THE MOCK-UP OF THE "RATTO DELLE SABINE" BY GIAMBOLOGNA:
MAKING AND UTILIZATION OF A 3D MODEL

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ABSTRACT

Within a project for the knowledge and preservation of the mock-up of Giambologna's Ratto delle Sabine housed in the Galleria dell'Accademia in Florence, the GeCO laboratory has made laser scanner acquisitions to create surface models at different resolutions for structural analysis, on which to check the coverage of the photographic campaign and to create a three-dimensional thematic mapping of data relating to investigations and restoration works. The PDF3D file format has been used to easily manage data on a platform immediately available to all operators.

Key words: Laser scanning, 3-D modelling, PDF3D, Cultural heritage, Mesh

1. INTRODUCTION

The present paper, promoted by the Galleria dell'Accademia within the project of restoration of the sketch of the "Ratto delle Sabine", constitutes an anticipation of the complete documentation of the restoration that will be published soon.

The creation of digital surface models is now a widespread practice for the most diverse applications of documentation, preservation and communication of cultural heritage (Guidi et al, 2009, Trinchão Andrade, Mazetto Mendes, 2012, Arbace et al. 2013). When we design a model, two conflicting requirements must be considered: on the one hand, obviously high resolution models reproduce at best the tiniest details, on the other hand, small files are preferable for viewing on non-dedicated hardware and software or on-line. It is therefore necessary to optimize the models in order to reduce the file size while maintaining a proper resolution.

The survey of the mock-up done by Giambologna for the "Ratto delle Sabine" ("The Abduction of the Sabine women"), was run as support to different lines of research, each of which requires outputs with different characteristics. Initially, the Galleria dell'Accademia (that is the Museum in Florence which houses the statue) demanded a model for structural analysis, for which a very simplified model is usually sufficient, because the structural simulations and Finite Element Analysis software are not able to import surface models consisting of very complex meshes.

It also emerged the need to verify the completeness of the existent photographic documentation and to summarize in a visual way the analyses and restoration

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interventions, applications requiring more detailed models. In this way, the case study has also offered the opportunity to study how to create three-dimensional maps of the restoration works, overcoming the limitations of most GIS 2D tools used for this purpose, and our 3D model was put at the disposal of the other working groups for referencing the results of their investigations.

2. THE KNOWLEDGE AND RESTORATION PROJECT OF THE ABDUCTION OF THE SABINES

The Galleria dell'Accademia in Florence hosts the preparatory sketch of Ratto delle Sabine, made with clay by Giambologna around 1580, whose final version in marble is located in Piazza della Signoria under the Loggia dei Lanzi. This statue is one of the few still existing sketches of large sculptures in full scale.
The sculpted group, 4.30 m tall (without the pedestal) is characterized by the a-whirl movement of three figures, whose bodies spin around their axes, intersect and overlap, and is considered a masterpiece of Mannerist sculpture.
The artist created this model as a training to face the most demanding challenges for sculptors, both ancient and his contemporary ones: get many figures from a single block of marble, balance masses of a figure who supports another one, create a perfect composition from everywhere you look. (Avery, 1978).
In addition to this full scale maquette, there were other small models which testify to the attention of Giambologna for this statue originally without name, if we rely on the writer Vincenzo Borghini who reports that he had personally recommended to Giambologna the name of "Ratto delle Sabine". The famous Latin legend tells that the first generation of Roman men (who were descendants of the Trojan survivors) kidnapped some girls from the neighboring Sabine families to acquire wives for themselves. So the bent figure could represent a Sabine father, the standing young man could be the Roman Thalassius and the raised woman one of the abducted girls (Borghini, 1584).
For the restoration of an artifact whose characteristics and construction materials are little known and that is in poor condition, the Galleria dell'Accademia considered essential to have a team of specialists a wide diagnostic and learning campaign. For this project, developed between 2011 and 2014, both restorers and research institutes (including the ICVBC-CNR, the IUAV and the GeCO lab) were involved.

3. ACQUISITIONS

The data acquisition was made by two operators on November 21, 2011. The digitization was done as a complementary part during the survey of the Galleria dell'Accademia, where the statue is located. So the scanner employed has been the same phase-shift scanner (Leica Geosystems HDS7000) used for the architectural survey, whose resolution was adequate for a surface model for structural analysis, as requested by the Client at first.
Although it is known (Tucci, Bonora, 2007) that the triangulation scanners allow to scan large statues with greater accuracy than with phase-shift or TOF tools, the

resolution obtained proved to be suitable to the expected goals, as described below, for each of them was indeed necessary to reduce the amount of data. Furthermore, with that tool was possible to do scans from a longer distance, without risks for a very delicate artwork, and to complete quickly acquisitions without interference with the normal museum activities.

During survey project, eight scan positions were identified to capture completely the surface of the sculpture: four scans at the sides of the pedestal and four at the corners from about 3 m away. From these locations two sets of scans were made, one on the ground and another at about 4,50 m height using a scaffolding for a better acquisition of the highest parts of the statue from different points of view. Three additional ground scans were done to also acquire undercut areas not visible from other scan positions. All project metadata are recorded on a sketch and a log.
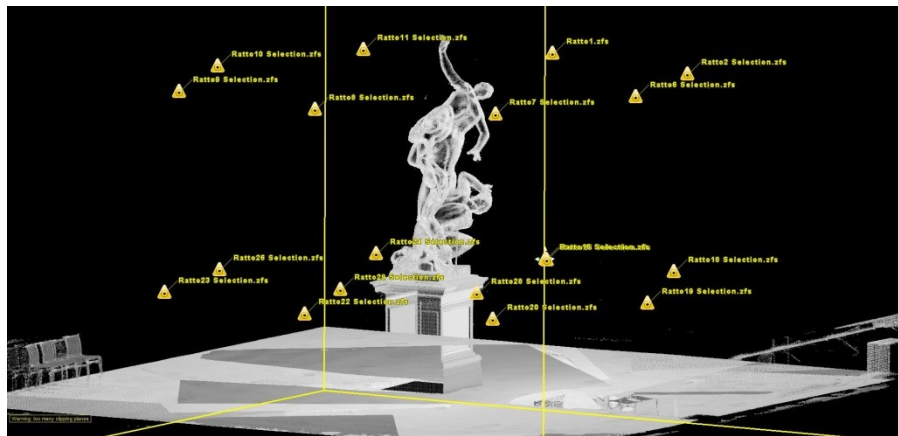

Figure 1: Scan position network.

4. SURFACE MODELLING

The 19 scans were taken at 360° to use the geometry of the room for a more accurate registration. The alignment was made using natural points; the complete model includes more than 164 million points. Selecting only the statue and its pedestal, the point cloud was reduced to about 66 million points.

After cleaning, resampling and merging (all these steps were made with Leica Geosystems Cyclone software, as the alignment), it has obtained a model of 3,563,629 points that it was imported in Geomagic for mesh creation. The overall mesh was then segmented separating the statue and the pedestal, as they require different processing and decimation.

Figure 2: Alignment of pictures on mesh: an image of the photographic campaign (left); mesh model (center); aligning with *Image alignment* tool(right)

The two meshes have been optimized and made watertight by closing the small holes located mostly in hidden places. It was obtained a 2,162,114 triangles mesh for the sculpture and a about 780,000 triangles mesh of the pedestal.

As FEA software is not usually able to process meshes with so many triangles, other simplified models (with different percentage of decimation) were made for static studies.

The model of the statue has been decimated to 1,000,000, 500,000 and 50,000 triangles meshes, and from the pedestal model simplified meshes of 350,000 and 35,000 triangles were got . The structural studies, carried out by the Laboratory of seismic risk analysis of IUAV in Venice, are forthcoming.

5. ASSESSING THE COMPLETENESS OF THE PHOTO CAMPAIGN

The Museum requested to verify if the photographic campaign, carried out to record the artwork before the restoration, showed entirely all the sculpture.

Since the images were taken without a proper photogrammetric project with an uncalibrated camera and using a zoom lens, it was deemed sufficient to locate the point of view and orientation of the 77 images using *Image alignment* tool included in MeshLab (ISTI-CNR) software. It uses a Mutual Information algorithm to optimize the alignment between the 3D high resolution model and 2D images. This function is not very accurate but allowed to meet quickly and effectively the requirements.

By backprojecting all pictures on the mesh, it has obtained a texture that leaves uncovered, for difference, the areas not shown in the photos.

It was calculated that gaps area is about 0.28 sq. meters, that is 1.8% of the surface of the statue, which is 15.5 sq m. Gaps were very small and located in very close areas as between the limbs of the figures. Acquiring these parts of the statue with

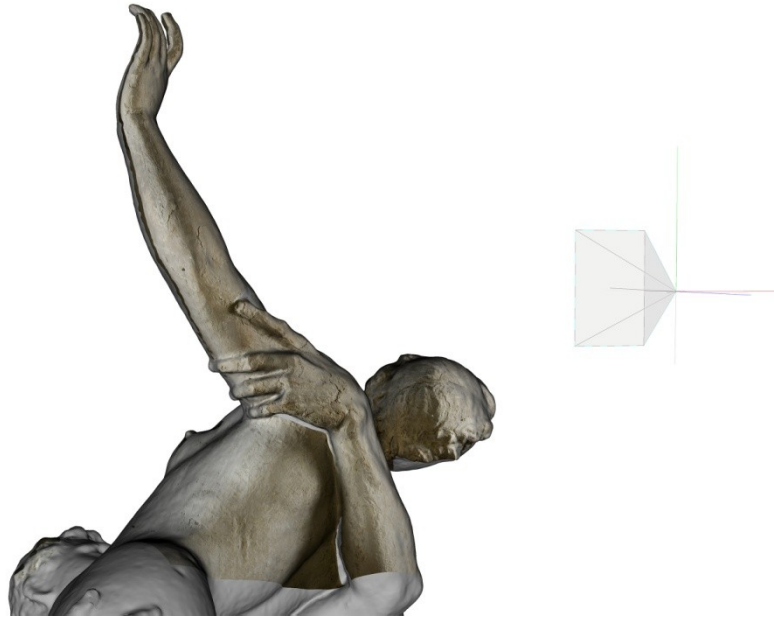optical sensors is difficult, since camera and laser scanner both require direct visibility.

Figure 3: Backprojection of an image on the mesh.

6. 3D REFERENCING OF INVESTIGATIONS, ANALYSIS AND INTERVENTIONS ON THE SURFACE MODEL

As it's usually done in restoration sites, the restorers recorded their diagnostic tests and interventions drawing directly on prints of the images of the photographic campaign. These drafts were scanned selecting nine thematic queries (kind of materials, deterioration, etc.) and projected onto the 3D model, attributing to each image the same orientation parameters that were identified in the previous phase. For the best viewing, it was used the full-resolution 3D model.

The sharpness of thematic overlays has been improved using MeshLab tools for radiometric color processing. In this way we obtained many models, each one textured according a single theme.

By selecting only the textured triangles and by superimposing them as layers on the overall model (in Bentley Microstation CAD software), was obtained a three-dimensional thematic mapping. It's also possible to insert hyperlinks and annotations to attach further data to 3D geometry.

Figure 5: Points of view of all the images of the photographic campaign

7. DELIVERABLES

An obstacle to the widespread use of 3D models to a non-specialist audience is that they require to handle large data sets whose management often requires specialized software.

The most widely adopted solution is therefore the spread, for broader purposes, of geometrically simplified versions in file formats viewable on- or off-line with a special plugin. The drawback of this solution is the quick obsolescence of technologies, formats and plugins, so, sometimes, models become no more viewable in few years.

For a simple and immediate management on most hardware and software platforms, the Universal 3D (U3D) open format was chosen, on which the PDF3D technology is based. It can be viewed (also on the Internet) with software already present on virtually all computers, like Adobe Acrobat or other non-proprietary applications (Manferdini, Garagnani, 2011). This format allows to organize the themes as separate layers in a hierarchical structure, enabling the semantic data organization and maintaining hyperlinks to other PDF pages, which in turn can include additional 3D views of the same or other models. The final model, optimized for off-line view, consists of 1,570,750 triangles in 11 layers and takes up 33 MB. Although it consists

of many overlaid high resolution meshes, it's relatively small and therefore easy to view. It is planned the realization of more decimated 3D models for online view. Using Acrobat Reader Pro it's also possible to use measuring tools and transect the model according to user-defined plans.
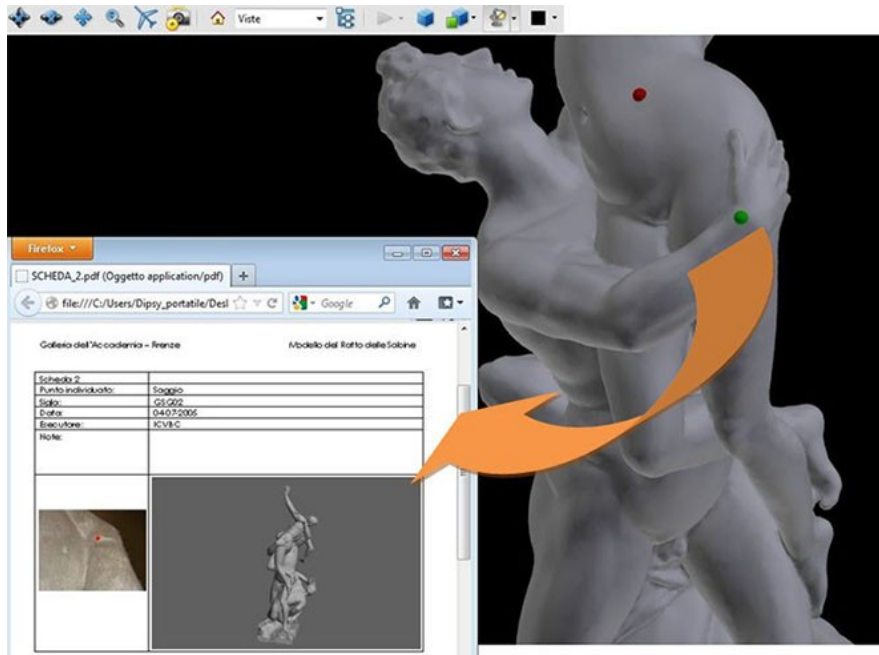

Figure 5 : Links between 3D models and other PDF files

8. FURTHER DEVELOPMENTS

As the ISTI-CNR research institute had previously produced a model of the final marble statue (which is located in Florence under the Loggia dei Lanzi), it has been possible during the work a comparison of the two versions. The result, (to be published), showed that, even if they appear similar, the artworks have significant differences, especially in the different twisting of the body and position of the arms of the female figure.

This example of "second thought" is rarely witnessed in sculpture and therefore is an important indication of the creative process of Giambologna. The ongoing analysis can help to understand whether artistic, static or technical issues prevailed.

9. SOFTWARE

This work was done using the following software:
Leica Cyclone   alignment
Geomagic   meshing
Meshlab (ISTI-CNR)   mesh elaboration
Bentley Microstation   model optimization and PDF3D creation
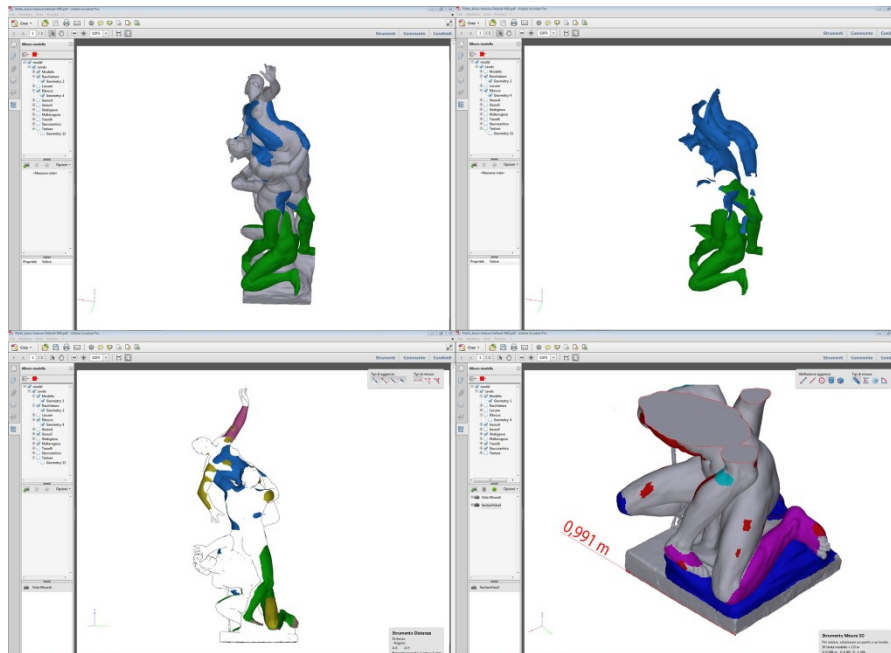Adobe Acrobat Pro   PDF3D optimization

Figure 6 : PDF3D model visualization in Acrobat Reader Pro

10. CONCLUSIONS

The paper shows some applications of 3-D models for investigating cultural objects with a high three-dimensionality. In addition to models for static analysis, a methodology was found to get 3-D multilayer models to show thematic queries using PDF3D format. Each layer consists of a portion of the surface that is possible to view alone or together with the others. In this way it's possible to understand the relationships and overlapping of materials and deterioration.
Unlike other software for recording restoration interventions, which only allow a 2-D mapping on photographs, in this way we can get a real 3-D description of the requested phenomena on a detailed model.

In addition to cultural heritage applications, this technique can be easily applied in all fields in which a 3-D mapping is useful, as in architecture and archeology.

11. ACKNOWLEDGEMENTS

REFERENCES

-Tucci, G., Conti, A., Fiorini L. (2014). Realizzazione ed impiego del modello 3D. (forthcoming).

-Callieri, M., Tucci, G., Scopigno, R. (2014) Copia fax-simile o reinterpretazione? Un confronto dei modelli 3D del marmo e del bozzetto del Ratto delle Sabine. (forthcoming)

-Arbace, L., Sonnino, E., Callieri, M., Dellepiane, M., Fabbri, M., Iaccarino Idelson, A., & Scopigno, R. (2013). Innovative uses of 3D digital technologies to assist the restoration of a fragmented terracotta statue. *Journal of Cultural Heritage*, 14(4), 332-345.

-Trinchão Andrade, B., Mazetto Mendes, C. (2012). 3D preserving XVIII century barroque masterpiece: Challenges and results on the digital preservation of Aleijadinho's sculpture of the Prophet Joel. *Journal of Cultural Heritage*, 13(2), 210-214.

-Manferdini, A. M., & Garagnani, S. (2011). Virtual Exhibition and Fruition of Archaeological Finds. *ISPRS-International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 3816, 429-436.

-Guidi, G., Spinetti, A., Carosso, L., Atzeni, C. (2009). Digital Three-Dimensional Modelling of Donatello's David by Frequency-Modulated Laser Radar. *Studies in Conservation*, 54(1), 3-11.

-Cole, M. (2008). Giambologna and the sculpture with no name. *Oxford Art Journal*, 31(3), 337-359.

-Tucci, G., Bonora, V. (2007). Application of high resolution scanning systems for virtual moulds and replicas of sculptural works. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Vol. XXXVI, Part 5/C53 721-726.

-Avery, C. (1978). Giambologna's sketch models and his sculptural technique. *The connoisseur*, 199(799), 3-11.

-Borghini, R. (1584). Il riposo. Facsimile (Rosci M. cur.) Labor riproduzioni e documentazioni, Milano, 1967.