POLITECNICO DI TORINO
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***Honors theses***

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**Solid image extraction from LIDAR point clouds. Application to architectural heritage**

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Laser scanning is a surveying technique currently used in a large number of applications, spanning from reverse engineering to cultural heritage documentation. The scanner measures a large number of tridimensional points on the surveyed object surface, describing it as a point cloud. To survey a complex object is usually necessary a number of different scans (or point clouds), made by millions of points that require to be post processed to filter out the measurement noise, to colorize the points and finally to align the scans in a common reference system. The surface modeling can also be required to produce tridimensional models, orthogonal projections or sections.

In architectural surveying it is necessary to extract orthogonal projections from the tridimensional model, plans, elevations and cross sections. In my thesis work, I studied the workflow of architectural drawings production from laser scans. Because of the surface modeling take a considerable amount of time (about the 30% of the total workflow) and a huge computational load, I studied how to extract the architectural drawings directly from point clouds, avoiding the surface modeling step. Moreover the surface modeling generally produce a loss of the finest details, that in this way can be retained.

In a first step, I studied the accuracy of laser scan observations, as function of the distance between the scanner and the surface and of the incidence angle of the laser beam on the surface itself. It has been observed that also the surface reflectivity has a non negligible impact on accuracy. It has been necessary to understand the accuracy and scan point density required by the application to architectural surveying.

In a second step I worked on the definition of the geometric procedures to extract the orthogonal projections of point clouds. The products of these projections however are not traditional drawings, but are in the form of solid images. The solid image (or 3D image) is a concept introduced in photogrammetry by Prof. S. Dequal in 2003. While in a traditional bi-dimensional digital color image, consisting in a 3 band pixel-matrix, the RGB information is stored, in a 3D image a fourth band is required to store the third dimension, for example the distance from the section plane. I used also a fifth band to store the surface reflectivity measured by the laser scanner.

The studied procedures have been applied to the case study of the San Pietro church in Portovenere, integrating the architectural surveying with an existing bathymetric and coastal surveying, realized by Istituto Idrografico della Marina Militare and Codevintec in 2006. The survey consists of 15 scans in the interior and of 20 scans in the exterior, for a total of 743 millions of scanned points. The survey campaign required two days, while the post processing of the scanned points has required 3-4 weeks to filter and colorize the data, to align the point clouds and to produce the solid images of plans, elevations, cross sections and projection of the vaults. Finally I produced a video of the scanned point cloud, representing the San Pietro promontory, that is intended to be used by the Comune di Portovenere for touristic promotion and divulgation purposes.

The high level of automation of the laser scan technology reduces the surveying time and costs, providing results and products that are useful not only for the specialists but also for a wider non specialized public.

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