A SYSTEM BASED ON TERRESTRIAL LASER SCANNING

Building Information System

In Lombardy (Italy) one has started a project on risk-assessment of buildings of historical-architectural importance. For this purpose a Building Information System (BIS) has been created, based on archived and surveyed data. Essentially a multi-sensor approach has been applied to archive the inside and the outside of the monument. The primary technology is terrestrial laser scanning. The authors treat the activities done for creating the BIS of the Santa Maria Maggiore in Bergamo, build in 1137.

The Santa Maria Maggiore monument includes the Colleoni Chapel and holds the graves of the well-known composer Gaetano Donizetti and of the famous commander Bartolomeo Colleoni. The exteriors are very irregular and built in different architectural styles. A BIS is the most effective technique for geo-referencing, analysis and visualising 2D and 3D models of the monument. The steps carried out to built the BIS are twofold.

- Collection, classification and transfer to digital format of all archived descriptive and graphical information of the monument as found in Bergamo's historical archives; first the most recent documents going back to the early 1900s were digitised, in a next step the older ones were processed.
- A survey with advanced geo-data acquisition techniques to create a multi-level model of the morphology of the building.

The BIS, which is still under construction, is based on ArcView: the GIS adopted as standard by Lombardy authorities.

Network
Documents on the building geometry are few and poor in accuracy. Furthermore, a large scale network for georeferencing was lacking. To collect directly horizontal plans of the inside and outside of the monument and vertical sections of the vaults we carried out a survey over the monument with motorised instruments. Laser-scanners were used to acquire data about the 3D morphology of the walls. Furthermore by photogrammetric and land surveying techniques ortho-images and photo-textures were created. The network consists of:

- 26 primary vertices; 18 outside the monument and 8 inside providing a correct connection between the outside and the inside of the building
- reference grid (RMSE 5mm) useful for the acquisition of horizontal-vertical sections and laser scanning data.

A Microsoft FrontPage based procedure will be soon available to document each vertex through hypertextual links in a sensitive map. Those vertices were selected, which belong to the network of the 1:1,000 technical map of Bergamo. They are referenced to the Roma40 system (map projection Gauss-Boaga) and surveyed with GPS techniques (WGS84 and UTM projection). Through these tie-points, local coordinates could be transformed in height (vertical plane) and then subdued to a horizontal plane to relate each vertex to the above map projections.

Wire-frame
In order to produce a wire-frame model of building details the following data had to be acquired:

- building plan
- horizontal profiles of the inside and outside of the building
- wall thickness
- set of vertical sections.

The data collection survey has been done with reflectorless and motorised total-stations. Although possible, we did not extract these data indirectly by processing laser scanning data because of reliability and accuracy reasons. So far, we have acquired around two thousand points for representing the plan at the requested accuracy of 1-2cm. To verify uncertainty in point positioning and to remove erroneous points many horizontal distances were measured with hand-held lasers. The outer profile of the building (archived in CAD as a polyline) details the intersection of the walls with the ground level. This choice results from the irregularity of the terrain and from space lack around the monument.
The building has a complex vertical morphology - the vaults are wide with rich decorations; the dome is nearly forty-two metres above floor level. The measurements, carried out automatically with a motorised total station , resulted in eight vertical sections along the aisles and

the transept of the Basilica and two sections inside the Colleoni Chapel and yielded forty thousand points. The main axes of the Basilica were independently staked out, with reference to the pillars of the building core; the pillars appear to be not perfectly orthogonal. These measurements still need completion.

Textured Representation

The laser scanning data will be integrated with close-range photogrammetry and then assessed through surveying measurements. Analysis and management of large sets of points are the biggest bottlenecks of laser scanning. For high quality Virtual Reality representation of the Basilica image texture mapping has to be carried out. To enable this photo-rendering step, we took colour photos with a Sony digital camera. The steps necessary to arrive at the final textured representation are:

- registration of each scan into a general point model
- georeferencing of this general model in a selected reference system
- creation of a surface model through mesh generation.

Georeferencing requires mounting of reflecting targets on walls. These targets are also necessary to check the metric quality of the point model. We evaluated the functionality of terrestrial laser scanners and processing software by performing a field test over the south front of the Basilica. First, the points were processed with Cyclone, software by Cyra Technologies shipped by Leica Geosystems. The registration of the single cloud in the final point model was performed, with good results, according to three methods: target-based, point feature-based and combined targets and point features. Only RMSE values lower than one centimetre were accepted.

Tools

Surface model generation and photo-rendering were carried out with 'reconstructor'. This professional package for managing range and photogrammetric data is distributed by Inn. Tec., Brescia (Italy) and developed in Ispra (Italy) by EU-JRC (Joint Research Centre of European Commission). The software carries out automatic connection of scans for point model generation, georeferencing, mesh production and optimisation, and texture mapping. Raster data like RGB images can be draped (point to point) over the clouds or over the triangular elements describing a solid model. The 'surveyor' package allows geometric measurements on the model, perspective views, hedge detection and definition. It provides also automatically sections from clouds or triangulated model, generates Roth-photos and compares two subsequent models of the same object for evaluating metric differences.

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Further Reading

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