ISSUES OF 3D VIRTUAL COLLECTION FOR SMALLER INSTITUTIONS

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RYBENSKÁ, Klára – BORŮVKOVÁ, Barbora – TOMIŠKA, Ondřej. Issues of 3D Virtual Collection for Smaller Institutions. In Studia Historica Nitriensia, 2023, vol. 27, no. 1, pp. 287-303, ISSN 1338-7219, DOI: 10.17846/SHN.2023.27.1.287-303.

One of the most significant global trends today is the use of three-dimensional technologies in various segments. 3D models can be created by using special software or by digitizing a real-world object using a 3D scanner. The technologies capable of converting analog objects into digital 3D are also a part of the sphere of memory institutions, where we increasingly come across 3D models of selected historical collections often created under the auspices of specialized workplaces or universities. The process of digitization itself, particularly 3D scanning, can harbour many pitfalls. Creat-

ing a virtual museum collection is not an easy task, as there are many ways to present 3D models since each of them can be used in different ways. The objective of the article is to describe the possibilities and the process of creating a 3D virtual collection of smaller historical objects, and its presentation by means of selected online tools or web services designed for the purpose. The article also focuses on the subsequent use of the models in the creation of a virtual web exhibition. Another objective of the article is to outline the basic issues of 3D scanning of selected smaller historical objects.

RYBENSKÁ, Klára – BORŮVKOVÁ, Barbora – TOMIŠKA, Ondřej. Problematika 3D virtuální sbírky pro instituce menšího rozsahu. In Studia Historica Nitriensia, 2023, roč. 27, č. 1, s. 287-303, ISSN 1338-7219, DOI: 10.17846/SHN.2023.27.1.287-303.
Jedním z významných trendů současného světa je využívání trojrozměrných technologií v různých segmentech. 3D objekty mohou vznikat vymodelováním ve speciálním software anebo digitalizací již existujícího reálného objektu pomocí 3D skeneru. Technologie schopné převádět analogové objekty do digitální 3D podoby se nevyhýbají ani sféře paměťových institucí, kde se čím dál tím častěji můžeme setkávat s 3D modely vybraných historických sbírek, vznikajících mnohdy pod záštitou specializovaných pracovišť anebo univerzit. Již samotný proces digitalizace, mluvíme-li o 3D skenování, v sobě může skrývat mnohá úskalí. Tvorba virtuální muzejní sbírky není jednoduchým počinem, neboť možností, jak prezentovat 3D modely je více a každý z nich může být využitelný jiným způsobem. Cílem článku je popsat cesty a proces tvorby 3D virtuální sbírky menších historických objektů a jejich prezentaci skrze vybrané online nástroje či webové služby k tomu určené. Takové možnosti, jaké mohou být užité při následovné tvorbě virtuální webové výstavy. Zároveň nastínit základní problematiku průběhu 3D skenování vybraných menších historických objektů.

Klíčová slova: Digital humanities; Sketchfab; virtuální sbírka; digital heritage; museum; software;

Keywords: Digital Humanities; Sketchfab; Virtual Collection; Digital Heritage; Museum;

Introduction

Memory institutions, such as museums, libraries and archives, have undergone considerable historical development into the form they are today. Along with traditional full-time analog exhibitions, virtual or, in other words, digital exhibitions are coming to the forefront. Memory institutions are greatly interested in the possibilities of digitizing their collections. So far, digitization has been used for the preservation of cultural heritage, mainly in two-dimensional design. In this respect, however, three-dimensional design has been shown as an attractive way of making information and collections accessible to the general public. The technologies, such as virtual reality, augmented reality or web3D, have already been used worldwide in order to create virtual museum exhibitions, and thus attract mainly younger generations. Similar exhibitions can be implemented not only by means of web technologies, but also by means of information kiosks[1].

3D objects can be created by digital 3D scanning or 3D modeling. The process of digitizing and using a 3D scanner itself harbours many pitfalls. In addition, the modification of the scan and the consequent selection of an appropriate service to present data could pose a difficulty which some memory institutions rightly do not want to encounter.

[1] STYLIANI, Sylaiou – FOTIS Liarokapis – KOSTAS, Kotsakis – PETROS, Patias. Virtual museums, a survey and some issues for consideration. In Journal of Cultural Heritage [online], 2009, 10 (4), s. 520-528 [cit. 2021-9-1]. Available from: doi:10.1016/j.culher.2009.03.003.

Our objective was not only to explore the possibilities and the process of creating a 3D virtual collection of smaller historical objects, but also to describe the ways in which 3D models can be presented by means of online tools or web services. These tools allow museums or similar institutions to create a virtual web exhibition. However, they may sometimes have to pay a higher price or hire an expert to create the most appropriate solution. Our aim is to find a service or a tool that could serve almost anyone.

The article was written with the help of students and supported by specific research entitled 3D Digitization of Selected Historical Clocks from the Regional Museum Náchod documenting specific research taking place at the Faculty of Arts of the University of Hradec Králové.

Current situation of 3D digitization of historical objects

At the present time, 3D digitization for the field of memory institutions is beginning to expand rapidly due to the COVID-19 Pandemic worldwide paralysis, which resulted in the closure of public access to museums, galleries, libraries and archives. Institutions around the world have been trying to present their collections to the public by means of virtual tours of digitized objects.

On a global scale, CyArk, a California-based non-profit organization, is probably the most important company with the aim to digitally preserve and present the most important cultural heritage of the world.[2] There are a number of large and small 3D digitization projects, with a truly global scope, where all outputs of the projects are concentrated through a single web portal.

One of the largest European projects for 3D digitization was the 3D-ICONS subproject[3] funded by the European Library-Europeana, a kind of a hybrid among all memory institutions, trying to present the picture of the overall European culture. As a part of the 3D-ICONS project, more than 3,000 3D models relating to archeological sites, architecture, iconographic collections, and many others[4] were created during the years from 2012 to 2015.

Another very successful project is the Time Machine Europe project with the aim to combine Europe´s rich past with the latest digital technologies. Its goal is to create a collective digital information system that allows to map European economic, cultural, social and geographical evolution at different times.[5]

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2 Our Mission: Mission statement. CyArk [online]. Kalifornie, 2021 [cit. 2021-7-2]. Available from: <https://www.cyark.org/ourMission/>.

3 SOLTER, Anna – GAJSKI, Dubravko. Project "towards the virtual museum" – exploring tools and methods for 3d digitalization and visualization. Opvscvla archæologica [online]. Zagreb, Croatia, 2018, (39), 117-124 [cit. 2021-7-5]. Available from: doi: <https://doi.org/10.17234/OA.39.10>.

4 MALIK, Umair, Shafqat. Massive 3D digitization of sculptures: Methodological approaches for improving efficiency. IOP Conference Series: Materials Science and Engineering [online]. IOP Publishing, 2018, (364) [cit. 2021-7-2]. Available from: <https://iopscience.iop.org/article/10.1088/1757-899X/364/1/012015>.

5 Explore the history of Time Machine: About us. Time Machine [online]. Europe: Time Machine Organisation, 2021 [cit. 2021-9-1]. Available from: <https://www.timemachine.eu/about-us/>.

There are several smaller projects in progress in the Czech Republic, however, they are limited either locally, in scope or in time. The initiators of these projects are mostly memory institutions, or universities. The smaller institutions do not have sufficient technology, time, experience or staff.

In the Czech Republic, 3D digitization is rather in its infancy. There is neither relevant uniform process methodology nor specific literature. Fortunately, it is possible to draw on a number of information sources concerning technical procedures, however, they usually do not directly affect a specific field of cultural monuments. In the case of Digital Humanities, foreign literature together with scientific articles is, as opposed to the Czech one, significantly richer. The most common articles seem to be the articles of case studies, comparisons between different technologies and tools both for the conversion of material into 3D and for their presentation and mapping of the entire process of 3D digitization of defined collections. Good examples of this are the articles „Exploring tools and methods for 3D digitization and visualization [6] and „Massive 3D digitization of sculptures – Methodological approaches for improving efficiency"[7], both published in 2018.

The International EuroMed Conference 2010 was very important for scientific activity in the field of 3D digitization in memory institutions[8]. This conference is held every year on a different theme, and it was just in 2010 when the theme was Digital Heritage. The output of the conference was an extensive 500-page magazine, where the first part of a series of articles and presented topics, e.g., A Processing for Digitizing Historical Architecture[9], was devoted to the issues of 2D and 3D digitization. Especially in the last decade, as a part of the process of the protection and presentation of historical models[10], the use of photogrammetry as an alternative solution for creating 3D models from the original ones has been on the increase. It is mainly because it is a faster and, above all, cheaper alternative to

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[6] SOLTER, Anna – GAJSKI, Dubravko. Project "towards the virtual museum" – exploring tools and methods for 3d digitalization and visualization. Opvscvla archæologica [online]. Zagreb, Croatia, 2018, (39), s. 117-124 [cit. 2021-7-5]. Available from: doi: <https://doi.org/10.17234/OA.39.10>.

[7] MALIK, Umair, Shafqat. Massive 3D digitization of sculptures: Methodological approaches for improving efficiency. IOP Conference Series: Materials Science and Engineering [online]. IOP Publishing, 2018, (364) [cit. 2021-7-2]. Available from: <https://iopscience.iop.org/article/10.1088/1757-899X/364/1/012015>.

[8] We can say that the issue of 3D digitization for memory institutions is not a new topic, and, at least on a broader scale, it is a relatively well-established thing.

[9] Cheng H., Yen Y., Chen M., Yang W. A Processing for Digitizing Historical Architecture. In: Ioannides M., Fellner D., Georgopoulos A., Hadjimitsis D.G. (eds.). Digital Heritage. EuroMed 2010. Lecture Notes in Computer Science, vol 6436. Springer, Berlin, Heidelberg. Available from: <https://doi.org/10.1007/978-3-642-16873-4_1>.

[10] MAIWALD, F., T. VIETZE, F. SCHNEIDER, S. MUNSTER a F. NIEBLING. Photogrammetric Analysis of Historical Image Repositories for Virtual Reconstruction in the Field of Digital Humanities. ISPRS International Archives of the Photogrammetry [online]. 2017, 3 (42), 447-452 [cit. 2021-7-4]. Available from: <https://ui.adsabs.harvard.edu/abs/2017ISPAr42W3.447M/abstract>.

the more traditional use of 3D scanners.[11] New comparative analyses of individual tools have been carried out and new work procedures have been described. An example is the article „ To 3D or Not 3D: Choosing a Photogrammetry Workflow for Cultural Heritage groups"[12] from 2019. Photogrammetry does not require an expensive 3D scanner, it is possible to use only a camera, software (it can be an open source or freeware, both free of charge, or some versions / paid services) and a powerful computer.

In spite of this, 3D scanning is still a preferred and more widely used method for obtaining a 3D point cloud. It is often combined with photogrammetry in order to obtain as accurate texture as possible, since traditional 3D scanning cannot record it accurately enough[13] or record it at all (e.g., for some specific measuring devices, such as scanners from the GOM company, for example, GOM ATOS Q measuring device[14]).

The process of creating a 3D virtual collection

Let us write a few words on the issue of creating a 3D collection from the beginning. It all starts with the selection of suitable objects for digitization unless it is clearly a rescue operation where digitization is one of the ways to preserve gradually disappearing objects. For example, when we digitize a collection, not only for the purpose of subsequent virtual archiving, but also for the purpose of an exhibition or a presentation to the general public and experts, it is appropriate, if possible, to make a selection before the digitization starts. This selection is also suitable when the workplace does not have any specific tools for 3D scanning, which would allow digitization in various sizes, shapes, colours and textures. However, it is always possible to use specific methods of 3D digitization, such as the already mentioned photogrammetry.

Basically, the creation of 3D objects is possible in two ways: by creating a 3D model (for example, using period sources) or by means of 3D scanning. 3D scanners, various types of measuring machines, the method of photogrammetry[15] or

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[11] CHAMPION, Erik – RAHAMAN, Hafizur. To 3D or Not 3D: Choosing a Photogrammetry Workflow for Cultural Heritage Groups. Heritage [online]. Australia, Perth: Curtin University, 2019, 2 (3), 1835-1851 [cit. 2021-7-4]. Available from: <https://www.mdpi.com/2571-9408/2/3/112>.

[12] CHAMPION, Erik – RAHAMAN, Hafizur. To 3D or Not 3D: Choosing a Photogrammetry Workflow for Cultural Heritage Groups. Heritage [online]. Australia, Perth: Curtin University, 2019, 2 (3), 1835-1851 [cit. 2021-7-4]. Available from: <https://www.mdpi.com/2571-9408/2/3/112>.

[13] SOLTER, Anna – GAJSKI, Dubravko GAJSKI. Project "towards the virtual museum" – exploring tools and methods for 3d digitalization and visualization. Opvscvla archæologica [online]. Zagreb, Croatia, 2018, (39), 117-124 [cit. 2021-7-5]. Available from: doi: <https://doi.org/10.17234/OA.39.10>.

[14] ATOS Q: Quality starts with a Q. GOM a Zeiss Company [online]. Europe: GOM a Zeiss Company, 2021 [cit. 2021-8-7]. Available from: <https://www.gom.com/en/products/3d-scanning/atos-q>.

[15] Both in the field of photogrammetry and in the field of RTI, it is not directly about 3D scanning as such. By means of photogrammetry, it is possible, at the end of the whole process, to reach a three-dimensional object by calculating the location of a point in three-dimensional space using photographs. These photographs must be taken from the whole angle and cover the object in such a way that they partially overlap each other. ZUZA, Mikoláš, Photogrammetry- 3D scan-

RTI[16] rank among the most usable methods in this sphere. The chosen method should always depend on a particular digitization workplace (and its available tools, knowledge and possibilities) and, of course, on the objects that will be digitized.

If we are talking about scanners capable of capturing a three-dimensional object, it is necessary to point out the fact that there are many types and approaches to digitization, and that it would take a long time to categorize them. We can name, for example, the categories of laser, optical, contact or contactless scanners, scanners with structured light and scanners with blue light. We can also include the method of computed tomography or various sensors, namely the ToF sensor and its successor LiDar, which is popular and probably known mainly from Apple and the use of this technology in iPads and iPhones[17].

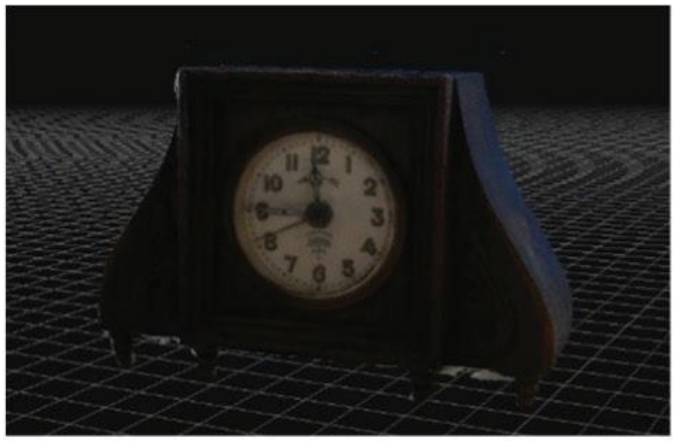

Figure 1. On the left, an example of 3D model obtained through the method of photogrammetry. In the middle, the original photo of the clock. On the right, 3D scan, as of yet without texture. It is clear from the picture that despite the fact that it was not a very intricately decorated clock, the resulting scan did not show the best carved decoration on the sides. The photo from the photogrammetry seems too dark. Finished 3D model can be viewed on KPVHA's Sketchfab. The clock comes from the Náchod's Museum, Czech Republic.

ning using a camera or a mobile phone. Josef Průša (online). The Czech Republic: Josef Průša, 2018 (cit. 2021-02-20). Available from: <https://josefprusa.cz/fotogrammetrie-3d-skenovani-s-pouzitim-fotoaparatu-ci-mobilu)>.

[16] The RTI method or Reflectance Transformation Imaging is more often used for digitization in such cases where 3D scanning or even photogrammetry fails. This can happen, for example, when dititizing a really small object, which also has a very rugged surface/ a more complicated image (for example, a coin, a Celtic iris, a seal, a piece of jewelry, a hieroglyph or an inscription on the wall…). RTI uses a sequence of digital photographs of an object, from which it is possible to synthesize a mathematical model of the surface of the scanned object. PLZAK, Jindrich. Documentation of coins via Reflectance Transformation Imaging (RTI). In: Numismatic sheets (online). Prague: The National Museum in cooperation with the Czech Numismatic Society, 2016, pp. 169-174 (cit. 2021-07-21). ISSN 2533-5650. Available from: doi: 10.1515/ nl-2016-0010.

[17] In this field, we could also point out the currently very specific possibility of digitization, namely by means of modern smart devices such as tablets or smartphones. This is not possible without the use of certain programs installed on similar devices. The programs may differ in function and operating system on which they work (iOS, iPadOS, Android), the basic hardware requirements of the device, and many other specifics. Among these programs, we can name, for example, Trnio (iPadOS, iOS) or Qlone (iPadOS, iOS, Android).

In 3D scanning, as previously mentioned, the digitizer may encounter many pitfalls that have to be taken into account. Therefore, the chosen digitization techniques are definitely related to the objects intended for digitization. Furthermore, it is necessary to take into account the complexity of the objects and, last but not least, the fact that the chosen technique might prove to be inappropriate. For example, it is necessary to be careful when digitizing shiny, too light or, on the contrary, too dark objects. A common problem with 3D scanners is the fact that they do not capture similar objects very well. Then it is possible to consider an alternative, for example, the above-mentioned method of photogrammetry.[18]

How does the digitization process work? Whatever method we choose (ie, 3D scanner, photogrammetry, or 3D modeling), the digitization process always consists of creating a scan and then the basic model. An example of a 3D scan of a historical artifact from the Museum of Eastern Bohemia in Hradec Králové can be seen in Figure 2.

Figure 2. On the left, a demonstration of 3D digitization through the Artec Leo 3D scanner. In the middle, an example from the process of creating a 3D model (cloud of points). On the right is the finished model. Finished 3D model can be viewed on KPVHA's Sketchfab.[19] The model of head comes from the Museum of Eastern Bohemia in Hradec Králové, Czech Republic.

It is usually necessary to consult the model with an expert or a collection administrator to determine whether it corresponds to the original object. If the original object is available, it is possible for the digitizer to verify this. However, when it comes to modeling, for example, on the basis of written sources (3D model created mainly thanks to written sources can be viewed in Figure 3), it is always appropriate to consult the result with an expert on the given object/ historical period (if the digitizer is not an expert).

[18] Budík (fotogrammetrie): KPVHA-FF-UHK. Sketchfab [online]. 1: Sketchfab, 2022 [cit. 2023-03-23]. Available from: <https://skfb.ly/oF9Qy>.

[19] Model tělověda – průřez hlavou: KPVHA-FF-UHK. Sketchfab [online]. 1: Sketchfab, 2022 [cit. 2023-03-23]. Available from: <https://skfb.ly/oAXFt>.

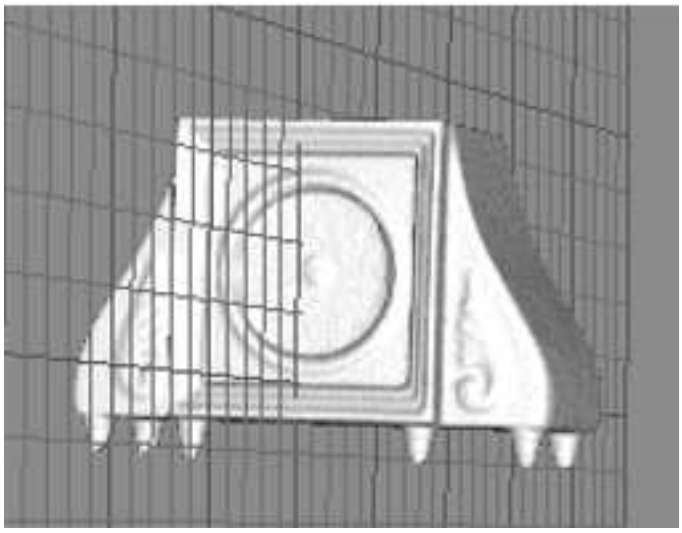

Figure 3. Creating 3D models based on historical written sources can present a variety of challenges. These may include issues such as insufficient source base, difficulties during the model creation process, texturing, lighting, and more. The images depicts several possible versions of a 3D model of the defunct bell tower at the Kuks hospital, created by the author Bc. Tomáš Pechánek. Unfortunately, the true appearance of the bell tower has not been preserved. Finished 3D models can be viewed on KPVHA's Sketchfab.[20]

In this case, it is often necessary to modify the model. The next step is uploading the model to the database or to the web, depending on where or if the data will be presented or just stored.

Problems of presenting 3D models of virtual collections

For any type of work with 3D models, whether within Digital Humanities or not, the arrival of Windows 10 for displaying 3D models natively within the operating system proved to be crucial. There was no need anymore to install other applications that represented this function.

The introduction of HTML5 standard had the main impact on the presentation of 3D models and on the substantial growth of popularity of web services that traded in 3D models or just represented them. Since 2014, due to the WebGL library, natively integrated into HTML5 standard, it has been possible to display 3D models naturally inside the browser without the need to install any extension[21]. That way the whole process became relatively simple since these two technical aspects were relatively problematic for the presentation of 3D models[22].

[20] Zaniklá zvonice u hospitalu Kuks (1B): KPVHA-FF-UHK. Sketchfab [online]. 1: Sketchfab, 2022 [cit. 2023-03-23]. Available from: <https://sketchfab.com/KPVHA-FF-UHK/collections/3d-modelling-fcf9d69345ea4a0ca366765fc06535f3>.

[21] WebGL: 2D and 3D graphics for the web. Mozilla: MDN Web Doc [online]. Mozilla, 2021 [cit. 2021-7-2]. Available from: <https://developer.mozilla.org/en-US/docs/Web/API/WebGL_API>.

[22] SCOPIGNO, R., M. CALLIERI, M. DELLEPIANE, F. PONCHIO a M. POTENZIANI. Delivering and using 3D models on the web: are we ready? Virtual Archaeology Review [online]. 2017, 8(17), 1-9 [cit. 2021-03-25]. Available from: doi: <https://doi.org/10.4995/var.2017.6405>.

The digitization process itself harbours its own pitfalls. The digitization workplace requires a qualified worker and the technology needed to create 3D models. In both cases, it is a rather expensive matter, not only when it comes to purchasing 3D scanners, a sufficiently powerful computer for post-processing, possibly a camera and a powerful graphics card[23] with CUDA cores when using photogrammetry. It is also necessary to ensure an adequate financial evaluation for the qualified worker.

Besides working with the above-mentioned tools, post-processing in particular is a relatively time-consuming activity[24], which also requires some expertise in working with 3D graphic editors such as Blender, 3D Max, Maya, Autocad or Meshroom (and others).

With the expansion of web markets with 3D models, along with the increasing importance of Digital Humanities, new possibilities for easier presentation of 3D models from the collections of memory institutions started to emerge. Until then, they had been standardly presented only in the largest and most important memory institutions. The main reason was the fact that the whole process of presenting 3D models online was very demanding. It was necessary to provide both software and hardware, i.e., to create your own web application for presenting 3D models, to provide your own technical solution and to operate the whole system.

Smaller institutions, such as regional museums, simply did not have enough resources, neither financial nor technical. This has been exacerbated by the fact that the smaller memory institutions often suffer from a relatively limited number of technically oriented workers, the know-how, the technology itself and, above all, finances. However, that does not mean that the "in house" solution disappeared with the arrival of these web services. Larger institutions still use it quite often[25] due to their main advantage, i.e., adaptability as well as security. It is possible to create your own solution exactly according to your own needs so the user has control over both technical means and data storage (unless he rents it). Thus, he is assured of data sustainability and, de facto, he is in control of all technical aspects. This way he does not have to rely on a service and its limitations.

Web services

Web services alleviate a lot of these problems. Standardly, their technical complexity is reduced. The user uploads the data directly to the web service repository, through which they can be easily presented directly by means of internal search engines or by embedding them in already existing "in house" websites. The memory institution will pay only for the service, but does not have to deal with the technical aspect of the presentation. This is more or less a complete so-

[23] CPU acceleration is not widely used as it is much slower than GPU acceleration, sometimes.

[24] TUCCI, G., D. CINI a A. NOBILE. Effective 3d Digitization of Archaeological Artifacts for Interactive Virtual Museum. ISPRS International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences [online]. 2011, (37), 413-420 [cit. 2021-7-4]. Available from: <https://ui.adsabs.harvard.edu/abs/2011ISPAr3816W.413T/abstract>.

[25] An example of this is the previously mentioned CyArk, or Europeana-related projects.

lution to presenting 3D models[26]. The disadvantage is the fact that the user thus transfers some control over the overall solution to a third party on which he, to some extent, depends.

When choosing a web service for the presentation of 3D models for a virtual collection, the main limiting factor, in addition to price, is the adaptability to the needs of the virtual collection from the point of view of the memory institution. A vast majority of these services focus more on the mere presentation of models or on their sale within digital marketplaces, i.e., the commercial sphere, which makes them relatively limiting for the needs of a museum or an archive, most often by their functions or licensing agreements.

Some tendencies to simplify and speed up this process are beginning to emerge for the web presentation of 3D models for memory institutions. An example is the 3DHOP project (3D Heritage Online Presenter, a Javascript framework under the FOSS license, which accelerates the creation of interactive web presentations of 3D models for the needs of cultural monuments[27] . Similar to P3D.in or Sketchfab, it allows to embed an interactive 3D model directly into your own web portal, and thus simplifies the process of creating your own solution[28]. A tremendous advantage of this solution is its independence from the back-end server. The user does not have to control the web backend (PHP, SQL, communication between client and server, etc). As a result, however, this solution is still suitable only for more technically oriented IT staff because embedding such content in web pages still requires the knowlege of at least front-end technologies such as HTML5, CSS3 and JavaScript. Moreover, this whole project is still in its infancy. Although these are fully functional libraries, it has a relatively small user base and the development is based mainly on three employees[29], which poses certain risks such as loss of support, problematic further development and provision of functionalities.

P3D.in

P3D.in is a cloud service that provides the possibility to upload and present your own 3D models online. natively in a browser without any plugins[30]. It offers its own repository and a website with a database in which you can search for individual models of both the user and other users. In addition to this display of models, it is also possible to embed content into personal websites using your own code. The process of embedding the embedded content from P3D.in is explained and described in a user-friendly way on their website. All uploaded models are owned by the user according to the license agreement.

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[26] BARRETTARA, M. New methods for sharing and exhibiting 3D archaeology. The Post Hole [online]. 2013, (31), 1-6 [cit. 2021-03-25]. Available from: <https://www.theposthole.org/read/article/218>.

[27] About 3DHOP. 3D Heritage Online Presenter [online]. 2020 [cit. 2021-03-25]. Available from: <https://3dhop.net/>.

[28] This system does not use a standard file server for storing 3D models, but it stores models directly on a web server together with back-end web applications and does not need any special plugins for its function.

[29] <https://www.3dhop.net/contacts.php>.

[30] P3d.in. P3d.in [online]. 2021 [cit. 2021-03-27]. Available from: <https://p3d.in/>.

In addition to the standard commands for inserting content, it is possible to modify the inserted model by using several commands (e.g., display the model without the possibility of zooming in, without the possibility of automated rotation, etc.) A certain advantage is that each command has, besides a basic description of what it does, also an attached reference to the model where the command is applied, so they all also have a visual[31] representation.

Along with the basic FAQ and a sufficiently in-depth information service, P3D. in also provides various basic options for editing the model even after uploading, so there is no need to edit, delete, and then reload the models.

P3D.in exists in two variants: basic version and plus version. The basic version may not be sufficient for the needs of presenting a 3D collection of some memory institutions, because it is limited by storage to only 100 MB and the maximum number of models to 5 pieces. Moreover, this version is also considerably limited by the resolution of the recorded objects (textures). The plus version offers storage expansion to 6 GB, an unlimited number of resolution models, as well as more advanced setting when embedding embedded content into custom web pages. The cheapest version of Plus costs $6 for 6 GB of storage. where the capacity can be increased for a higher monthly tariff. Each additional level of the Plus version costs $15 for 15 GB of storage. That means that + 1 GB of storage equals + $1 a month. With any version of the Plus account, it is possible to upload an unlimited number of models without limiting the maximum number of uploads per month, etc.

Overall, p3d.in is a relatively good solution for the presentation of 3D models. Its main disadvantage is that this portal is not fully adapted to the needs of many memory institutions, and so it does not allow some things that are common to museum collections, i.e., primarily sufficient depth of description of the object. The second disadvantage is the fact that this solution is nearly not as popular as Sketchfab, which is likely to work due to its massive user base (including museums or other memory institutions) in the next few years. P3D.in does not offer this warranty, so the fact that this service may not work in a few years should also be considered. There is no need to worry about losing uploaded models, but it can still be a risk that many institutions will not want or be able to take.

Sketchfab

Sketchfab is a commercial platform in the form of an online service, which is today de facto considered the standard for publishing 3D models online[32] not only in the commercial spfere, but also in the sphere of cultural monuments. In 2019, Sketchfab had over 100,000 available 3D models[33] distributed over more than

[31] Reference to examples with visual representation: <https://p3d.in/faq/embed>.

[32] SCOPIGNO, R., M. CALLIERI, M. DELLEPIANE, F. PONCHIO a M. POTENZIANI. Delivering and using 3D models on the web: are we ready? Virtual Archaeology Review [online]. 2017, 8 (17), s. 1-9 [cit. 2021-03-25]. Available from: doi: <https://doi.org/10.4995/var.2017.6405>.

[33] Over 100,000 Cultural Heritage 3D Models on Sketchfab. Sketchfab [online]. 2019 [cit. 2021-03-30]. Available from: <https://sketchfab.com/blogs/community/over-100000-cultural-heritage-3d-models-on-sketchfab>.

400 museum, archive and other monuments and memory institutions, including Czech ones.

Sketchfab supports both embedding content into your own websites and presentation directly in your own portal. Compared to p3d.in, Sketchfab has more content filtering options when it is possible to filter directly individual museum institutions, their virtual exhibitions, etc. The filter can also use the tagging[34]. system. The user can filter the desired content more efficiently and find exactly what he needs much more easily than in the case of p3d.in. P3D.in (at the time of writing this article) allows filtering only by the user who uploaded the model and does not have a full text model search engine. Since Sketchfab is well-suited to 3D museum virtual collections, it also supports more detailed model annotation options, which can add sufficient contextual information to the model itself, including a relatively in-depth description of models that also have a comment section where users can write or inquire. Thus, there is a certain interactivity between the museum / memory institution and the visitor, which is very important and, according to our current (2020/2021) information, no other above-mentioned systems offer. Standard description[35] on the Sketchfab platform for each model contains a brief description of the real object that the 3D model copies. Furthermore, it contains the basic bibliography, the links to other information and the actual location of the object, including the previously mentioned tags for easier orientation, and licensing agreements. It copies the physical, real description of the museum object in the museum, which also improves the ability to insert links and comments. This point is very important because no other solution that we have found has such a deep description and a certain interaction common for real museums. Other solutions allow the recording of models and their presentation; however, they lack a sufficiently deep description, including the previously mentioned interactivity using a chat system.

In addition, Sketchfab also allows to view all content with the help of VR glasses that are gradually reaching museums or galleries, where they have become popular in the last five years.

Sketchfab offers several possible payment models based on subscription. A special discount can be applied to memory institutions (including museums), nonprofit organizations and businesses with an annual profit of less than $100.000 Many museums benefit from this, which is one of the reasons why Sketchfab can be considered the best service for the presentation of 3D models in the sphere of memory institutions that we are currently familiar with. Other reasons are the already mentioned editability, interactivity, sufficiently deep description, filtering, tagging and searching, and orientation in the content. Examples are the works New methods for sharing and exhibiting 3D archeology and Eight technologies with Significant Impact on the Future of Sculpture.[36]

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[34] For example, tags such as Egypt, bust, Neffertiti, etc.

[35] Example: <https://sketchfab.com/3d-models/what-is-the-genuine-nefertiti-1295e14c5e634465aa2438004bb8886c>.

[36] BARRETTARA, M. New methods for sharing and exhibiting 3D archaeology. The Post Hole [online]. 2013, (31), 1-6 [cit. 2021-03-25]. Available from: <https://www.theposthole.org/read/article/218>.

More specifically, Sketchfab exists in 3 versions, i.e., basic, plus and pro. Basic and plus versions are not suitable for the needs of many memory institutions and for the presentation of their 3D models. This is because they allow to upload maximum model size of only 50 MB for the basic version and 100 MB for the plus version, which is too little to present high quality models. Especially to museums or memory institutions in general, partly also to universities and schools, Sketchfab offers its pro version free of charge, a 50% discount on annual subscription of premium version or a specific payment plan[37]. The pro version has its limitations. The maximum number of models uploaded per month is set to 30, the maximum file size to 200 MB. The number of annotations is limited to 20 per model and the number of sounds to 5 per model. In addition, pro version allows unlimited downloading of models, as well as allowing the visitor to download a model for further personal use. Pro version is not limited by maximum capacity limit, only by the number of models uploaded per month.

Sketchfab also offers a 50% discount on the premium version, which significantly pushes these limits, i.e., the maximum number of uploaded models per month to 200, the maximum file size to 500 MB, the maximum number of annotations for the model to 50 and the number of sounds to 10. This version costs $79 a month with an annual subscription, i.e., with the 50% discount $39 a month. In addition to this premium version, it is possible to create your own plan that would suit the institution.

In addition to, in our opinion, quite favourable prices and the possibility of editing the content, its filtering and labeling, Sketchfab brings another great advantage, which is its user friendliness. Sketchfab is available for any modern device, i.e., smartphones, personal computers, tablets, VR glasses, etc. It offers a simple user interface; however, its disadvantage is that it is not in multiple languages.

The process of uploading and embedding content is user-friendly, with a set of tutorials and user support. It has a low technical ceiling which is a useful feature for memory institutions. Overall, it is a technically undemanding, problem-free solution, which is the only one that allows a sufficiently deep museum description of objects, including a certain interaction through its commentary section.

Comparison of selected web services

The following table functionally compares the above-mentioned solutions together. Since Sketchfab has several payment models, the table compares the version pro (as of 2021) as the most suitable solution for the specific needs of this project.

As a result, there are a number of possible solutions that allow the presentation of 3D models of memory institutions. The best of them is, of course, the system itself providing that the institution has sufficient technical, financial and human resources, which does not usually apply to smaller institutions. In this case it is appropriate to use services that will deal with the technical aspect.

[37] Sketchfab for cultural heritage. Sketchfab [online]. 2021 [cit. 2021-03-30]. Available from: <https://sketchfab.com/museums>.

	Sketchfab	P3D.in	Turbosquid
Download models	Yes	Yes	No
Support for VR glasses	Yes	No	Yes
Annotation	Yes	No	No
Museum description	Yes	No	No
Links	Yes	No	Yes
Comments	Yes	No	No
Embedded	Yes	Yes	No
Search	Yes	No	Yes
Model size	200 MB	unlimited	unlimited
Sound support	5 sounds	No	Yes
Storage size	unlimited	6BG	unlimited
Monthly limit	30 models	is not	is not
Charge	free of charge	6 dollars	No
Bibliography	Yes	No	No
Editability of models	Yes	Yes	Yes

Table 1. Summary of advantages and disadvantages of individual solutions.[38]

Conclusion

Presenting 3D models within web services may not be their final destination, as their use is much broader. In addition to presenting 3D models of cultural monuments to the public, these virtual objects have great value in their documentation, complementing traditional photograps and textual description[39]. Another inter-

[38] It is possible to mention representatives of commercial systems, with Turbosquid web service being the most widely used representative for commercial use. However, the Turbosquid service is rather unsuitable for Digital Humanities, as it does not support a sufficiently deep technical description that is based on the overall concept of this service, which is clearly commercially based. The commercial basis of the Turbosquid web service is the reason why we are not describe this system in more detail in this article. 3D Models for Professionals. Turbosquid [online]. 1: Turbosquid, 2023 [cit. 2023-03-23]. Available from: <https://www.turbosquid.com/?&utm_source=google&utm_medium=cpc&utm_campaign=RoEurope-en-TS-Brand&utm_content=Brand-TurboSquid-Misspellings&utm_term=turbsquid&mt=p&dev=c&itemid=&targid=kwd-811250597719&loc=9062855&ntwk=g&dmod=&adp=&gclid=Cj0KCQjw8egBhD0ARIsAJiDsaVAqhty33ui0Wg669W2QYxN2Aa0bA8EFwEiv5ZWf87_1bNPhgcjQgkaAqJEALw_wcB&gclsrc=aw.ds>.
Another way to present 3D objects is by placing them in a digital (virtual) library or gallery built on-premises through open-source software such as DSpace. Vítejte na českých stránkách o systému DSpace. DSPACE CZ: AKVŠ [online]. 1: Masarykova univerzita, 2023 [cit. 2023-03-23]. Available from: <https://www.dspace.cz>. However, the web services described earlier are better known and more suitable for the general public, at least for our purposes.

[39] YASTIKLI, N., O. EMEM a Z. ALKIŞ. MODEL GENERATION AND VISUALIZATION OF CULTURAL HERITAGE [online]. Yildiz Technical University, Istanbul, 2003 [cit. 2021-7-5]. Available from: <https://www.cipaheritagedocumentation.org/wp-content/uploads/2018/11/Yast%C4%B1kl%C4%B1-e.a.-3D-model-generation-and-visualization-of-cultural-heritage.pdf>.

esting thing is the possibility of animating 3D objects, which could be used in the future for demonstrations such as the functions of various techniques, mechanical machines, firearms, inventions, etc.

At present, there are several projects concerning the use of 3D models of cultural monuments and their presentation using game engines type Unreal Engine 4[40], Cry ENGINE[41] or the popular Unity[42] engine. The result should be the creation of a computer game in which its user could go through the entire modeled environment using VR glasses[43]. That might have a relatively great potential in the popularization of memory institutions, cultural monuments and an interest in history.

A specific use for 3D models is also their printing using a 3D printer. This can be useful especially in their trouble-free rental[44], presentation, and in addition to other material, such as facsimiles of seals and many others.

The objective of the article was to outline the possible pitfalls of 3D scanning and the creation of 3D models suitable for placement in a digital online collection. The main objective was to describe and compare the possibilities of creating online collections by means of online selected tools or web services designed for that. Based on our experience, the Sketchfab project seems to be the best option and we believe that in many respects it can fairly well present individual 3D models of memory institutions online[45].

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40 <https://www.unrealengine.com/en-US/>.

41 <https://www.cryengine.com/>.

42 <https://unity.com/>.

43 SMITH, M., N. S. WALFORD a C. JIMENEZ-BESCOS. Using 3D modelling and game engine technologies for interactive exploration of cultural heritage: An evaluation of four game engines in relation to roman archaeological heritage. Digital Applications in Archaeology and Cultural Heritage [online]. 2019, (14) [cit. 2021-7-5]. ISSN 2212-0548. Available from: doi: <https://doi.org/10.1016/j.daach.2019.e00113>.

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Počet slov: 5 959
Počet znakov (vrátane medzier): 39 526