3D digitation of museum sculptures for model-making purposes: difficulties and possible solutions

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ABSTRACT: This paper describes the process of digitizing sculptures in an arts museum with the purpose of producing scale models with rapid prototyping techniques. The resulting scale models will be used by the museum curators for planning a new layout for the sculptures exhibition. Initially, different techniques were laboratory-tested for efficiency and viability. Next, one of the techniques was tested on the site. One of the difficulties encountered was the digitations of shiny, dark objects, and the impossibility of applying whitening sprays or gluing marks on the sculptures´ surfaces, due to conservation issues. So far, it was only possible to define a viable technique for 3D-scanning light color sculptures.

1 INTRODUCTION

The Laboratory for Automation and Prototyping for Architecture and Construction (LAPAC), from the School of civil Engineering, Architecture and Urban Design (State University of Campinas) is concerned with the digital production and of architectural models for supporting the design process, from form conception throughout building construction. The laboratory has been set up in 2007 with the support of public research funding agencies (FAPESP and CAPES), and is equipped with additive and subtractive prototyping machines, as well as software for automating the digital fabrication process, such as flattening 3D models for laser-cutting.

More recently, LAPAC´s team has become interested in 3D-scanning, for two main purposes:

- To obtain digital models automatically from hand-made models, so they can be reworked digitally and then converted into physical models again through digital prototyping techniques (Figure 1);
- To digitize special architectural details (such as cariatides, atlantes, column capitals, and other ornaments) or other objects that are part of historical buildings or urban spaces, such as sculptures and fountains, so they can be prototyped at a reduced scale, when producing models of existing buildings (Figure 2);

Other important requirements of the technology that will be implemented at LAPAC are easiness to use, so students are not discouraged to employ these techniques in their projects, and cost, since the laboratory has limited budget.

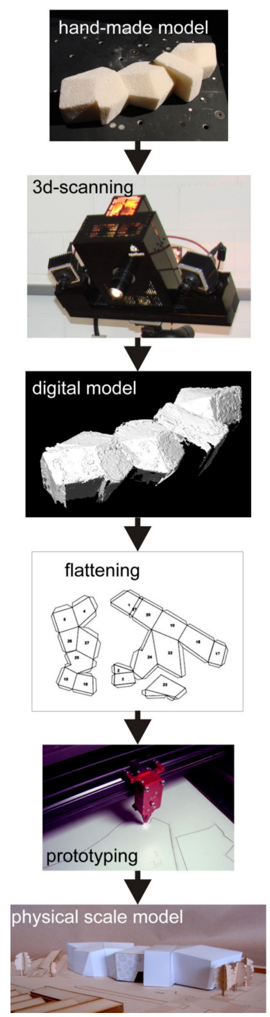

Figure 1: The design process workflow using 3D-scanning techniques.

Figure 2: Examples of historical buildings with complex ornaments: bronze atlantes in a XIXth century building in Catania and a carved stone fountain at the Patio of lions, at the Alhambra, in Granada.

2 CASE STUDY

In order to test the available 3D-scanning technologies and find out which one is the best suitable to LAPAC´s purposes, a case study is being carried out. The case study consists of a scale model of an arts museum in São Paulo, Pinacoteca do Estado. The museum curators´ team needs a large physical model for planning exhibitions. The first part of this project, which consisted of a 1:25 scale model of the 18 permanent exhibition rooms of the museum, and miniatures the almost 1000 paintings, has already been produced at LAPAC, as described at Celani, Pupo & Piccoli 2008 (Figure 3).

Figure 3: A museum curator using the 1:25 scale model produced at LAPAC.

The second part of the project consists on the production of miniatures of the museum sculptures (approximately 100). The museum´s sculpture collection is very heterogeneous in terms o materials and geometry. This part of the work started with a survey of the available 3D-scanning technologies, which has been published at Celani et al 2008. Next, some tests were carried out in the laboratory (Figure 4). This part of the research allowed us to categorize the museum´s sculptures according to material, geometry, and the level of difficulty we can expect.

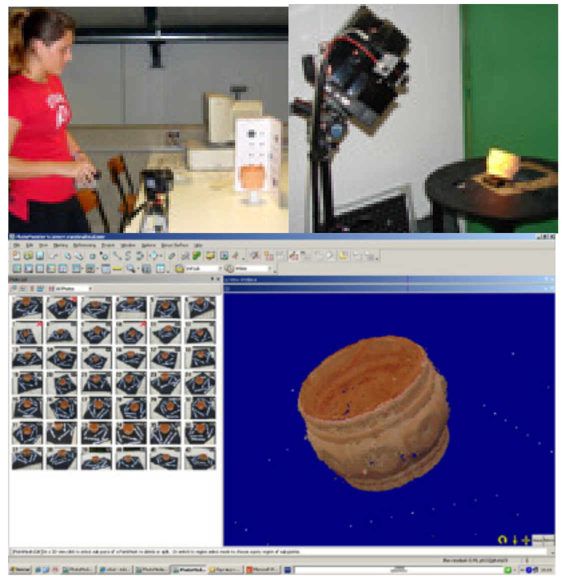

Figure 4: Testing three different 3D-scanning technologies in the laboratory: David Laser Scanner software, Spatium 3D equipment (at LOPCA, another laboratory at the University of Campinas), and Phomotomodeler Scanner software.

The three technologies tested are summarized below:

- David Laser Scanner (laser triangulation). It´s necessary to capture, with a regular camera, the image of the object being swept with a laser beam in front of a special background pattern. Costs about 80 EU$. Easy to use, although it requires a complete dark room. It´s necessary to produce background pannels in proportion to the size of the object. The results show lots of noise, which cannot be removed by the software. It was impossible to obtain a water tight, 3D printable model.
- Spatium 3D (structured light). The system projects a light pattern on the object and then captures the image with two cameras. Costs about 50.000US$. The system uses Geo Magic software, which is not very easy to use. The equipment needs careful calibration and is not very portable. The results also showed lots of noise, which could be treated to a certain level in Geo Magic.
- Phomotomodeler Scanner (Photogrammetry). It´s necessary to take pictures of the object from different viewpoins, with a regular camera, using special marks. Costs about 7.000US$. The software is not very easy to use, but the system is very practical, because there is no equipment or backgrounds, just a good resolution camera (7MPixels). The results also showed some noise, which could be treated on the own software.

The laboratory tests showed that the photogrammetry software technique was the most suitable for the work in the museum, because it didn´t require to carry around heavy equipment or large background panels. Next, the team went to the museum to test the photogrammetry software technique with sculptures made of different materials and at different ambient lights (Figure 5). No special light was used; a piece of black fabric was used as background.

Figure 5. Taking pictures at the museum for testing the photogrammetry software technique.

Sculptures made of three different materials were tested: terracotta, bronze and marble. After importing the photographs into Photomodeler Scanner it was possible to conclude that the technique only worked satisfactorily for the white marble sculpture. It was possible to obtain a proper 3D model, which was then 3D-printed (Figure 6). The worst results were obtained from the bronze sculpture, due to its reflective surface. It´s important to say that the museum conservation department does not allow to apply any type of product on the surface of the sculptures, such as whitening sprays or target stickers.

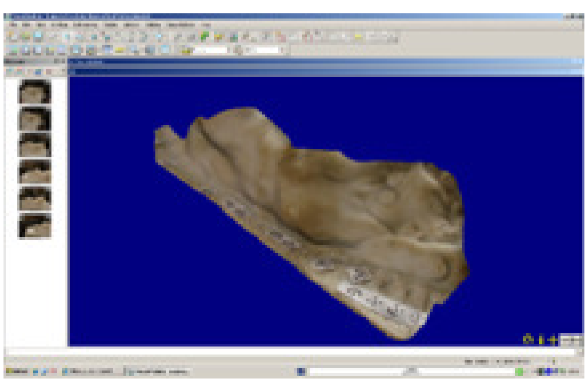

Figure 6. 3D-model from marble sculpture obtained with Photomodeler Scanner, ready for 3D-printing.

3 DISCUSSION

In this work in progress it was possible to conclude that certain materials present a real challenge for 3D-scanning - typically, dark and/or shiny materials, such as bronze and terracota, which are very common in building ornaments.

LAPAC needs a fast, easy-to-use system that does not require heavy training and is flexible in terms of size-range and materials.

A literature review on cases of applications of different 3D-scaning technologies in the field of architecture and the arts is now being carried out. Most authors acknowledge the difficulties with shiny/dark objects. Iuliano & Minetola 2005, for example, have compared a laser triangulation (Konica-Minolta Vivid-900) and a structured light (ATOS Standard) techniques for 3D-scanning a small sculpture (100x80x300mm) for 3D-printing. Both technologies were considered appropriate for the task. The test sculpture was made of white material and reference targets were glued to its surface.

According to the authors, however, "optical 3D scanners work correctly while digitising clear and opaque surfaces, but they have problems when objects are very shiny or too dark. A glossy object reflects the light and the acquired scan data might be noisy. A very dark surface, black at worst, totally absorbs the light and no data is acquired" (Iuliano & Minetola 2005).

Achille et al. 2007 have tested Creaform HandyScan 3D, a portable 3D-scanner, for scanning bronze sculptures at the chapel of Saint Isodoro in Venice. This system requires the application of reference targets on object´s surface, with a grid patch of 20 to 100mm. The technology is based on "a laser plotter and a system for recognizing reflecting targets that enables the instrument to automatically position itself in relation to the object being surveyed" (Achille et al. 2007). The strength of the laser and the time of exposure of the cameras can be adjusted to adapt to the environment´s light and to object´s color and finish. However, according to the authors, "for objects with shiny, dark, transparent or particularly reflective surfaces, the response of the laser signal can be disturbed and end up generating noise in the data or errors in rectification of the cloud points." They suggest the use of a matte spray, but acknowledge the impossibility of applying chemicals on historical heritage objects.

Heritage 3D 2009 describes the 3D-scanning process of a 18th-century gilded wood table with a Modelmaker X laser scanning system, fixed to a heavyweight tripod. With this technology it was possible to 3D-scan the shiny surface of the object without applying any chemicals or stickers.

The next phase of this research will consist of new tests with technologies that seem to work better with dark and reflexive surfaces, such as Modelmaker X.

We expect that this paper can lead to discussions that may help us finding suitable solutions for our needs.

4 ACKNOWLEDGEMENTS

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