USING OF CLOSE RANGE PHOTOGRAMMETRY IN IMAGE BASED MODELLING FORM FOR ARCHAEOLOGY

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ABSTRACT: This proposed paper deals with the documentation and visualization of several small archaeological artifacts or findings. It can be done using several techniques like laser scanning or close range photogrammetry. The result can be used for the virtualization of museum objects or the creation of facsimiles – there is a big problem in archaeology – a lot of findings are in private collections. In our laboratory we use the Agisoft PhotoScan or Photomodeler Scanner software and freeware software like Visual SFM and Autodesk 123D Catch. The final product of the processing is a high quality textured 3D model. This method can be considered as a inexpensive way of documenting large amounts historical objects or findings with quality results suitable for future visualization. Nowadays, 3D printing technology is on the rise and has become more and more popular. 3D printing technology allows that the object not to be only visible but also gives us the opportunity to touch it and manipulate with it. A case project in cooperation with specialists in archaeology has been made. First is a basic 3D documentation of a typical archaeological dig in open terrain (Tepla monastery). The second deals with documentation on creating of replicas of bronze artifacts from 8th and 9th century from Central Bohemia. The third is on 3D documentation in distant archaeological sites – like developed countries, where there is a problem with special instrument transport and with expensive permissions. Based on our last expedition to Peru in 2012, we collected a large amount of photographic material for archaeo- astronomical reasons, such as local small archaeological artifacts. These archaeological finds are of course not possible to transport to the other countries. Based on our experience, we decided to use Agisoft Photoscan to make a real 3D model and printed it in scale on 3D printer. In conclusion, precise results are discussed.

1. INTRODUCTION

Beginning in the nineties, new technology for the documentation of archaeological and historical objects has been preferred in research (Křemen, Koska, 2013). Very rapid development of the new technologies based on computer processing or computer–aided techniques with rapid digital camera development such as laser scanning meant a great change in general. The modern approach in spatial documentation deals with image-based modeling (Debevec, 1998, Remondino, El-Hakim, 2006, Mach, 2009). This technology of the object documentation using the photogrammetrical method is based on the capturing of several images which cover the whole object. The 3D models were created in the photogrammetrical software (image based modelling) and can be edited in several different software intended for laser scanning processing (Marčiš, 2013). The 3D model can be considered to be a final product which can be visualized with various methods. We can divide them into two categories – online or offline presentation. The first category covers the visualization using web browser plug-ins like BS Contact or Cortona3d viewer (WRML format) or in Adobe Acrobat 3D. Nowadays, it is also popular to upload final models into existing online 3D viewers such as Sketchlab, which uses the WebGL technology. Our Laboratory of photogrammetry has been focused for a long time on the documentation and visualization of cultural heritage and collaborates with archaeologists, restorationists, and with other specialists from related areas (Musílek et al., 2001, Pavelka et al., 2011). Based on image based modeling, our laboratories use the Agisoft PhotoScan or Photomodeler Scanner software and freeware software like Visual SFM. The final product of the processing is a high quality textured 3D model. This method can be considered as a non-expensive way of documenting large amounts historical objects or findings with quality results suitable for future visualization. Nowadays, 3D printing technology is on the rise and becomes more and more popular. A replica created with this technology is a perfect copy of the real artifact. 3D printing technology allows that the object not to be only visible but also gives us the opportunity to touch it and manipulate it. It can be used for the virtualization of museum objects in modern virtual museums projects. In our laboratory, Zprint 450 by Z-corporation is used for 3D prints of replicas. Output of this 3D printer can be textured by original texture from photos, for example (Koska, Surma, 2012).

2. CASE PROJECTS

2.1 Documentation of typical archaeological digs – Tepla monastery

In the spring of 2014,an archaeological excavation in the Tepla monastery in the western part of the Czech Republic was performed. Modern methods like georadar etc. were used (Bílá et al., 2013, Řezníček el al., 2013). Of course, excavations were documented by traditional methods like photos, sketches and plans. We have pointed out the possibility of very fast spatial documentation using image based modeling. In a few minutes, small excavations were photographed and images on site were processed on a powerful notebook to the textured 3D models.

Fig.1: 3D textured model of archaeological object created from photos only – Tepla monastery

2.2 Archaeological artifacts – bronze objects

The test objects were three small bronze archaeological findings that were borrowed from the Archaeological Institute of the Czech Academy of Sciences. These objects were a spur, a piece of spur and a tongue-piece (all 8th - 9th century, Central Bohemia).
Input data in the Agisoft PhotoScan software is a sequence of images. For the purpose of documentation the DSLR camera Canon EOS 5D Mark II was used. The setting of the camera corresponded with the current lighting conditions in the laboratory. The small bronze artifact was captured all around and altogether 62 images were obtained.
The Agisoft PhotoScan software provides us with an automatic process of 3D model creation. Before the automatic process of 3D modeling, it was necessary to create masks of unwanted parts of images i.e. a background of the artifact. The parts that are covered by the mask are not included in the process.
The workflow of the 3D modeling process includes several steps: the first step deals with finding correspondences between all the images. Image alignment leads to automatic calibration and the positioning of each image in the space that is obtained. The result of this step is a sparse point cloud. Once the positions of the camera are known, a dense point cloud can be calculated based on sparse point cloud. After that, it is possible to calculate a polygonal mesh that represents the object's surface. The final part of the processing is adding a texture to create a real copy of the artifact. During the processing it is important to do manual editing that includes detached point removal, closing holes, and mesh decimation. It can be done directly in the Agisoft PhotoScan software but sometimes it is better to use other software intended for laser scanning processing such as Geomagic Studio (Pavelka et al., 2011, 2013).
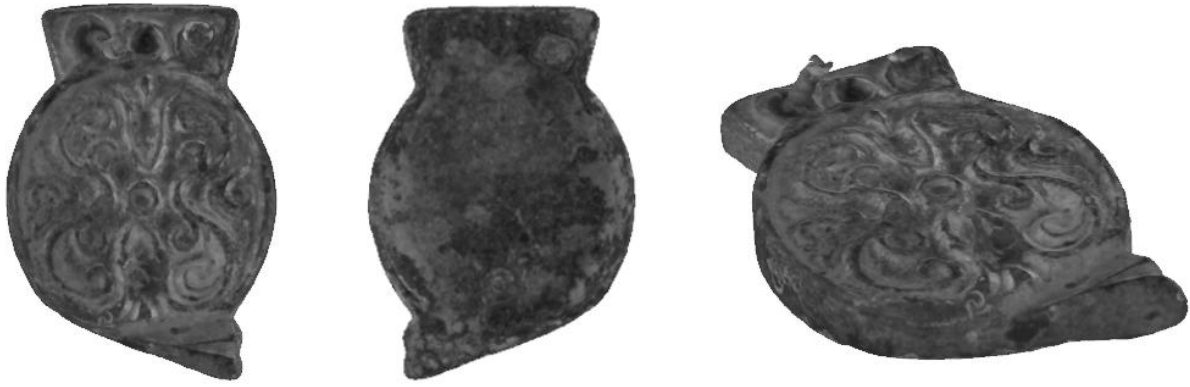
Fig.2: Borrowed bronze artifact

Fig.3 Models of bronze artifacts created on Zprinter 450

2.3 Stone artifacts – Peru (Intihuana etc.)

The famous Peruvian cultural heritage is one of the most famous cultural heritage sites in the World. The Laboratory of photogrammetry of the Czech Technical University in Prague (CTU), Faculty of Civil Engineering has been focused on the cultural heritage project in Peru for a long time. Since 2004, we have collaborated with the University of Applied Sciences in Dresden and carried out many expeditions to Peru. At CTU, we started a new project focusing on archaeo-astronomical orientations of important objects in Peru. This new project is a part of the long term "Nazca" project. A lot of mysterious objects in Peru (like in other parts of the world) are astronomically oriented. In Peru, the orientation of religious objects is mainly sun-oriented. For modeling or exploring, it is necessary to have a 3D model of objects. Many objects are easily accessible and therefore are not problem to take detailed photos and some base measurements, for example with a tape or even use a 3D scanner. But for a lot of objects, it isn't possible to systematically photograph and measure without a special permit, which is usually difficult and expensive to obtain in some countries…

As an example, astronomically oriented objects on Machu Picchu can be mentioned. Based on a set of photos taken by a Canon 20D, a 3D model of well-known Intihuana (astronomical device) and 3D models of other objects has been managed (Hanzalová, Pavelka, 2013).

Fig.4: Intihuana 3D model created from photos

Fig.5: Other astronomical device or altar on Machu Picchu; 3D model created from photos

2.4 Burial artifacts – Peru

The computer performance is high; it is not a problem to process hundreds of digital photos based on a fully automated process of image orientation, image correlation, creating of dense cloud of points and texturing of 3D results. For the creation of 3D models it is enough to use an ordinary digital camera and special software only. In today's possibility we investigated a small project based on images of archaeological finds from Palpa/Peru. Based on our last expedition to Peru in 2012, we collected a large amount of photographic material. Because of financial and transportation reasons we used only the calibrated camera Canon 20D, common GNSS navigation, and tape for basic distance measuring. Like in 2008, we documented a ceramic vessel from Nazca time in Palpa city. This

archaeological find is of course not possible to transport to the Czech Republic. Based on our experience, we took around 50 images (the vessel rotated step by step around two axes). Next, processing was made in Agisoft Photoscan. After masking the main object on images, the process was automatic. The output was textured and transformed to the 3D Adobe Acrobat viewer. The original model has 2 millions points and the accuracy reaches (standard deviation) 0.4-0,5mm, which seems to be optimal for this purpose and credible. The new Agisoft Photoscan version has the spatial transformation to the control points set. After this, we get a precise characteristic (Řezníček, 2013, Pavelka, 2012).

Fig.6: Archaeological object – burial ceramic vessel

4. CONCLUSION

This article is focused on the simple documentation of cultural heritage using modern digital photogrammetry and computer vision technology. The aim is to demonstrate an easy to use technology that allows full or semi-automated external orientation of images, camera calibration and creation of 3D models from images based on image correlations technique. Experience with the free software solution for image correlation techniques and their utilization in close range photogrammetry and historical objects documentation are described. A new approach of documentation using multi-photo photogrammetry and visualization has been presented. It was shown how a modern photogrammetrical image-based correlation method could be used for creating 3D virtual model of historical objects. Types of visualization of such a model were presented. The first type of digital representation of the real object is a 3D model that can be viewed in the Adobe Reader software or in Cortona viewer as a part of web browser. The second is a real 3D model given by 3D printer. We can say that nowadays it is possible to use a simple photogrammetric technique for precise non-expensive documentation in close range photogrammetry. It is a very good sign for cultural heritage documentation and visualization. By good configuration and quality photos taken by digital camera, the accuracy (standard deviation) reaches from 0.2 to 1mm from distances 1-5m. In case of larger and more distant objects the accuracy is, of course, worse, but still acceptable. All used images must have a necessary overlapping e.g. 80% (greater than by aerial photogrammetry); images with low convergent axes are appropriate (for better image correlation). Finally, there now exists a lot of software which can be used in the cultural heritage documentation area. The user can choose according to their capabilities and effort and documented object character. Image-based modeling method can be considered as a low-cost method that doesn't rely on special equipment. All that is need is a good quality SLR camera and software for data processing. This method can be considered as a good solution for specialists who deal with culture heritage preservation and documentation but cannot afford expensive technology.

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