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A DIGITAL KEY TO UNDERSTANDING THE LANDSCAPE

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Abstract

This essay deals with the relationship between the laser scanner survey, the digital modelling techniques and the forms of architectural representation applied to the analysis and the project. Carried out in an archaeological site a few kilometers north of Trento, the central theme of the research is the elaboration of images that are both the result of scientific processes of knowledge and awareness–raising tool, preservation and enhancement of the building and the entire territory: images that look to cultural tourism as to the reinforcement of local identity. The goal is twofold: the virtual reconstruction of the past, when the artefacts and their functions were more clearly recognizable; and the study of a lighting project that will involve architecture in environment even in the dark of night.

Keywords

3D modelling, architectural representation, laser scanner survey, lighting project, virtual reconstruction.

1. *Introduction*

The "digital key" through which the meeting with the landscape is proposed, Trentino in this case, uses architectural survey in a particular way in favouring certain significant aspects all aimed at broadening the traditional way of viewing the state of fact, as observed in detail.

In the theoretically and scientifically most rigorous studies, drawings and models produced by the researcher's work primarily comply with a fundamental need: to highlight a specific moment of transition of the building and its context, caught in a complex process of historical development. The "thematic maps" are the preferred instrument for the representation of the "life forms", as Henri Focillon would say (Focillon, 1990): that is, all those "natural geometries" and physical changes due to the passing of time and caused in part by use, in part by the progressive abandonment as well as by climatic events. These "accidental geometries", rather than the "intentional" ones desired by the inventor, are the clear track of the evolutionary paths lived by architecture through the ages, of which survey wants to catch the actuality, both transient and valuable (Torsello, 1988). In this context, computer modelling and multimedia communication are powerful tools for managing spatial and temporal data: the novelty value, compared to the traditional methods of geometry and graphics, lies in the "syncretic" nature of advanced techniques, in which the methods of replication, simulation and mathematical formalization converge (Maldonado, 2005).

On these remarks is based a research carried out in an archaeological site a few kilometres north of Trento, which identifies a whole territory and its community. Digital representation techniques have offered new solutions to process the collected data and project it towards the construction of interpretative design models that focus on the different relations between landscape and cultural heritage; among these, the indissoluble bond of reciprocity between local morphological characters (as understood by Heidegger) and the human forms arising from the singular, and sometimes exceptional, architectural, typological or artistic solutions that qualify the place itself. Sometimes they make absolutely unique examples; in some cases, in fact, it is surprising to see how architectural inventions enhance already extraordinary naturalistic environmental situations.

Fig. 1: Overall view of the castle in the rocky crown and from the castle on the Piana Rotaliana.

The first objective focuses on the representation of a geometric–figurative model that while documenting every detail of the current status, also makes it possible to see the place as it was in the past, when the artefacts and their functions were more clearly recognizable. Therefore, the virtual reconstruction theme is not addressed by a mere graphic description, even if precise and analytical, but through the extraordinary power of images that come alive and change, retaining the authentic charm of architecture and exalting its change (Ambrosi, 1991).

The second objective extends the effectiveness of representation as simulation in another direction. The survey model is used as the basis of experimentation for a lighting project that makes noticeable the archaeological remains in the landscape more at night than during the day, thus emphasizing the emotional power exercised by a highly evocative presence. The employment of artificial light for the landscape enhancement has a recent history and has always been conditioned by economic factors (Bianchi, 1991); now the exploitation of renewable sources and energy–efficient technologies allow us to hypothesize actually achievable interventions.

The use of digital procedures for analysis and spatial visualization has carried out the construction of images that are both the result of scientific processes of knowledge and awareness–raising tool, preservation and fruition of the building and the entire environment: images that look to cultural tourism as to the reinforcement of local identity.

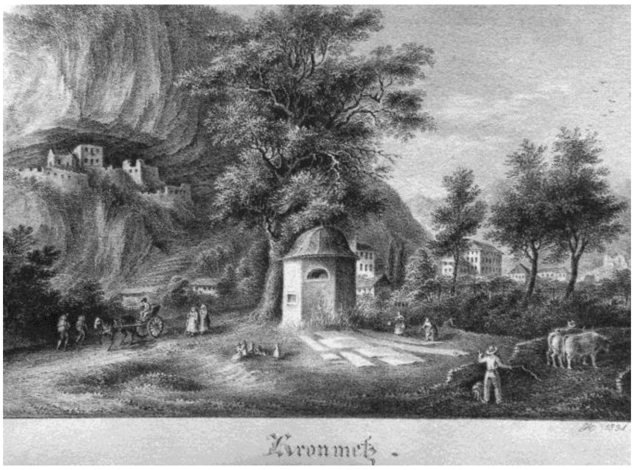

Fig. 2: Kronmetz, engraving by Johanna von Isser, 1831; San Gottardo already appears in the present conditions, with the exception of the still intact church (Perogalli, a Prato, 1987, p. 33).

2. *Kronmetz*

With this background, the study of the castle of San Gottardo was implemented. Located on a large horizontal crack in the rock about 150 meters above the village of Mezzocorona, in a spectacular location difficult to reach but easily visible from much of the Adige valley (Fig. 1), San Gottardo is a "crown castle", *krone* in German, which are located in caves as the Wolkenstein castle in Val Gardena or the Covolo di Bustione in Valsugana.

The location, used since the Bronze Age, in the Roman era was an area of trade and viticulture. Around the twelfth century, the Counts of Appiano thought to exploit the vast natural cave to build a key judicial district in the employ of the Bishop Prince of Trento; until the fifteenth century several noble families of South Tyrolean descent lived there, including the Metz, whose name, combined with the unique location of the castle, originated the name Mezzocorona. In the second half of the fifteenth century, the property was inherited by the Firmian dynasty who preferred to move into the fortified residence at the foot of the mountain: the building became the abode of hermits. Place of pilgrimage until the end of the eighteenth century when, the stronghold was abandoned and exposed to repeated looting of material which, together with climatic factors, triggered a progressive deterioration affecting the stability of the structures (Fig. 2); the last maintenance works were carried out in 1910 by Count Vigilio Firmian.

The architectural system consists of three buildings plus a fourth to the West collapsed entirely, enclosed by walls built along the perimeter of the rocky plateau (Fig. 3). The eastern building is the castle itself, whose original structure dates back to the twelfth century and undergoes changes probably till the fifteenth

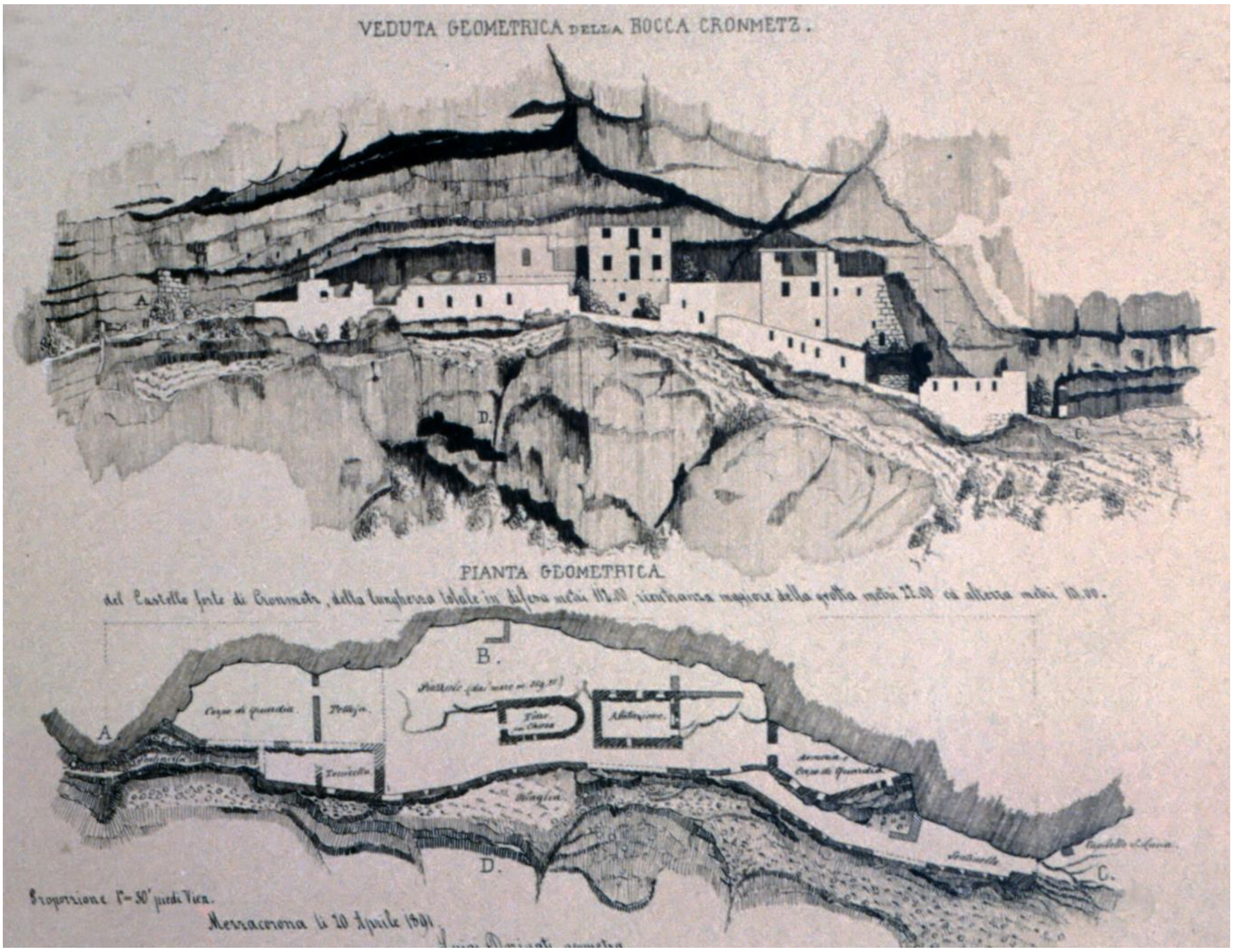

Fig. 3 View and geometric map of the fortress of Kronmetz or San Gottardo, survey by Luigi Dorigati, 1891 (Melchiori, 1989, p. 23).

century. The hermit building is rectangular, placed in a central position, is part of the castle but the upper floors date to the seventeenth century. The church was probably built before the castle and dedicated to San Gottardo, as evidenced by a 1278 document, and it gives its name to the whole complex; rebuilt in 1634, and closed in 1782, then converted into a tub in 1910.

Fig. 4: The ruins of the church in a picture filed in the Historic Photographic Archive in Trento, ca. 1930, and in the corresponding survey photograph, 2014 (Paoli, 2015, p. 103).

Today San Gottardo is a great archaeological remain, the morphological complexity of which depends on both the singularity of the surviving architecture and the accidental disposal of collapsed elements, as well as the particular rocky conformation of the crevice in which it is located (Fig. 4). Such old architecture is in a critical situation due to the hydro–geological hazard of the site, for the lack of safe access conditions and the difficulties related to property constraints. And yet the castle still retains its, constantly renewed over the centuries, role of landmark as perceived from the gravitating routes and villages.

The latest cartographic documents dates back to 1985: it consists of a manual planimetric survey by Remo Carli drawn at a scale of 1:100; this paper was the foundation of the measurement campaign that would provide all the geometric data needed for action, proposals of protection and fruition.

3. *Survey to preserve*

The survey addressed the problem of accurate, artificial and natural, geometry description with the exclusive use of laser scanning procedures (Fig. 5): not only the instruments are compatible with the difficult logistical conditions, they also offer a potentially unlimited acquisition ability to quickly upload spatial data and images good enough for qualitative assessments.

In the last decade, the debate dealt a lot with the comparison between the so–called "range–based" technologies, whose measuring devices emit a signal – total station, laser scanner and GPS

Fig. 5: The west front of the hermitage and the foundations of the church represented in the archive picture, the survey photograph and the orthophoto by 3D scanning.

Fig. 6: The project of laser scanner survey and the view of a single scan: the instrumental positions are blue, the orientation targets are red.

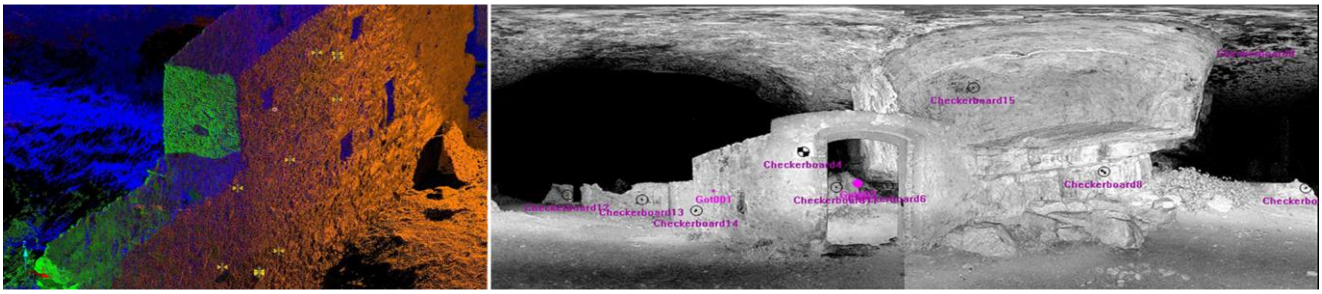

Fig. 7: Data processing and scans registration by applying Faro Scene.

Fig. 8: 3D view of the “points cloud” finished recording; normal mode (top) and clear view mode (down).

– and the photogrammetric technologies otherwise appointed “image–based”, that rely on the chance to obtain 3D geometric information from the digital images capture. On the one hand, the competitiveness assessment refers to the achievable metric accuracy levels; on the other hand, to the cost in terms of equipment and data processing times[1]. In the reality of things, the choice is highly conditioned by the study case features and by the planning of field operations, because the greater burden of the laser scanner survey are also well–balanced by faster measurements and guaranteed results; whereas the multi–image photogrammetry, applied to complex spaces such as San Gottardo in particular, can produced scientific results only when linked to a careful and extensive topographic survey, able to be a general

[1] Workshop “Low–cost 3D: sensori, algoritmi, applicazioni”, held at the Foundation Bruno Kessler in Trento (March 8-9, 2012) and organized by F. Remondino (3DOM - FBK Trento) and R. Scopigno (ISTI - CNR Pisa).

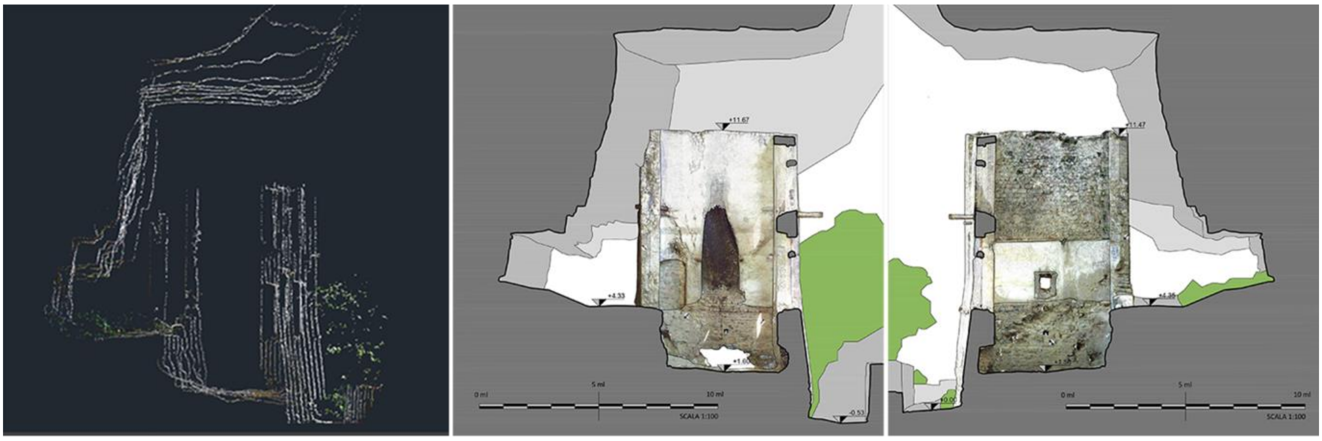

Fig. 9: The hermitage: graphic representation of the vertical east and west sections, coded for 1:100 print.

framework for the shots (Russo, Remondino, Guidi, 2011).

However, the question is another: it is not sure that too much information produce knowledge automatically; if it does, it must also build a communication process. If our awareness of the environment starts with the third dimension perception, a “3D digital ecosystem” provided with a greater number of data should accelerate the learning dynamics. We may infer that the technologically advanced instruments, such as laser scanner, give us models that will convey knowledge not only because of their geometry, consisting of millions of faces, but mainly because their representation stimulates the construction of mental maps (Forte, 2006).

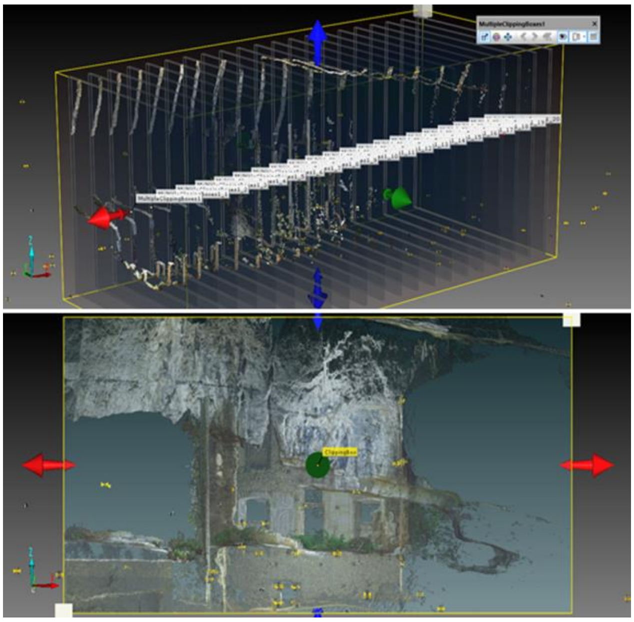

Fig. 10: Clipping boxes used to isolate from the “points cloud” the parts for the drawing of plans, sections and elevations; multiple boxes (top) and single box (down).

To detect San Gottardo a Faro Focus 3D laser scanner was used, with an almost spherical field of view and an integrated camera with resolution of 70 MP[2]. The project has taken into account the size of the area, about 1400 square meters, the irregular shape of the land, exposure to sunlight and the inability to detect the south elevation of the fortification due to the cliff (Fig. 6). In May 2015, in one day, twenty–eight 3D scans were taken; the measurements were processed with the application Faro Scene, cleaning and filtering the raw data, as well as aligning and registering the scans through the recognition of at least three targets (Fig. 7). The irregular geometry of the area has often prevented the use of automatic algorithms and manual intervention was necessary with long data processing.

At this stage, a first analytical model is generated, displayed through a “points cloud” faithfully describing the 3D geometry of the castle and the rocky vault in two ways (Fig. 8): static views, first of all orthophotos of map and elevation, and dynamic views, that is videos virtually simulating visiting paths. Then, the digital model was manipulated further to obtain 2D and 3D, vector and raster representations, useful for preservation and restoration; the critical problem lies precisely in having experienced the interoperability conditions of representation and management applications of the large amounts of data acquired with the laser scanner.

The 2D drawings’ stretch were conducted

[2] Scan velocity 122.000 pt/sec, mesh size 6.136 mm at a distance of 10 m, color scan RGB pt 2845x4267. Data acquisition carried out by Technical Studio Alberto Leoni in Rovereto.

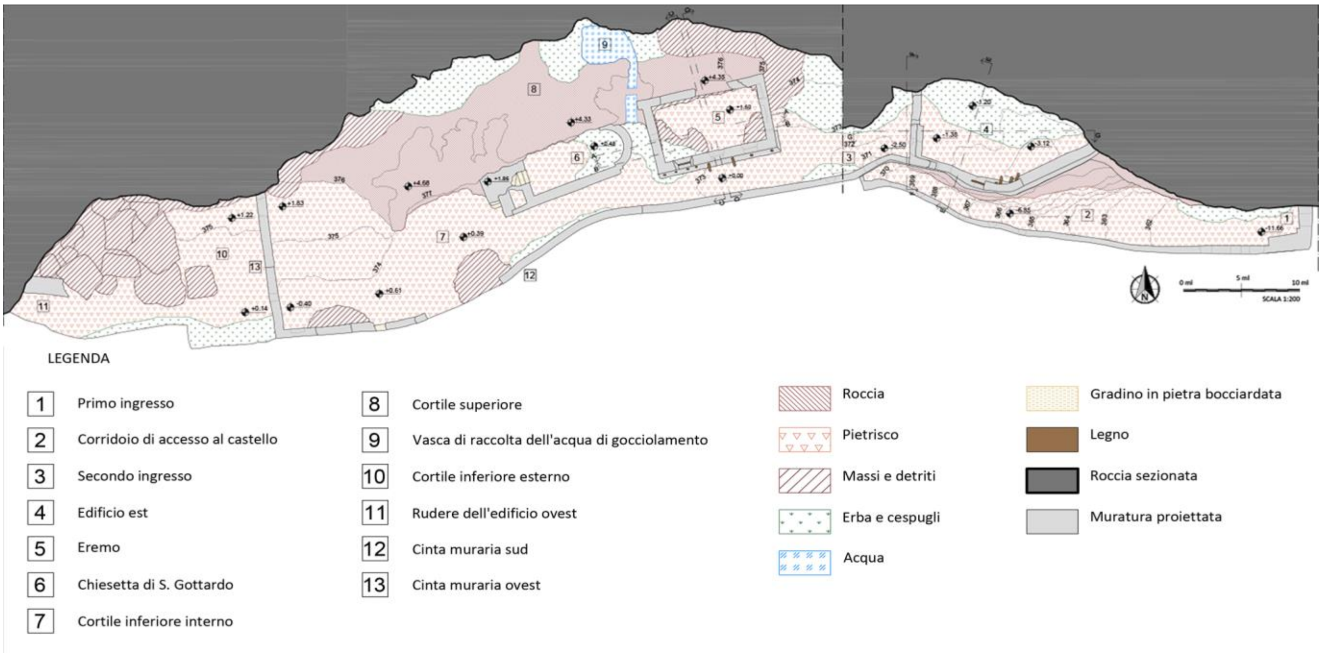

Fig. 11: The archaeological site: graphic representation of the layout, coded for 1:100 print.

with Autocad 2016, directly exporting from the "points cloud" horizontal and vertical "thick sections", selecting with Scene by clipping boxes; orthophotos for each architectural perspective were produced with the same criteria (Fig. 9, Fig. 10, Fig. 11). The simple outlines extracted from the "points cloud" model are very accurate and immediately usable for metric–spatial controls, but not sufficient for the design, for which architectural drawings are necessary.

Finally, the general layout and useful vertical sections of the complex of San Gottardo, coded for 1:100 print, were drawn up to meet the needs of stratigraphic analysis and the study of materials, degradation and damages; leaching, disintegration and biological attack affecting the surfaces are attributable both to vegetation and water, evident in the drip from the ceiling and the capillary infiltration (Fig. 12).

The graphic rendering drawings are also essential to the interventions' definition, both conservation and consolidation aimed to stop the inexorable loss of walls' texture, and increasing defence of the raised parts from the effects of hydrogeological instability.

4. Survey to communicate

The ruins of the fortress can only be reached from the ancient poorly–indicated path, arduous, subject to landslides and to accidental fall of crushed stone; they are located in an area with a high hydrogeological instability and belong to different owners; despite many repeated attempts over the years, the local administration failed to acquire them and to ensure their protection. The interplay of these three factors makes it difficult to directly visit the site; above all, it addresses the design proposals to compatible solutions with physical reality and the lack of economic resources; in fact, any functional restoration would mean the path renovation and the application of safety measures to the entire area, with too high costs.

Among the choices, it is feasible to pursue a "mediated" enjoyment of the archaeological asset through the new ICT, by citizens as tourists. IT tools not only give a contribution to the digitization of cultural heritage, they may increase the interaction between this one and users, they may expand the social awareness of historical, artistic and archaeological memory and create an emotional relationship on site and remotely, also via Web (Campana, Francovich, 2006).

This is often done placing side by side the mathematical models, the codified representations and some non–metric parameters. For example, the landscape and its objects can be read through the elements of the "perceived geometry" we have learned from the lesson of Kevin Lynch (Lynch, 1969); the points are the nodes and references, the lines are the

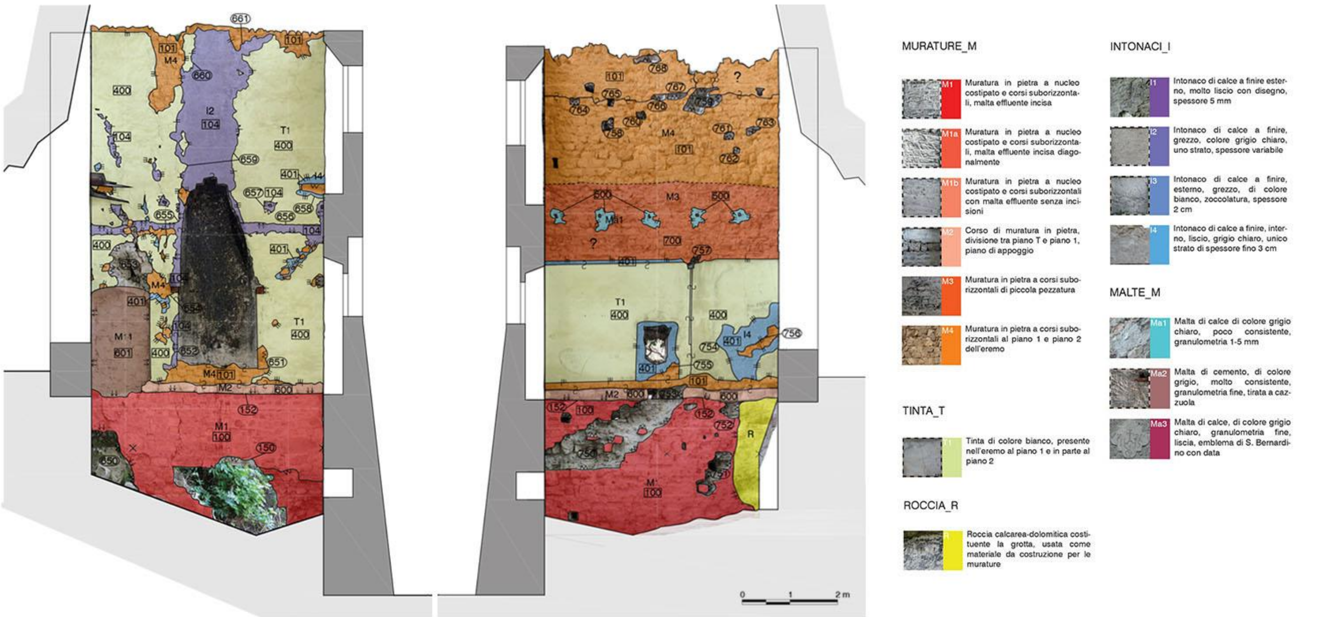

Fig. 12: The hermitage: map of degradation of the inner west wall (Paoli, 2015, tav. S04).

paths and margins, the surfaces are the neighborhoods of a complex territorial and human reality, that undergoes sometimes slow and sometimes sudden constant changes. These observations suggested the two design ideas outlined in the first page of this essay.

Firstly, the 3D model of the current state has been used for the buildings' virtual reconstruction, namely for representing the original appearance and volumes which are documented by historical and archival research. The integration between the figurative model of the present and the geometric model of the past aims to make still perceptible the overall vision of a disappeared totality. Using open source software Meshlab and CloudCompare, we tried to transform the unstructured "points cloud" into polygonal mesh, suitable to represent the surfaces of solids. The data, already processed using Faro Scene, were converted to compatible formats, imported in OS software and sampled, reducing their number; then the perpendicular lines associated to the points were created and the Poisson algorithm was applied. The result is not satisfying, also working on parts and locally acting to correct the wrong surfaces, due to the size and consistency of laser scanner data and despite the use of high performance computer (Fig. 13). Therefore, the trial version of Pointools v8i was tested; the compression of data format allows a fast import of the full model from Faro Scene and an easy surfing; still life pictures of the

Fig. 13: Screens of solid modelling tests made with Meshlab (top) and Cloud Compare (down).

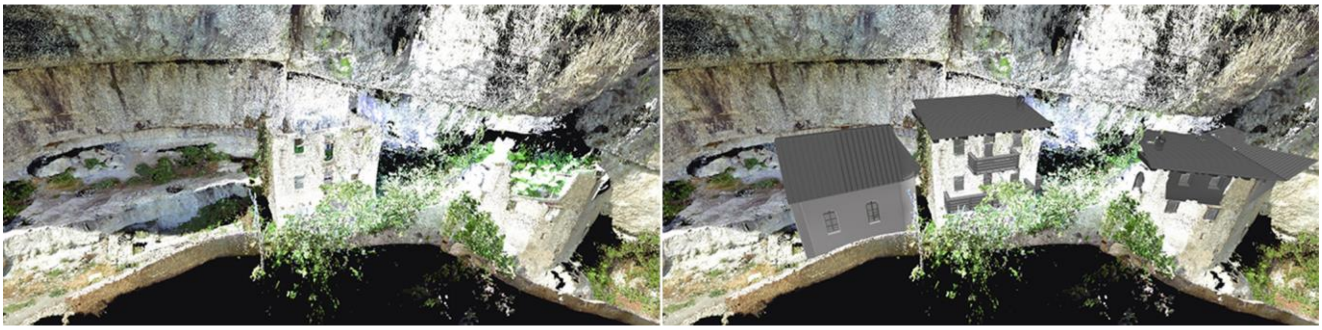

Fig. 14: A view of the 3D model before and after entering the volumes as they were, digitally rebuilt on the basis of historical and archival assumptions.

Fig. 15: The archaeological site: virtual reconstruction of the original layout.

"points cloud" as well as animations in orbit mode or fly through may be produced, with the free positioning of the cameras anywhere in the spatial model, thus obtaining unusual images or video for the eye. The three–dimensional geometry of the missing parts of the hermitage, east building and church were modeled with Rhinoceros 5.0, then imported in Pointools v8i: the hybridization between the colored "points cloud" and the grayscale solid volumes gives the ancient image of walls and roofs, finishes, windows and doors (Fig. 14, Fig. 15).

Modelling and visualization of digital data highlight the added value provided by the use of ICT in archaeology; the second working hypothesis tested in San Gottardo is not so much linked to the historical relations between the past, the present and the future, as to the geographical dynamics between small and large events, permanent elements and transformation factors.

The digital representation foreshadows the final effect that you could get with the future development of a lighting project, to be entrusted with a specific action based on the enhancement of light and on the will to emphasize the perception of the archaeological site in the landscape, allowing enjoyment even at night[3]. The lighting design always involves the check of a "triangulation", that is an interaction between three elements. The first one comes from the sources of light, which can be natural or artificial, immersive or focused; the second one lies in the subject, in our physiological and psychological reactions to the perceived phenomenon; obviously, the third element is the environment, the space in which the electromagnetic radiation is distributed (Rossi, 2008).

After considering the performance features of the lighting fixtures, the LED technology Disano Cripto small–asymmetric spotlight was chosen, which ensures the materials correct perception, a very good color rendering, the energy efficiency maximization as well as several maintenance advantages. The simulation was developed with the software DIALux evo, which performs calculations on a specially crafted simplified geometry, here obtained by the survey model.

[3] The project is developed in compliance with the law no. 16, October 3, 2007 "Provincial plan of action for the prevention and reduction of light pollution".

After some testing and renouncing the use of colored LED, 14 lamps were placed in the digital model in order to emphasize the visible outcrops of the hermitage, the castle and the surrounding walls; nine external lamps with 4000 K color temperature and five inner lamps with 2700 K; both the fixing points and the paths of the power cables were designed for them (Fig. 16).

The software solves the equations as a function of some parameters set by the operator: power, luminous flux and color temperature, with a 45% luminous reflection applied to the model textures. In this way we can check the value of the surface average luminance so that it does not exceed the limit imposed by law (Fig. 17).

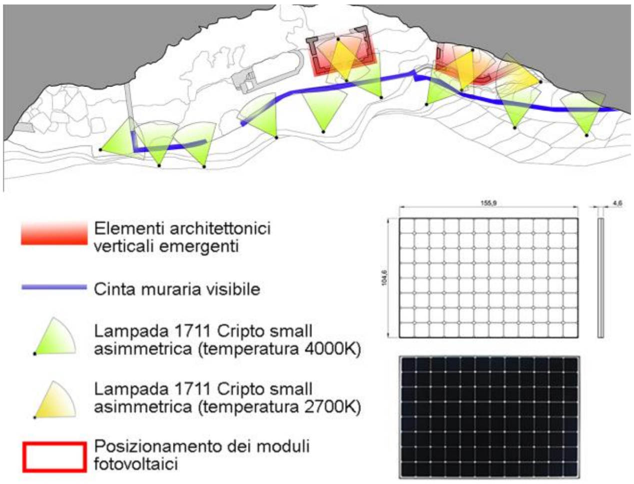

Fig. 16: Lighting project: placement of the spotlights and photovoltaic panels.

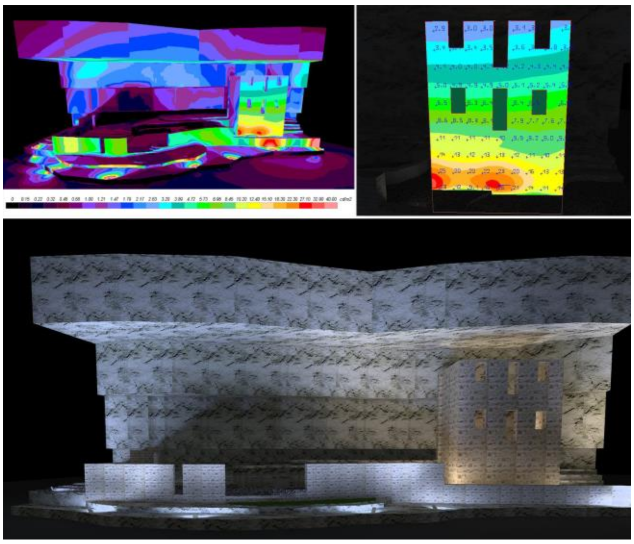

Fig. 17: Lighting check through indexed colors rendering, detail of the hermitage front, lighting simulation with DIALux (from left to right).

Finally, the plant engineering solution was verified with the use of renewable energy: the SunPower 315 photovoltaic modulus was chosen, considering the annual productivity and daily delivered power; it was found that four modules would be enough to meet the demands of the lighting system proposed for the complex of San Gottardo.

5. Conclusions

The laser scanning tools are certainly one of the fastest solutions for designing the shape of the archaeological and architectural heritage; the quality of the obtained data should be assessed considering two fundamental aspects: the measurement accuracy and the practical possibility of using information. As regards the first aspect, the constant technological improvement has shown it can achieve higher and higher levels of data accuracy and quantity, enough to be able to return a "virtual imprint" of physical reality. On the other hand, the second aspect is linked to the possibility to easily extract a series of discrete information just from that virtual cast, useful to the section drawing and aimed at the development of analytical and design models.

In both cases, it is certainly profitable to have a "points cloud" characterized by a very high density, but this results in a significant increase in file size being worked on, with obvious operational difficulties. A kind of mediation between the potential of advanced remote sensing techniques, the features of the work and the intentions that trigger the survey should necessarily be found. 3D visualization is not a kind of aesthetic whim covering the lack of critical content, or a process of data popularization; rather, it is a tool of "increased knowledge" critical for communication, especially if the investigative role exists alongside the reconstructive one. When it is properly implemented, the virtual model becomes a "holistic container" of information, able to process a "cognitive geometry" of cultural assets.

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