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Simulation and virtual approach: from architecture to landscape

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Abstract

Purpose:
This contribute aim to explore 3D modelling and its practical applications investigating scales of representation and scales of contents from architecture to landscape.

Method:
The goal of this research work was to test the flexibility of modeling tools – in this case AutoCAD 2011® and Rhinoceros 4.8® – to different field of application and to draw shared methods, even if they are applied in so different context.

Result:
During the research occurred some problems that should be considered as central for future developments. They will drive the mainlines for the refinement of software and application technologies, but it must be remembered that, first of all, the direct experience and the validation with practical case studies must be absolutely taken into account.

Discussion & Conclusion:
The experience made and the reflections on the achievements allowed to compare digital techniques of representation for architecture and territory. On the basis of the outcomes and of research directions for the future, it has paved the way to thinking useful to the implementation of the method and to the management of the graphic results.

1 Introduction

This contribute aim to explore 3D modeling and its practical applications investigating scales of representation and scales of contents from architecture to landscape. Changing the scale, is obvious, the language change – because is necessary to recompose symbolic and iconographic elements – themes and scales of representation change.

The goal of this research work was to test the flexibility of modeling tools – in this case AutoCAD 2011® and Rhinoceros 4.8® – to different field of application and to draw shared methods, even if they are applied in so different context.

So is possible to pave the way to strictly disciplinary thinking on outcomes and on instrumental and methodological guidelines for further research.

2 Simulation and virtual approaches: a 3D models for the restoration project

Elena Marchis

2.1 Premise

This paper will address some issues related to three-dimensional modeling as a potential medium for subsequent restoration in order to assess their applicability in specific areas of importance to the restoration. This research was developed at the Department of Building and Territorial Engineering - DISET - Politecnico di Torino and was part of the more complex activities of the project around the restoration site of the Chiesa di San Giovanni Decollato della Confraternita della Misericordia (Church of the Mercy) in Turin started in 2008 and then followed and developed within my PhD thesis in Cultural Heritage is here presented.

The activity started in January 2008 when the first relief operations were launched, and continued along the various phases of the yard until completion of the first batch of intervention in July 2009.

The research team, coordinated by Professor Secondino Coppo, in cooperation with Professor Fulvio Rinaudo, was composed by a group of young researchers: the author of this paper, the engineers Maurizio Bocconcino and Paolo Piumatti, and the architect Marco Vitali.

2.2 Method and results

The presence along the various steps of the research, chronologically synthesized below, and the large collection of processed data, has allowed to obtain a comprehensive view of the yard, is in its most practical and concrete aspects as well as in its complexity.

3D scanning technology is an outstanding medium for rapidly generating reliable inventory documentation in civil and structural engineering as well as for architectural recordings, especially in the heritage field.

- January-February 2008: In this first phase a reliable inventory documentation of the church has been performed using the total station and laser scans. The automatically acquired data have been integrated with local detailed analysis of critical areas and with traditional measures in order to obtain an efficient filtering of the data. Of significant importance was the photographic documentation.

- **March-May 2008**: The graphical restitution of the acquired data and their elaboration took three months of intense work. The level of graphic detail and the information accuracy, needed to obtain a precision detail in 1:50 scale, often obliged the research team to review the data and to newly compare and directly verify them on site. The relief activities have been performed starting from the necessities of organizing the metric measurements. (fig. 1)

The timing and delivery of the documents have been staged along a schedule based upon the needs of construction, and required a real time coordination in order to produce the results according to the exigencies foreseen and to those unexpected in every job phase. The rigorous deadlines made the operation more complex than expected, because of the tight schedule and in particular of the difficulties of working in parallel on the same process. The final drawing preparation times were as follows:

- 15 days for the plan drawings at different levels;
- 20 days for the two longitudinal sections;
- 15 days for the three cross-sections;
- 7 days for the plan of the ceiling vaults;
- 7 days for the details in 1:20 scale.

Data processing of the space points has been performed via algorithms capable to build a surface model bounded to the measured points.

- **June 2008**: all the drawing and attached papers were delivered made: sections, plans and details. The client, analyzing what has been achieved, required some additions on the drawings of architecture details.

- **September 2008 - July 2009:** Restoration activities. The yard involved the workers and the technicians for a period of 10 months during which they performed the restoration and cleaning of the church internal walls. (fig. 2) The removal of the paint film, a nineteenth-century stage, on the surface of the walls was needed to bring to light the decoration clearer and brighter below. The tearing of the frescoes with the four Evangelists located in the eyepiece of the vault of the hall and the six plumes in the dome with the angels have been taken off. This operation was necessary for the reopening of the original windows in order to restore the natural light as foreseen by the original project. In some areas it was necessary to integrate the paintings according to traditional methods. The site was continuously monitored with periodic visits, meetings with management, following the activities under the surveillance of the Ministry of Cultural Heritage representatives. (fig. 3)

In particular, the most significant actions were:

- Removal of the various paint layers;
- Mapping and recording of layers' images;
- Taking off of frescos in the surface of the vault, and opening of the oculi; (fig. 4)
- Opening of the four round windows in the vault of the hall and lowering of the six pentagons located in the dome above the altar; (fig. 5)
- Consolidation of the drum supporting the dome above the sanctuary;
- Consolidation of the wall near the counter- affected by a lesion evident.

All operations were rigorously documented with photographs and technical drawings. (fig. 6)

- **September 2009** - **December 2009**: When the operations of the yard were completed, in order to be able to reach a critical review of work done, the team proceeded to the analysis of existing scientific literature. This was done with a direct comparison with the experience gained on site. During this period it was reached a fully consciousness of the importance of restoration yard activities, an experience that can hardly found in literature, even if supported by drawings and models.

- **January 2010 - December 2010:** After the survey of the internal ambient of the Church of the Brotherhood of Mercy of Turin was fully completed, with a final reorganization of maps and data, the research has been directed toward the creation of an alternative support of the data concerning the areas needed for restoration. This "tool" has been designed to quantify, analyze and evaluate the areas of degradation and to foresee the needed actions. This computer based support will be organized no longer on a two-dimensional, but on a three-dimensional frame. (fig. 7)

The initial idea about this software tool was to create a three-dimensional mathematical model to serve as the basis for a database, and capable to assist during all operations and stages of "big" restoration sites. The data collected during the survey have been organized into a database, where data and images were not included in, but were simply connected to the grid. This aspect would not to overburden the system in reading, and so making easier the information query supported by a "light" structure of data.

In the project, this information system would be combined to a dynamic three-dimensional model, but it has not been still completed for insurgent's integration computer problems, having to interconnect different work packages. It is hoped that a future standardization of software and especially its portability and flexibility can make feasible the central idea of this research.

The initial hypothesis was directed toward the preparation of a 3D GIS model, a local informative system, capable to be questioned at different levels of detail as required in the different research stages, but also suitable of improvements. Despite it were the most interesting and stimulating solution, already in the first steps of the research it was realized that the staff of technicians to whom refer and discuss with was not enough for supporting the initiative, and for this reason it was impossible to complete the experiment with this method. Currently, the tools available are still unable to support and develop the mass of information contained in the point cloud, which must be very detailed in order to describe and render the representation under consideration, and especially to describe the process of acquisition of the data necessary to calculate the areas of the degraded surfaces.

The standard computers used in a yard or in a technical design studio are not capable to handle such a mass of data. Only a technical evolution of computing hardware and software can afford a solution in this sense.

The model that the author of this paper tried to build, with special attention to data precision, conceived as a design idea, could also be used as a basis for structural controls in order to provide a simplified view of the stress and strain dynamics, but also for acoustic and illumination analysis. There are many cases in the literature using three-dimensional models to communicate information, but also to study and to simulate a variety of possible interventions. The definition level of the selected model shall have a good precision level and be sufficiently reliable, but at the same time it must be easy to use. One of the key points of this research was the definition/creation of a method capable to be exported in other situations, with the necessary modifications according to the ambient where it can be suitable for operation. The method shall be economically sustainable for documentation and mapping of the areas of intervention, in the different working times of middle- and large-sized restoration yards. It is important to stress that this research is evolving and does not mark a definite end to it. The model has to be developed to serve as support to project and to compute the surface contained within a polygonal, being this a damaged area, a painted zone, or variously decorated paintings. The regions, defined by means of traditional techniques in order to project them on the model, must be vectorized. It should be paid close attention to the areas "spread" on the model so that they coincide with the real areas and that the real magnitude of the errors be acceptable. This process should be a tool to place in the 3D space the 2D mapped surfaces and to calculate the effective areas. (fig. 8)

To create the model we started from the point cloud which was followed by their interpolation by means of the Sir-IO software, developed for managing data geomatics. With this software it is possible to get contour lines with a pitch of 10 cm, useful to create a "virtual surface" as close to reality as possible. (fig. 9)

One of the main uses of this model is the mapping and quantification of the degradation of defined areas, for purposes as the accounting and the management of the yard. Such a system could be of great help to monitor and to quantify the work of craftsmen working in restoration projects and more. Interviews have been conducted by technicians and professionals, asking information about their use of tools for the calculation and quantification of the restoration work on complex surfaces and developed in three dimensions. Most of them now in fact are using tools very approximate, acting on 2D models. By simply multiplying by correction factors the interested surface areas applied to a curved surface projected on the plane, the errors that occurr are significant and the calculations are inaccurate. Such evaluation of the measure of the curved surface areas cause errors in economic evaluation, that can be unacceptable especially in the case of construction yards of relevant importance.

On the so created model it has been tested the magnitude of the errors that arise from the use of simplified systems in the evaluation of areas placed on vaulted and non linear surfaces. As a test is has been considered the simple case of a hemisphere, this being the geometry closer to the case of a curved ceiling typical of architectonic halls It follows that a simple use of the computations carried out on 2D projections can be taken neither as an absolute, nor as a relative reference. It is therefore necessary an exact evaluation of the curved surfaces; for such a computation shall be very useful those tools that use very accurate computational methods but are at the same time economically sustainable also with respect to the resources of a medium sized yard. By analyzing the results, it can be inferred that most of the technicians are very concerned by the possibility of working on a dynamic three-dimensional model that can provide accurate data, but the fact is that most of them still work on two-dimensional media.

Finally, it emerged the need of a three-dimensional digital model that can be used, even just for the communication to the "general public", which is increasingly interested in the restoration sites and their evolution. This tool would be extremely useful to document and to store the life story of the architectural “good”. The activity of mapping the degradation of a surface by acting directly on the three-dimensional solid picture results in 3D polylines that with the actual information tools are difficult to be used by the technicians operating on the yard. (fig. 4)

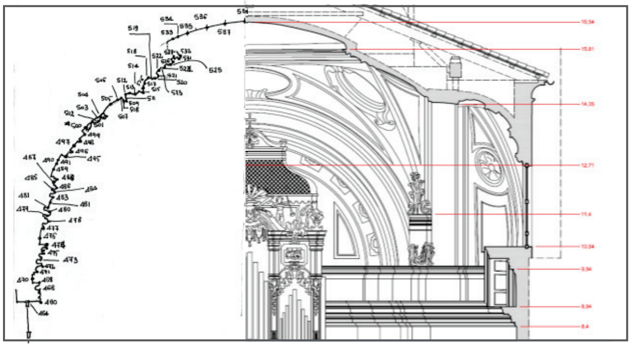

Fig. 1 – Eidotype and architectonic survey

Fig. 2 - Restoration site

Fig. 3 - Removal of the various paint layers;

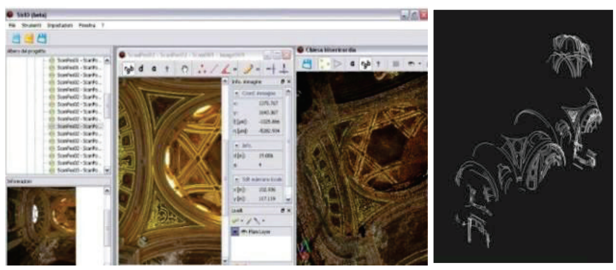

Fig. 4 - Software Sir-IO, allows to operate directly on the three-dimensional model and specifically on the photo solid

Fig. 5 - Opening of the six pentagons located in the dome above the altar after the untap the paint surface

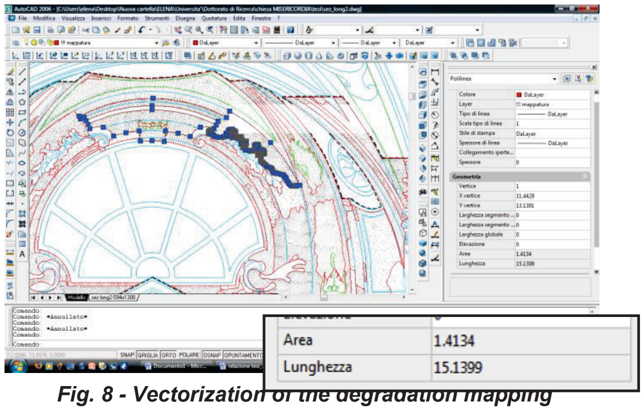

Fig. 8 - Vectorization of the degradation mapping

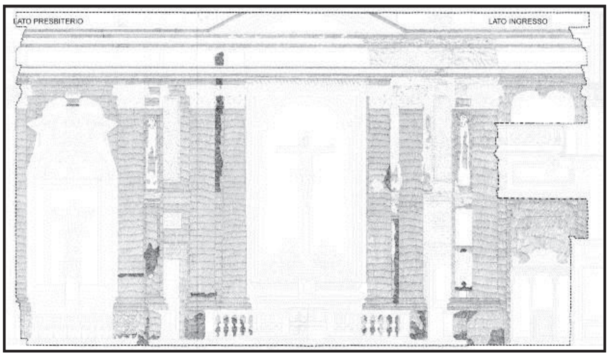

Fig. 6 - Mapping of degradation on a survey drawing

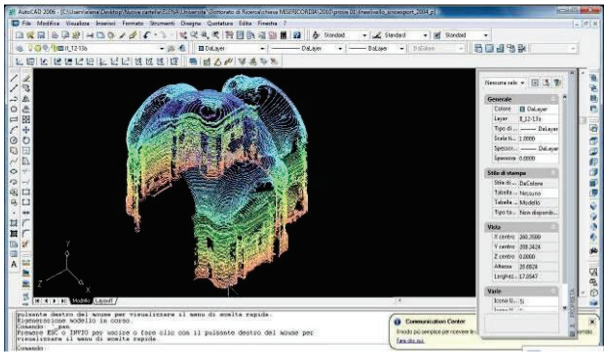

Fig. 9 - contour lines with a pitch of 10 cm, useful to create a "virtual surface" by the laser scanner

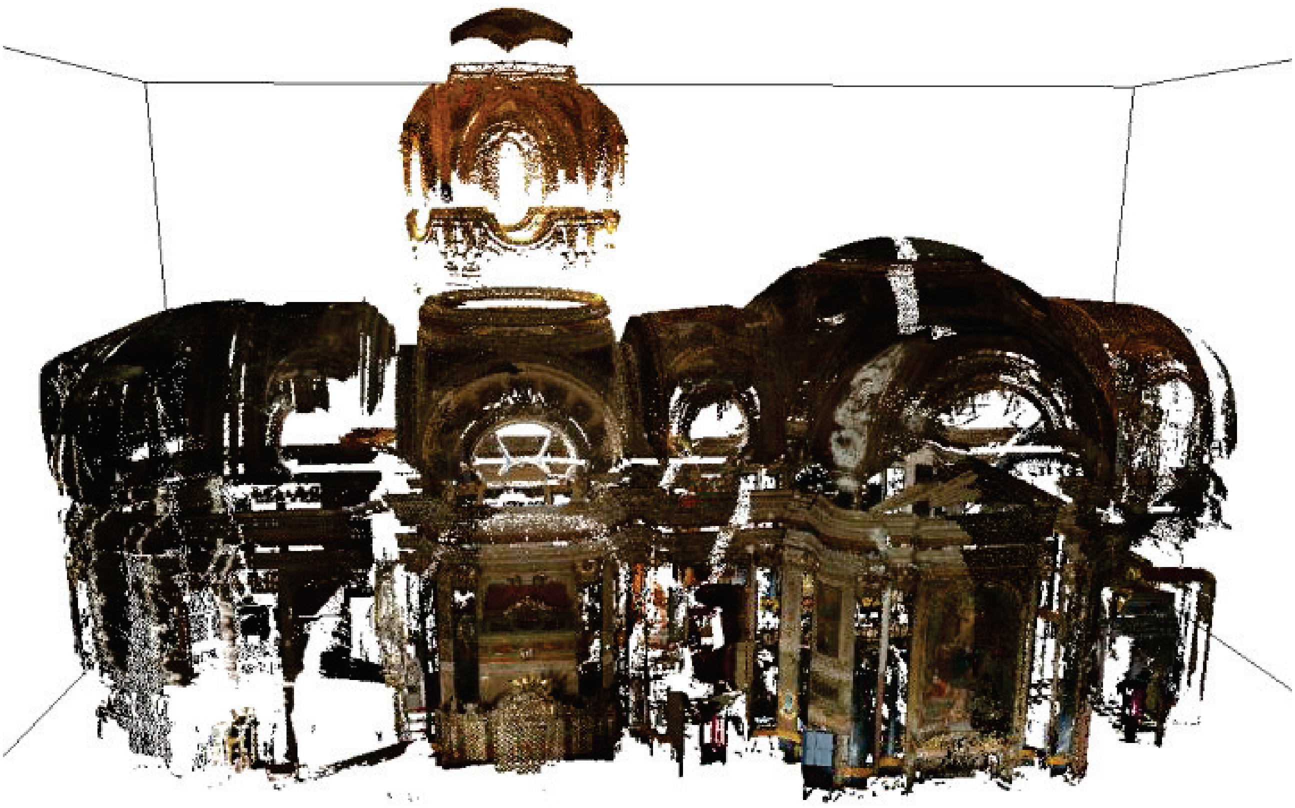

Fig. 7 – Point cloud images created by the laser scanner

3 Simulation and virtual approaches: a 3D models for analysis and representation of the territory

Marco Vitali

3.1 Premise

This contribute shows the results of a work of analysis and representation at the territorial scale, realized for a project on a UNESCO (United Nations Educational, Scientific and Cultural Organization) nomination, presented in January 2011 for the site "The vineyard landscape of Piedmont: *Langhe-Roero* and *Monferrato*". The presentation of the nomination dossier represent the concretization of years of work and cooperation between SiTI (Higher Institute on Territorial Systems for Innovation), the Piedmont Region, the Regional Directorate for cultural heritage and landscape assets of Piedmont and the Alessandria, Asti and Cuneo Province, that have strongly believed in it[1].

The proposed site is a serial site, constituted by nine "excellence areas" (Core Zones), for a total of 74 Municipalities, distributed inside the administrative boundaries of the Alessandria, Asti and Cuneo Provinces. (fig.10). For this nomination *Langhe*, *Roero* and *Monferrato*, known in all the world for the production of high quality wines, constitute a Cultural Landscape, defined by UNESCO as "the result of the combined anthropic and natural action": a landscape where culture and traditions related to the wine are deeply settled and they manifest itself in all the aspects of the daily life, including literature, arts, festivals, gastronomy, language.

Together the selected areas represent the variety and the excellent quality of the vineyard landscape of Piedmont and of its products, for which a wide buffer zone was defined, with the aim of ensuring a higher protection of the nominee site and of giving continuity to the landscape of the individual areas, in the light of the close relationships between them related to territory, history and culture.

3.2 Method and results

In this context, that necessary involves multidisciplinary skills and considerable human resources, a strategic role was played by a work of representation aimed to study and analyze characters of uniqueness (related to the morphology of the territory, deeply influenced by humans) and at the same time elements of relationship and homogeneity at large scale

In fact, the utilization of 3D modeling for the visualization and the understanding of the territory allows to put in relationship data from various sources and to verify some hypothesis, like that related to the perimeters of Core Zones, as well to highlight the peculiarities of each area and the common features that justify the seriality of the nomination.[2].

Early stage, for the creation of the 3D model two tests were made on the first Core Zone "Freisa": the first test provided the realization of a surface model that uses as a basis the contours of the Regional Technical Map in 1:10000 scale, the second allowed the construction of a mesh surface starting from points of DTM (Digital Terrain Model) of the Piedmont Region[3].

In the first case, from the technical point of view, the creation of the model is quite heavy: in fact starting from the vector contours of the Regional Technical Map, equidistant 10 meters, a series of steps in AutoCAD 2011® are necessary, before exporting the data, in this case in Rhinoceros 4.8® for the construction of the surface model, with the plug-in Rhino Terrain.

First, The Regional Technical Map (in .dwg format) is made in sections of small dimension (6500x5500 meters about): for this reason is necessary to join a quite number of sections to obtain a sufficiently large basis to make the model of the terrain of each Core Zone.

Moreover it is necessary to:

- purge the base map;
- close each polyline – contour, to avoid anomalies in the model;
- assign to each contour its altitude.

After this it is possible to proceed to the exportation in Rhinoceros and to realize the surface model whit the special tools of Rhino Terrain

This procedure guarantees the realization of an excellent surface model even if, as already said, definitely onerous in terms of time and work. The base material is, in fact, in a too big scale related to the dimension of the parts of territory to model (fig.11). On the other hand, the selection of contours with an equidistance of 50 meters produces a model that is too simplified.

In the second case the construction of the model is significantly more simple and fast: the base material is constituted by a sampling of altitude points of the terrain, setted out in a square mesh of 50 meters and acquired with photogrammetric procedure with an accuracy of 1/10000 scale. In Rhinoceros is very easy to mosaic the matrix of spatial points related to sections or folio of the Regional Technical Map and to realize the mesh surface of the terrain.

In this case the surface model is less accurate than the first one, even if is capable to describe, with a acceptable level of discretization, the orographic shape of the terrain: considering the processing time and the obtained results (in relationship with the subsequent phase), it was decided to use this procedure for the creation of the models related to the other eight Core Zones.

After this first phase it was possible to thematize the model according to slopes and gradients. The models thematized in this way allow:

- analysis and thinking on the shape of the perimeters of the Core Zones, that necessary have to face with the morphological peculiarities of each core zone;
- comparisons between the orographic characteristics of each excellence area.

A further step was to thematize the model on the basis

[1] AAVV, *Unesco world heritage list - the vineyard landscape of Piedmont: langhe-roero and monferrato*, Torino 2011.

[2] EMPLER Tommaso, BIANCONI Fabio, BAGAGLI Roberto, *Rappresentazione del paesaggio. Modelli virtuali per la progettazione ambientale e territoriale,* DEI, Roma 2006.

[3] RAO Sebastiano, *Nota tecnica . Il Modello Altimetrico Digitale della Regione Piemonte,* http://www.regione.piemonte.it/sit/argomenti/pianifica/cartografia/dwd/dtm_notatecnica.pdf

of to the prevailing land use of Piedmont Land Cover[4], a homogeneous geographic database on the territory of the region. For this phase was used a chromatic symbolism associated to the shape files of the Land Cover of the Alessandria, Asti and Cuneo Provinces: on the basis of the aims of this work the themes was grouped in categories like vineyards, urbanized areas, woods, shrubberies, pastures, fields, etc.

Those processing was the tool to verify and communicate with images, especially to a specialized public, some hypothesis related to the position of vineyards and others themes on valleys and hills, that develop very different configurations under the morphological characteristics of each area, depending from dimension of vineyards and fields, shape and distribution of woodlands, shrub zones and pastures.

Further hybrid visualization was obtained overlapping on the model the projection of Land Cover map data with orthophotomaps mosaicking to make understandable data and suggestions also to a wider audience (fig.12)

The models of each Core Zone, thematized in this way, was then used to obtain 2D images, to represent the considerations that support the serial nomination.

With the aim to make comparable, also from a dimensional point of view, the characteristics of uniqueness and of seriality of the areas, for each, was chosen the position of section planes useful to realize typical sections that can allow a comparison, both from an orographic and morphological-landscape point of view.

With a series of 3D operations it was possible to obtain, directly from the model, special characteristic profiles for each core zone (fig. 13-14): those special profiles represent also, with a symbolic-chromatic language, land cover data. With further section planes, parallels to the principal one, it was possible represent the most important hills for each core, to overlap in orthographic projection on the thematic section, to take care also of the landscape characteristics.

The sections, as follows, was collected in summaries (fig. 15) and compared with:

- pictures that allow an integrated reading of the landscape peculiarities
- parts of thematic maps (zenith view of the 3D model in 1:10.000 scale) with the indication of the section plane for the spatial profile.

The reading of each summary and the comparative reading allow as a comparison between symbolic-technical and iconographic languages and an immediate representation of the salient features of each area of the serial site of the nomination. This comparison has also addressed this work to cognitive insights on the territory and on the representation techniques appropriate to describe it.

3.3 Discussion and wrapping up

Starting from considering that the urban and territorial landscape is the outcome of a collective process of stratification, where spontaneous and planned transformations, produced and induced, follows one another with continuity and caesura, in the analysis and in the preliminary studies on management and protection of the landscape is common goal to preserve the identity features that qualify local contexts and to define the compatible changes in relation to the transform processes. It follows the utility to define compatibility criteria in relationship to identity of the countryside to protect existing landscapes.

Accordingly, with the aim to pursuit a complete and comprehensive wealth of knowledge, after the phases of documentation and survey exploration in the field of intervisibility were taken, founded on the possibility of derive visual catchments (viewshed), related to viewpoints placed in strategic positions.

This part of the work, still at the beginnings, provides the use of the 3D model of the territory for further processing, related to the modeling of principal urban sites, trough extrusion of the volumes of the built and of the most important architectures and of the most significant vegetations. This model, although with a purely symbolic language, shows anyway quantitative features that make it particularly suitable to assessments related to intervisibility, that basing its operations on projective-geometric principles, can't leave aside quantitative-numeric values.

The definition of the intervisibility field, based on the construction of the 3D model, as well as to allow a immediate approach to the territory, provide a good contribution to the analysis of paths and views, to the definition of perimeters and areas of particular architectural/landscape value, as well to define the local architecture (defined by the morphology and by the identification of the visual barriers) and the landscape architecture (defined by the fundamental components of the landscape. The tool of analysis, prepared in this way, could allow making subsequent evaluations on perception and intervisibility of the elements that compose and structure the landscape.

It is better to note that those hypotheses are strictly to the definition of the objectives of landscape quality in relationship to the features of the different landscape units, to the transformation dynamics, to the opportunities of compatible developments. To interpret the "dimension" of the landscape is the fundamental operation to individuate and implement the appropriate strategies of redevelopment, protection and compatible transformation.

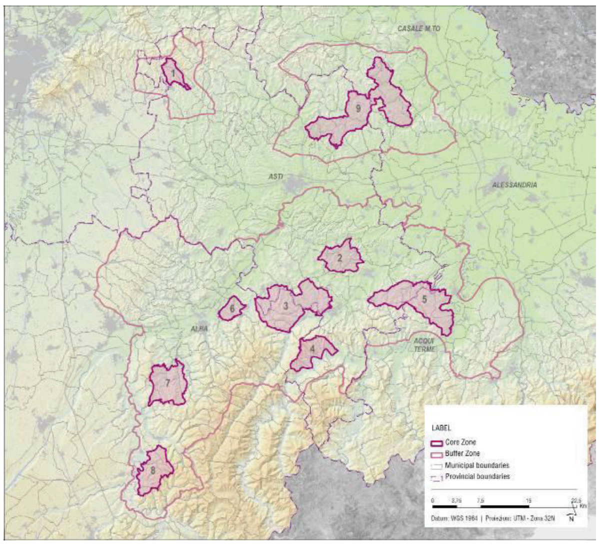

Fig. 10 – Map of the nominated site (E 392.269 – N 5.001.237; E 484.966 – N %.001.249 E 392.139; N 4.915.186; E 485.001 – N 4.915.171

[4] DIEGOLI Barbara, GARRETTI Luigi, GOTTERO Franco, PETERLIN Gabriele, *Land Cover Piemonte: progettazione di un database geografico sulla copertura e l'uso delle terre della Regione Piemonte*, Atti 11[a] conferenza nazionale ASITA, Centro Congressi Lingotto, Torino 6-9 dicembre 2007.

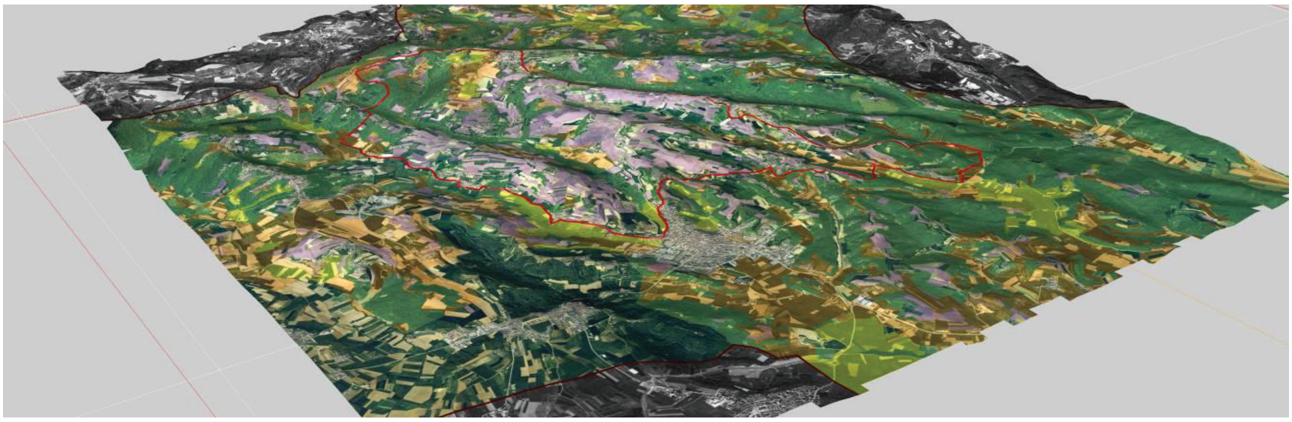

Fig 11 - 3D model of the territory of Core Zone 1 "Freisa", created starting from spatial points of DTM of the Piedmont Region points, subsequently thematized with Land Cover data.

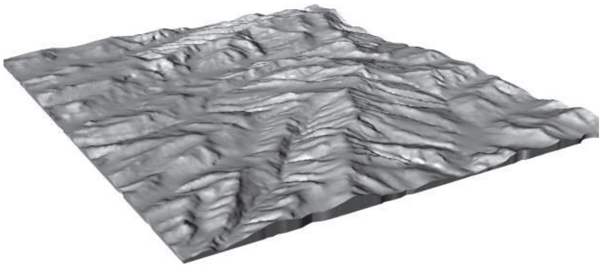

Fig.12 – 3D model of the territory of Core Zone 1 "Freisa", created starting from contours of the Regional Technical Map of Piedmont (equidistance of 10 meters)

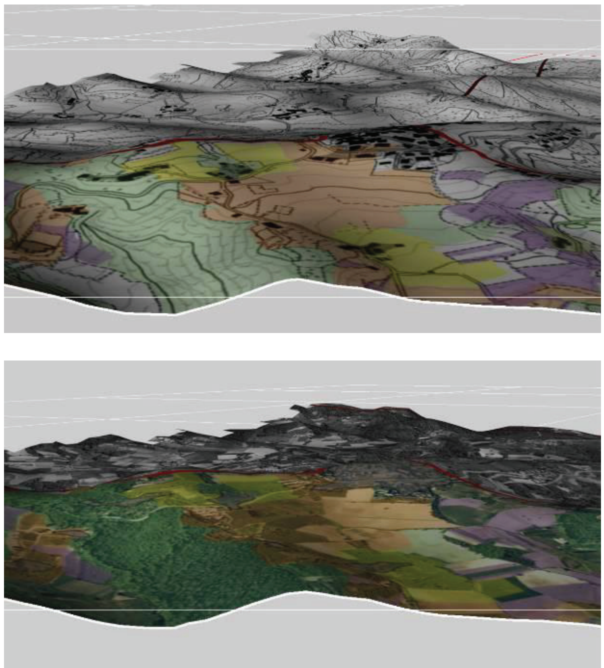

Fig 13 – Comparison between sections obtained from the 3D model: a) with the overlapping of themes related to IGM map and Land Cover b) with the overlapping of themes related to the orthophotomaps and Land Cover.

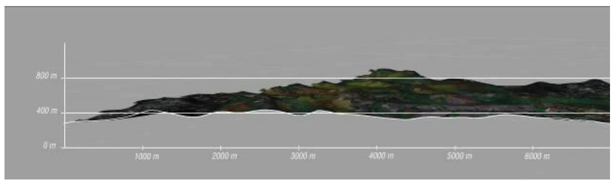

Fig 14 – part of the in scale spatial profile obtained from the 3D model.

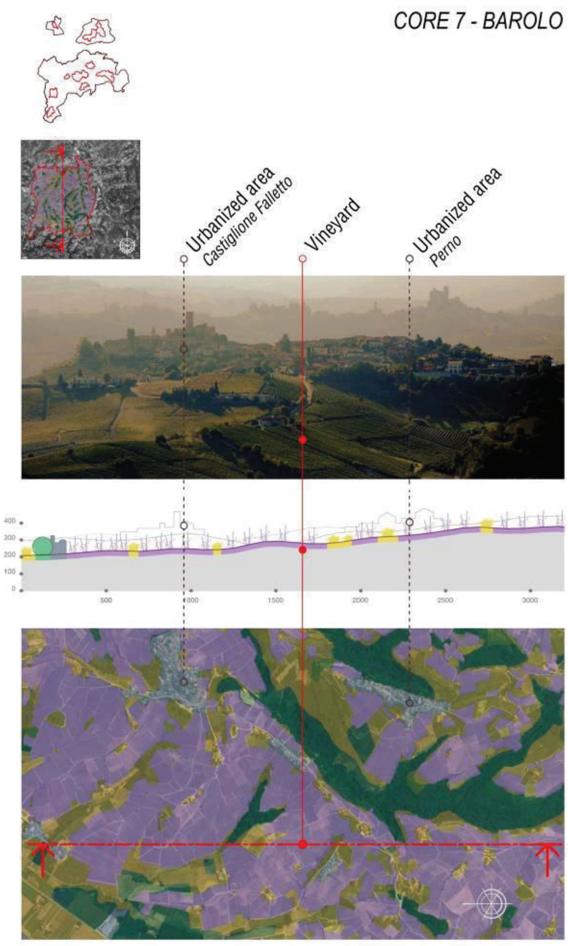

Fig 15- Summary related to the Core Zone 7 "Barolo", drawn in 1:10000 scale.

4 Conclusion

During the research, which had to struggle with quite a lot of critical aspects, there occurred some problems that should be considered as central for future developments. They will drive the mainlines for the refinement of software and application technologies, but it must be remembered that, first of all, the direct experience and the validation with practical case studies must be absolutely taken into account.

This research has demonstrated that are the real practical needs that give the input to the development of new theories. Only a direct presence in contact with the reality of the yard can provide the correct pushes for the creation of new tools, even theoretical, from which depends the future of an integrated knowledge, in a society where operators and engines increasingly will find points of agreement.

In conclusion, the experience made and the reflections on the achievements allowed to compare digital techniques of representation for architecture and territory and to prepare methods for the study and for the management of data at different scale: on the basis of the outcomes and of research directions for the future, it has paved the way to thinking useful to the implementation of the method and to the management of the graphic results, both in terms of contents and purely disciplinary.

5 References

[1]. Eros AGOSTO, Secondino COPPO, Anna OSELLO, Fulvio RINAUDO, *Survey And Representation Methodologies In Teaching Experience*, in International Archives of the photogrammetry, remote sensing and spatial information sciences, 2005, pp. 5, ,Vol. Xxxvi-5/C34.

[2]. BERALDIN e Marco GAIANI, *Valutazioni delle prestazioni di sistemi di acquisizione tipo 3D active-vision: alcuni risultati*, in "DDD rivista trimestrale di Disegno digitale e design", Poli Design editore, Anno 2, n. 5 Gen-mar 2003, pagg. 115-128.

[3]. Carlo BLASI, Eva COISSON, *La fabbrica del Duomo di Parma. Stabilità, rilievi e modifiche nel tempo*. Editore Grafiche Step, Parma 2006.

[4]. Maurizio BOCCONCINO, Elena MARCHIS, Paolo PIUMATTI, Marco VITALI, INTEGRATION OF DIGITAL TECHNIQUES FOR Three-dimensional survey: the case study of the baroque church of "San Giovanni Decollato" in: "The CIPA International Archives for Documentation of Cultural Heritage, editor in chief: Yutaka Takase" , 22nd CIPA Symposium - Digital Documentation, Interpretation & Presentation of Cultural Heritage, Kyoto (Japan) 11-15 ottobre 2009.

[5]. Valentina BONORA, Antonia SPANÒ, *Strutture voltate: rilievo laser scanning e modellazione delle geometrie*, in Atti del Workshop "Tecnologie per Comunicare l'Architettura", Ancona, 20-21-22 maggio 2004.

[6]. Valentina BONORA, Filiberto CHIABRANDO, Antonia SPANÒ, Grazia TUCCI, *Fruibilità e precisione di modelli architettonici multiscala da rilievi laser scanner*, in Atti della 7a Conferenza Nazionale ASITA "L'informazione Territoriale e la dimensione tempo", Verona, 28-31 ottobre 2003, Vol. I. pp. 405-412.

[7]. Leandro BORNAZ, Sergio DEQUAL, *The solid image: a new concept and its applications*. In: "The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences", Ancona 2003, Vol. XXXIV, Part 5/W12, pp. 78-82.

[8]. Fausto BREVI, Nicolò CECCARELLI, Marco GAIANI, *Il cantiere di restauro visualizzato*, in "Disegnare idee immagini" n. 29/2004, pp.64-79.

[9]. Giorgio GARZINO, Secondino COPPO , *I disegni per il governo del processo di cantiere*, in: *Il cantiere edile*, Piergiovanni BARDELLI, Secondino COPPO, a cura di, Flaccovio, Palermo, 2010, vol. unico, pp. 451 – 458.

[10].Filiberto CHIABRANDO, Francesco NEX, Dario PIATTI, Fulvio RINAUDO, *Il rilievo metrico della Chiesa della Misericordia di Torino a supporto del cantiere di restauro*. In: "Bollettino della Società Italiana di fotogrammetria e topografia", 2008, Vol. 1, pp 61-82.

[11].Alfonso IPPOLITO, *La modellazione delle superfici murarie del Tempio del Divo Claudio a Roma* in "Disegnare idee immagini" n. 38/2009, pp.76-85.

[12].Andrea LINGUA, Paolo PIUMATTI, Fulvio RINAUDO, *Digital photogrammetry: a standard approach to cultural eritage survey*, in "The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences", Ancona 2004, Italy, Vol. XXXIV, Part 5/W12, pp. 210-215.

[13].Andrea LINGUA, Paolo PIUMATTI, Fulvio RINAUDO, *Digital photogrammetry: a standard approach to cultural eritage survey,* in: "The international archives of the photogrammetry, remote sensing and spatial information sciences, International Society for Photogrammetry and Remot", Ancona, 2003, pp. 210 – 215.

*[14].*Massimiliano LO TURCO, Paolo PIUMATTI, Tecniche integrate per il rilievo ed il progetto: immagine digitale e modello virtuale a confronto, in: *Il disegno di luoghi e mercati a Torino*, Secondino COPPO, Anna OSELLO, Celid, Torino, 2006.

[15].Marco GAIANI, *Strategie di rappresentazione digitale: modelli per la conservazione e il restauro*, in "Quaderni Centro Ricerche Informatiche per i beni Culturali", Scuola Normale di Pisa, n. X, 2000, pagg. 47-69.

[16].N. MILELLA, M. ZONNO, A. LERARIO, *Il rilievo digitale dei beni architettonici*., http://fabrica.ba.cnr.it/.

[17].Pina NOVELLO, Giorgio GARZINO, *Dal rilievo critico alla rappresentazione attraverso tecniche informatiche*, in: *Il Recupero - Metodi e Modi*, Politecnico di Torino - Diset, BE-MA Editrice, Torino, 1990.

[18].Giorgio VERIDIANI, *Il Battistero di San Giovanni in Piazza dei Miracoli a Pisa. Note sul rilievo digitale*, in Firenze Architettura. "Il disegno come conoscenza dell'architettura". Periodico semestrale del Dipartimento di progettazione dell'Architettura, Anno VII (2003), n. 1& 2, pagg 32-39.

[19].Chiara VERNIZZI, *Considerazioni sul rilevamento per la valutazione strutturale: le volte della navata centrale del Duomo di Parma*, in "Disegnare idee immagini" n. 35/2007, pp.74-85.