A SURVEY OF "THE SALA DEGLI STUCCHI", AN ORNATE BAROQUE HALL.

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ABSTRACT

The "Sala degli stucchi" is a heavely decorated baroque hall, as the name itself suggests, in the Royal Palace in Turin. The present work describes a survey of this historic object. This work is a part of a wider project on the study of Architectural Patrimony carried out for the Piedmont Cultural Heritage Safeguard and Management Office. It is a chance to test the modern survey techniques of photogrammetry and LIDAR. This article focuses on the integrated use of digital photogrammetry and LIDAR in a demanding environment, in order to take best advantages of both techniques. Different survey products were obtained, ranging from 3D and photogrammetric models to orthophotos. The adopted techniques, the problems and difficulties that arose during the survey process are shown in the paper. The obtained and stored results were also used to make a complete 3D model of the whole hall.

1. INTRODUCTION

The "Sala degli stucchi" is a baroque hall inside of the Royal Palace, an important historical building in Turin (fig. 1).
In the past it belonged to the Italian Royal Family.
The paper describes a survey of the hall, and focuses on the integrated use of two modern survey techniques: digital photogrammetry and LIDAR, paying particular attention to the problems that arose during the survey /representation process.
The information acquired during the survey was used to make integrated survey products: photogrammetric models, and orthophotos. It was also possible to use LIDAR acquisitions to generate a complete 3D model of the "Sala degli stucchi".
A realistic 3D model of the surveyed object can be an important tool for a correct documentation of cultural heritage buildings; Its exploration could let the user obtain detailed data about shapes and colours of various degrees, depending on the level of inquiry. An integrated use of different survey technologies allow to achieve this goal, adopting a unique reference site system.

Fig. 1 – The Royal Palace in Turin

2. THE SURVEYED OBJECT

2.1 The Royal Palace and the "Sala degli stucchi".

Turin is a city of great historical importance and artistic significance.
In the past it was the residence of the Savoy Royal Family while Turin was the capital of Italy. The effects of this historical period are still visible in the architecture of the city and surely influenced the art and the engineering choices.
This paper describes a survey experience concerning a historical monument located in the heart of the city of Turin: the Royal Palace.
The decoration of the halls and the style of furniture, made by artists and craftsmen from many different countries, are an artistic treasure. They were planed to celebrate the King's qualities.
The "Sala degli stucchi" is a hall located in the west wing of the Palace. It is placed in the centre of this wing on the first floor just above the main entrance.
The design of the hall is classical: a typical rectangular structure with a high ceiling and wooden floor. There are two stately windows in the longer side and a decorated fireplace over the opposite wall (fig. 2).
In this side of the palace there are still some offices of the Regione Piemonte: the hall is used as a conference hall
The survey work enters is part of a general survey of these building belonging to the Region and regards the interior of this hall. Particular attention was paid to the study of the interesting decoration of the walls and the ceiling.
The hall in fact is magnificently decorated, as the name itself suggests, in a baroque style. A greater number of stucco works cover the walls and part of the ceiling where allegorical frescos adorn and cover the whole surface.

3. THE SURVEY TECHNIQUES

At first, an inspection of the hall was carried out in order to plan the survey. It was decided to use digital photogrammetry together with LIDAR for the acquiring of the walls and ceiling data (Ullrich A., 2004).

In fact, the LIDAR technique can provides high productivity in creating a Dense Digital Surface Model (DDSM). It allows "in situ" the surveying time to be reduced but it slightly increases the processing time. By using an accurate planning and some defined procedures, it is however possible to reduce the time necessary for the batch processing.
Digital photogrammetry methodologies and LIDAR techniques, in recent years have undergone an important technological progress; furthermore their integrated use allows complete and accurate survey products to be easily created.

3.1 Digital photogrammetry

Photogrammetry is a well known and consolidated technique; with the development of computers, it has become "digital", both as far as site operations and office operations (digital plotters, cameras, etc.) are concerned.
As a result, photogrammetry has become a very quick technique: *in situ,* there is the chance of immediately viewing the taken photos, and of seeing whether they have turned out as planned. Thus it is possible to immediately pass to *in office* operations, because there is no waste of time due to development and digitalisation process. Radiometry can be adjusted via software, and digital images create no long-term deformation problems, moreover, the internal orientation process is automatic, and complex computations are possible.

3.2 The LIDAR technique

LIDAR (LIght Detection And Ranging.) is a relatively new technology; a great deal of effort by both the University and industry has been made to test its applications in different contexts. A laser scanning instrument can be considered as a high automation reflectorless total station; by means of a laser based measurement of distance and accurate angular movement, the target object is sampled in a regular mesh of 3D points.
The operator only selects the portion of the object he wishes to acquire and the density of the points he desires in the scan. Once these initial values have been choosen, the acquisition is completely automatic.
Today the laser scanners are widely used in the field of architectural, archaeological and environmental surveying because of their practicality and flexibility.
One of the most interesting applications of such an instrument is the fast and economic way of creating a DDSM; if other techniques (e.g. total stations, photogrammetry) where to be used it would be an incredibly time-consuming process. Most laser scanner machines can nowadays also have a digital camera mounted on them: in this way, it is possible to immediately assign RGB information to each point.

4. THE SURVEY METHODOLOGIES

Several ad hoc instruments were used to survey the object. A Riegl LMS-Z420i "time of flight" laser scanner was used: this meant it was also possible to record information on the reflectivity of the materials. In order to assign RGB information to each stored point this machine was equipped with a Nikon D1x camera digital camera (Riegl J, 2003).
In this way the position of the camera is a known position in the laser acquisitions. In fact the position of the centre of the camera is known with regards to the centre of the laser instrument.
The hall was scanned using the LMS-Z420i laser scanner, with a scan resolution of 0.030 degrees.
The work was planned dividing the hall into nine scanning regions. In fact the hall presents several particular decorations which would be hid in a single scan position. Moreover, there is a huge chandelier at the centre of the ceiling which in the laser acquisition hides parts of the opposite sides of the hall. Figure 2 shows the planned scan positions. Two scans were made for the shorter sides of the hall, three scans were planed for the other ones. In addition to these, a scan position was set up to survey the upper part of the hall. The laser was place in the middle of the floor and several acquisitions were made from this position to obtain a complete survey of the ceiling.
Some reference markers were attached to the surveying objects to put together the different scans (the marker surfaces are covered in a special glue that does not damage the hall decorations). The markers were about 3 x 3 centimetres each. The coordinates of the markers were determined using a Topcon 8001A total station. In this way the data acquired by the different scans could be aligned to create a single point could of the hall.

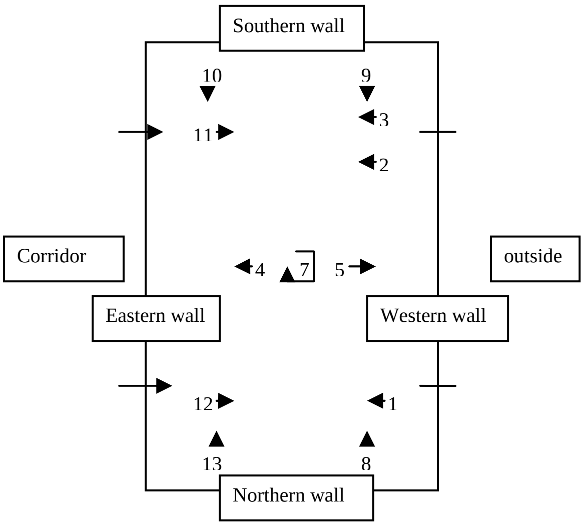

Fig. 2 – The scan positions used to survey the hall.

As the laser scanners randomly acquire a dense set of points the result of the laser survey is a very dense point cloud acquired in a completely arbitrary way, except for the parameters set by the operator. Therefore particular attention must be paid during the analysis, the processing and the modelling phases of the laser scanner data. This means that it is necessary to manage this data in a critical way.
The laser scanner data treatment consists of the pre-treatment (or preliminary treatment) of the laser data and the solid modelling of the point cloud.
The "preliminary treatment" is carried out directly on the point cloud. This operation consist of different phases such as the data filtering (noise reduction), the point clouds registration and georeferencing operations.
As the data acquired by laser scanner devices always has noises which are smaller than the tolerance of the used instruments, filtering is a fundamental operation in the preliminary treatment of the terrestrial laser data.

The noise, due to the divergence of the laser beam, do not allow a correct interpretation of the object details. In order to obtain a “noise free” model of the object, it is necessary to use specific algorithms that are able to reduce or eliminate, as much as possible, the acquisition errors that can be found in the point clouds.
Using the LSR 2004 filtering (part of the LSR 2004, Laser Scanner Registration, that is a software package for the preliminary laser scanner data treatment that has been developed at the Politecnico di Torino) (Bornaz L, 2004) a complex “noise free” point cloud without outliers, gross and systematic errors was obtained.
The surveyed object has a complex shape and a single scan was not sufficient to record the whole object. Each scan acquired during the survey process has is own reference system. The reconstruction of the 3D model of the surveyed object requires the registration of the scans in a unique (local or general) reference system. This operation was realized using The LSR 2004 automatic register unit.

5. THE SURVEY PRODUCTS

5.1 The 3D model

When the previously mentioned instruments (Riegl LMS Z420i Laser Scanner and Nikon D1x camera) are used, the data (point clouds and images) are stored in a single reference frame.
A navigable 3D model can be easily generated. This kind of model is an extremely topical and useful tool to make a representation of a complex object. It has a remarkable impact on the public and it is suitable, for example, to show the 3D products in a show room. However, an untrained user could find this representation not so easy to deal with.
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. However, some information could be lost when this kind of data is processed.
By starting from the 3D model, it is possible to realize a section with a horizontal and vertical plane in the different zones of interest. To do this it is necessary to reduce the amount of processing data before the data is resampled. Without the
previously explained operation the creation of a section from the whole point cloud takes too much time because it uses redundant data.

5.2 The orthophotos

The stored data were handled to create another tool: the orthophoto. By using the orthophoto as a metric support it is possible to carry out in deep analysis in a better a simpler way.
The orthophotos are digital images where the distortions due to the acquisition perspective are corrected. The geometry of the survey object is obtained by orthogonal projection of each pixel of a digital image onto the 3D surface model (DDSM) acquired by the Riegl instrument.
In this way, the original perspective representation is transformed into an equivalent metrically correct image. Unfortunately the radiometry of the image decays during the resampling process.
As an orthophoto is a metrically correct photographic representation of the surveyed object, it allow to measure distances (in a known scale factor) and read coordinates directly on it. Therefore, it is possible to directly measure details from the orthophoto where 2D metrical information is stored.
An orthophoto can be a good quality survey product where the object is represented as it really appears in a RGB image, without using codes or symbology as in a topographic survey. This means that an othophoto is an easy and user friendly survey product to understand even by an unskilled user.
The orthophoto could also be used as a support to obtain 2D vector elements of the surveyed object and in case as a base for a GIS. In this way in the future orthophotos can be used as a tool for the analysis of historical buildings made by different experts: vector elements could be created and alphanumeric data could be associated to them.
In fact dealing with cultural heritage surveying it is important to represent in a geometric base materials, colours, decorations, physical and chemical decay and other phenomena.
As the othophoto provides geometrical precision and it is rich in information, it represents a more popular tool than the 3D model among users.

Fig. 3 – The orthophoto of the eastern wall.

Fig. 4 – The orthophoto of the southern wall.

In this particular case, the orthophoto of the hall was made

Fig. 5 – The orthophoto of the western wall.

using the acquired data. An orthophoto was produced for the "Sala degli stucchi" wall by wall while another one was produced just for the ceiling.
The images shown the orthophotos of the eastern wall (fig. 3), the southern wall (fig. 4), the western wall (fig. 5), the norther wall (fig. 6) and of the ceiling (fig. 7).
Some problems arose during the creation of the orthophotos.

Fig. 6 – The orthophoto of the northern wall.

The main problem was produced by the irregular illumination of the hall: two windows are present in the hall and the sun passes through these windows and illuminates the inside of the hall in an irregular way.

6. CONCLUSIONS

In order to obtain a correct representation of complex architectural objects it is necessary to plan specific survey and representation techniques.
This study case shows that the integrated use of LIDAR and digital photogrammetry allows 3D metrical models of a complex architectonical object such as the "Sala degli stucchi" to be produced in an acceptable time and in an quite automatic way.
The 3D model is a correct and complete representation of the examined architectural object, but it is a no so easy tool to deal with by unskilled user.
A 2D representation, that can be obtained through the creation of the orthophoto, is a useful and easier way of elaborating metrical data also by untrained users. In fact, using orthophotos, it is possible to measure 2D elements, obtain 2D vector elements and carry out different analysis.

Fig. 7 – The orthophoto of the ceiling.

A future development of this research regards the realisation of the solid image using the same acquired data. The solid image lets the user access and manage 3D data simply by viewing a 2D monoscopic image; it adds correct 3D metric information to simple photos, so that information is much easier to access by users.

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