Cultural Heritage Surveying: The Experiences Of The Photogrammetry Laboratory Of The Politecnico Di Bary In Summer School 2011

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Abstract. This paper reports the experiences of the second edition of an international, educational programme named "Summer School 2011". It was held by the Laboratory of Architectonic Photogrammetry of the Politecnico di Bari Institute, in Italy. The main goals were to spread the importance of cultural heritage preservation, and to emphasize the potential of application of LASER scanning techniques to the surveying of cultural heritage sites. It involved five professors and seventeen professionals and students from different areas from Italy, Brazil, Turquey, Venezuela, and Romania. It had an itinerant programme, from the city of Noci, to the community of Laterza, and the cities of Lecce and Bríndisi. The methodology adopted was: (a) technical presentations; (b) the "on-site" presentations and descriptions of the cultural and historical highlights of the objects of interest, and; (c) the demonstrations and practice of LASER scanning surveying. This paper also reports the results of the surveying at The "*Cantina Spagnola*" cavern, and The "*Tiempio di S. Giovanni al Sepolcro*" in Bríndisi, Italy. The main conclusion was the spreading of the thinking about cultural heritage inventory techniques, relevant for maintaining the historical records of a country. The Laboratory of photogrammetry of The Rio de Janeiro State University, in Brazil, has started a joint technical project with the Politecnico di Bari Institute toward the surveying of two historical sites in the State of Rio de Janeiro: (a) the ruins of a city, "São João Marcos", and; (b) the "*Palácio Guanabara*". This paper includes the results of that international cooperation.

Key words: Architectural Photogrammetry, Archaeology, Cultural Heritage, LIDAR, Surveying.

1. Introduction

1.1 Motivation

In 2010 the Laboratory of Architectonic Photogrammetry of the Politecnico di Bari Institute, in Italy, developed an international, short-term educational programme named "Scuola Estiva" or Summer School. The main goals of that educational programme were: (a) to develop the thinking about the importance of cultural heritage preservation, and; (b) to emphasize the potential of application of close-range digital photogrammetry, and remote sensing techniques to the surveying of cultural heritage sites. Those techniques encompass LASER scanning, close-range photogrammetry, termography, and ground-penetrating RADAR.

1.2 Goals and Overview

This paper aims to presenting the main results of the second edition of Summer School, named "*Summer School 2011*."

The written work is organized into 7 sections, including this introductory part. Section 2 describes the technical programme of Summer School 2011; Section 3 presents the methodology used in the surveying, including the description of the sites chosen. Section 4 summarizes the results of the surveying and post-processing work; Section 5 concludes this paper. The references and acknowledgements are also presented in Sections 6 and 7, respectively.

2. The summer school programme

2.1 Description and focuses

The scope of this second edition of Summer School educational programme was: "*New Technology and Cultural Heritage Protection: from Remote Sensing to Architectonic Survey*". In such a context, the focuses of this short-term instructional programme were: (a) to develop the thinking about the importance of cultural heritage preservation, and; (b) to emphasize the potential of application of state-of-the-art techniques and equipments to the surveying of cultural heritage sites. This short-term educational programme was held from September 5th till September 10th,2011. It had an itinerant schedule, starting from the city of Noci, located in Puglia, Southern Italy, and going down into Puglia province, by visiting the community of Laterza, and the cities of Lecce and Bríndisi.

The Summer School involved two invited teachers, one from Brazil and other from Romania; ten Italian teachers and technicians, from both public and private support organizations; and seventeen professionals and students not only form Italy (8), but also from Brazil (7), Turkey (2), Venezuela (2), and Romania (3). The technical backgrounds of the participants were the areas of remote sensing, architecture, digital photogrammetry, civil engineering, and surveying.

2.2 The Cultural Heritage Recording

There are many possibilities for recording cultural heritage objects. Close-range photogrammetry techniques, for instance, are commonly used. This technique uses both film and digital, small and medium-format cameras. LASER-scanning devices are being developed along the time, are becoming more popular, and are getting higher accuracies and lower scanning times along the time. Termography is also a very promising field of research for cultural heritage diagnosis and recording. Close-range or ground-penetrating RADAR scanners and similar devices are useful for underground searching for archaeological and historical signs and sites. Those techniques above mentioned can be used together with GNSS and other topographic devices to give georeference for cultural and historical sites and objects. Furthermore, those surveying and recording techniques are non-invasive. This characteristic makes a difference when compared with invasive techniques. This characteristic increases the potential of applications of non-invasive techniques for historical and cultural heritage surveying and recording. The key concept, however, is not only centred the use of those devices and techniques but also in the thinking about the necessity of recording for preservation of the cultural heritage of a society or Nation.

2.3 The First Edition of Summer School

The *Scuola Estiva* educational programme had its first edition in 2010, by an initiative of the Laboratory of Architectonic Photogrammetry of the Politecnico di Bari, and by the

financial support of both public and private Italian institutions. In its first edition, a Brazilian, undergraduate student in Cartographic Engineering attended to that programme. As a result of his participation in that educational programme, he is finishing his final project on an historical site in the South-western region of the State of Rio de Janeiro, in Brazil. This site is named "The São João Marcos ruins". That site has its historical relevance due to the XVIII century, the colonial period of Brazil, and remaining as an important city in that epoch, until the construction of a dam for water service for the city of Rio de Janeiro. The point that needs to be stressed is the fact that the Brazilian student learned not only how to recording an historical site, but also the thinking about the importance of cultural and historical heritage surveying for preservation. This paper also includes one of his results.

3. Methodology

The general approach adopted for developing the technical and cultural programme of Summer School 2011 was to divide the programme into three main parts: (a) a theoretical part held by technical presentations; (b) "on-site" presentations and descriptions of the cultural and historical highlights of the objects of interest, and; (c) demonstrations and controlled practice of recording and surveying by close-range photogrammetry, LASER scanning, GNSS georeferencing, and ground-penetrating RADAR

3.1 Description of the Historical Sites Chosen

3.1.1 The city of Laterza

The City of Laterza is located in the province of Puglia, Southern Italy. The city is characterized by a considerable rocky area between the sanctuary of Mater Domini and the ravine. The deep ravine Laterza is 200 meters, 500 meters wide and 12 Km long. The ravine Laterza, located approximately at latitude 40^0 38' N and longitude 16^0 48' E is at the center of the district of ravines (60 ravines surveyed between Matera and Grottaglie), the ravine Laterza was formed millions of years ago and reveals the human presence, as attested by archaeological findings from as early as the eleventh century B.C.. The human settlement of this area is evident from the testimonies of underground funerary furnishings and tools of flint and bone found in this area. These elements demonstrate the presence of a population of Balkan origin. The population settled in these places between the third and second millennium BC, giving rise to the Eneolithic civilization of Laterza. Behind the ravine Laterza were surveyed 30 rock churches carved into the tufa rock, located mainly along the blades.

3.1.2 The Cantina Spagnola

The Cantina Spagnola in Laterza known by the common name of "the cave of Mammuécce" is one of the most significant settlements of the city of Laterza, for the uniqueness of its kind, formed by the variety of its decorations and sculptures. his underground has undergone several changes of intended use as is apparent from a reading of architectural sites: from its use as a church, then as a meeting place of the "nobility Laertina" use as a place of grain storage and recovery of sheep, and finally as a millstone for the production of oil. The plan of the building is irregular with uneven walls, but all painted. Three steps allow the entrance to the hypogeo, which is not dug over a unit time and that can be divided into three rooms.

The first environment that is very simple has the presence of two wells of irregular shape and two meters deep for the storage of grain and wine. In the left side of this small room is a wall of "tompagno", performed to divide the cave from another adjoining room. Arouse great attention a carved mask (once there were two masks, one was stolen), the mask is formed in

low relief and is an expression of apotropaic masks used on the entrance gates of the residences feature with merely superstitious. A large arch, composed of blocks of tufa, introduces and reinforces the turn in the other room that looks quite irregular. In fact there is a difference at the floor and ceiling, most likely because of different times of the excavation. The left wall, with the presence of a niche, and the remains of an ancient altar and a seat, is the clearest evidence of the use of the cave as a church, because the altar is oriented to the east according to the canons of Christian churches. (Bongermino, 1993). The third room, placed in the bottom of the cave, is bounded by a partition, painted with two gates built into the original excavation (now there are three openings, the centre opened in recent times most likely to allow the animal shelter).On the left side of this partition is the sculpture in high relief with the inscription "CAVALLO DI RISPETTO ", horse parts, a factor that has made people believe that to some that the cave was used as a place to change horses. Of particular attention to the decoration within this environment represented by a dozen priests vestments and objects of worship, these were popular in the decoration of ceramics of Laterza.

3.1.3 The Tiempio di S. Giovanni al Sepolcro

The church of *S. Giovanni al Sepolcro* is located in the city of Brindisi, southern Italy. It is a building of Romanesque style and was built around the XI century. Although tradition has it that the building was built by Boemondo, but the most accepted hypothesis that the building connected to the "*Ordine cavalleresco dei Templari*".

The medieval city of Brindisi is a major port for boarding in the Holy Land, so the presence of temple architecture is justified in this sense as a place to welcome the pilgrims and the Knights Templar themselves from Northern Europe reached from the port Brindisi holy places. The temple of "San Giovanni al Sepolcro" is a circular building. The plan interior stirrup-shape formed by two concentric circles of columns reminiscent of the Holy Sepulchre of Jerusalem, is supported by eight columns from the stem smooth with fine capitals with acanthus leaves alternating with cubic capitals, the original vaulted roof has been replaced by the current one in wood.

Frescoes on the walls with images of saints dating from the twelfth and fifteenth centuries, including the "Deposition" dated to the early '300. The main portal, with a marble architrave surmounted by a spire porch is supported by two columns resting on lions. The sculptures are reminiscent of the medieval model of Bestiarium among the themes represented: the Nereid, the fight between bull and lion, the griffin, the deer are decorative elements used in all Mediterranean areas since remote antiquity, and from there subsequently exported throughout Europe.

3.1.4 The São João Marcos Ruins (Brazil)

The ruins of the archaeological of São João Marcos are located in the south-western part of the State of Rio de Janeiro, Brazil, in the county of Rio Claro, approximately at latitude 22^0 48' S and longitude 44^0 02' W. The major part of the ruins are the former foundations of buildings, bridges, roads, and remaining of the main church, The city was constructed in 1739, around a chapel built in the honour of São João Marcos. The city has prospered by the time of its construction mainly due to coffee plantation and market. In fact, according to historical records, São João Marcos was one of the most rich and populated cities in the Rio de Janeiro State, by the colonial period. (Serra, 2011). With the ending of the coffee plantation and market the city of São João Marcos completely lost its economical importance. In 1938 it was attached to the city of Rio Claro, and two years later, it was destroyed by a presidential decree. Theoretically, the order for destroying the city of São João Marcos was justified by the construction of the dam of Ribeirão das Lajes, for water supplying for the city of Rio de

Janeiro. After dam filling, however, only a small part of the ruins was flood. This fact has permitted the foundation of the first Brazilian archaeological urban park.

3.1.5 The *Palácio Guanabara* (Brazil)

This beautiful construction was built in the city of Rio de Janeiro in 1853 and was formerly used as a private home until 1860, when it was purchased by the Brazilian Imperial family. The building suffered its first restoration in 1864, for hosting the Princess Isabel. In 1908 the Brazilian military republican government took it and gave its actual name of "*Palácio Guanabara*". In 1960 The *Palácio Guanabra* became the headquarters of the Rio de Janeiro State government. In 2009 the palace had its domes, roofs, and gardens completely rebuilt, aimed to recovering its original appearance, and the colour of its façades. (Araújo, 2012).

3.2 Equipment Used

3.2.1 LASER Scanners

Generally speaking LASER scanner equipments consist in a LASER beam assembled with optical, mechanical, and electronic components and parts. The major parts of LASER-scanners are: (a) a LASER-ranging device, which range varies from 2.0m to 1,400m or more; (b) a scanning mechanism; (c) hardware components for measuring and recording main and auxiliary data, like inclination sensors, laser plummet, and compass, and; (d) software components for configuration of data acquisition and for data post-processing. Optionally LASER scanners devices can be integrated to a GNSS receiver and or antenna, and to a digital, small-format photographic camera. LASER scanners are becoming more common in many surveying and recording applications. In fact, there are many possibilities and prices for terrestrial, industrial or close-range LASER scanner devices for recording cultural heritage objects. Table 1 below shows a summarized fact sheet about the LASER scanners used in Summer School 2011:

Table 1. Fact Sheet about the LASER Scanners Used in Summer School 2011.

Equipment	Facts
RIEGL VZ1000	• Maximum distance of operation: 1,400 meters; • Has inclination sensors, a laser plummet, and a compass; • Can be integrated to a GNSS receiver with antenna; • Can be integrated to a digital, small-format photographic camera.
FARO Focus3D	• Maximum distance of operation: 120 meters; • Has an automated leveling system; • Has a digital, small-format photographic camera of 70 Mpixels integrated to the system.
TRIMBLE GS200	• Maximum distance of operation: 350 meters; • Has a digital, small-format photographic camera integrated to the system.

3.2.2 Thermal Imaging Camera

Thermal, infra-red cameras show temperature differences in structures and objects. For instance, the thermal measurement of building façades and walls is based upon temperature differences of the interior of the building, the outside temperature, and the temperatures of the façades. Thermal imaging cameras help preserving cultural heritage, by measuring the temperatures inside and in the structure of ruins and ancient façades, thus permitting to detect water infiltration and other defects.

4. RESULTS

4.1 The Cantina Spagnola Surveying

Figure 1 below illustrates one of the practical results achieved in the Summer School 2001. It is the result of a 3D LASER scanning, where one can clearly see some historical paintings in one of the walls inside that cave. This surveying was performed by a RIEGL-VZ1000 LASER scanner. The recording time interval of the LASER profiling was about **one hour for four shooting stations and point clouds acquired consist of approximately 23 million points.**

Figure 1. Left: Detail of the rendering of a photographic image over a LASER Scanning Surveying of a wall inside the *Cantina Spagnola.* Right: A Panoramic photography of the *Cantina Spagnola* in Laterza, Italy. (*Courtesy of The MicroGeo Company*)

4.2 The Tiempio di S. Giovanni al Sepolcro Surveying

Figure 2 illustrates the Surveying of the entrance of the *Tiempio di S. Giovanni al Sepolcro,* in Bríndizi, Italy, and an overview of a rendering of the photographic images over the 3D LASER scanning. This surveying was also performed by a RIEGL-VZ1000 LASER scanner. The post processing software used was the RIEGL Riscan Pro.

Figure 2. Left: The LASER Scanning Surveying of the *Tiempio di S. Giovanni al Sepolcro,* in Bríndizi, Italy (*Courtesy of The MicroGeo company*) Right: A rendering of photographic pictures over the 3D LASER Scanning Surveying of the *Tiempio di S. Giovanni al Seplocro,* in Bríndizi, Italy. (*Courtesy of The MicroGeo Company*)

4.3 The São João Marcos Ruins Surveying

The surveying work of the city of São João was concentrated on the ruins of its main church. We used the Faro Focus 3D LASER Scanner for that purpose.

We performed 13 LASER scanner positions around the ruins of the main church. Two scanning were performed in each station: one with low precision and high horizontal angle,

and the other with high precision and low horizontal angle. The clouds of 3D points were post-processed, merged, and visualized by the SCENE post-processing and visualization software package. Figure 3 shows a photography of the ruins of the main church and the cloud of points created by the survey. One can notice in the upper-left part of this picture one of the stations of the LASER scanner used.

Figure 3 – Left: The ruins of the main church of the city of São João Marcos, located in the State of Rio de Janeiro, in Brazil. Right: Cloud of points of the ruins in São João Marcos.

4.4 The Palácio Guanabara Surveying

Figure 4 depicts an oblique, photographic colour view of the main façade of the *Palácio Guanabara* and the results of the imaging with the using The FLIR 660 camera. It is worth mentioning that this picture was taken in February, 2012, rather after the conclusion of the restoration work of the building, in 2011.

The surveying work of the *Palácio Guanabara* focuses not only on the LASER scanning of the main façade of that building, but also in the using a thermal infra-red imaging camera. One can notice the colour of one the main dome (in red), indicating the difference in temperature of this part of the building, if compared with the walls, for instance. This image permits the analyst to conclude the differences between the material used in the dome (a metallic cover structure) and in the walls, that have a green-to-blue colour aspect, thus indicating lower temperatures. For example, in the pointing cross depicted in the upper-left part of the thermal image, one have the temperature of 35.8 ^{0}C.

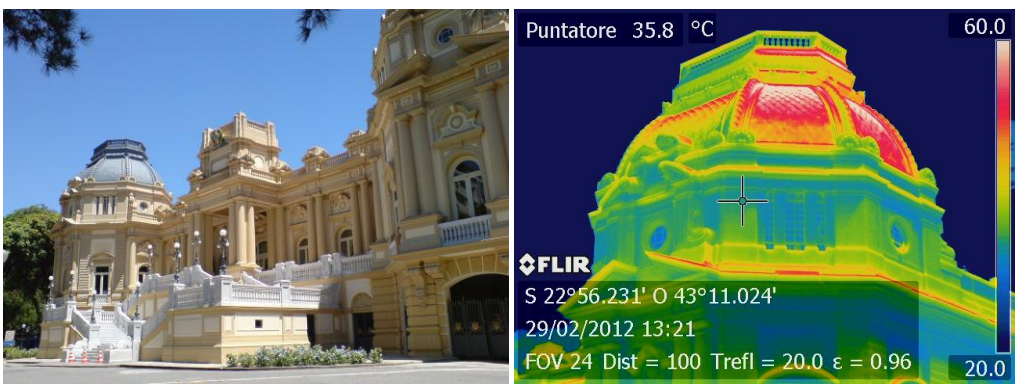

Figure 4 – Left: An oblique, close-range photographic image of one of the main façades of the *Palácio Guanabra*, the head-quarters of the Government of the State of Rio de Janeiro, in Brazil. Right: An image taken by the FLIR 660 thermal infra-red imaging camera of one of the domes of the *Palácio Guanabara.*

5. Conclusion

The combination of LASER scanner, digital photographic and/or infra-red thermal cameras, and GNSS data can provide photo-realistic 3D reconstruction of objects and scenes, thus leading to an effective cost/benefit recording and surveying technique for cultural and historical heritage inventories. These techniques could be extended to many industrial and civil engineering applications in benefit of the society in general.

The most relevant conclusion of this multicultural, international programme Summer School 2011 was to spreading the thinking about cultural heritage inventory techniques, sought to be fundamental for maintaining the historical records of a country.

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