

INTERACTIVE 3D MODELS OF COLLECTION ITEMS FOR EDUCATION AND PRESENTATION APPLICATIONS

Sven Ubik^a, Jiri Kubista^a

^a CESNET, Zikova 4, Prague, Czech Republic, {sven.ubik|jiri.kubista}@cesnet.cz

ABSTRACT: Digitization of cultural heritage artefacts is now widespread. However, most spatial objects are now represented by still photographs in databases and portals such as Europeana. We believe that using interactive 3D models can bring new opportunities for education, research, scientific collaboration and popularization of cultural heritage. We discuss design options for each phase of the whole chain of using interactive 3D models. We describe a web-based architecture that allows scalable and collaborative visualizations of interactive 3D models ranging from mobile devices to large video walls in classrooms and laboratories. Finally, we summarize our practical experience and suggest directions for future work.

1. INTRODUCTION

Many museums and other heritage institutions with collections of precious cultural or natural history artefacts now often create digital representations of these items. In most cases, items are just photographed to create a searchable digital archive of images of their collections. The motivation is primarily to record items in the collection and their current state. Therefore, items are often photographed before and after they are exhibited or reconstructed.

Digital representations are useful to document the current state of artefacts (which may deteriorate), allow study of artefacts without physical contact and might serve as a form of backup, to help restore precious artefacts, should damage occur.

Some countries build their national archives of digital representations of collection items. At the European level, there is a Europeana portal (www.europeana.eu) that includes digital images of millions of items obtained from national and regional archives.

Current technologies allow non-contact creation of digital 3D models of collection items. The models can be even interactive, allowing virtual manipulation with the items, such as opening, disassembly, etc.

We foresee a large potential of digital representations of cultural artefacts, and particularly interactive 3D models, for education, research, scientific collaboration and popularization.

There are several use cases where interactive 3D models can provide an added value to still photographs. For example, to enhance an online collection presentation or a physical exhibition to allow visitors to look inside the collection items, providing visitors with more information, hands on feeling of the exhibited objects and making the exhibition more attractive, especially for young visitors.

2. PROBLEM DESCRIPTION

We concentrate on tangible three-dimensional objects, because this part of cultural heritage and natural history is now less well represented in digitalized forms than flat works, such as prints or paintings.

In order to enhance digital archives with interactive 3D models, we need scalable and cost effective technologies and processes to create the models, store them, protect their intellectual property and visualize them on output devices ranging from mobile phones to video walls in laboratories, with low-latency interactive feeling of virtual manipulation with the collection item. We pay particular attention to mobile devices and large video walls.

Smart phones and tablets with powerful CPUs and high-resolution displays are now common and they can be conveniently used for virtual and augmented reality applications, instead of expensive specialized glasses.

Laboratories and classrooms are now often equipped with LCD video walls, thanks to the decreasing cost of LCD panels. Laboratory video walls can be setup such that full resolution of each LCD panel is utilized, rather than just projecting an HD video to a set of LCD panels, which is common in digital signage applications. Video walls allow seeing a "big picture" to create context and small details at the same time, without the need to zoom or pan, enabling to concentrate on content.

If we can share one or more 3D models in real time across a set of output devices, such as mobile phones, laptops and video walls distributed in one or more locations, we can enable collaboration applications between a teacher and students or a group of researchers.

For interactive feeling of object manipulation, the latency between commands and visualization changes should be small. Empirical evidence has shown that users feel that a communication system responds instantaneously, when its delay is less than approx. 150 ms [1].

3. DESIGN OPTIONS

In this section we discuss available options for individual phases of the whole chain of using interactive 3D models of collection items.

3.1 CREATING 3D MODELS

3D digital models are usually created by using three methods - optical scanning, photogrammetry and in modeling software. Each method has its advantages and limitations. Optical scanning can provide high geometry precision, photogrammetry provides high-resolution textures and modeling software can be used to create details inaccessible to the optical scanner or photography. For most applications in cultural heritage, high quality textures are very important. With the advancements in photogrammetry software, which now can provide also high precision of geometry, photogrammetry tends to be preferred for individual collection items, while optical scanning is used for large scale mapping, such as buildings and archaeological sites. An example of a 3D model of a statue

created using optical scanning and photogrammetry is shown in Fig. 1.



Figure 1: A 3D model of a statue of Jan Amos Komensky created using optical scanning (left) and photogrammetry (right)

3.2 INTERACTIVE 3D MODELS

We can extend 3D model usability for a larger set of educational and research applications and to make it more attractive for presentations, if we make it interactive. It means that users can open the virtual object, look inside, disassemble it and assemble again, etc. There are several technologies currently available to create interactive graphical applications. For web-based applications, the two most widely used options are Unity Engine with WebGL [2] and Blender with Blend4Web. In both cases, we first create and 3D models of individual movable parts of the whole collection item and import them into the Unity Engine or Blender. Then we specify a sequence of possible interactions and animations. We found that Blender with Blend4Web resulted in faster startup (model opening) and it allowed creating more naturally looking camera orbit. This was in line with a comparison published in [3]. An example screenshot of an interactive 3D model using photogrammetry and Blender with Blend4Web is shown in Fig. 2.

3.3 LOCAL AND REMOTE VISUALIZATION

In general, visualization can be computed on the client side (usually inside a web browser) or on the server side.

Sketchfab [4] is a popular platform for client-side visualizations of 3D models. It uses Javascript, WebGL and the OSGJS framework, running inside a web browser. The advantage

of client-side visualizations is scalability to many concurrent client devices, where each device can compute visualization in its own resolution.



Figure 2: An interactive 3D model created using photogrammetry and Blender with Blend4web

Another advantage is a small volume of data transferred to the client device, which is important for mobile devices and networks. A limitation of client-side visualization is that the actual 3D model is transmitted in some form to the client device and the model access rights can be breached.

In server-side visualization [5], the model remains on a server, which renders visualization and sends the resulting images as a video stream to a client device. The user navigation commands are sent back to the server and processed in real time. The advantage is stronger protection of model access rights. The disadvantages are a higher volume of data transmitted over a network and lower scalability for multiple client devices. An example of a 3D model with server-side rendering without transmitting the model data to the client device is shown in Fig. 3.



Figure 3: Server-side rendering of a 3D model of the Langweil model of Prague (the physical and digital model are property of the City Museum of Prague)

3.4 HIGH RESOLUTION VISUALIZATION

High-resolution video walls in laboratories and classrooms differ from digital signage multi-LCD displays in two ways. First, in a laboratory we usually want to keep the full resolution of each LCD panel in a wall. Second, we need to display content generated in real time by an application, rather than just playing out a pre-recorded video.

The SAGE2 framework [6] can be used to implement scalable visualization applications for video walls without the need to care about particular resolution and configuration of LCD panels. The video wall is connected to one or more servers, each for a set of LCD panels. Each server runs one Chromium or Electron web browser displayed across its set of LCD panels in their native resolution. Applications run inside web browsers in Javascript and communicate with the SAGE2 server for synchronization.

We implemented used a Sketchfab Viewer application for the SAGE2 framework using the Sketchfab Viewer API [7]. The application can present any Sketchfab model across multiple web browsers. Multiple instances of the Sketchfab Viewer application can be started and presented at the same time. Each window of any application instance can be freely moved and resized, while always keeping the full resolution across any number of LCD panels.

3.4 INTEGRATION OF MOBILE DEVICES

For group collaboration, a user with a regular PC or a mobile device can connect to the SAGE2 server and display the content of the video wall on his device. However, given the smaller size of the PC monitor or a mobile device display, it would be useful to see a selected model separately and still be able to interact with the model in a synchronized way with other users. Also, rendering must be performed in a resolution of a particular device.

Therefore, we developed a Mobile extension to the SAGE2 server. It allows users to start some SAGE2 application directly in their web browsers of their PCs or mobile devices. Touch control and gestures recognition were implemented using the Hammer.js library. The gestures are mapped to WebSocket

messages, which are exchanged through the SAGE2 server with web browsers of other users, allowing all users to see the same content.

The architecture is illustrated in Fig. 2. When a user interacts with his instance of the Sketchfab Viewer or with the SAGE2 User Interface, which arranges windows on the video wall, the visualisation changes are propagated through the SAGE2 server to other instances of the Sketchfab Viewer.

Presentation of multiple 3D models on a video wall and a selected model on a mobile device for group collaboration is illustrated in Fig. 5.

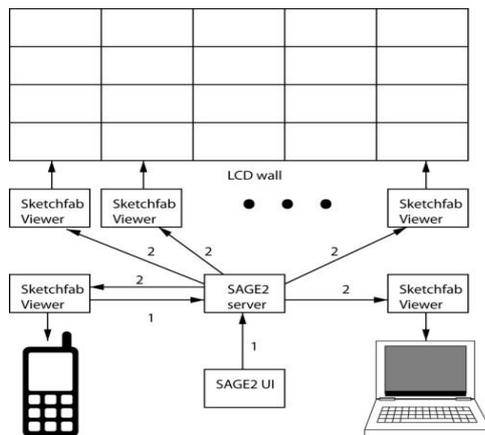


Figure 4: Architecture of Sketchfab viewer for group collaboration

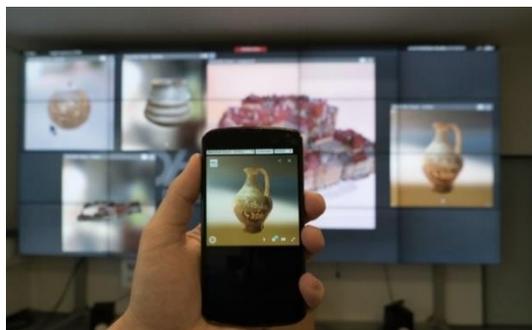


Figure 5: Sharing a 3D model between a video wall and a mobile device

4. EVALUATION USE CASE

To evaluate usability and performance of the collaboration environment, we used a set of models created from three sources: a) modelling applications Blender and 3ds Max, b) photogrammetry software (Agisoft Photoscan and custom software used for the Langweil digitization project) and c) 3D scanner Creafom Go!Scan 50. We selected several models that differ significantly in the

number of faces and vertices and in the size of textures.

4.1 RESPONSE TIME

We measured system response time for models varying in number of polygons and texture size [8]. The response time at the order of 150 ms was achieved for models up to 10^5 polygons and tens of MBs of textures.

4.2 USER SATISFACTION

We conducted a subjective usability evaluation test in order to obtain user feedback [9]. Due to a low number of subjects, the results are not statistically significant, but provided useful qualitative feedback. Each subject used his/her mobile device while a person in the teacher's position was observing at the video wall. The evaluation environment is shown in Fig. 6.



Figure 5: Usability evaluation of collaboration environment

Each subject was asked to perform 12 tasks on three models. For example, to show peer students and the teacher a specific part of a model or to compare parts of two models. The subjects should then indicate their perceived level of difficulty to perform individual tasks. The most important improvement requirements were to decrease sensitivity of orbit look and pan when zooming in and to move the centre of orbit look such that it remains at the centre of the currently visible model part.

5. CONCLUSIONS

Current technologies allow creating interactive 3D models that can be presented on devices ranging from mobile phones to large video walls. These visualizations can be accessed in a distributed way, enabling real-time distance collaboration. If needed, server-side rendering

can help protect the model data. Such an environment opens possibilities for using our cultural and natural history artefacts in education, research and for attractive presentations to real or online visitors.

Our implementation currently allows real-time sharing of 3D in a scalable way across devices with different resolutions. Interactive models can also be shared, but resolution is given by one device. In our future work we will extend scalability to interactive 3D models. Most importantly, we plan enabling support of interactive 3D models for our national portal of digital heritage.

6. ACKNOWLEDGMENTS

This work was in part supported by the project “E-Infrastructure CESNET - modernization”, no. CZ.02.1.01/0.0/0.0/16_013/0001797.

7. REFERENCES

- [1] ITU-T Recommendation G.114, 2003.
- [2] *WebGL Specification*, Khronos WebGL Working Group, <https://www.khronos.org/registry/webgl/specs/latest/>
- [3] Prakhov, A.: *Blend4Web vs Unity: WebGL Performance Comparison*, <https://www.blend4web.com/en/community/article/280/>
- Sketchfab Viewer API, <https://sketchfab.com/developers/viewer>
- [4] Shu Shi, Cheng-Hsin Hsu: *A Survey of Interactive Remote Rendering Systems*, ACM Computing Surveys, Vol. 47, No. 4, May 2015.
- [5]
- [6] Marrinan, T., Aurisano, J., Nishimoto, A., Bharadwaj, K., Mateevitsi, V., Renambot, L. Long, L., Johnson, A., Leigh, J.: *SAGE2: A New Approach for Data Intensive Collaboration Using Scalable Resolution Shared Displays*, 10th IEEE Int. Conf. on Collaborative Computing: Networking, Applications and Worksharing, 2014.
- [7] *Sketchfab Viewer API*, <https://sketchfab.com/developers/viewer>
- [8] Ubik, S., Kubišta, J.: *Interactive scalable visualizations of cultural heritage for distance collaboration*, Euromed 2016, Int.

Conf. on Digital Heritage, Nov. 2016, Nicosia, Cyprus.

[9] Ubik, S., Kubista, J.: *Scalable real-time sharing of 3D model visualizations for group collaboration*, 14th Int. Conf. on Cooperative Design, Visualization and Engineering, Sep. 2017, Mallorca, Spain.

[10] Ubik, S., Kubista, J.: *Scalable real-time sharing of 3D model visualizations for group collaboration*, 14th Int. Conf. on Cooperative Design, Visualization and Engineering, Sep. 2017, Mallorca, Spain.