 3D model, processing it with Meshlab and contributing the 3D model to the database and linking it to associated metadata. Experience indicates that two types of participant are required to support such a toolchain. One is a volunteer who only needs the ability to take photographs and upload the pictures to a webpage (task 2 has been automated). This was deemed as necessary as to remove any training requirements so everybody will be able to participate with the basic skills of being able to take photographs. This skill is very basic; hence, the participation could be opened to a wider profile of volunteers. The second participant is a more specialised and committed volunteer who can perform more specialised tasks after some training.

One of the biggest advantages of crowdsourcing, is that heritage organisations do not need to acquire equipment to perform the digitisation as digital cameras are widely used by the public. However, they will still require some basic equipment, such as a PC, to be able to visualize the resulting 3D models.

The time required to acquire a 3D model from volunteers' effort varies greatly depending on the quality of the photographs that are used as an input. We expect that from all the contributions there will be a good set of photographs which will be sufficient to generate a 3D model within a few hours. This time is needed for the software to process the model and for somebody more specialised in the use of Meshlab to clean the mesh and upload the 3D model to a server linking it to any metadata associated to the 3D model. The acquisition of the photographs through crowd sourcing could take hours or days; so it is more difficult to estimate.

Quality is a critical issue when considering any crowdsourcing project. This is because it is necessary to ensure the quality of the contributions of volunteers, as well as the quality of the 3D model. Hence, this model requires careful consideration and assessment of this issue, which requires additional effort.

Moreover, because photographs are being contributed by a wider variety of users, the license selected to protect such work and the 3D models is the Attribution-Non Commercial-Share Alike 2.0 UK Creative Commons (Creative Commons 2001). This will enable the 3D models to be produced from the effort of all volunteers which will be acknowledged by naming the users whose pictures where using to produce the 3D model.

Assessment of the socio-economic impact of this model, as of any activity, is dependent on whose perspective it is viewed from. It is evident that in this particular case there are three different groups involved with three different perspectives. These are the:

- organisers of the experiment
- volunteers taking part in the experiment, and
- end-users of the data produced by the experiment.

Each group will have different motivations for taking part in the experiment or using the data generated and will naturally incur different benefits and yield different impacts.

5. Conclusions

The 3D-COFORM project aims to make the use of 3D technologies a practical option for the Cultural Heritage sector. As such, experiments are taking part to understand how these technologies could be deployed on a larger scale. Researching on these issues opens up a new set of questions regarding the business process and associated protocols required to use the technology. Further deployment experiments will attempt to answer these questions and; critically, generate guidelines for other organisations to take on the lessons learnt from the research project.

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