S.MARCO'S CHURCH IN VERCELLI: THE SHAPE MODEL FOR THE REUTILIZE LIDAR PROJECT IN A SIMPLE ARCHITECTURAL SPACE SURVEY

E. Agosto(*), A.Osello(**), L. Peretti(*), F. Rinaudo(*)
(*) DITAG, Politecnico di Torino, 10129 Torino, Italy - eros.agosto@polito.it - fulvio.rinaudo@polito.it
(**) DISET, Politecnico di Torino, 10129 Torino, Italy – anna.osello@polito.it

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ABSTRACT

The aim of the present work was to evaluate the cost/benefit ratio of laser scanners use to describe a quite simple architectonic space, compared with traditional techniques. The real question behind the article is the one everyone has at least once asked himself; LIDAR acquires the coordinates of an enormous amount of points, but perhaps the necessary information could be retrieved more quickly using traditional techniques, surveying a defined number of chosen points; therefore information LIDAR gives worthwhile? The surveyed object and the aim of the survey are discriminant in answering. This work is anattempt to refleet on this topic and a case of study is given; the test was carried out on a deconsacrated church in Vercelli (north of Italy): the S. Marco church
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1. INTRODUCTION

The church of S.Marco is situated in the centre of Vercelli, in the North West of Italy, about 80 kilometres from Turin. Its construction started in 1344.
In the years preceding its construction begging monks were already present on the site where the church would later be built. They did not have sufficient money to build the church, but Pope Clemente IV helped them; through the sale of indulgences he managed to give the monks the necessary financing.
The works for the construction of the church lasted for 200 years. First four aisles were completed, subsequently three more were added; the presbytery was concluded, then the balcony and the windows were added and in end the bell tower was built.

Figure 1. Historical Map of Vercelli

In 1701 the church was desecrated and from that moment different events led the S.Marco church to be used for different proposes: initially it was used as a barn, then for a long period it was a stable, for then it become a store and finally it was purchased by the municipality to be a public market.
Only in recent years the municipality of Vercelli shown any interest in the ex-church of S.Marco, protecting it as a building of historical interest.

2. CHOICE OF THE TEST SITE

The object that had to be taken into examination was not to be an excessively complex building: it would otherwise have meant a notable waste of time for the data management and it would have hindered the search for a universally applicable method. If the test site geometry were instead too simple, the test would have been meaningless. For instance, in a Gothic or Baroque building, it is difficult to find the primitive geometries, since they are hidden by many decorations; they also involve very long scanning and elaboration times. If the test were too linear and without complex building elements, it would have led to an excessively simplified. The universality of the method that it was intended to find had nothing to do with the definition of a valid standard procedure for all the possible building typologies, but was rather an analysis of the "steps" that had to be followed to face a single or multiple scanning with the purpose of optimizing the dimensions, the management of the file, the number and the quality of information.

3. INSTRUMENTS

The used instrumentation is made up of an ultimate generation of laser semiconductors scanner; it has a particularly wide field of view, that allows the number of scannings to be decreased and therefore also the time necessary for the digitization of any manufactured article.
The maximum distance of acquisition is about 400 meters in laser class 1 and 800 metres in laser class 3, the precision of the tool is equal to 6 millimetres and the speed of acquisition is 12000 points per second. A digital camera rigidly fixed onto the top of the laser scanner through a calibrated arm allows the acquisition of the colour information to be made.

4. TOPOGRAPHIC NETWORK

Before the scannings began it was necessary to build a topographical network to define a unique reference system for the surveyed object. This meant, therefore, the choice of an arrangement that led to the maximum mutual visibility of the points; it had to guarantee the coincidence of at least two vertices for each station. The reason for this lies in the fact that it furnishes a support for all the subsequent measurements.

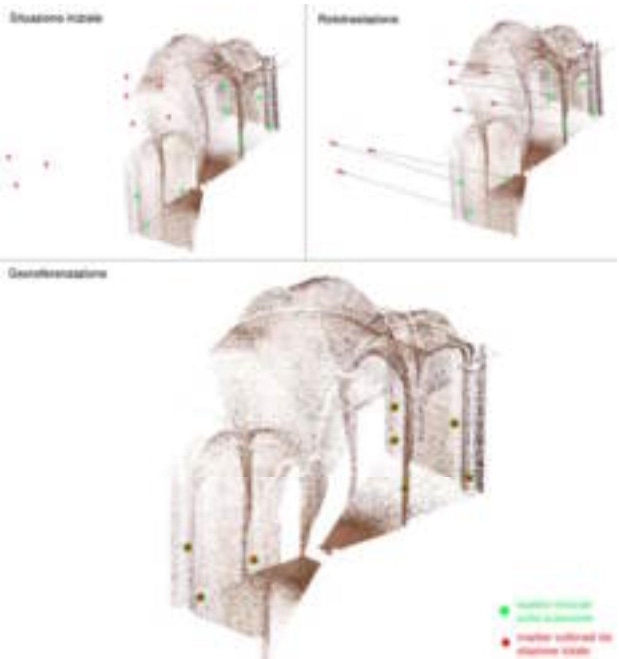

Figure 2. Scans Georeferentiation

In the case of the ex-church of S.Marco five vertices were positioned, four of which were inside the central aisle to form a rectangle and one outside in front of the principal façade.

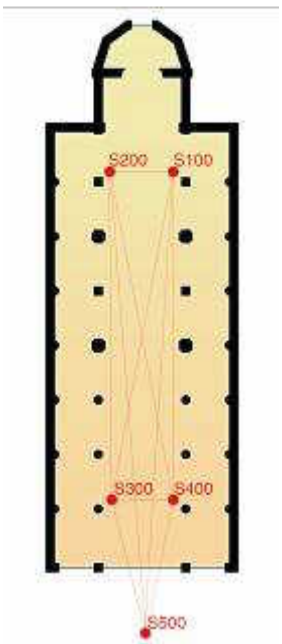

Figure 3. Topographic Network

The registration, operation by which the scannings are merged, can be obtaned in two ways: the first by forms recognition, the second by use of reflective targets (markers). The coordinate of markers are measured by total station Topkon8001A that has a very high precisions (0.3 mgons).

The acquisition of markers is the base of the good result of the scannings registration: in fact, each scanning obtains its georeferentiation information from the marker coordinates; they are reflective elements that behave very differently from the context and can be automatically recognized by the software of the laser scanner; they are usually bee-nest reflectors.

In the present case the markers were square form elements of about 3 centimeters per side; they had an adhesive side opposite the reflecting one, and also a central dot, given by the diagonals, that identified their geometric centre in order to measure it with the total station; during the data elaboration the laser scanner software automatically recognizes the centre, by calculating it from the areas with high reflection. The arrangement of the markers also follows a logical procedure based on the planned scannings. Each scanning needs a minimum of 3 points to be georeferenced, but more points are preferred, because the middle quadratic discards statistical elaboration will be applied. In the case of the ex- S.Marco church they were put on the walls of the smaller aisles and on the central pillars.

Figure 4. Taking arrangement

5. SCANNING

Before proceeding to the scanning of the ex church of S.Marco, as for every architectural object, an appropriate strategy has to be decided to determine the footstep of scanning, to optimize the number of scannings and to minimize the shadow zones.

Concerning the scanning goals, two things that have to be considered, one connected to the geometry and the other one to the present decorations inside the building. The structure of the ex-church of S.Marco is relatively simple and without many decorations, with the exception of the presbytery and its niche. These characteristics guided the choice of a scanning footstep equal to 80 mgons: in this way a good detail is obtained of the whole church and at the same time the scanning times are not excessivey long.

The subsequent step is the optimization of the number of scannings to have a complete coverage of the whole area. To complete the planning of scanning positions is necessary to know the characteristics of the used instrument, in fact, laser scanners of different types have different range action. In this case a semiconductor laser was used, in which the acquired data are recorded in spherical coordinates, exactly as happens with total stations; this instrument has got a very wide field of view: 360° around the zenith axle and 80° along that azimuthal.

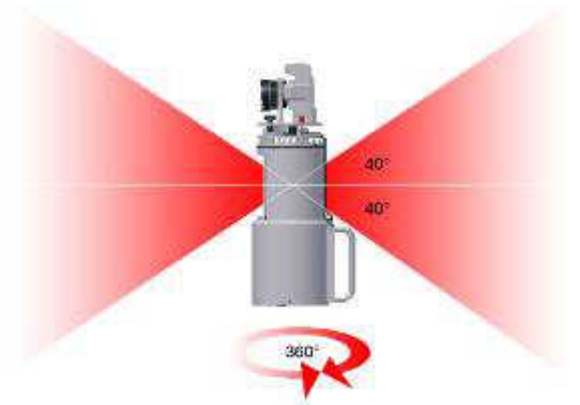

Figure 5. Laser scanner field of view

Another very important aspect that must be dealt with concerns the shaded zones, this means that, in the taking phase, the laser scanner bean notices only what it first meets on its journey. The laser scanner, obviously, does not take the objects behind other objects.

In our case, the shaded zones were minimized, except a upper zones of capitals; this problem could be obviated with the use of a scaffolding. The purpose of this work was different therefore this detail was considered of little importance.

A sequence of scannings of the transversal aisles were used; nine scannings was made in the centre of the major aisle, eight (four for each side) in minor aisle and three orizzontal in the centre of church. In this way all the church was covered.

6. POST PROCESSING

The post elaboration can be separated into two phases: the treatment of the geometric data and the modelling.

The first "step" concerns the compensation operations of the topographical network, the calibration and the addition of the information of colour through the images on the pointcloud and finally the filtering of the pointclouds. LSR was used for this last passage, this is a software that was developed inside the DITAG of the Politecnico di Torino to have a greater control of the elaborated data. At the end of this operation scannings were impoerted into Geomagic in order to begin to model the pointcloud.

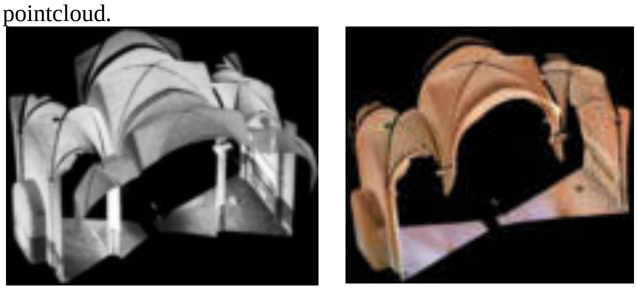

Figure 6. Point cloud without (left) and with (right) colour information

A series of attempts was then made to create a surface; initially it was tried to work on the whole scanning, but in this way a control of the details was impossible in many zones. For this reason, it was decided to proceed with a segmentation; in this way the similar parts are geometrically identified and isolated. Different details are chosen for each part in which the model has been divided.

Figure 7. Two different mesh precisions

Figure 8. Subdivision of the model to decrease the elaboration times

Each part of the church (figure 8) was then subdivided; the division in subparts was based on the architectonical function they had. It was therefore possible to isolate the main plains, vaults, capitals and pillars.

This operation was terminated for each scanning and subsequently the decimation of the points was performed intervening to various degrees according to the previously defined categories.

Figure 9. Segmentation

Different precision was used in the approximation of surfaces with triangles: for planar surfaces, for example triangle vertices had an average distance of 0.05 meters, whereas in the capital case the distance was about 0.01 meters. After the data elaboration 0,01 meters is the best precision we can have. During decimation phase the detail in the curved zones was always kept to a maximum to avoid the loss of information in proximity of the edges. After having completed this operation the surface was created only to this point. In this phase the same detail that as used for decimation was maintained. The created surfaces had some small defecs and holes that were filled using a tool provided by the modelling software.

Figure 10. Welding of different meshes

In order to conclude the modelling, the final "step" is to overlapping and welding all the different surfacie. What we have is a single surface with different. The advantage of using this method is that is possible to metrically create a correct surface and, at the same time, it is sufficiently light to be consulted by any user.

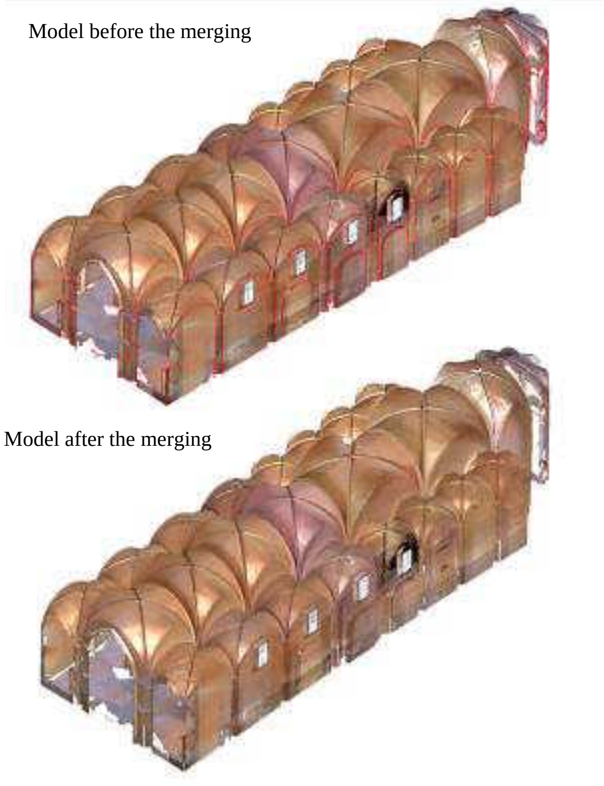

Figure 11. Overlapping the entire model

7. CONCLUSIONS

A fundamental concept can first of all be underlined: this technology does not attempt to be a substitution of the traditional and by now consolidated techniques, but rather an integration.

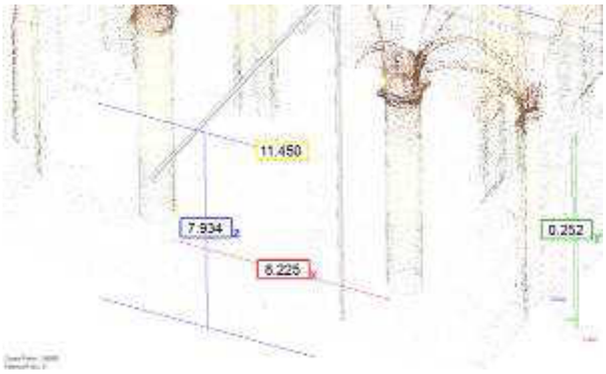

Figure 12. Measurments in virtual model

From the pointcloud it is possible to furnish a virtual model of the object to complete the direct measurements, just like if the user were physically present on the site. The advantages are notable if the acquisition time is considered: in comparison to the two days that were necessary to survey the ex-church of S. Marco, the possibility of consulting the data at any time is gained. Furthermore, the model is an objectve tool, that it is not affected by intermediary interpretations and it offers the user the possibility of making choice. Nevertheless, there are also some disadvantages, such as the elevated instrumental costs (both hire and purchase of the instrumentation) and by the elevated elaboration times for specialized use. Another negative point concerns the edges: no matters how accurate a scanning can be, the an intrinsic problem of any laser scanner technique, remains the inability to distinguish the edges.
The creation of a surface is necessary to be able to compute sections of the object. Therefore, the precision of section lines depends on the mesh accuracy and detail.

Figure 13. Example of section on model

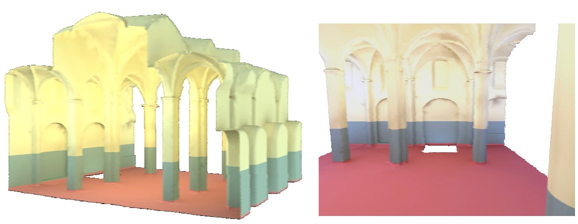

Figure 14. Rendering of the ex-church of S.Marco

The restitution phase could then start. The surveyed laser scanner and digital camera's data could be used to create an orthophoto.
It was also possible to make a render or a video by elaborating the same data with different methodologies. These are very

powerful tools for architettonics project, to study the geometry of new buildings; they make it possible to view new projects in the real existing scenario where the object will arise and to explain it to not technician users.
Another way to exploit the available data is to print in 3-D the created survey model, in order to have another possibility to study the model.
Since a few years a new printing system was born: the "printing 3D". The press process is not theoretically complex but very expensive, as it requires hi-tech instruments: it conceptually makes many bidimensional presses on chalk layers, which have different thickness. The result is amazing, a perfect scaled model. The chance of "touching with hand" the hardly created model is a strange and exciting feeling after months that were spent watching it through a monitor.

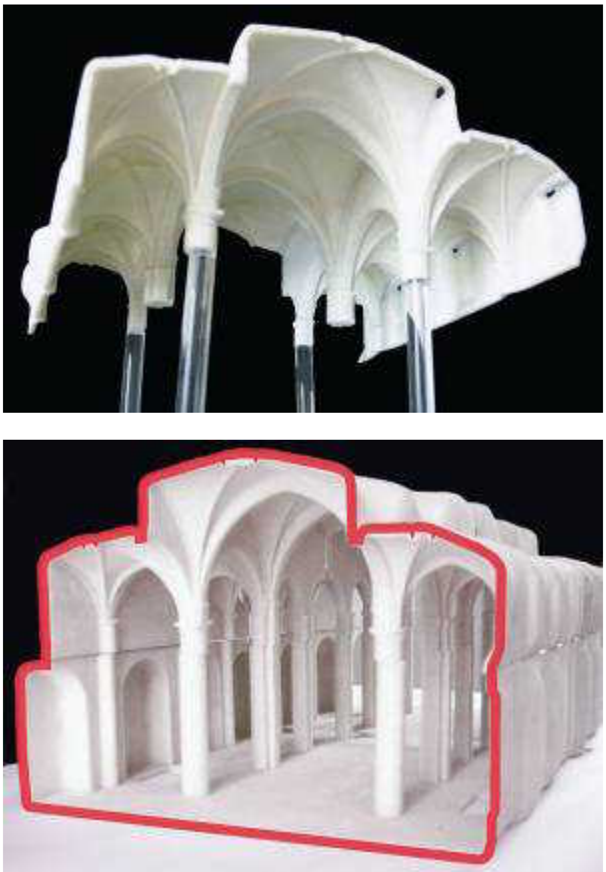

Figure 15. Two pictures of 3D printing

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