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THROUGH THE EYE OF THE 3D LASER SCANNER: THE DIGITAL COLORS OF THE HISTORIC CITY OF ENNA

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ABSTRACT

The study of historic cities is nowadays enriched with new knowledge and tools for “digital storytelling”. The design of the city, previously made by simple techniques, is now replaced by sequences of images taken by laser that *narrate* the urban environment. Sequences of lights and colored point clouds redesign the town, portraying it in all of its complexity, even chromatic, and permeating its materiality. The operator is not ousted from this process, indeed; every action is mediated by his intuition and ability. The 3D laser scanner is to be considered as the pencil of digital era and a precious resource for the acquisition of geometric/morphological data. The color of clouds is in fact digital index of physicochemical properties of materials: color changes represent the material characteristics of building components. The digital color scanning is then an investigative instrument, useful for the conservation of historic towns. This paper documents research activities in this field.

Keywords: Architecture , Cultural heritage, Laser scanning, Surveying.

1. INTRODUCTION

The only way to know a town is *living* it, going around, losing yourself in it and between its people, breathing its intimate nature during the day, experiencing its parts in order to grasp the different colors offered from continuous light changes due to the sun movements. The designer is a traveler who likes to let himself go in the cities in order to catch emotions and feelings, making them immutable, stopping the moment through a sign (exactly the drawing). This paper intends to be a chronicle of a tour in the town of Enna, for the purposes of which, the old traveler’s notebook, has been replaced by the “eye” of laser scanner. Walking the streets of the old city with this instrument, has allowed the authors to capture its soul, through the point clouds acquired by a colored digital sensor. As well as the old designers discovered the most suggestive sites for representing their “city corner”, in this work, the authors tried to find out, the most hidden and charming places in the old town of Enna. The point clouds, like a drawing, have a great documentation value, as they can “freeze” an area that certainly will change over time. Like a drawing of an ancient

landscape, laser scans are important evidences that would guarantee, in the future, knowledge and understanding of places that in a few years could be very different, or no longer exist. As opposed to a drawing, the point clouds, are not a plain projection of a real object, but they represent a virtual model of reality. If a drawing can be only observed from the center of projection from which the designer has chosen to represent the scene, the point cloud can instead be “questioned” from several points of view; from them it is actually possible to obtain more representations of the town, simply by changing, from time to time, the observation point.

2. THE TOWN OF ENNA: ITS MONUMENTS AND SIGHTS

The city of Enna, is still relatively little known and studied if compared with the extent of its historical and artistic treasures. City of the *Siculi*, an ancient Sicilian tribe, and a centre of the pre-Hellenic cult of Demeter and Kore (Persephone), early came under Greek influence. After a brief period of Carthaginian rule (4th century BC) it passed to the Roman domination in which rose to a strategic role in Sicily. Taken by the Saracens in 859, it was elected as the new capital of the island and named Qasr Yânnah (Fort of John) until 1087, when the Normans captured the town. The city's name was then converted in the form of Castrogiovanni and so will remain until 1927 when it resumed the name of Enna. During the Norman conquest, Castrogiovanni became an important cultural and political center of the kingdom. In 1130 Roger II restored the ancient Sicanian fortress, now known as “Castle of Lombardy”. After the brief Angevin parenthesis, culminating in the Sicilian Vespers (1282) that lead to the Aragonese conquest of Sicily, Enna rose again. In this period, several monuments were restored and the city embellished. The Spanish and Borbonic domination, left its indelible mark in the urban architecture, by building some of the most significant monuments of the town, from a religious point of view. During this period, the city was enriched with churches and convents: in the 18th century, the so called at that time, Castrogiovanni boasted 133 churches, approximately one for every hundred inhabitants. Today we can count only 35 of them, roughly one every one thousand residents. The Cathedral is without doubt the most remarkable monument, built in the medieval period by the queen Eleonora, Frederick III's

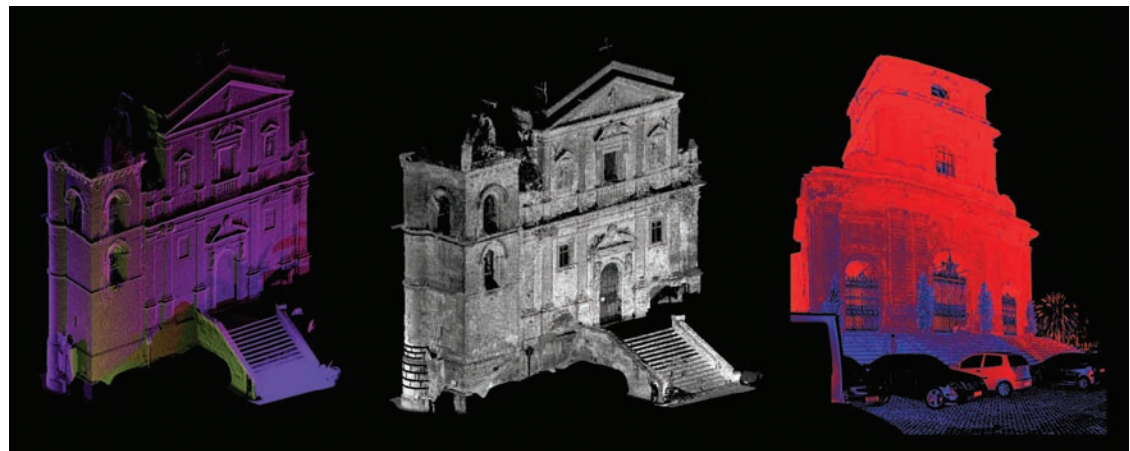


Fig 01
Color reflectance pictures: case studies applied to the Church of Enna

wife and, after the fire of 1446, many times renovated and restored, including in the 16th century when an imposing facade surmounted by a massive campanile was added (Garofalo [1]). However, other praiseworthy monuments and churches can be found among Enna's streets: the Church of Carmine (Chiesa del Carmine) dating from 18th century, the Church of Santa Maria la Donna Nuova, whose the first nucleus presumably dates from the early 12th century, or even the Church of St. John (Chiesa di San Giovanni), a fine example of Gothic lines with Arabic construction. Another rich testimony of the medieval architecture in Sicily are the towers, initially components of the impressive fortification system of Enna, latter incorporates into churches as belfries, as evidenced by Boscarino [2]. This is the case for the Torre del Carmine, characterized by a strange semi-cylindrical lateral protuberance or even for that of St. Thomas (San Tommaso), dating from the 15th century, composed of three orders and characterized by windows framed by an agile full-centered archivolt.

3. THE CITY TOUR WITH THE FARO® PHOTON 120

In the past, drawing from the "real" was the way to recreate and narrate the "spatial feeling" coming out from the observed city. The "sketch" was (and actually still is) almost like a picture purified from redundant information, designed to capture the essence of the space that faces the travelers. For the knowledge of places, survey drawing represented the moment immediately following the in-depth stage: the eidotype added to the spatial feeling, other information related to the metric data, the building materials, the architectural features of the sites observed. As a preliminary drawing, aiming to obtain a detailed scientific knowledge of the city observed, the eidotype was in fact essentially a basic document, a canvas on which to set and develop subsequent ideas (as results from Docci [3]). While the traditional technique required the realization of a considerable mass of drawings to document plans, elevations and other architectural details, starting from sketchbooks on which to note down measurements made (as well as the peculiarities of the buildings themselves and their state of conservation), the laser scanner has partially changed the way to approach the city.

Actually, the use of laser scanning technology unifies the two phases, the one related to the first knowledge and the other of subsequent elaboration; the digital sketch in fact guarantees metric survey and characterization of building materials of the city, at the same time, observed and measured, both in its forms and in its colors. Today, therefore, the eidotype elaboration of the object is less important than the survey planning, when not even necessary. As highlighted by Bartolucci [4], the correct choice of number and locations of scan stations, the definition of scans steps and the resolution of scans, are essential elements to obtain a global cloud, able to totally cover the architectures, limiting as much as possible hidden areas.

Especially for architectural elements characterized by a particularly complex geometry– like as for the monuments concerned by this paper- in this experience it has been necessary to take into consideration issues related to the alignment (in jargon, registration) of each scan and the need to contain the error in a tolerance limit of the same order of that of the measurement instrument (at the end of the registration, the scan of a masonry wall should overlap, not to give rise to two different surfaces, placed on plans staggered between them).

Walking in the streets of Enna with the laser scanner, to the traditional target now obsolete, it was been initially planned an eventual replacement by calibrated spheres, because they do not need to be arranged orthogonally to

the station; a simplification that in any case would not result in a significant decrease in measuring time, due to the need to always place the spheres near buildings and in places visible to more stations. The idea of “telling the city” needed to crossing it quickly (as quickly as a traveler-designer who draw a glimpse in a time of half an hour), to make several acquisitions in many different places; it has been therefore preferred a much simpler survey methodology, which does not need the use of a target nor the use of calibrated spheres, but benefits of the combined and integrated utilization of different software. For the digital acquisition of the monuments of Enna it has been used the new FARO® Laser Scanner Photon 120, based on the phase shift technology, much faster and more accurate than traditional time-of-flight instruments.

The survey projects have been developed by carrying out several scans, carried out at regular intervals along the sides of Churches of most interest (the Church of Carmine, the Church of Santa Maria la Donna Nuova, the Cathedral); “environmental 360° scans” have been conducted, so reducing *in situ* measurement time.

The speed of data acquisition and measurement given by this instrument is such as to make it more affordable (in terms of reduction of working time) the acquisition of all of the information and then the cleaning of unnecessary clouds of points, rather than to adjust the scanning angle and the resolution in any single scan. Measurements were then followed by refunds and processing of measured data: clouds were first filtered and then pre-aligned by the software FARO Scene®, and finally recorded with a new shape control algorithm by the software GEXEL JRC-3D Reconstructor (see Vassena [5]).

4. THE TALE OF A THOUSAND COLORS OF ENNA'S CHURCHES

The same places have been then reviewed several times, both in the morning and in the evening; with the sun low on the horizon or at its zenith, with colored lights of the night or with those of the urban environment. Left the laser scanner at home but still accompanied by his “digital eye”, the photo camera with it combined and calibrated (the new models of laser scanner does not incorporate it, but of them it is an additional accessory) the authors has retraced



Fig 02)
Examples of 3D decay map-
ping: the case study of the Ca-
thedral of Enna

the streets of downtown, acquiring images and colors in order to “chromatically cover” the same scans. The tour of Enna has dressed the clouds with images processed and filtered in order to highlight the degradation and alteration of materials on the monuments and the architectural elements of interest. The point clouds have been considered as “tailor made dresses” designed for the morning, noon or evening, obtained by mapping on the same scan images of the architecture, taken at different times of the day (including night images). They have in fact been used as a kind of “dresses”, colored by the thousands of colors of the images that can be mapped on them.

The colorimetric information is no longer a simple representation of the real, but it may be precious both in the diagnostic and monitoring phases. The usual practice is to represent in “false” colors the reflectance values resulting from the scans (famous is the change from green to red, performed by Leica scanners depending to temperature and reflectance changes); it is rather more unusual to process images using software that alter the RGB channels, the hue, the saturation and brightness, as evidenced by Carbonara [6] and Fiorani [7]. The mapping of several images properly treated with the filters of the most common image editing applications, allows returning situations barely visible or completely hidden from a visual examination. A filter which allows the *edge contrast* may highlight the masonry wall textures, the *noise & grain reduction filter* can hides the dark areas due to the unevenness of the plaster, allowing an easier reading of the geometry, or even the *render lighting effect filter* allows to detect –lighting them- only the areas of interest. The use of multilevel images, obtained with the *color filter overlapping*, from a picture taken from the same point of view each about an hour in the day, can return photometric light curve of light quantity (lighter because the areas are overexposed in the sun for several hours in the day; darker because underexposed, those shadow for longer).

Enna scans have also been dressed of maps of decay drawings: like as a picture, drawings can indeed be superimposed on scans, coloring them with information related to degradation's phenomena (parts removed, crusts and scales).



Fig 03
Filtered images to overlap to
the point cloud, Churches of
Enna

4. CONCLUSIONS

This paper, in describing the surveys tour carried out in the city of Enna, has intended to illustrate the enormous possibilities offered by laser scanning that are not confined to the mere acquisition of geometric and morphological data. Remarkable, indeed, are the results that can be obtained from a “creative mapping” in which the image, properly retouched and processed, become rich of features and information that go far beyond the simply documentation of the real. Actually, the mapping, carried out with these particular images, permits to select and highlight certain aspects, transforming the scans in a series of thematic 3D maps (i.e. accompanied by spatial data). Color plays a key role in this process because it allows to obtain several information on some aspects otherwise hidden from direct observation.

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