

THE RELIEF OF THE *PORTA PALATINA*: A COMPARISON BETWEEN DIFFERENT SURVEY METHODOLOGIES AND REPRESENTATIONS.

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KEYWORDS: Architectural, Comparison, Model, Representation, Survey

ABSTRACT

Within the historical urban fabric of Turin, the *Porta Palatina* is the most conspicuous part of the Roman boundary walls and towers still preserved: the research proposes the analysis of an architectural monument that belongs to the cultural heritage buildings, linking integrated survey techniques and representation methods.

This work starts from Survey and History of Architecture courses carried out by the teaching staff of the Department of Building Engineering and Territorial Systems of the *Politecnico di Torino* (DISET); the Department of Land, Environment and Geotechnologies (DITAG) organised the metrical and instrumental survey steps.

The research evaluates different results of the survey, focusing on contents, the restitution scale, the relationship between symbol and reality, taking into consideration user needs and pinpointing the time required with each method.

1. INTRODUCTION

Augusta Taurinorum was presumably founded around 27 B.C. as a *castrum*; it was constituted by square blocks and crossed by two principal arteries (*cardo* and *decumano*).

The *Porta Palatina*, called "*porta principalis dextera*", seems to have been built in a period of social and political stability. In fact its monumental and decorative functions are clear. Probably the doors of the city, from narrow and well defended passages between the boundaries, developed into monumental buildings built to show the importance and the greatness of the city to the visitor. (LA FERLA, 2003)

The two towers, characterized by sixteen sides, were built before the *interturrio* (the part between the towers) and the surrounding walls. In the *interturrio* there are four passages with barrel vaults that could be closed by shutters or *cataractae*. The towers rise on a thick squared plinth and they were internally divided into five or six levels by wooden planks that leaned on brick frames and probably connected with winding staircases.

Over the centuries the *Porta Palatina* has undergone many changes and transformations, both in its functions and in its structure, as often happens to historical buildings.

Between 1860 and 1871 a heavy restoration process provided a progressive isolation of the building that practically consisted of a real reconstruction. During the restoration some medieval ornaments were destroyed in the process of re-establishing the original shape of the building. (BALDI et Al., 2004)

Today the ancient *Porta Principalis* shows the two towers and the central body. It doesn't represent a typical work of fortification: this is evident from the number and the width of the openings and the importance of the front decorations of the *interturrio* facing outside the city.

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This collaboration was considered by the two different research groups as a chance for an analysis of the relationships and

integrations between survey methodologies and representation methods.

In fact, when dealing with cultural heritage surveys, the correct procedure is to plan and manage different survey techniques, considering user needs for the in-depth study of the monument.

2. SURVEY TECHNIQUES

The conservation and the study of cultural heritage requires an accurate and reliable knowledge and efficient communication between experts with different skills: means could be a correct and detailed measured base.

The intention is to obtain a complete and exhaustive documentation in order to make a critical reading of the monument, on the basis of the information gathered.

For an accurate documentation of a cultural heritage object it is important to have a realistic 3D model; its exploration could let the user obtain detailed data of various degrees, depending on the level of inquiry. Nowadays, the preferred way to achieve this goal is through an integrated use of different survey technologies; in addition a unique reference site system should be adopted. In fact Cultural Heritage surveying frequently requires integrating survey data from different sources.

In this case study a LIDAR (terrestrial laser scanner) survey and a photogrammetric survey were carried out. A complete topographic survey was previously planned and performed to georeference the laser and photogrammetric models, using a Topcom 8001A total station. Four control points were identified around the building in order to materialize a local reference system. The survey scheme adopted for the network was gained measuring from each vertex all the others. Monographs of the vertices were carried out to make their use again possible.

Several markers were uniformly placed on the target object, but the total station survey phase was aimed also to measure the manually unreachable points on the façades and also to carry out the integration with the manual data.

Furthermore it was necessary to place the instruments in some auxiliary positions other than the network vertices; they were linked to the net in order to georeference all the measured data in the unique object reference system. Some of these surveyed points were also useful in the following survey phase.

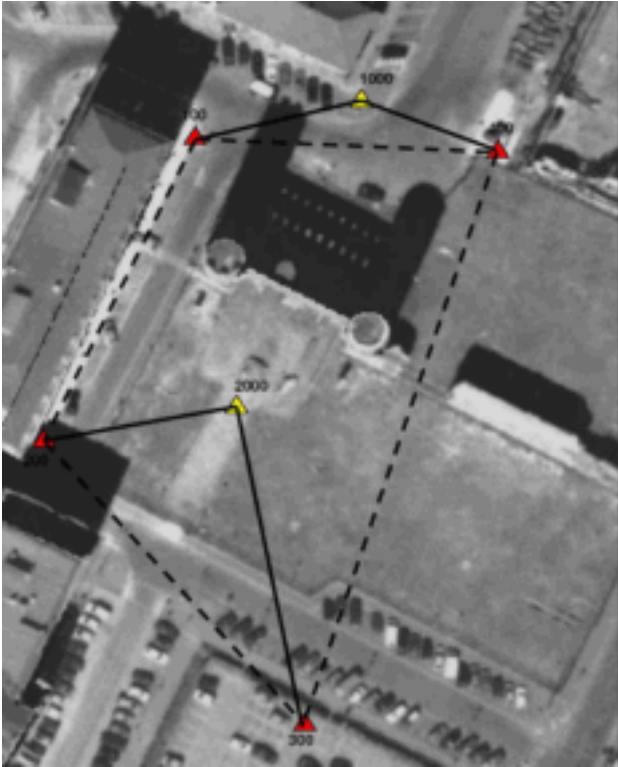


Figure 1. topographic network

A Riegl LMS-Z420i “time of flight” laser scanner was used for the laser survey; this instrument, besides the spherical coordinates, acquires and records data on the material reflectivity. Furthermore this laser machine can be equipped with a digital camera (Nikon D1X) in order to obtain the radiometric information. In fact, the camera is rigidly mounted onto the laser, so the position of the centre of the camera is known with regards to the centre of the laser instrument. The position of the camera becomes a known position in the laser acquisitions. It was decided to carry out six different scanpositions to acquire the whole building, using a resolution of 0,040 degrees.

Using the markers (of about 3 x 3 centimetres) applied on the surveying object, data acquired by the different scans could be aligned to create a single point cloud (BORNAZ, RINAUDO, 2004).

A laser scanning machine is practically a high automation reflectorless total station; by means of a laser based measurement of distance and accurate angular movement, a target object is sampled in a regular mesh of 3D points. One of the most interesting applications of this instrument is the fast and economic way of creating a DDSM (Dense Digital Surface Model); using other techniques (e.g. total stations, photogrammetry) would require an incredibly time-consuming process. And thanks to the digital camera mounted on scanner machines, it is possible to immediately assign RGB information to each point.

In general the LIDAR technique allows “*in situ*” the surveying time to be reduced but it slightly increases the processing time. By using some defined procedures, it is however possible to reduce the time necessary for the batch processing.

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3. THE SURVEY PRODUCTS

Using the previously mentioned instruments (Riegl LMS Z420i Laser Scanner and Nikon D1x camera), the data (point clouds

and images) are stored in a single reference frame.

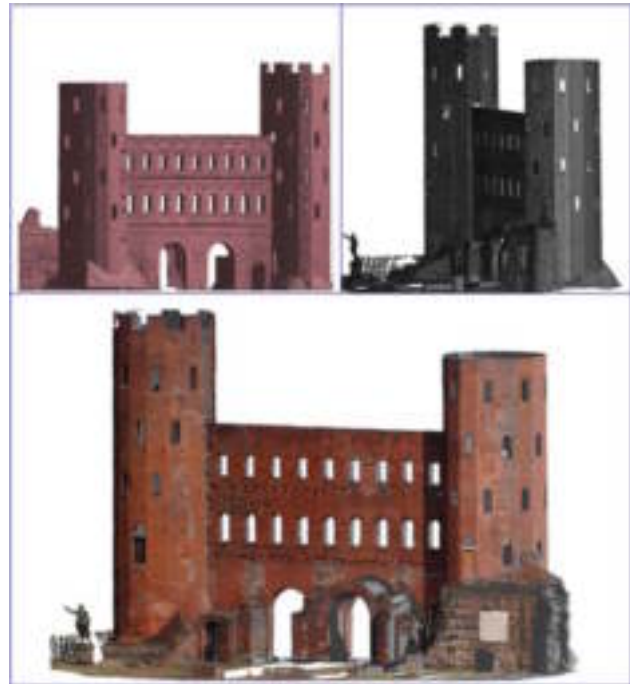


Figure 2. 3D model

A navigable 3D model could be easily generated. This kind of model is a useful tool to describe a complex object. In fact it has a significant impact on the users and it is suitable, for example, to show the complex shape of an historical building. However, an unskilled user could find this representation not so easy to deal with. In fact it is very difficult to extract data and measurements from it. It is required to reduce the amount of processing. Without the reducing and resampling process several processes on the whole point cloud take too much time because they use redundant data. As these models are heavy data processing products, the users are obliged to have a dedicated computer. Nevertheless, it is possible to produce low resolution models by resampling the data before they are processed. Obviously some information will be lost when this kind of data is processed.

3.1 The orthophotos

With the acquired data it is also possible to create another useful tool: the orthophotos. They allow users to carry out analysis in a simpler way. Orthophotos are complex survey products. They are digital images where the distortions due to the image perspective are corrected. The geometry of a particular survey object is obtained by orthogonal projection of each pixel of a digital image onto a 3D surface model, a DDSM acquired by LIDAR instruments in this case. In this way, the original perspective representation is transformed into an equivalent metrically correct image, although its radiometry decays because of the resampling process.

An orthophoto is a metrically correct photographic representation of an object; it is possible to measure distances (in a known scale factor) and read coordinates directly on it.

It is necessary to use a specific procedure for the production of an orthophoto. The high cost of the equipment and software, means that producing an orthophoto is much expensive. Operators with specific skills are also required.



Figure 3. The orthophoto

A good quality survey product can however be acquired, in which the object is represented as it really appears, without the introduction of codes or symbology as used in a topographic survey. An unskilled user can understand and correctly read an orthophoto, while the correct interpretation of a topographic survey requires a specific technical background.

As 3D supports are still not popular among users, orthophotos could also be used as a support to obtain 2D vector elements of the surveyed object and in case a familiar base for a GIS. This in fact could be a useful tool for the analysis of an historical building made by different experts: vector elements could be created and alphanumeric data could be associated to them. In fact dealing with cultural heritage surveying, geometry and measure don't complete the survey purposes. Also materials, colours, physical phenomena (stratigraphic chronology) and chemical phenomena, are components that could be represented on a geometric base. (TUCCI, et Al. 2003)

3.2 Solid Images

A Solid Image can be easily created by adopting photogrammetry and LIDAR techniques. It turns the philosophy of orthophotos upside down: the original radiometric contents remain unaltered and 3D information is added to it, by reprojecting the DDSM. In this way it is possible, through a common photo looking 2D interface, to have the 3D coordinates of each point in the image, and to use a set of predefined tools to perform analysis and measurements. This product can be created using specific software called LSR2004® which was developed by the *Politecnico di Torino* geomatics research team. It can also be used with common commercial software such as Adobe Photoshop®, using a free plug-in. The Solid Image allows the user to access and manage 3D data by simply viewing a 2D monoscopic image; it adds correct 3D metric information to simple photos, so that information is much easier to be accessed by people who are not survey experts. The Solid Image lets the user access data on reflectivity and distances acquired by the laser sensor.

It is possible to obtain Solid Image, using the camera mounted on the laser scanner machine. In this way it is possible to immediately obtain the external orientation parameters of the photos. This data can be acquired directly from the scan acquisition. There is no need for a time consuming orientation process, or for a specific technical background; the main disadvantage is to be bound by the chosen scanpositions: to sample the object in an accurate way, a proper distance has to be adopted for the taking, and this can limit the field of view of

the photos. This can be a problem because the object is divided into several Solid Images, and the users have to analyse the whole object managing different Solid Images.

The Solid Image however lets the user to insert vector points in the project by recognizing them in the image; in this way it is possible to select objects of interest. This offers great potentiality compared to photogrammetry: there is no intermediation involved in choosing which elements of interest have to be returned. These vector points can be exported and then managed in a CAD file.

4. RESTITUTION

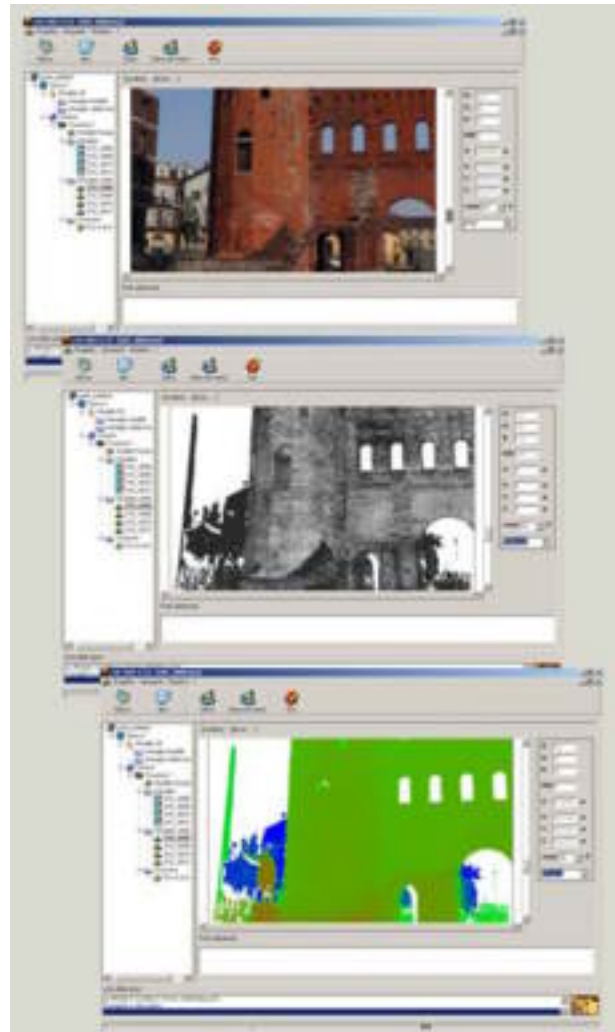


Figure 4. Solid Image: RGB Image, Reflectivity, distances

In the drawing operation bidimensional representation were preferred. A 3D model was carried out using the point cloud acquired by LIDAR. A geometric abstract model should have been achieved by simplifying the object in basic geometries. Considering complexity and unevenness of the surveyed object this abstract model has been lost important and essential information.

The problem was to represent a 3D complex object in a 2D drawing. Architectural scale surveys on historical buildings using digital photogrammetry and LIDAR methodologies have several peculiarities, such as the instruments used (degree of reliability and precision), representation methods (flexibility degree and amount of information), research approaches (degree of explorability, interdisciplinary nature and transformation)

and means of communication (degree of compatibility with other technologies and ability to diffuse).

When analysing the different survey products and considering the surveyed object, the orthophoto was chosen as a support for a 2D drawing of the south front.

A survey based on an orthophoto lets users to put together different levels of abstraction (such as in the traditional drawings) with the realism of a photographic image.

An orthophoto is an uninterpreted survey product and allows specialists to point out and manage information about many elements on the surveyed object on different layers: e.g. architectural elements, shape relationships, construction techniques, material texture, historical phases, colour values, decorative elements, decay conditions, etc.

These elements are legible on the orthophoto with a metric reliability and a verifiable precision.

After producing the orthophoto, the first step for the representation process was to verify the dimensional accuracy: in this way it was possible to check if the precision required in the planning phase would be satisfied.

This verification was carried out by overlapping points acquired in the topographic survey on the orthophoto.

The points, in dxf format were loaded on an AutoCAD file. The difference between the digital image and points grid was comparable to the precision that we attended from the survey project (2-3 centimetres).

With this level of precision (related to the graphicism error that is about 0.2 mms for the restitution scale chosen) it is possible to graphically produce an image on a 1:100 scale.

Using AutoCAD to check out in the best way the precision and the measures of the drawing of architectural elements, the front of the building was traced.

During the drawing phase, some groups of layers were used in order to approach different themes. Some layers reproduced the object geometry: different thickness of the lines represent the relationships between different surfaces on the object.

Other layers describe chinks in walls. Some lines of different intensity grey scale signal various types of chinks, which have



Figure 5. Front of the Porta Palatina

been drawn on the orthophoto.

A single layer is used to describe bricks; strongly influenced by the drawing scale and the image detail, the choice is only to represent the brick ranks.

The images recall the restitution steps and some different possible representations of the South front on a 1:100 scale. The wall chinks and the material description are placed over the geometric model.

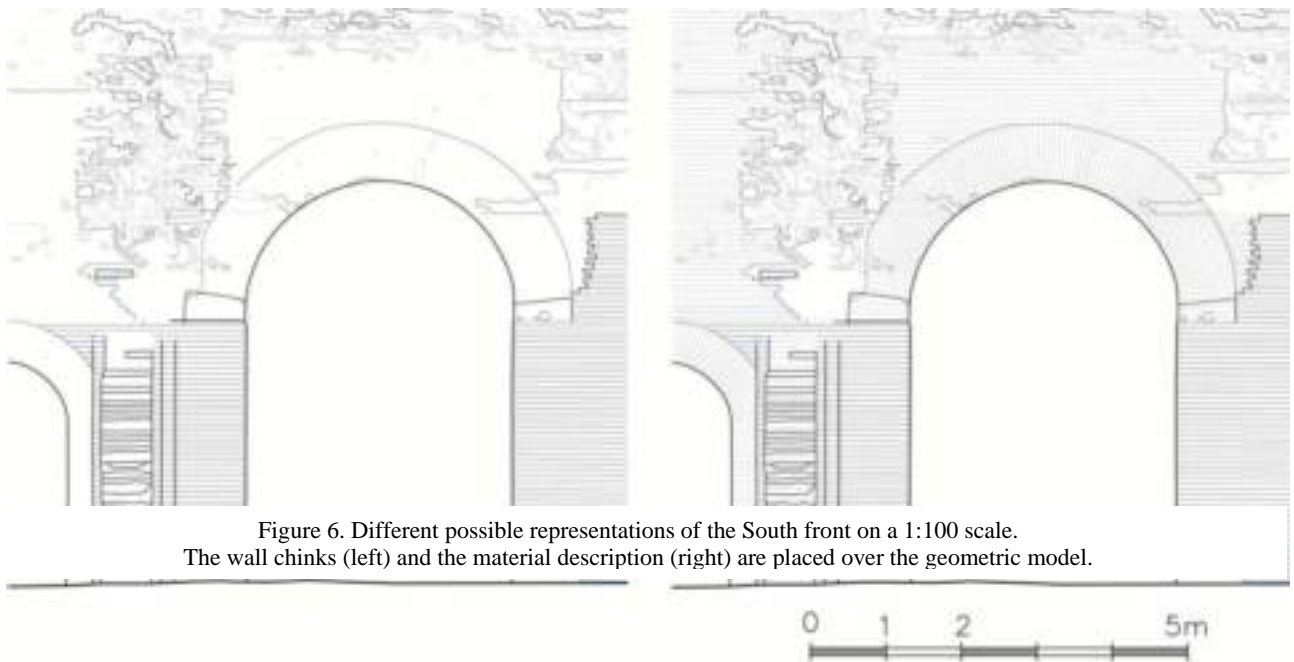


Figure 6. Different possible representations of the South front on a 1:100 scale. The wall chinks (left) and the material description (right) are placed over the geometric model.

5. CONCLUSIONS

This work was useful occasion to share skill and competences between different research groups. In dealing with a cultural heritage survey, the cooperation of different specific skills is often required. Therefore it is important to choose the correct tools for a multidisciplinary analysis.

Different survey products were evaluated from different points of view. In this work the research was focused on the orthophoto because it is a product that connects the survey data and the representation. Therefore it allows easier a communication between the two research groups compared to other survey products.

We would like to extend the analysis also to 3D models and Solid Images, especially on Solid Images which could be used in many different situations in the near future. In particular, it is relevant to the automation of the production process, and its user friendly approach.

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