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WEB-SHARING FOR A CULTURAL HERITAGE COMPUTER DATABASE OF CENTRAL SICILIAN MONUMENTS

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Abstract:

Paintings, etchings and lithographs are a way of documenting and journeying into the past. One of the most important values of pictures, though often neglected, is that they are an inexhaustible source of knowledge both for architectural historians and for architect restorers. 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 and 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 artifact. Unlike images, however, 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". 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 goods, starting from the objectives (and showing the first results) of a wide-ranging project of Web-documentation of the cultural heritage of Central Sicily.

1. INTRODUCTION

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 (Fig. 1). The main purpose of this paper is to narrate a journey through the historical towns of Central Sicily, along an imaginary itinerary that fans out concentrically from the heart of the island and has its points of departure and arrival in the town of Enna. Walking through the ancient streets, pausing in the squares and living among the inhabitants, we have tried to capture the soul of these places, both by means of traditional sketches and photos (rectified and referenced), and through coloured point clouds acquired by a digital sensor. 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. We wanted this to be a journey of discovery, but our objectives also included critical understanding and effective cataloging. So on this trip we used both the classic, unchanging and always useful sketchbooks and innovative acquisition techniques. 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 artifacts and of their urban contexts. Our tour was thus a critical journey among the monuments of the fascinating towns and villages of Central Sicily, using several surveying techniques, both classic and modern. And our ultimate objective is to provide an instrument for the revival of these areas, where the main "actors" are unfortunately affected by urban pollution, congestion and physical decay.

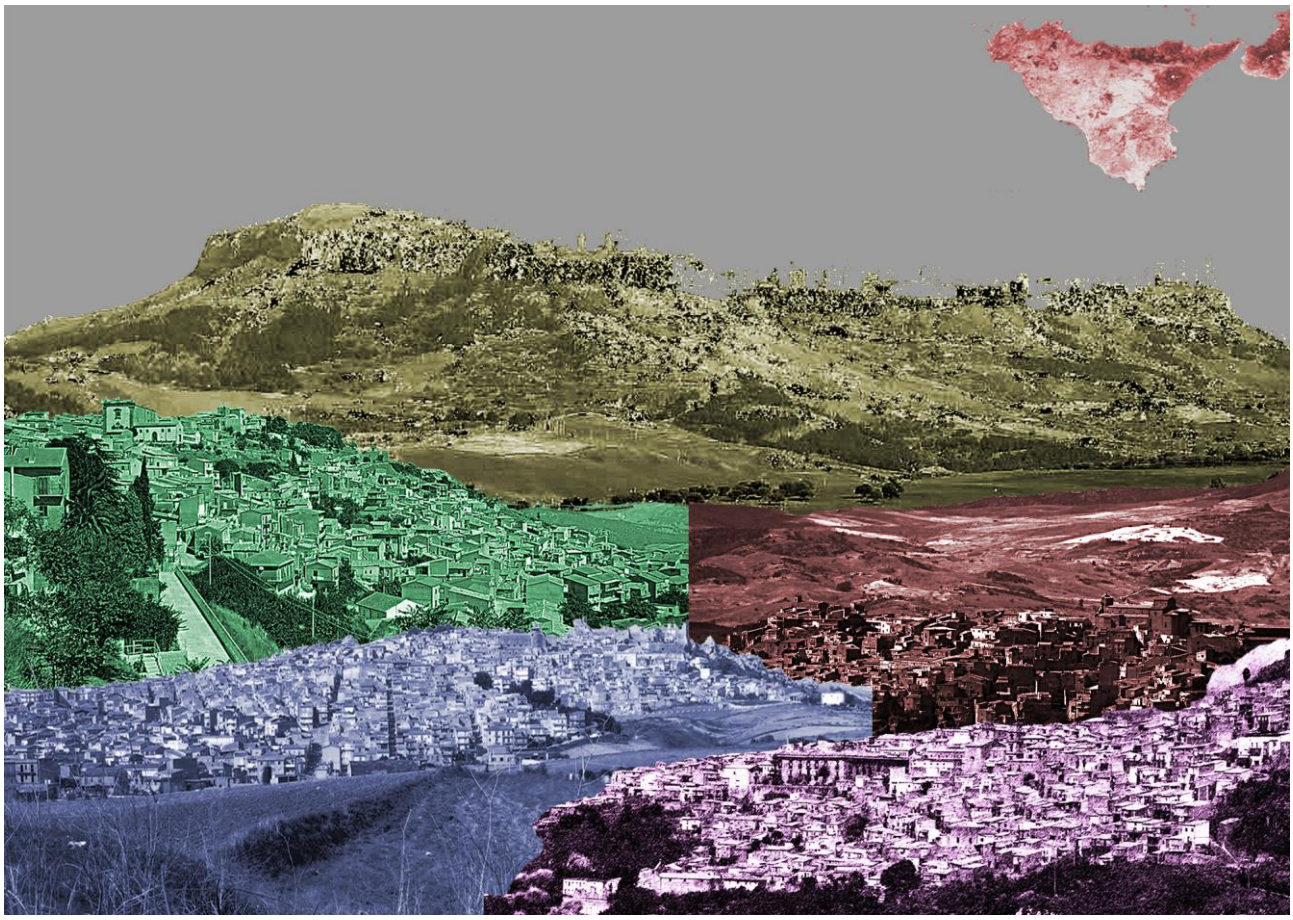

Figure 1: View of Enna and its surroundings

2. WALKING ALONG THE STREETS OF CENTRAL SICILY, LOOKING AT ITS MONUMENTS

Central Sicily is still relatively little known and studied in proportion to its numerous historical and artistic treasures. Contemporary tourists, like the travelers of the 18th and 19th centuries, continue to prefer the classical or coastal areas of Sicily. But as one moves inland a more secret Sicily emerges (almost an island within the island), which is no less interesting from cultural and/or natural point of view and which deserves to be better appreciated.

The founding of Enna dates back to the 14th century BC, well before the Greek period. Following Roman rule, Enna became an important fortress for the Byzantines. In 859 it was taken by the Saracens, who made it the new capital of the island and named it *Qasr Yânnah*. In 1087, when the Normans captured the town, its name was converted to Castrogiovanni and so it remained until 1927, when it reverted to the name of Enna. During the period of Norman rule, Castrogiovanni was a "royal" city and became an important cultural and political centre of the kingdom. In 1130 Roger II restored the ancient Sicanian fortress, now known as the *Castello di Lombardia*, one of the most important and best maintained medieval castles in Sicily. The advent of the period of Angevin rule brought new vigour to the city: several monuments were restored and, at the behest of Queen Eleanor, the wife of Frederick II of Aragon, King of Sicily, the *Duomo* was founded in 1307. Over the centuries, this magnificent monument, based on a medieval structure, has undergone repeated renovation and adaptation work. The main one dates from the 17th -18th centuries [1] when an impressive tower-shaped avant-corps was added to the façade [2]. Another rich expression of medieval Sicilian architecture is the towers that were initially part of the imposing fortified sighting system of Enna and later often integrated into ecclesiastical complexes. This is the case, for instance, of the *Torre del Carmine*, which has a strange semi-cylindrical protrusion on one side and also features elements of a Renaissance character; or that of *San Tommaso*, adjacent to the church of the same name and characterized by Catalan Gothic windows. And last but not least, the majestic *Torre di Federico II*, a military stronghold built in the 13th century on the foundations of an earlier fortification, restored a century later and nowadays considered one of the major symbols of the city (Fig. 2).

Figure 2: Enna – from the Tower of Frederick II to the Castle of Lombardy

On the heights facing Enna stands the town of Calascibetta; burial grounds dating from the 9th to the 5th century B.C. show that this area has been inhabited since ancient times. The town was later built by the Arabs, who named it *Kalathos-Scibeth*, and then expanded by Count Roger in 1062. To the southeast lies the Arab-Norman town of Aidone, nicknamed "the balcony of Sicily" for its views and featuring the 16th century Church and former convent of *San Domenico* with its diamond-pointed rusticated façade (Fig. 3); then to the southwest, is the city of Pietraperzia which, according to some, was the site of ancient Caulonia. Its present town centre was established in medieval times around an Arab fortress that was subsequently restored by the Normans. The centre also contains the Cathedral Church, built in 1308 and rebuilt almost completely, in a larger and lavish form, around the year 1500 (Fig. 4). Leonforte lies to the north of Enna.

Figure 3: Aidone – the Church and former convent of San Domenico

Figure 4: The Cathedral of Pietraperzia – longitudinal cross section

Founded in 1610 by Branciforte family, it is dominated by their outstanding Palazzo and by the *Granfonte*, the monumental fountain built in 1652 (Fig. 5). Historical documentation and research concerning these monuments, in terms of both graphics and critical analysis, are unreliable, except for the work produced by Walter Leopold, a young Italian-German engineer who came to Sicily in 1910-11 to study the medieval architecture of the Sicilian interior, including Enna [3]. Although impressed by the accuracy of this study and even inspired by the excellent results achieved by contemporary artists, we decided not to follow in the footsteps of our predecessors. Conscious of the fundamental importance of surveying in the preparation of restoration and conservation projects, we based our work on a close integration between traditional and innovative tools and methodologies, developing an approach based not only on logical processes of a

historical and aesthetic nature, but also supported by those intuitive and perceptive values that are stimulated only by on-site observation.

Figure 5: Ortophoto of the *Granfonte* in Leonforte

3. 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, both for architectural historians and for 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 traveler (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 [4]. 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.

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" [5], support the traditional drawing techniques, putting important 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 revolutionized 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 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 eidotype of the object is less important than the planning of the survey, and may 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 [6] to the data processing phase (in the office).

In the framework of our tour, the digital acquisition of the monuments was carried out through the *Focus*^{3D} laser scanner, an innovative instrument based on the phase shift technology produced by CAM2-Faro Technologies, which is much faster and more accurate than the traditional time-of-flight instruments. The survey projects were developed by executing "360° environmental scans" thereby reducing in situ measurement time. 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. 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 (of the order of centimetres) or required higher resolution-levels, with a consequent increase in scanning time. With *Focus*^{3D}, however, coloured, high-resolution point clouds (10 dpi to 10 meters), can be obtained with very short acquisition times.

The idea of "recording places" implied the need to visit them quickly (as quickly as a traveler-artist who draws a landscape in half an hour) and to make several acquisitions in many different places. For this research project, it was therefore decided to use several registration carbon spheres (Ø 145 mm) as targets, that were fixed to metallic elements on and around the buildings, always in places visible to several scan stations. It should be noted that the laser scanner used is not only extraordinarily light (5 kg), but also includes an integrated color 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. By the first software, the clouds were first filtered and then coloured in a very short time. (applying colour to a *Focus*^{3D} 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.

4. 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 5D Mark II mounting EF 24mm f/1.4 L II USM Lens) collected during the tour, the material was used to represent and communicate the information obtained. 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 [7]. The mapping of several images (even in this case, that provided by the laser scanner and others 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, elaborated by the students of the Architectural Restoration Workshop (a.y. 2009-2010) of the Faculty of Engineering and Architecture of the "KORE" University of Enna, Italy (Fig. 6).

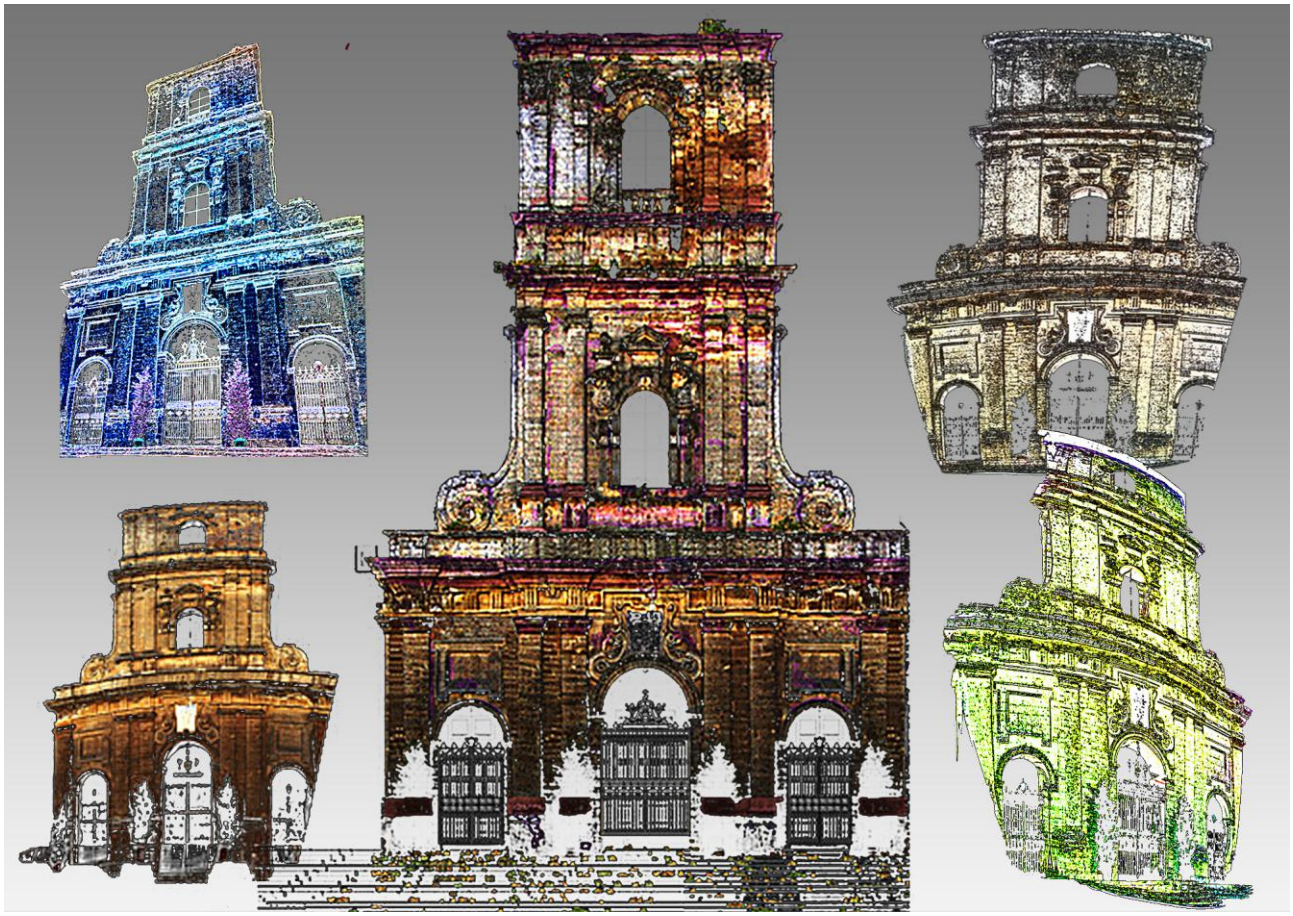

Figure 6: The *Duomo* of Enna – mapped point clouds

5. CONCLUSIONS

Integration of all these techniques has yielded a rich database 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 (Fig. 7). 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 obtained from a point cloud is an incredible database, a kind of "solid" photograph which allows us to "penetrate" the material state of an architectural object. 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 Plug-in™) and then exported in Google Earth.

The new frontier of laser scanning methodology thus offers significant new opportunities for cataloging 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.

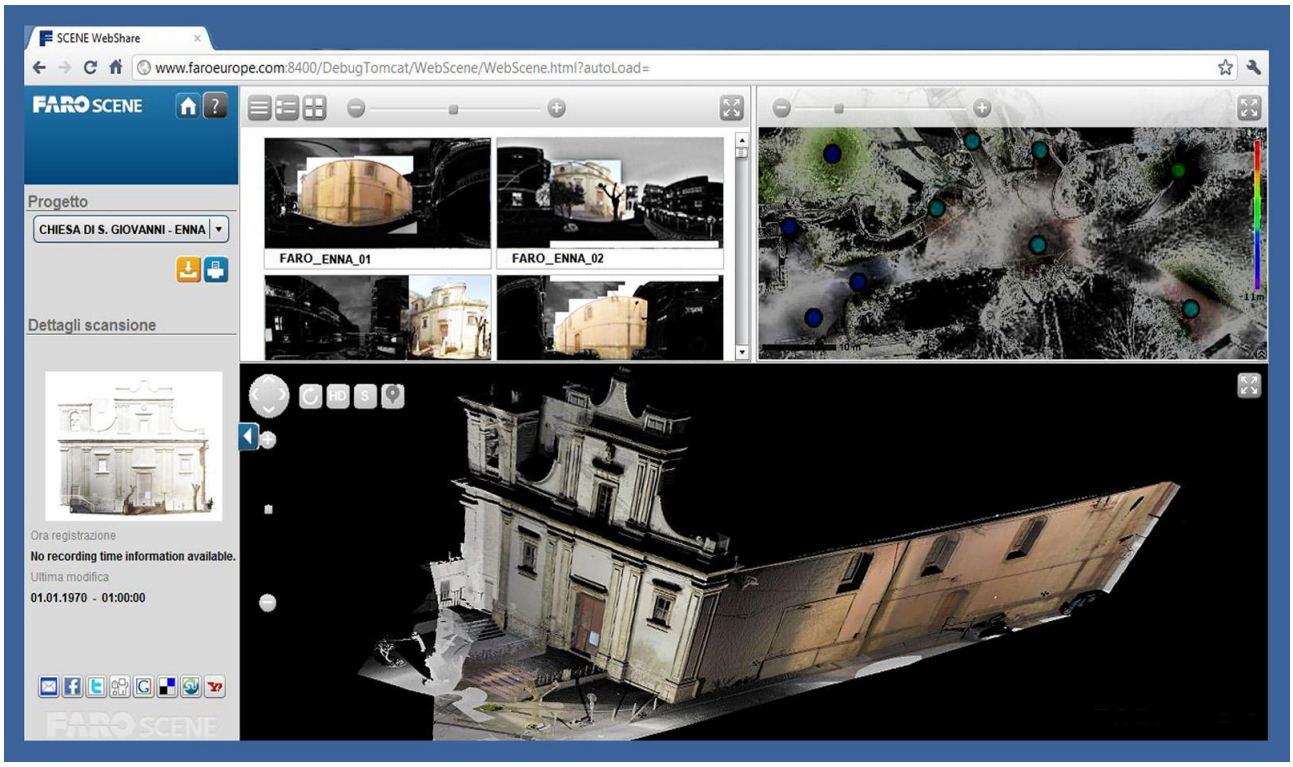

Figure 7: WebShare's documentation

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