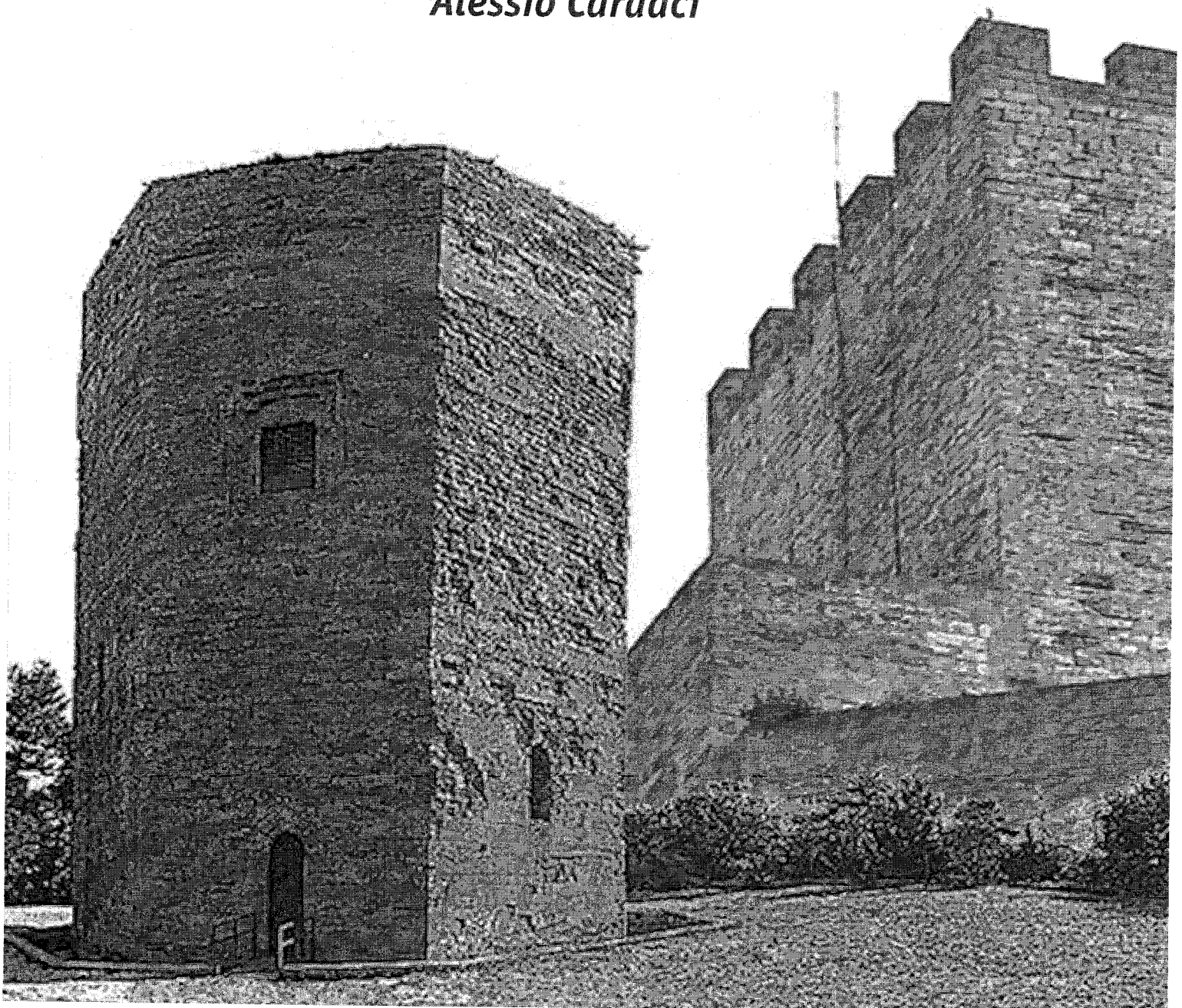


**BETWEEN TRADITION AND INNOVATION:
3D DOCUMENTATION OF
ENNA'S MONUMENTS**

*By
Antonella Versaci
Alessio Cardaci*



The most important value of pictures, though often neglected, is that they are an inexhaustible source of knowledge for both architectural historians and restoration architects. Nowadays, tools for sharing photo albums like Flickr, Facebook, Picasa, etc., fulfil an essential function of "reality" documentation. The new generation of laser scanners can deliver accurate measurements of architectural structures and their environment, and also makes it possible to publish scanned data on the Internet. Differently from images, however, the model obtained from a point cloud is an enormous catalogue, a sort of "solid" photograph which allows the material state of an architectural object to be "penetrated". This paper aims to address the issue of the new frontier represented by laser scanning methodology and its usefulness in the field of documenting cultural assets, starting from the objectives (and showing the first results) of a wide-ranging project of Web-documentation of Central Sicily's cultural heritage.

Introduction

Paintings, etchings and lithographs are a way of documenting and journeying into the past. Today, these works of art offer a visual record of monuments, landscapes and urban sites; they contain a lot of important data and this information can be an extremely useful aid to understanding cultural heritage in urban and historic sites. The lithographic prints made by Grand Tour travellers (even allowing for the possible subjectivity of the artist's interpretation), the guides, the albums and the collections of images especially created to increase the aesthetic and cultural values of private libraries, provide an iconographic description (and at the same time a catalogue) of an architectural heritage and landscape that are not always recognizable today. Photography later supplemented and developed this documentary role of paintings, although it did not completely overcome the constraints arising from the personal vision of the photographer.

With the advent of social networks, the role of photography, once restricted by the local diffusion environment and limited by the heaviness of paper, crossed many of its borders. Tools for sharing photo albums like Flickr, Facebook, Picasa, etc., allowing people almost instantly to share

photos taken anywhere in the world, fulfill an essential function of "reality" documentation. This "random" material is a public catalogue, easily accessible and continuously updated, even if still limited to the status of mere "image".

Nowadays, the new generation of laser scanners, ever smaller, lighter and equipped with integrated coaxial cameras, can deliver accurate measurements of architectural structures and their environment in a very short time. These instruments can provide point clouds that are in reality 3D photographs, from which a wide range of information can be extracted and they can create 3D models to be published on the Web for cataloguing and archival purposes. In particular, the FARO SCENE 4.8, the latest version of the scan processing software for the FARO Laser Scanner, incorporates the specific one-click WebShare function. This application makes it possible to publish scanned data on the Internet, thus enabling everyone to share images, including metric, technical and material property information. Unlike photographs, which deliver only the image of the monument, the 3D model can be sliced in order to obtain cross-sections and plans; it can be examined and processed to give orthophotos; finally it can yield data which is useful for understanding the chemical and physical properties of

the artefact. Unlike images, the model obtained from a point cloud is an incredible database, a kind of "solid" photograph which allows the material state of an architectural object to be "penetrated".

An Electronic Eye Over the Historical Towns of Central Sicily

The Italian island of Sicily originated from the tension that separated it from continental Europe: a violent wrench that tore it from the rest of the world to make Sicily an "island" in the heart of the Mediterranean Sea. The creation of the Straits of Messina, described as a *fretum terribile* by Seneca, isolated Sicily and gave it both independence and the opportunity to have a "centre". Its heart beats exactly where this centre is located, in the town of Enna, where the Normans built an octagonal tower to indicate the midpoint of the island, naming the town: *Ombelicus Siciliae*. The immediate surroundings are as rich in history as they are little known: small towns and villages for which Frederick II's Tower is their principal point of reference (Figure 1).

The main purpose of this paper is to narrate a journey through the historical towns of Central Sicily [1]. Like the old view painters, who searched out the most beautiful scenes to represent their "ideal city", we technicians of the digital age also cast about for the most secret and attractive corners, for architectural perspectives that could communicate the true essence of the old island centres. The traditional pencil was combined with the electronic "eye" of the camera and the more advanced (lighter and faster) 3D laser scanning instrument, able to permeate the material and grasp the true nature of the architectural artefacts and of their urban contexts.

Surveying for restoration projects: visual perception and analysis, tradition and innovation

In the past, representations of the built environment were mainly in the form of paintings and engravings, works of art that now constitute invaluable archives, for both architectural historians and restoration architects. The lithographic prints made by those who undertook the Grand Tour, the guides and albums of images designed to enhance the aesthetic and cultural values of private libraries, offer a visual record (and catalogue) of monuments, landscapes and urban sites that are often no longer recognizable.

"First-hand" drawing was once the means of recreating and recounting the spatial feeling of the observed city; the sketch was (and still is) a plausible depiction of reality aimed at capturing the essence of the space seen by the traveller (although it was always mediated by his own personal interpretation). Historically, the survey has always been the phase immediately subsequent in the approach to places: the eidotype added metric details to spatial sensation as well as the material properties and formal aspects of the sites observed. A preliminary drawing, aimed at providing detailed scientific knowledge of the studied sites, the eidotype was, essentially, a basic document, a kind of canvas on which to set up and develop ideas [2]. The traditional technique then involved the elaboration of a mass of drawings designed to document plans, elevations and architectural details of buildings, focusing on their geometrical, linguistic and technical aspects (Figure 2).

The advent of photography partially modified this approach to the city, enriching it with new contents and faces. Images obtained by cameras, seen as "fast sketchbooks" [3], support the traditional drawing techniques, putting important

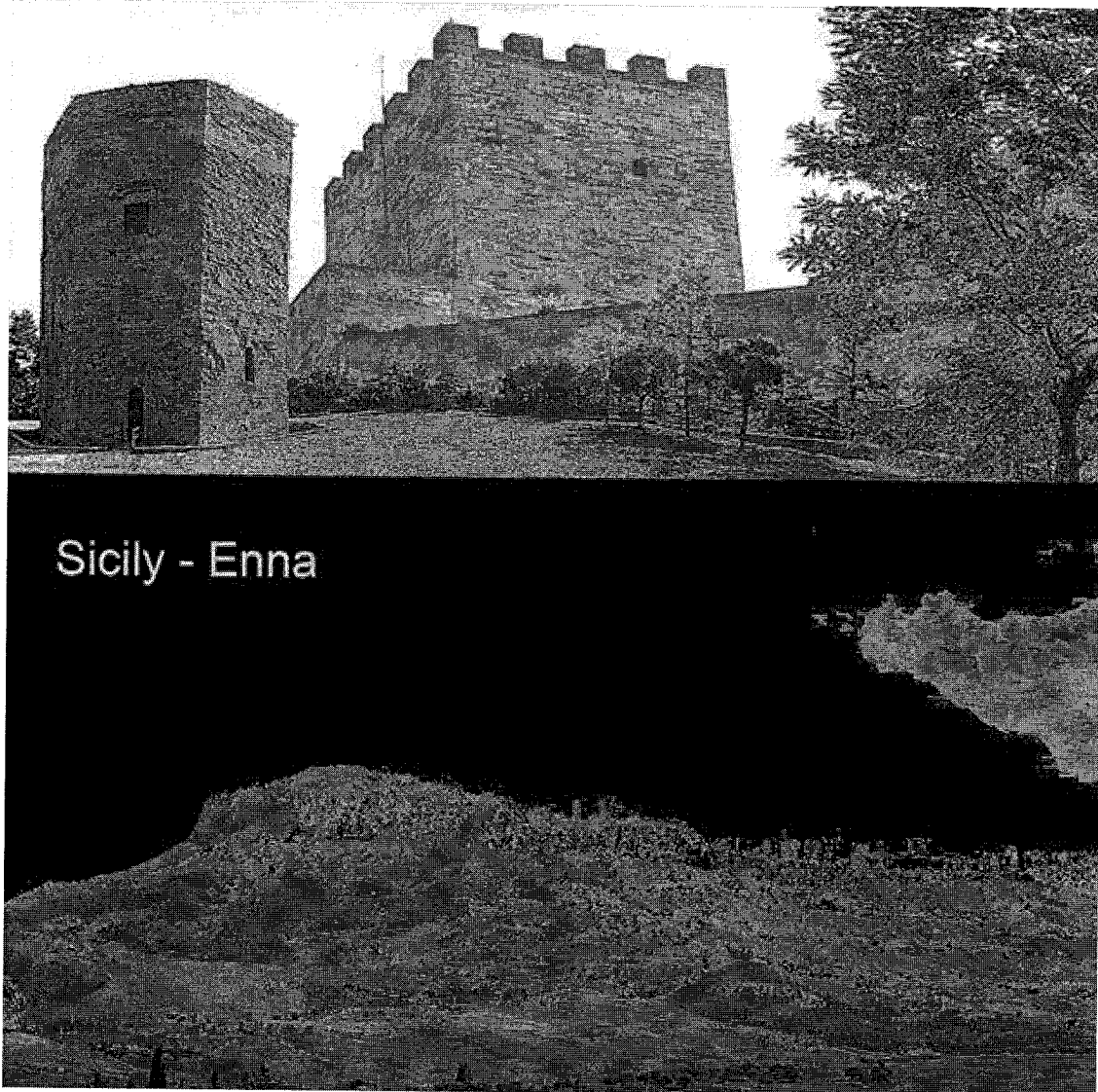


Figure 1. The Castle of Lombardy and the tower of Federico II (image montage).

new documentary tools at our disposal. The photograph, in fact, enables the “fervour” of the city to be depicted. Its ability to freeze the “moment” and block an action can reveal moments so brief that they are normally imperceptible to the human eye. The camera offers an opportunity to create a linear and temporal chronicle through pictures, something of great value for those who work in the field of protection and raising awareness and appreciation of the cultural heritage. And finally, laser scanning technology has completely revolu-

tionized the practice of surveying for restoration purposes. It offers the possibility of digitally capturing three-dimensional objects, even very complex ones, and reproducing them as point clouds, quickly and extremely accurately. Unlike a drawing, these are not planar projections of real objects, as they represent a virtual version of reality that can be investigated.

A drawing can be observed only from the centre of projection from which the designer has chosen

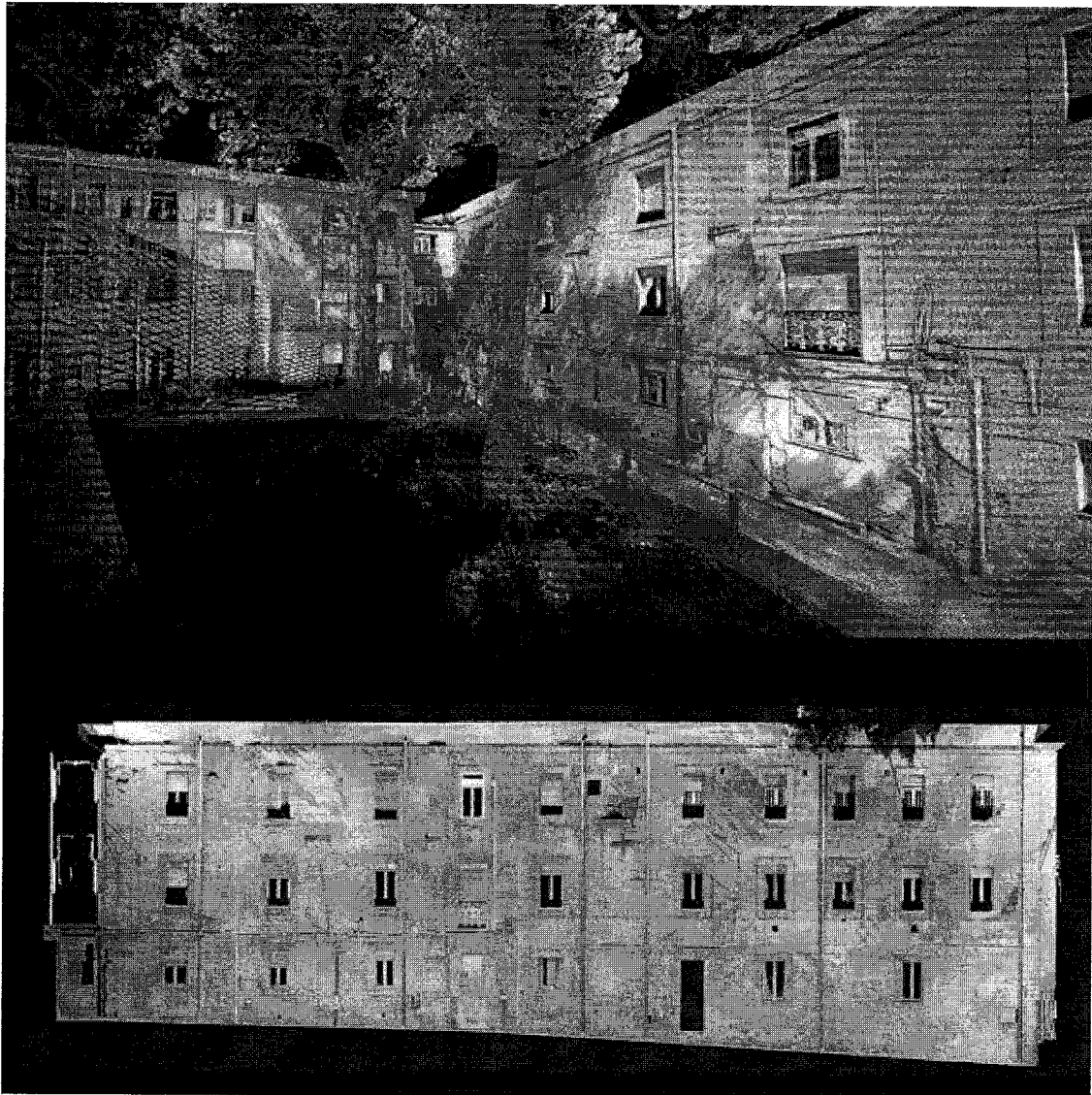


Figure 2. Ex Convent of Carmine (Ortophoto and 3D Scanner Model).

to represent the scene, but a point cloud can be explored from several projection centres. Indeed a point can be made to yield more than one representation by changing the point from which the architectural work and the city as a whole is observed. No less important is also the chance to investigate the morphological and/or compositional components of the 3D model obtained by laser scanning technology. From a procedural point of view, as already mentioned, the use of 3D laser scanning technology has dramatically

reduced execution time because it unifies the initial phase of data acquisition and that of subsequent analysis.

The digital sketch already provides a metric survey and characterization of the building materials of the city, observed and measured at the same time, both in its forms and in its structural components. Using this technique, the preparation of the eido-type of the object is less important than the planning of the survey, and may



Figure 3. The Church of St. Tommaso (3D Scanner Model, 3D Cad Model and traditional draw).

even not be necessary. It is in fact possible to make a full record of the geometry of an architectural object and to postpone the extraction of the characterizing elements of the buildings and their representation through CAD [4] to the data processing phase (in the office).

In the framework of our work, the digital acquisition of the monuments was carried out through the Focus3D laser scanner, an innovative instrument based on the phase shift technology

produced by Faro Technologies, which is much faster and more accurate than the traditional time-of-flight instruments. The speed of data acquisition and measurement offered by this instrument is so high (up to 976,000 measurement points per second) as to make it more affordable (in terms of reduction of working time) to collect all information and then clean the point clouds of unnecessary data, rather than to adjust the scanning angle and the resolution in each individual scan.



Figure 4. The Duomo of Enna (sketches and 3D Scanner Model).

One of the key parameters of the laser scanner is the scanning step: in other words, the step between two points measured by the instrument. The first scanning systems only allowed very high mesh steps (in the order of centimetres) or required higher resolution-levels, with a consequent increase in scanning time. With Focus3D, however, coloured, high-resolution point clouds (10 dpi to 10 meters), can be obtained with very short acquisition times. It should be noted that the laser scanner used is not only extraordinarily

light (5 kg), but also includes an integrated colour camera featuring an automatic 70 megapixels parallax-free colour overlay. This has enabled point clouds to be coloured automatically, with a considerable reduction in post-processing time. Measurements were then followed by the processing of data measured in situ by the combined and integrated utilization of different software: the FARO Scene 4.8.1 and the GEXCEL JRC 3D-Reconstructor. With the first software, the clouds were first filtered and then coloured in



Figure 5. The Church of St. Giovanni (WebShare's documentation, orthophoto and traditional draw).

a very short time (Figure 3) - applying colour to a Focus3D laser scan, through the latest version of this scan processing software for the FARO Laser Scanner which used to require about 20 minutes for a medium resolution scan, now takes only less than 1 minute. Scans were finally aligned and geo-referenced by the second software in order to obtain virtual models of the monuments and of significant fragments of the towns and villages.

From graphic representation for restoration projects to web-shared cataloguing

At the end of the phase of data acquisition, drawings, scans and photographs (that obtained automatically by the internal camera of laser scanner and others taken by a Canon EOS) collected during the tour, were used to represent and communicate the information obtained (Figure 4). Pictures, sketches and colours were used to flesh out the metric data of the scans, not only chromatically.

The restitution phase allowed the point clouds to be mapped with images processed and filtered in order to highlight the state of decay of materials and the more interesting architectural elements. "Tailor-made clothes" were superimposed on the point clouds: additional photographs of the architectural monuments, taken at different times of the day (including night images). This is because the colorimetric information obtained by the laser scanner is no longer a simple representation of reality but may become very valuable both in the diagnostic and monitoring phases.

The usual practice is to use "false" colours to represent the reflectance values resulting from the scans (famous is the change from green to red typical of Leica scanners, depending on temperature and reflectance variations); it is rather less usual to process images using software that can alter the RGB channels, the hue, the saturation and brightness [5].

The mapping of several images (even in this case, provided by the laser scanner and taken by the external camera) properly treated with the filters available in the most common image editing applications, allows the depiction of situations that are barely visible or completely hidden from visual examination. A filter providing edge contrast can be used to highlight masonry wall textures, the noise/grain reduction filter can hide the dark areas due to the unevenness of the plaster, allowing easier reading of the geometry, and the render lighting effect filter enables only the areas of interest to be detected by lighting them. Finally, in attempting to implement new forms of representation of the decay and deterioration of material surfaces, our scans have also been "clothed" by drawings mapping the decay of buildings (Figure 5).

Conclusions

Integration of all these techniques has yielded a rich register that will be made universally accessible through Web platforms; its value is inestimable, not only as a basis for ensuring proper restoration, appreciation and use of the monuments now, but also in the future, to understand their evolution in the frame of an ever-changing urban environment. With the aim of creating a web-shared catalogue of the monuments of Central Sicily, the data acquired have been converted into 3D models which are gradually being published on the net.

The scan processing software used for this research incorporates a specific one-click WebShare function. This application makes it possible to publish scanned data on the Internet, thus enabling everyone to share scanned images, including metric, technical and material property information. Unlike photographs, which deliver only the image of the monument, the 3D model created from a point cloud is an incredible database, a kind of "solid" image which allows us to "permeate" the architectural object till its material essence. It can be sliced in order to obtain cross-sections and plans; it can be processed to create orthophotos; and finally it can provide useful data about the chemical and physical properties of the artifacts, as well as of their states of health. Scans data are progressively going to be converted in order to be re-used inside the free software Google SketchUp (via the related Pointools Plugin™) and then exported in Google Earth. Thus, the new frontier of laser scanning methodology offers significant new opportunities for cataloguing and storing cultural goods ensuring, over time, the transmission of valuable information about their state of conservation and the restoration work carried out, in order to safeguard their authenticity.

Acknowledgments

The authors thank Dr. S. Zuccarello for the images related to the Ex Convent of Carmine, Dr. A. Canale, M. Candido, G. Felice and S. Privitera for the 3D CAD models of the Church of St. Tommaso, G. Di Bartolo, V. Dipasquale and I. Modica for the sketches of the Duomo of Enna, V. Castiglione and R. Iudica for the drawings of the Church of St. Giovanni and all the students of the Architectural Restoration Workshop (2009-2010) of the Faculty of Engineering, Architecture and Motor Sciences of the "KORE" University of Enna, Italy for helpful comments.

References

- [1] W. Leopold, *Sizilianische Bauten des Mittelalters in Castrogiovanni, Piazza Armerina, Nicosia und Randazzo*, Wasmuth, Berlin, 1917
- [2] G. Vassena, M. Sgrenzaroli, *Tecniche di rilevamento tridimensionale tramite laser scanner*, Brescia, Starrylink, 2007
- [3] M. Docci, *Manuale di rilevamento architettonico e urbano*, Bari-Roma, Laterza, 2009
- [4] G. Carbonara, *Trattato di restauro architettonico*, Secondo Aggiornamento, Grandi temi di restauro, Torino, UTET, 2008
- [5] D. Fiorani, *Restauro e tecnologie in architettura*, Roma, Carocci, 2009

ANTONELLA VERSACI Civil Engineer

Antonella Versaci is Assistant Professor at the Faculty of Engineering and Architecture of University of Enna "KORE". She has a degree in Civil Engineering (University of Messina, Italy), a D.E.A. "Urban and Architectural project" (School of Architecture Paris-Belleville, France), as well as a Ph.D. in Architecture (University Paris VIII, France) on the subject of the French legislation for the safeguarding of historical centres. Until September 2008, she worked at UNESCO where she was in charge of cultural operational projects in South-East Europe. Since 2010, she holds the chair of Architectural Restoration at the University of Enna KORE, Faculty of Engineering and Architecture. She is also director of the "Survey and diagnostic applied to cultural heritage" laboratory of the same Faculty.

ALESSIO CARDACI Engineer

Alessio Cardaci is a professor and researcher at the Faculty of Engineering of the University of Bergamo. He obtained a Master Degree cum laude in Building Engineering (University of Messina, Italy) and a PhD in Building Engineering: Restoration Design (Department of Drawing and Design, Faculty of Engineering, University of Messina, Italy). Since 2008, he holds the chair of Drawing at the University of Bergamo, Faculty of Engineering, Department of Design and Technologies. His main research interests are based on the assessment of the capabilities of laser scanning technologies with special regard to cultural heritage survey, structural testing and diagnostic, 3D visualization and virtual reality.