LOW COST METHODOLOGY FOR 3D MODELING AND METRIC DESCRIPTION IN ARCHITECTURAL HERITAGE

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ABSTRACT

The 3D geographic information and virtual reality have now become fundamental in the analysis and prevention of many environmental problems and in the documentation of Cultural Heritage.

In many application fields, such as virtual tours museums and so on, the simple 3D data visualization is required, but the 3D complex objects with metric data can be regarded as great aid in many other fields of application, such as territorial analysis connected to specific areas, rather than the management of territorial infrastructures or the management and monitoring of every kind of Cultural Heritage for the knowledge and the analysis connected to conservative intervention.

The last generation CAD softwares have improved the editing and the photorealistic visualization of objects above all for mechanics and industrial fields, whereas GIS software, by the use of georeferenced points, lines and polygons, have emphatically developed tools for spatial analysis of objects.

The study we are introducing wants to verify the achievable accuracy by different techniques of fast survey both in architectural and in infrastructural works.
The techniques of laser scanning has reached a maturity and an operational simplicity and therefore they allow a fast survey maintaining the typical accuracy of this technology.

The new motorized Total Stations with integrated cameras and simplified laser scanner carried out a fast and accessible survey both for the advent of digital technologies and of new low-cost software tools, and therefore it constitutes a valid alternative in the metric documentation in Cultural Heritage.

1. INTRODUCTION

The object of our relief is the road bridge of the ex S.S. n. 16 that it overhangs the river "Lama S.Giorgio", situated about 7 Km in direction southeast from the urban center of the city of Bari (South Italy).
The bridge is realized in local calcareous stone, with five spans and barrel vault.
The bridge in object - both for its structural and architectural characteristics and for its delicate function of crossing of the river - represents an interesting site of test.

In fact, the "lama S.Giorgio" crosses a portion of territory of notable geo-morphological interest with archaeological presences and it asks for a careful and repeated monitoring.
For this reason, this study surveys the bridge in three different following phases with more modern, inexpensive and simple tools.

2. NETWORK SURVEY

The first phase of topographical network and control points is realized with a new instrument: TOPCON - IS (Imaging Station) having the following features:
- Integrated dual-camera: array with wide-area and 30x scope view so you can zoom in on the detail you need;
- Photo Fieldbook: creates a 360° Photo Field book in few seconds;
- IntelligentScan: it automatically recognizes significant features in the images. Its 20 pps scan rate is ideal for most

applications, and its 2000 m precision reflectorless range is tops in its class;
- ImageDrive: it lets you visually operate from the controller and easily switch from imaging to prism tracking;
- Independent Control: it allows complete control from your computer, WiFi-equipped FC-2200, and other compatible devices;
- Robotic system features: one-touch quick lock feature that sets the standard in robotic target acquisition and taken, another step allows reflectorless measurement capable of precision at a mind-boggling 2000 meters.

Figure 1 – Test site with Topcon and Leica instruments

3. LASER SURVEY

The second phase is scanning using Laser Scanner Leica HDS- 3000 and processing survey data by "Cyclone" software.

The Laser survey was carried out with the aid of technology of the terrestrial Laser Scanner Leica HDS 3000, that it is able to extract the third dimension of objects in a fast way and makes an easy and efficient high-definition field data capture.

Cyclone provided by Leica Geosystem was the processing software used for this study and it is considered the most appropriate to manage a great amount of data of complex objects.

The system was set on high resolution grids (5 mm) and 90° scanning angle for the historical details, while lower resolution and 180° scanning angle for the completion areas and the whole coverage of the heritage were next scheduled.

After the preprocessing phase, all the scannings were aligned for registration, each with its own reference system, assigning a new and unique one to each (reference frame).

This operation was based on the recognition of the control points materialized from natural and reflecting targets, surveyed with conventional topographic instruments.
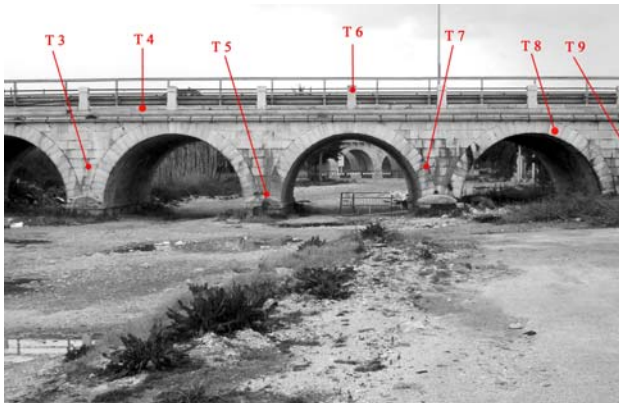

Figure 2 – Control points on the bridge

Later the integration by identifying the overlap areas among the different scannings was executed, evaluating the confidence values calculated during the phases of pre-processing and which precedes triangulation (Balletti et al., 2005).

In the triangulation phase, every scanning was first transformed into initial low-resolution meshes and then refined in order to reach a definite accuracy.
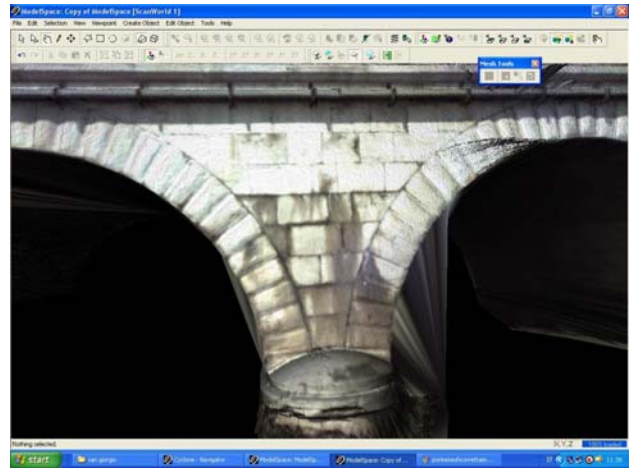

Figure 3 – Leica laser scanning (detail).

The great dimension of files derived from processing did not permit the creation of a single file with all the sections; however, since all the files are in the same global reference system, we worked on small groups of sections (Figure 3).

Once the detailed editing on each section was complete, the significant sections were imported into a new file in order to obtain the final model.
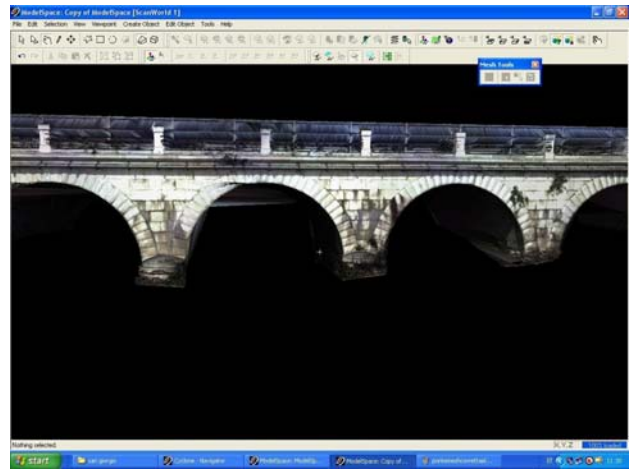

Figure 4 – Tri-dimensional model with texture

4. IMAGE STATION SURVEY

During the third phase we used the Topcon Image Station wich allows the survey exploiting the above mentioned features.
Successively, the bridge has been surveyed by a motorized scanning method which allowed to obtain a cloud of points as by a Laser Scanner but having a reduced number of points.
On the already surveyed model we linked the information gained from the images recorded by the same Total Station.
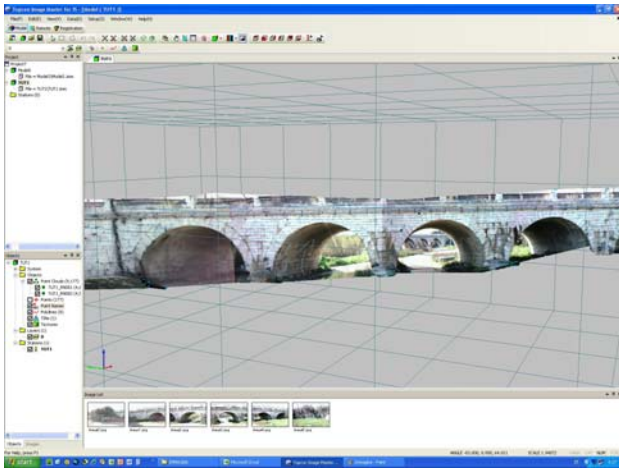
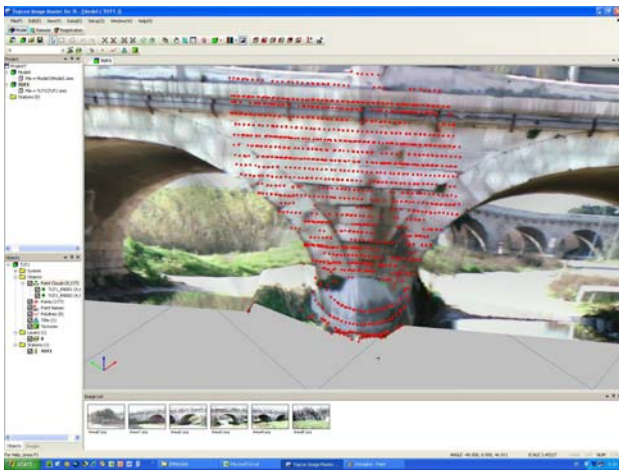Figure 5 – Topcon Image scanning

Figure 6 – Topcon Image scanning with laser grid (detail)

Several measures on the control points obtained in the two different clouds of points have been carried out in order to check the accuracy obtainable by the new instrument.
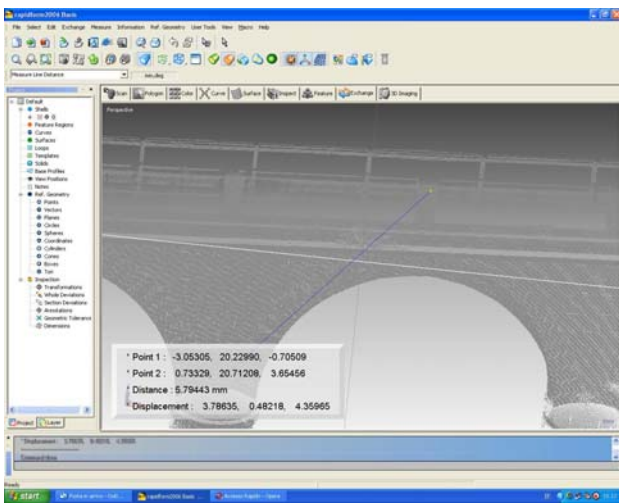

Figure 7 – Coordinates determination (Rapidform)

The coordinates of each point obtained in the two surveys have allowed the comparison shown in the following table.

	Total Station	Laser Topcon	Laser Leica	Delta TS-Topcon	Delta TS-Leica	Delta Topcon-Leica
T9 - T10	5,76	5,86	5,79	-0,10	-0,03	0,07
T7 - T12	33,80	33,82	33,94	-0,02	-0,14	-0,12
T7 - T9	15,23	15,12	15,22	0,11	0,01	-0,10
T7 - T8	5,22	5,26	5,31	-0,04	-0,09	-0,05
T7 - T10	19,46	19,45	19,38	0,01	0,08	0,07
T7 - T11	*35,81*	*35,63*	*35,61*	*0,18*	*0,20*	*0,02*
T12 - T10	14,59	14,63	14,70	-0,04	-0,11	-0,07
T12 - T9	18,78	18,89	18,68	-0,11	0,10	0,21
T12 - T8	30,49	30,37	30,21	0,12	0,28	0,16

Table 1

We can clearly see that the gaps among the different methods of surveying are about 10 cm.

5. CONCLUSION

The first results of this test show that, for particular sections of use of metric surveys (documentation and knowledge of Cultural Heritage), this new tool satisfies the required needs with respect to a low cost of purchase and simplicity of performance.

The next images show the final products obtainable by processing of gathered data.

Figure 8 shows the whole result of survey obtained by Topcon Image Master software, while the following figure 9 represents the reconstruction of the 3D Cad model of the bridge.
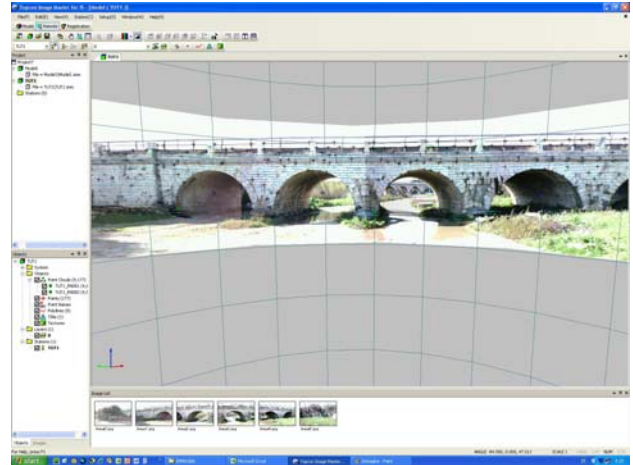

Figure 8 – Total survey of the bridge

Figure 9 - 3D Cad model

REFERENCES

Abdul-Rahman 2000. A., The design and implementation of two and three-dimensional triangular irregular network (TIN) based GIS, PhD thesis, University of Glasgow, Scotland, United Kingdom, p.250.

Balletti, C., Guerra, F., Gerbaudi, F., 2005. The Survey of the wooden Structure of the roof of Palazzo Ducale in Venice. IAPRS, Vol. XXXIV, Part 5/W12, pp.49-53.

Caprioli, M., Figorito, B., Scognamiglio, A., Tarantino, E., 2007. Implementing the Features 3D Multipatch for the Management of Territorial Infrastructures, WIT Transaction on Ecology and Environment, pp. 853-860.

Brooks, S. and Whalley, J. L., 2005. A 2D/3D Hybrid Geographical Information System, Proceedings of ACM GRAPHITE, Dunedin, December 2005, (unpaginated CD-ROM).

Molenaar M., 1998. An Introduction to the Theory of Spatial Objects Modelling, Taylor & Francis, London, pp. 1411–1420.