The fragment collection at the Museo Archeologico in Florence, Italy

Building a virtual model to extend its access

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Abstract: The subject of the project is a remarkable collection of ancient fragments currently located in a courtyard of the Archeological Museum in Florence. The site includes fragments from many different areas of the city at the age of the Roman Empire. Nevertheless its unique archeological value, currently the courtyard cannot be visited, because it would require too much effort for the museum to make it accessible. The objective of the research is to make the entire collection available for virtual visiting trough a digital model, both in an online and offline scenario.
A laser scan survey was already available from an extensive survey of the whole area, but the resulting point cloud data was too big to be easily managed and converted to a 3D model suitable for real time rendering. For this reason I focused on a small portion of the courtyard, a small temple shaped artifact made of fragments from the ancient Isis temple. A photographic survey was made with non-professional equipment, in order to keep the entire work-flow simple and extensible to the whole courtyard.
Then all the photos were processed by two different softwares, then the resulting 3D meshes were compared to the original point cloud in order to check reliability and integrity of the 3D model.
The more accurate model was then refined and optimized for real time render, decreasing the faces count and including extra detail in the texture data.
I designed an online interface that could easily allow virtual visit trough a website displaying extra information about each fragment. Also a more detailed model was set for an offline scenario (a kiosk placed inside the museum), using a powerful real-time render engine usually designed available for video games.
This approach can be easily extended to the whole site in a low cost survey scenario.

Keywords: digital survey, laser scanner, 3D modeling, museum, virtual model.

Subject of the project

The subject of this work is the courtyard inside the Archeological Museum in Florence, the so called “Cortile Romano”, a rich and unique collection of findings dating the Roman empire age from the 19th century excavations in the city center.
This place, even if visible from the inside of the museum, it's completely inaccessible to visitors, since the area is not designed for public access and not compatible with Italian safety laws.
For this reason the main goal of the research is to build a digital model for people to explore virtually, online and offline.
Also the big amount of data collected needed a long of processing and editing, so part of the work actually became studying and refining a workflow that could grant geometric accuracy and fast data processing at the same time.

Also the result I tried to achieve was to show in details how digital technologies can easily become complementary to the traditional way of enjoying the cultural heritage, before and during the visit, and how museums can use digital technologies in economical ways that enhance underutilized resources.
The digital content can be a replacement of the real visiting in case the space is not accessible, or can enrich the user experience before, during and after the visiting of the museum, and the workflow used in this research proved that this scenario doesn't need large investments for the museum itself.

The 19th century excavations in Florence

In the 19th century Florence city center was re-designed, and many buildings in that area were demolished. The excavations exposed many findings from the Roman Empire age, and the administration formed an archeological and historical commission to supervise the operations. The architect Corinto Corinti, as a member of the commission, took care of documenting, surveying and studies all the findings.
Based on the archeological evidence, he carefully designed views of the city at Roman age *Florentia*.
The drawings were later on published as postcards which became popular at the time; it was actually the first attempt to virtually reconstruct and make easily and widely available for common people the archeological data.

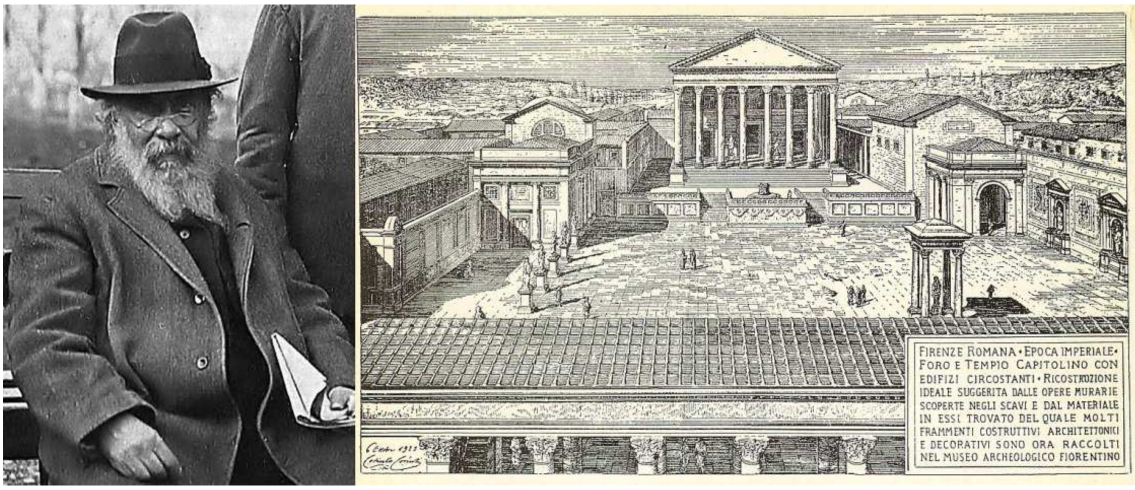

Fig. 1 – Architect Corinto Corinti, and one of the postcard he designed about Roman age Florence

The courtyard, today

All the findings from that excavations were stored in the courtyard, some of them in peculiar temple-shaped artifacts, made by joining different pieces one to another and adding a roof to protect them from the weather. The fragments, varying in size, material and original arrangement, include the base of the North gate from the city walls (I Century b. C.), some pavement mosaics (II Century b. C.) and some parts of a roman *domus* found next to the present Baptistery. Also many decorations from the Jupiter temple were found in the present Repubblica square, and many others from the Isis temple, which was placed just outside the city walls.

Fig. 2 – The courtyard named "*Cortile Romano*"

The laser-scan survey

The project got under way first collecting already available data, in this case a laser-scan survey made in 2002 by the Dipartimento di Architettura, from the Architecture Faculty in Florence, this survey was a part of the complete survey of the entire Museum and Soprintendenza Archeologica, developed as a scientific agreement between the Faculty and the Soprintendenza (under the coordination of prof. Marco Bini).

The digital survey of the coutyard was done using a time-of-flight laser scanner (Leica HDS 2500), using targets for the scanner to recognize, and then for the software to use as matching constraints to join back together all the multiple scans in a single point-cloud.

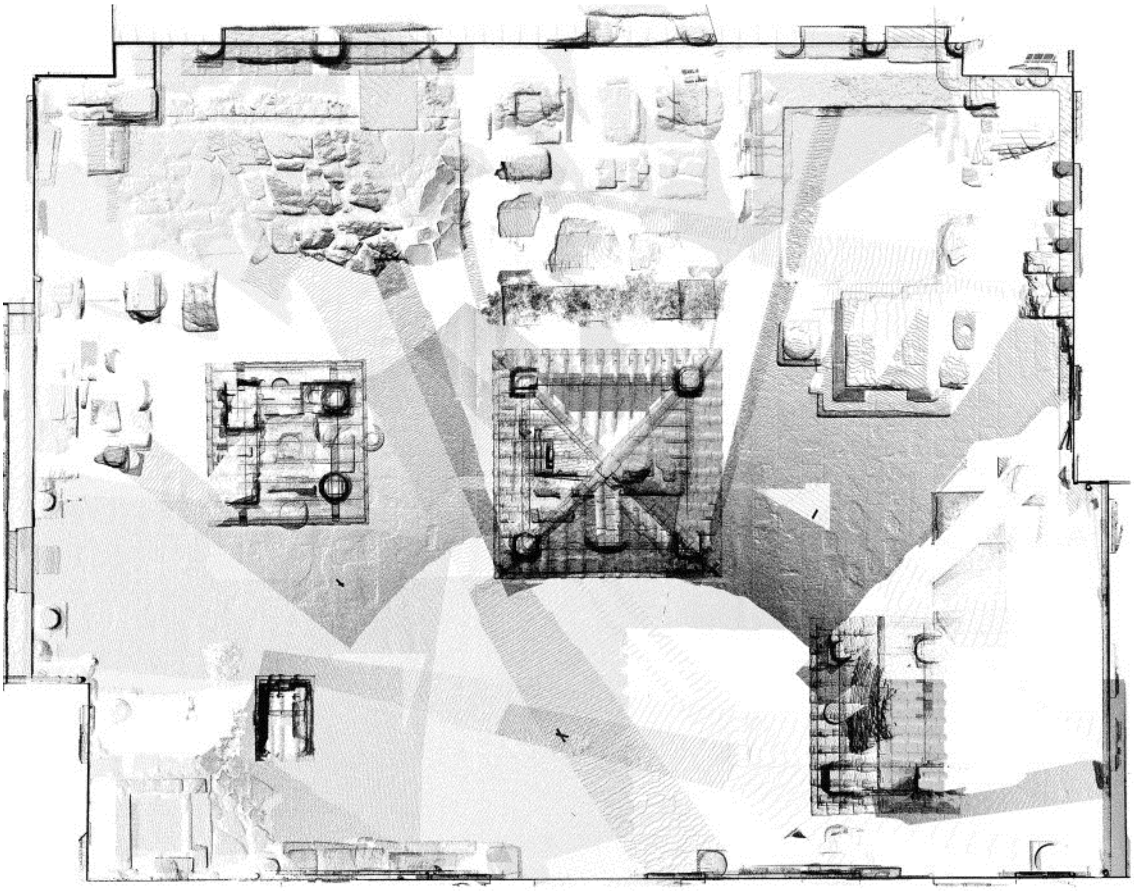

Fig. 3 – The laser-scan survey, view of the resulting point-cloud

Focusing on the *Isis Temple*

The resulting data set was a big point-cloud, with a remarkable variance in terms of data density, due to the topology of the courtyard itself that made some regions difficult to acquire.

We started to design a 3D model using the laser scanner data, focusing only on a smaller portion of the courtyard, in order to get a general idea of the main problems we would have to face later on, setting up at the same time a work-flow for the whole project.

The *Isis temple*, due to its position (cornered next to two main walls), was fairly representative: two sides had actually redundant points, while the two sides facing the walls where lacking geometrical information, and needed further survey that could be easily integrated into the point cloud from the laser scan.

Fig. 4 – The *"Isis temple*"

Integrating the data with photogrammetric survey

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We then decided to conduct a new photogrammetric survey, trying to reduce further on-site measurements as much as possible; also we used non-professional photographic equipment in order to set up a simple way to integrate missing point cloud data in the rest of the courtyard.

A single photo session was shot, made of 120 photos of the Isis temple from different points of view. Then two different softwares were tested: Agisoft Photoscan and Autodesk 123D Catch.

Testing software accuracy

Both Photoscan and 123D Catch can process photo sets of the same object without the need of any on-site measurement, since they can read lens data from EXIF tags and compare the photos to find matching features of the object from different angles.

At the cost of decent processing time, they can output textured 3D polygonal meshes, easy to edit and manage. Since all the process is completely automated, with none or little operator intervention, we needed to validate the result comparing it to the existing laser scanner data.

For that purpose a third software (Raindrop Geomagic Qualify) was included in the post processing workflow. This software was originally designed for proofing CAM generated objects comparing them to the original 3D model. Using the laser scanner point cloud as reference we tested both models from Agisoft Photoscan and Autodesk 123D Catch to check the overall accuracy and average deviation from the laser-scan survey data.

The deviation distribution revealed that the most part of the errors where in the range of 5mm and -5mm, that was accurate enough to merge the polygon mesh with the laser scanner data set.

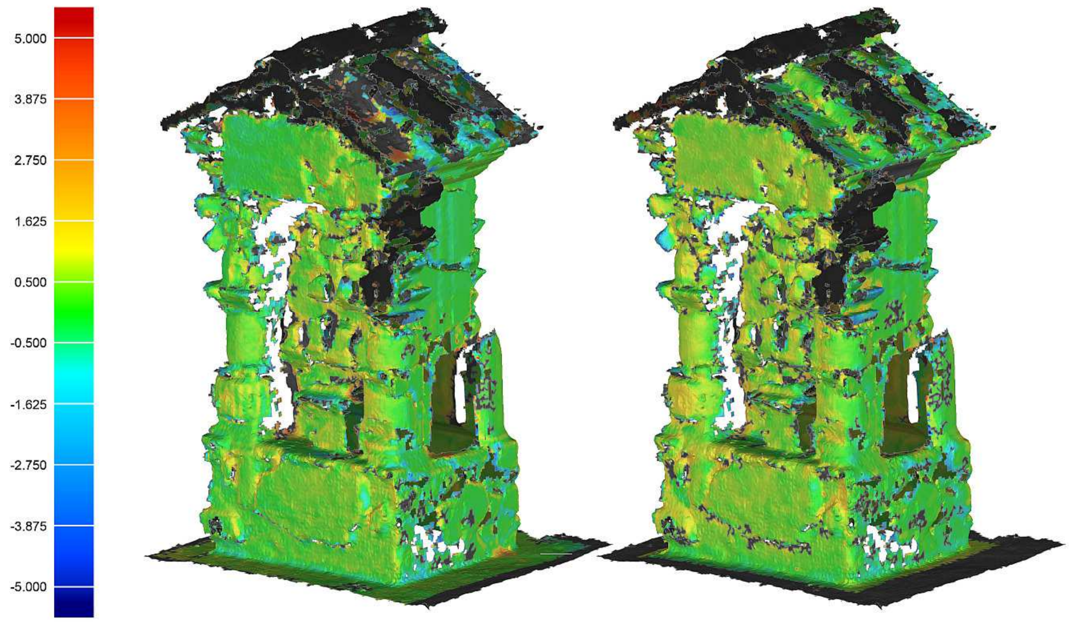

Fig. 5 – Results of the accuracy test on 123D Catch model (left) and Photoscan model (right)

Optimizing the 3D model

The 3D model was then refined and edited to correct local errors, and also a low-poly model was created, suitable for internet access and real time rendering.

The main steps of this part of the workflow included deleting the isolated triangles, capping holes and correcting the non-manfold triangles (not connected to the mesh on all sides).

The texture resulting from the photo processing, even if highly detailed, was remapped to a new UV map that could guarantee a more uniform pixel density on all the areas of the model.

Fig. 6 – Rendered low-poly model, with normal, diffuse and occlusion map applied.

Adding interactivity in a real time 3D engine

We extensively researched the current software panorama in order to find a proper 3D engine for real time display of such a complex and detailed 3D content that would be suitable for both an online scenario running as a browser plug-in to display content within a website, both offline, running on a dedicated kiosk. We decided our requirements to be:

- Real-time rendering capability of large amount of triangles:
- wide support and documentation:
- software access to graphic resources, in order to take advantage of graphic hardware
- user friendly 3D environment, with 3D WISIWIG editor
- sufficient user adoption as a browser plug-in (for the internet scenario only)

The software chosen was Unity 3D, a 3D engine originally designed for mobile devices and the gaming industry, which was optimized for our application, because of

– support for different devices and operating system (including iOS):

- included browser plug-in, not extensively adopted, but easy to install with one click;
- wide graphic hardware support;
- easy import of 3D models from 3D editing software from 3D Studio MAX
- normal maps support
- powerful yet easy to learn coding language.

The first step at this point was to optimize the model for real-time display, accordingli with the engine requirements, (small polygon count, normal maps applied, occlusion map to achieve a realistic look)
Once imported into the 3D engine, a basic user interface was designed to manage the viewing angle, panning, light set-up and mouse behavior.

Flash version of the application

The Unity platform currently lacks of widespread penetration on the desktop side, but its compatible with all mobile devices. So we decided to develop a Flash version of the 3D viewer, since the Flash player is included in all modern browsers, even if it’s not well supported for mobile devices. Adding a Flash version for the desktop/laptop environment, we made sure to cover any possible scenario and enhance dissemination. Since the Flash is not optimized for real-time 3D rendering, the 3D movement was limited to a rotation of the camera for each time one side of the temple. The animation was pre-rendered in 3D Studio Max, then imported into Flash as movie frames, adding a user interface to manage the rotation, adding hotspots that could trigger pop-up display containing additional information about each interesting part of the temple, and additional detail photos as well.

Fig. 7 – Interactive application: Unity 3D (left) and Flash (right)

Conclusion

When the project first started it was supposed to be mainly a virtual reconstruction using the available 3D scan, in order to allow the public to enjoy such a peculiar archeological site. The problems we encountered during the work, due to the particular nature of the courtyard and the resulting 3D point-cloud, forced us to plan carefully a consistent workflow, applying it to a small portion of the site, the Isis temple.
Always having in mind the original goal, we developed all the tools and the problem solving for this particular scenario, achieving a bigger result: the *Isis temple* is now virtually reconstructed and could be finally

implemented in a kiosk or an online website for everyone to see, meaning first of all a great innovation in the overall approach to this kind of elements inside a museum, reducing the costs and the complexity of the access for all needs. Also we can say that everything is ready, in terms of procedure and workflow, to extend the work to the whole courtyard, easily and with a low budget.

This research proves that the digital virtual model can be an economic way for all museums to enrich the user experience before, after and during the visiting, and can be a way to disseminate the knowledge of under-utilized resources, so abundant especially in the Italian museums current panorama.

We hope this research can be an example on how to give back to general audience the view of such a beautiful and peculiar site, even in cases like this when physical access requires much more resources and time.

Also it’s a way to continue Corinto Corinti's legacy, using nowadays technology, but keeping the will to share the beauty of our historical and archeological heritage.

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Imprint:

Proceedings of the 18th International Conference on Cultural Heritage and New Technologies 2013 (CHNT 18, 2013)

Vienna 2014

http://www.chnt.at/proceedings-chnt-18/

ISBN 978-3-200-03676-5

Editor/Publisher**:** Museen der Stadt Wien – Stadtarchäologie

Editorial Team: Wolfgang Börner, Susanne Uhlirz

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