3D-RECONSTRUCTION OF SMALL HISTORICAL OBJECTS TO EXHIBIT IN VIRTUAL MUSEUM BY MEANS OF DIGITAL PHOTOGRAMMETRY

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KEY WORDS: Surface Reconstruction, Structured Light, Digital Photogrammetry, Virtual Museum, Calibration

ABSTRACT

The automatic, non-contact measurement of object surfaces is one of the most important applications of digital close-range photogrammetry. Many objects to be measured do not show enough own texture to allow for a surface reconstruction. The projection of structured light onto the surface is one of the simplest methods to overcome this problem. The term “structured light” is here a synonym for the projection of patterns onto an object surface. For the measurement of surface of small historical objects, a system based on the projection of structured light has been used. The System has of a slide projector, a CCD camera and slides with regular dot pattern. This paper shows the application of digital photogrammetry for automated surface reconstruction with structured light. As an example a historical statuette from the archeological museum of Istanbul has been selected and the surface reconstruction has been carried out to obtain the exhibition possibilities in the virtual archeological museum on internet, which will be planned.

1. INTRODUCTION

Today, the 3D reconstruction and visualization techniques became very popular and useful methods in the field of close range photogrammetry. The integration of Photogrammetric Methods and Computer Graphics has brought many tools and techniques and most important synergy out. 3D modeling and visualization of historical objects are a very sophisticated and complex procedures in the job of documentation of cultural heritage. The need for documenting small objects in such areas as archaeology, museum collections, and industry may be accomplished using close-range photogrammetric techniques. The documented objects can be exhibited in virtual museums on the World Wide Web.

2. VIRTUAL MUSEUM

Virtual museums are the museums with entrances on the World Wide Web. A virtual museum is an virtual collection of anything which can be digitized. The collection may include historical objects saved on the virtual museum's file server. A virtual museum may have the following characteristics:

- The entrance must be user-friendly.
- It would take many visits to explore the contents.
- The museum offers many different kinds of learning activities (Object identities) besides documentation possibilities.
- The virtual visit is very easy and increases desire for a "real time" visit to the original museum building.
- Allows to the investigators to measure, archive and analyze the historical objects, which are fragile for repeated treatment.

The 3D models objects of the virtual museum are obtained using different methods. They must be visualized and must have metric charecteristics and depending on these conditions the information obtained from these artifacts must be reliable. Therefore metrical methods like photogrammetry must be used and a complete and thorough geometric recording of the object must be carried out. For this purpose several methods using Laser Scanning and optical scanning have been proposed by many organizations. (Joannides, 2003; Georgopoulos, 2004) Among them is a paper presented in the ISPRS Congress in Istanbul to be mentioned.(Tsiokas,2004) By this paper a construction and use of an optical scanning system for the 3D Reconstruction of small archaeological objects were presented.

3. SURFACE RECONSTRUCTION OF THE OBJECT

The automatic non contact measurement of object surfaces is one of the important applications of digital close range photogrammetry and there are many applicable methods for this purpose. The solution of this kind of Surface reconstruction is related to the problem of obtaining geometric models from multiple images. Such models are used widely by many applications, including virtual/augmented reality, reverse engineering and animation. Today, laser scanners are used to obtain 3D data of objects by irridating laser beams in the field of documentation of cultural properties and important results are achieved. But, the laser scanners are expensive and are still in developement phase. For the recording purposes of this work due to the classical photogrammetric approach, multiple overlapping images are taken with a calibrated Digital camera. The method used by this work is the automatic surface reconstruction with structured light. (Maas,1992) By this method the dot rasters were projected onto the object by a slide projector and recorded by standard CCD cameras (Figure 1) Data processing using the photogrammetric software programs from the raw digitized images for the surface definition is the next step of the method. First all of them the calibration of the used camera must be done. The aim of this work was to produce the three dimensional models of the small historical objects. The obtained high amount of detail data would give a high degree of realistic impression and reliability of measurements to be done on the object.

4. CALIBRATION

The Focal length, sensor format size, position of the principal point and lens distortion parameters of the used digital camera Olympus C-5050 are obtained as the calibration result of this digital camera. For this purpose the camera was calibrated once on the test field and afterwards a on the job calibration was performed and results are compared. (Bosch,2005)

Name of camera	Olympus C-5050
Date of calibration	31.12.2004
Focus	5 meter
Principle point [mm]	x0 = 0,0014 ± 0,0015
	y0 = 0,0003 ± 0,0016
Focal length [mm]	c = 7,1649 ± 0,0018
	A1 = -0,004658 A2 = 0,000103

The used camera provided very sufficient accuracy and robustness.

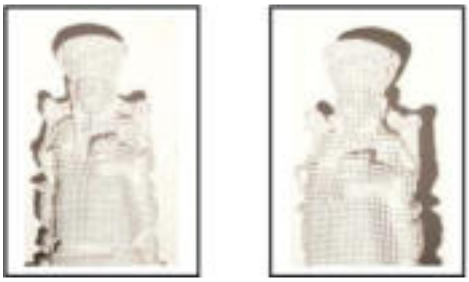

Figure 1. The objects with the measuring points projected onto the object and ready to be measured.

5. USED SOFTWARES AND METHOD

The used photogrammetric software package “ *Australis* “ (Australis Manual,2001) is designed to perform highly automated off-line measurements from monoscopic/convergent digital image networks, either using digital cameras or scanned film imagery. It is equally useful for high-precision metrology applications using ‘metric’ digital cameras (or scanned imagery) or low- to moderate accuracy measurement employing off-the-shelf, amateur still video CCD cameras. Through the integrated image measurement, preliminary orientation and bundle adjustment functionality, one can quickly and easily obtain three-dimensional object point coordinates and sensor calibration data from multi-sensor, multi-image networks of an effectively unlimited number of object points. Moreover, depending on the provision of an exterior orientation (EO) (Figure2, 3) device and high contrast targets, the photogrammetric orientation/triangulation and calibration processes can be carried out fully automatically, in semiautomatic mode, or even with manual image point measurement and a more sequential processing flow. (Figure 4) Australis is thus ideal for the teaching of photogrammetric principles and practices and it a valuable tool in both research and for practical measurement applications.
The outcoming problem to obtain the whole 3D model using the different faces of the object was solved manuelly by integrating the related point clouds. The obtained point cloud will be used with the Rapidform sotfware to reconstruct the surface. The use of this software gave us the best fitted surface. RapidForm is a comprehensive reverse modeling tool for all 3D data to be processed into polygons, curves and surfaces for the applications. 9 different workbenches of RapidForm have effectively met all the different needs from a wide variety of possibilities. The RapidForm software (Rapidform Website) allows users to clean up data from different providers, align multiple point clouds to each other, triangulate the point clouds into polygon meshes and as the most important feature to merge multiple 3D point clouds from different sources into one complete 3D model. RapidForm also, offers colour management, including virtual painting, blurring, smoothing and more. Text can be added to any model, and brightness and contrast can be adjusted to achieve the perfect photorealistic 3D model. Figure (5,a,b,c,d,e) shows the evaluation phases of a small object starting from the point cloud (Australis Software) and ending with the surface construction (Rapidform).

Figure 2. The EO device of the Software Australis

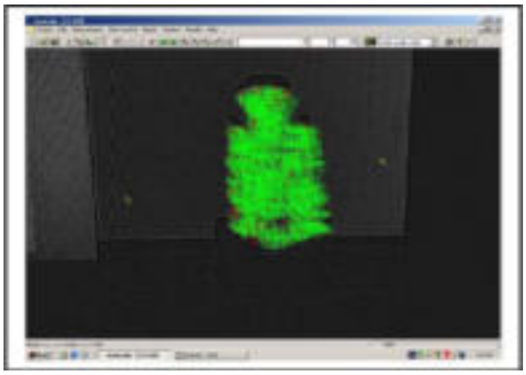

Figure 3. The pointcloud of the statuette

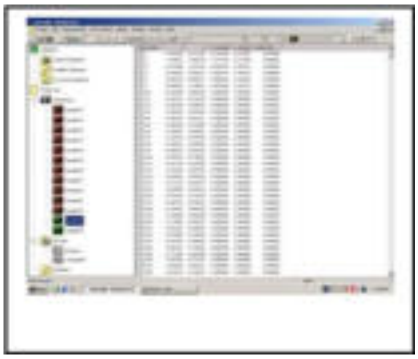

Figure 4. The point measurements

5. CONCLUSIONS

As a disadvantage of this system we can remind the long processing time for the acquiring of each model. The final result also provides an archival quality record for the museum and detailed documentation, measurements capability and could be used to obtain reliable information on the web. The system can also be used in different applications for the creation of 3D models of objects in industry and medicine. Furthermore, this process seems relatively cheaper than the Laser technology and could be used widely to collect the objects for the virtual museum in all conditions. Using the above defined method objects can be exhibited in virtual museums and reliable measurements can be realized.

Figure 5.a Original Object

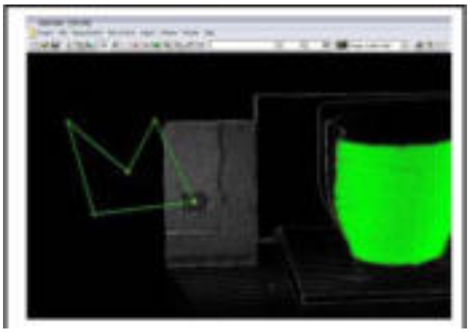

Figure 5b

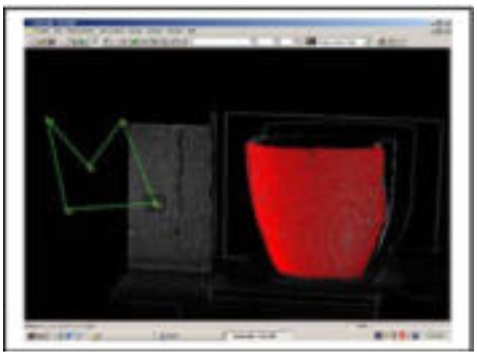

Figure 5c

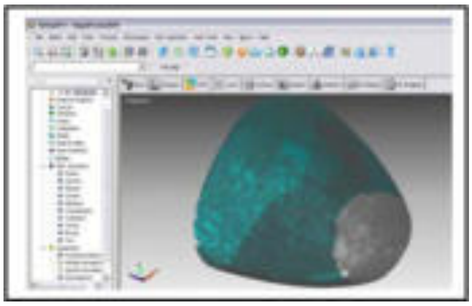

Figure 5d

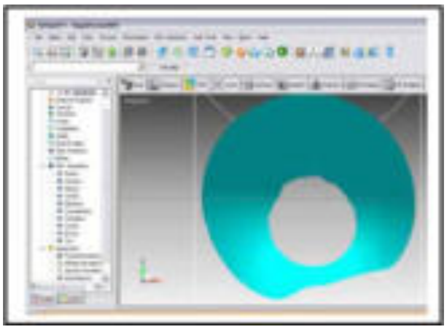

Figure 5e. Evaluation Phases of Model Reconstruction

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