The Use of 3D technologies in Cultural Heritage Communication

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Abstract - *Today 3D technologies represent necessary instrument for professional cultural heritage preservation, as they enable easier and more accurate protection of movable and non-movable cultural heritage. 3D technologies also offer wide possibilities of evaluation, interpretation and communication of heritage. Advantages of 3D technologies are in their wide connectivity and usage. Based on that it is possible for 3D digitized (documented and achieved) file of heritage object to be used in virtual presentation and for 3D printed model, as well as it is also possible to interpret the content of an object as a souvenir in other materials. In paper, most recent projects are presented, which are developed by company IB-PROCADD d.o.o., Slovenia, in cooperation with different partners, mostly with institutions active in the field of cultural heritage.*

Keywords - *3D technologies, 3D digitization, 3D models, cultural heritage communication, souvenirs*

1. INTRODUCTION

In this paper, two cultural heritage 3D digitization projects are presented, which are technically different by form, size, colour, material and environment, where they were digitized. The first project describes smaller polychrome wooden gothic relief of St. Hemma from Nemški Rovt, which were 3D scanned in cooperation with IPCH (Institute for the Protection of Cultural Heritage) Restoration Centre, above all for testing the technologies in conservation-restoration interventions (Fig.1.). The second object is the Narcissus fountain of baroque sculptor Francesco Robba, made from white marble (Fig.2.). 3D digitization process was made in cooperation with '360 - arhitekturni posnetki' company and with permission of The City of Ljubljana who owns the statue. Both motifs are interpreted as 3D virtual and as 3D printed models which are, in the form of protocol gifts, protected and riched with wooden frame and pedestal (Fig.9.).

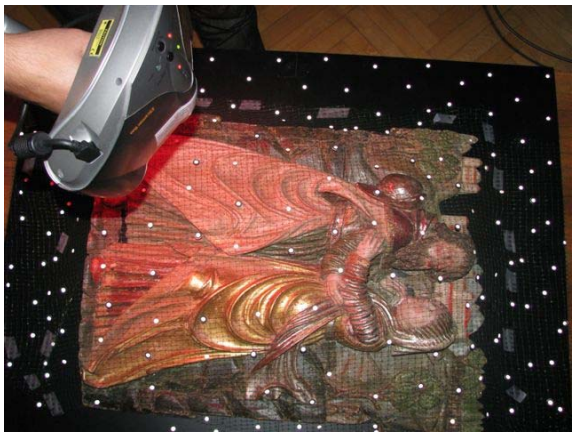

Fig. 1. 3D scanning of St. Hemma

Fig. 2. The Narcissus fountain

2. CULTURAL HERITAGE COMMUNICATION

Cultural heritage communication, its contents and value represent one of the fundamental aims of all activities of preservation, research and evaluation of cultural heritage. Communication of heritage value enters heritage into real lives of the people, into their community and builds it into their life quality. We could say that perception of heritage is created by its communication. Thus it is becoming a part of our identity, and a potential motive of tourist migrations, besides that we cannot neglect even its educational potential.

Heritage message enables us to come to know the past, understand the present, while at the same time it opens new opportunity of cognition in the future. [2]

3. 3D TECHNOLOGIES

As a segment of computer graphics, three-dimensional (3D) represents phenomenon of mathematical simulation of perspective drawing of spatial geometry to flat surface. Among 3D technologies, all digital technologies which we connect with spatial computer graphic, can be ranged. Today we divide them to software (3D modellers, 3D viewers ...) and hardware (3D scanners, 3D printers ...). Their purpose is to improve communication between subjects and/or visual conception of some process or object.

3D technologies development is in exceptional growth, and researching of its usefulness offers different opportunities in the field of cultural heritage communication. If we used to talk about RP – Rapid Prototyping, now we can talk about RM – Rapid Manufacturing, which enables, that 3D digitized object becomes physical as a model, souvenir or gift.

4. 3D TECHNOLOGIES

4.1. Introduction and intention

3D digitization of polychrome wooden gothic relief of St. Hemma from Nemški Rovt in Slovenia represents developmental project of verifying usefulness of 3D technologies during conservation-restoration interventions.

Because of bad weather conditions, the age of the artefact, poor preservation of the object, high age rarity and possibility of new damages, original in church will be exchanged with copy from lime wood, and the original will be exhibited in The National Gallery of Slovenia. Before exhibiting the original, conservation-restoration interventions are running on it, so the state of the relief will be returned to primary appearance. Technology testing is done with purpose of easier process of copy making and preserving intactness of the work of art. At the same time digitized data can be used for documentation, archiving and for heritage communication.

In this paper process of 3D digitization is described, as well as making of 3D printed monochrome model for the use in conservation-restoration interventions, and full coloured models for presentation uses. Editing of data and texturing for virtual presentation of the object are also discussed.

3D digitization of the relief was made out of several reasons with a common goal which is to protect and present important object of cultural heritage as much as possible. Making of copy usually runs with using a mould and a cast. As we mentioned, project is above all intended to verify the technologies in restoration, particularly for making a copy. In conventional copystics shape of the original is captured with piled artificial rubber on original that can lead to damage on the object. With the use of noncontact digital shape sampling uninspected effects can be avoided. When mould is made, we can cast in plaster or synthetic resin, thus we get a copy. By the classical carving process with copy device shape is transmitted into wood. Digital process is easier, faster and safe because cast can be replaced with 3D printed copy. Thus data of 3D printed copy can be transmitted into wood with copy device and without making a cast. It is also possible to use 3D shape of the relief directly for making a copy in wood by CNC machine.

At the same time we made some test samples of the detail of 3D printed relief. Every part is impregnated with different coat, which is used in standard fixing process of 3D printed parts. At the Institute for Research in Materials and Structures (ZRMK) tests on ageing are performed. If results will be positive, 3D printed copies of works of art could be used on original locations to exchange original with a copy.

With creating the digital documents, the work of art is archived for later generations. 3D digitization assures quality documentation with spatial component, which enables better preventive provisions in case of damage, or even in vanish of the product because of natural disasters, armed encounters, unprofessional handling, vandalism or stealing.

Advantage of 3D technologies use is shown also in repeatability of the processes, tracking and compatibility with different technologies. Thus documented and archived 3D model of the relief can be used also in the field of cultural heritage promotion and popularization in virtual environment (virtual museums), as well as in physical museum exhibition.

Monochrome or full colour 3D printed models in different scales are an excellent pedagogical tool, and with added frame or pedestal they can became protocol or promotional gift with geometrical competent. Similar products in touristic or promotional program are usually made in rescaled version, with big tolerance in geometry, which can

consequently lead to different reinterpretation of the artefact (from the original).

4.2. Content frame of the project

Polychrome wooden gothic relief of St. Hemma from Nemški Rovt in Slovenia was made in 1510. Author of this work of art in lime wood is Caspar Maler from Friesach in Carinthia (Slo. Breže na Koroškem). Relief is located in high altar of succursal church of St. Achatius (Slo. sv. Ahac) in Nemški Rovt in Bohinj which belongs to the parish of Bohinjska Bistrica. [3]

Different authors interpret the motif on the relief as Farewell of St. Hemma from her husband Wilhelm and as Meeting of Joachim and Anne at Golden Gate of Jerusalem. [4] - [5] Today we know that Hemma and Wilhelm are on the relief, because church of St. Achatius is located on transversal pilgrimage of St. Hemma. At the same time on woman's figure motiff of South-Tyrol coif is represented, which can't be attributed to St. Anne.

St. Hemma (Hema, Emma, Ema) of Gurk (995? 973? – 1045?) (Slo. Sv. Hema Krska) was a nun and the most powerful possessor in Slovenian region. She dominated to larger part of Carinthia, Posavje region, surroundings of Celje and some villages in Carniola. She arised from Peilenstein family and married Count Wilhelm of Friesach and of the Sanngau. She gave birth to two sons: Wilhelm and Hartwig. Some sources are saying, that children were killed by miners. Count Wilhelm in deep mourning entered the hermit order, however Hemma built cathedral and monastery in Gurk in Carinthia. [6] Other sources are mentioning that Hartwig died in his youth. After dead of Count Wilhelm, during returning from pilgrimage to Rome, Hemma stayed alone with son Wilhelm, who died in battle in 1035. For a long time people venerated Hemma, which, after death of her close relatives, found her sanctuary in faith, and was attending a great divine service. She was canonised for saint as late as in 1938. [7]

Scene is set into landscape with a town on a hill, in background we can see a clump of threes. Hugging figures are captured in exaggerated style of parallel folds. The work of art is denoted with large reliefness and curves of folds, which are visible as concave hollows on coats of figures. Hemma's coat is stressed with long stretches of drapery, one part of the coat is like the swallow's tail in spiral turned up – that hold true as artist signature. [5]

4.3. Methods and results

3D digitization of the relief was made in IPCH Restoration Centre (Poljanska cesta 40, Ljubljana), because at the moment conservation-restoration interventions are running on original, and it would be irrational to transport object elsewhere.

With digital capturing it is easy to define accurate size of the object. Size of the relief is 538 x 677 x 113 mm. At first, placing a net with reflective targets on it on the object was needed, so that the scanner could position in space. Noncontact shape sampling assures secure handling with an object, which is very important for heritage objects. Handheld laser 3D scanner ZScanner 800 works with ZScan 3.1 software, which generates polygonized surface in STL (Stereolithography / Standard Triangulation Language) file format in real time. Thus we avoided the step of generating point cloud to (STL) surface. In Geomagic Studio 11.SR2 software scanned data was edited to closed watertight model.

For preparation of the object and its scanning 8 hours were needed, and for data editing to watertight model additional 10 hours were needed. Time of digitization process depends on size and complexity of the object and its texture. Equable and matte surfaces can be captured easier and faster. If the object is not complex, we can 3D scan with lower resolution, which accelerates the process because of the smaller amount of data that the software needs to process. Digitization of wooden relief was divided to 8 individual scans – thus scanned object is made of 8 parts that are joined into one closed 3D model during data editing. Because front part of the relief is more complex, data was captured in 7 segments, in 0.68 mm^3 resolution, and with bounding box in the size of 350 x 350 x 350 mm. That means that individual scan is not larger as the size of the bounding box. Back part of wooden relief was captured in 1.59 mm^3 resolution and with bounding box in the size of 800 x 800 x 800 mm.

For making the copy a monochrome model in scale 1:1 was made on ZPrinter 510. Because the building space of 3D printer is smaller than the relief, model was needed to be built in 6 parts and glued together afterwards (Fig.3.).

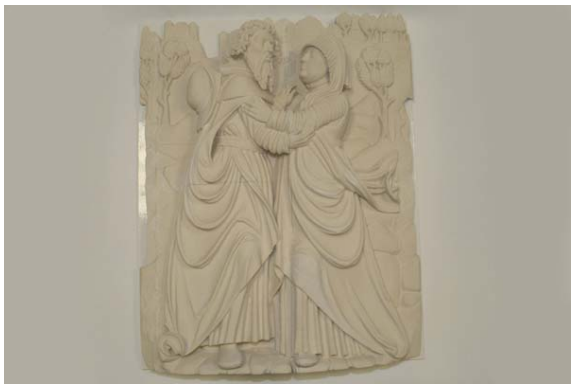

Fig. 3. 3D printed monochrome model

Texturing, for better presentation of virtual 3D model, was running in Geomagic Studio software for scan editing. Process of texturing is performed directly on 3D model (Fig.4.). Geomagic exports map as PNG, JPEG, BMP and does not enable manipulating with photographs directly in UV map, like animation software does. UV map describes 2D net of the 3D model. Coordinate points of the net are linked up with mesh points of 3D model.

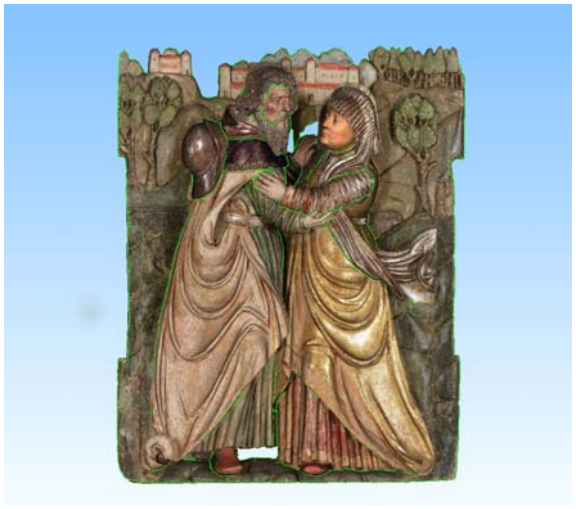

Fig. 4. Texturing of the relief

For texturing the relief 33 suitable details from more than 20 different photographs were used and added on the surface of 3D model. Photographs were made extra for texturing process, because they need to be recorded orthogonal to the object and from different views, which is not also a condition for documenting the museum objects, where usually three photographs are enough. All photographs need same hue and lightness; otherwise edges between individual photographs are too visible. Larger depth sharpness is welcome, as it reduces a number of photographs that we use. Finished files of relief were saved into standard VRML (Virtual Reality Modelling Language) file format.

On the internet we can find free 3D viewers for VRML files with basic interactive functions, which do not need huge computer virtual memory for their working. We tested widened and standard PDF (Portable Document Format) file format for 2D documents, which supports also viewing the 3D models.

VRML of relief was exported to Rhinoceros 4.0, over plug-in 3D PDF from Rhino V2.0 files in PDF were generated (Fig.5.). Files can be viewed in Adobe Acrobat (from version 7 ahead). 3D PDF enables rotation of the object, zoom in and zoom out, changing of background colour and different types of lightening. Export from VRML to PDF assures smaller file.

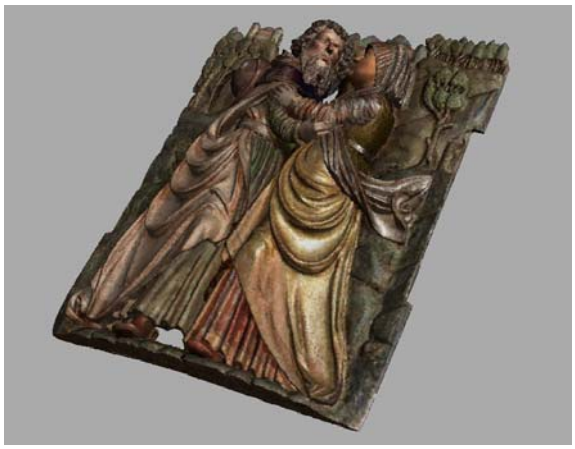

Fig. 5. 3D PDF of the relief

As regular PDF file, 3D PDF can be uploaded to the computer or send via e-mail. Here we also need to mention the copyright of a heritage object. As professional photographs on the internet are protected by reducing resolution, we similarly decided to reduce number of polygons of 3D model. By this process we manually “deform” file to be unused for copying with 3D printers or similar machines.

For heritage communication, interpretation and promotion more textured full colour copies (Fig.6.) of different scale were made on 3D printer ZPrinter 450. Some of them are equipped with wooden frame, which on one hand gives copy a support, and on the other hand gives value to the product, which can be used as protocol gift or a superior souvenir. 3D printed models are also an excellent tool in museum pedagogy. File checking for 3D printing ran in Magics 14.0. [1]

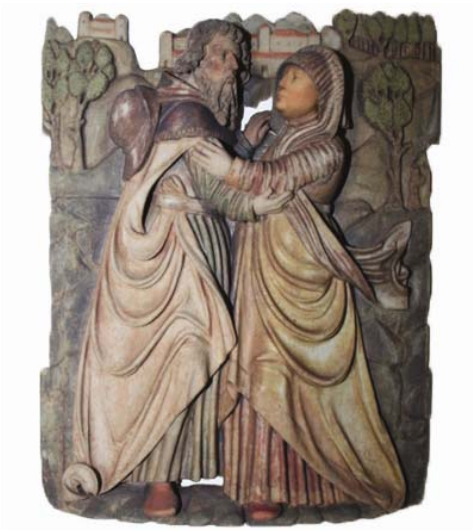

Fig. 6. 3D printed full colour model

5. THE NARCISSUS FOUNTAIN 3D DIGITIZATION PROJECT

5.1. Introduction and intention

The Narcissus fountain from the court of Ljubljana town hall was digitized with a purpose of verifying the 3D scanning of larger objects and capturing it in extreme weather conditions (moisture, cold). At the same time applicability of data for making rescaled models for pedagogy and for promotion purposes were verified. Fountain statue is owned by The City of Ljubljana. 3D scanning process was running in cooperation with Smiljan Simerl (360 - arhitekturni posnetki Smiljan Simerl s.p.).

5.2. Content frame of the project

The fountain statue of Narcissus is masterpiece of Venetian sculptor Francesco Robba (1698 – 1757). Most of his creative life the artist lived in Ljubljana, Slovenia. His most recognized work is the Fountain of the Three Rivers of Carniola, known as the Robba fountain, located outside the Ljubljana town hall. Narcissus fountain was standing in the Castle of Bokalce (Ger. Schloβ Stroblhof) near Ljubljana, in the year 1939, monument was transported to Ljubljana city hall, named also Rotovž, where today The City Council of the City of Ljubljana is taking place. Related to some sources, the work of art could be ordered by Leopold Karl Lamberg (1710 – 1770), who owned the Castle of Bokalce from 1737 till his dead.

Fountain is made from white marble. The figure of Narcissus is fitted onto a heap of large artificial rocks, encasing in a shape of a little grotto, from the depths of which fresh water once ran into the basin in front. Behind his back a tree in S-line grows. [8] Narcissus is sitting on a rock at the edge of his pool, his gaze is pointed to basin level, on which he recognizes his image. Different versions of the story about Greek hero Narcissus are known. Roman poet Ovid wrote about him in his Metamorphoses. Narcissus was a beautiful young man, many of young women were in love with him, but he ignored them. He took no notice even of mountain nymph Echo, so Nemesis punished him with making him to fall in love with his own reflection, while staring at himself in the pool. Reflection withdrawed from him, when he wanted to touch it. Unhappily in loved he passed away, and flowers Lent lilies, also known as narcissus, grew at his place. [9]

5.3. Methods and results

The Narcissus fountain was 3D scanned at the place, where statue is located, that is at the court of Ljubljana town hall (Mestni trg 1, Ljubljana). Despite the fact that fountain is protected by ceiling of the archway, fountain is situated in external environment and exposed to changing weather influences. Capturing of the surface ran in winter at temperature of around 4°C, partly snowing, which influenced to approximately 80 % dampness. Because of mentioned conditions shape sampling and processing of the data ran slower than with room temperature (like 3D scanning of St. Hemma), but final results were the same.

3D scanning was made by handheld laser 3D scanner ZScanner 700 with support of ZScan 1.2.09 software. Object is now restored, during digitization was however full of dirt (dust, lichens) and it was needed to be cleaned. Size of the statue is approximately 2.4 x 1.8 x 1.7 mm, contently most representative centred part in the size of 1.8 x 1.5 x 1.1 m without basin was scanned. For documentation and archiving the whole fountain basin can be 3D scanned additionally and joined together with yet scanned part.

As relief of St. Hemma, the Narcissus fountain was scanned in more segments, moreover in 9 parts: head; chest; right part of the body; left part of the body; back of the body; right stone and the tree; background, the stone and the tree; and treetop. Most parts of the statue were scanned with lower resolution of 1.59 mm³ and bounding box of volume 600 x 600 x 600 mm, some parts were scanned (head) in high resolution of 0.79 mm³ and bounding box of volume 350 x 350 x 350 mm. 3D scanning took 8 hours, and data editing of joining scanned segments to one watertight model in Geomagic Studio 9 additional 8 hours.

For presentation in virtual environment 3D PDF model (Fig.7.) and rendered model (Fig.8.) were made. Rendered model is done in V-Ray for Rhino, white marble is used for material. 3D PDF is interactive (possible to turn) 3D model, rendered is only a picture saved as JPEG.

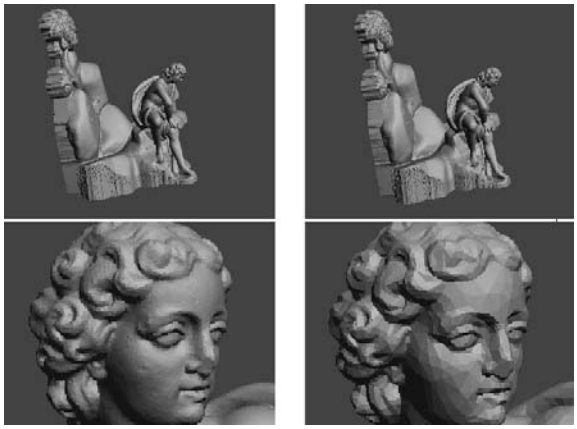

Fig. 7. Original (left) and reduced (right) 3D PDF of the Narcissus

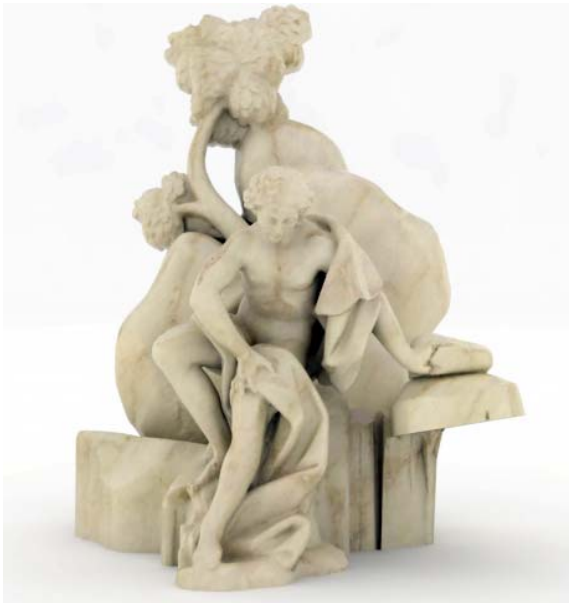

Fig. 8. Rendered model

For the presentation of the main motif on the statue white 3D printed model in scale 1:10 was made (Fig.9.). It took 9 hours for 3D printer to build it. Because of lower consumption of a material (lower costs and weight) the model is hollowed. Walls of the model are 5 mm thick. [1]

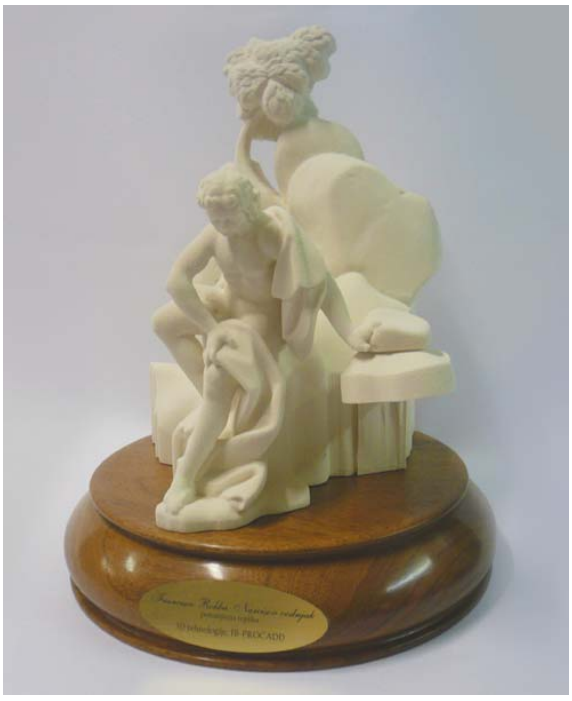

Fig. 9. 3D printed model on wooden pedestal

4. CONCLUSION

Greatest significance of 3D digitization of cultural heritage contents is, because of their compatibility, in wide usefulness of the data. That means, that digitized data, for the purpose of documentation and archiving, can be used in conservation-restoration interventions and additional applications related to cultural heritage communication in direction of its popularization and promotion.

With rapid manufacturing and other 3D technologies digitized content can become physical as models, souvenirs, gifts, jewellery etc.

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