**From the 3D survey “ad Oggetto” to the technological representation of the architecture**

*The case study of Caporciano*

Danilo Di Mascio¹, Pierpaolo Palka²

¹IDEA, Department of Infrastructures, Design, Engineering, Architecture; Faculty of Architecture, G. D’Annunzio University, Pescara-Chieti, Italy; ²Department of Ingegneria, G. d’Annunzio University, Pescara-Chieti, Italy

¹http://www.danarchitect.com, ²http://www.sitrilievi.it

¹ddimascio@danarchitect.com, ²ppalka@unich.it

**Abstract.** In this paper we are to present a research, still in progress, whose main objective is the desire to develop and test an alternative method of surveying, representing and analyzing buildings that are part of a minor historical-artistic heritage. The instruments used and the proposed methodology want to give an alternative to other solutions such as 3D laser scanners and photogrammetry, which would be not only expensive, but also difficult to use in small and irregular spaces, typical of the old Italian villages.

The case study that will be presented is Caporciano, a small medieval village in Abruzzo (a region at the centre of Italy), in the internal area of the region affected by a violent earthquake in 2009. This tragic event has put the spotlights on the problems and the fragility of these small villages, which represent an important local resource of cultural importance, and therefore must be preserved for the future generation. In order to properly act in these areas, it is necessary to thoroughly know the actions to be taken for its recovery or conservation, and the present methodology allows the creation of this knowledge made up of several drawings, both two-dimensional and three-dimensional.

**Keywords.** 3D survey; cultural heritage; 3d modeling; CAD; Abruzzo region.

**INTRODUCTION**

The research presented in this paper has as its specific objective the development of a survey and representation method of small historical villages, through the use and experimentation of different tools and software packages. During the centuries, under the pressure of practical needs or the desire to deepen their knowledge concerning the architecture of the past, there have been elaborated new theories, tools and methods to survey and represent buildings and places, both at the urban scale and at the scale of the single artefact. In Greece, between the seventh and sixth century BC, Heron of Alexandria invented a geodetic device, the “goal”, to obtain the measures of the azimuth and zenith angles of construction and inaccessible places such as bridges, towers, walls, river banks, etc. The Forma Urbis Romae (200 AD), a
marble map of ancient Rome, shows a very modern interpretation of the major urban areas. On the map the spaces, the public buildings and the private houses are represented in plan, with a good topographic precision and with a large number of symbols and graphic conventions. From the Renaissance to the nineteenth century, surveying plays an increasingly important role and interests related to the constructive knowledge of the buildings were added to the metric interests. Giovan Battista Piranesi (1720-89) not only redraws the visible elements, but attempts, through excavations and surveys, to document even the hidden parts. With the invention of the descriptive geometry of Gaspard Monge (1746-1818) the way to observe and study the work through plans, elevations and sections changes radically. Letarouilly Paul Marie (1795-1855) surveyed many buildings in Rome with the aim of creating a useful documentation for the design of new buildings. In his remarks, he also gives importance to the quality and graphic rendering: for example, the thickness of the lines varies slightly according to the position of the element. (Docci et al., 1992) These examples illustrate some important moments of the long path of the history of the survey and mapping, and they show how the evolution of tools, methods and concepts also occurred largely because of the different practical needs. Our research is not an exception, but is part of a wider challenge.

PROBLEM AND VALUE OF THE SMALL TOWNS IN THE ABRUZZO REGION
The Abruzzo region counts 305 municipalities, 224 of which belong to the mountain area that has a surface equal to 76.2% of the regional territory. According to a case study made by CRESA, the Regional Centre for the social-economic case studies and researches, the whole mountain system seems static in comparison to the dynamic system of the coastal area. The weaknesses and the disadvantages of this system can be caused by various aspects, starting from the demographic degradation, to the underdevelopment of the productive system, and to the scarcity of the services provided. The same situation is at the basis of our case study, the village of Caporciano. From the beginning of the past century to the present day, this town has witnessed a progressive depopulation. In 1901 in Caporciano there were 1478 inhabitants, while in 2007, according to the data from ISTAT (National Institute of Statistics) there were 255 inhabitants. This social desertification has generated a consequent abandonment and degradation of the existing built heritage.

THE CASE STUDY: THE VILLAGE OF CAPORCIANO
The tragic earthquake of the 6th April 2009 has heavily damaged the city of L’Aquila and the surrounding cities, including Caporciano, and consequently has brought back to life all these problems. The small villages like Caporciano constitute a rich artistic and architectural heritage that has to be preserved for the future generations in order to maintain our cultural roots. Its valorization could foster the economic development of the territory with new activities and initiatives. But these buildings could become really useful also during the after-earthquake phase, that still sees part of the inhabitants of the city of L’Aquila without their own houses.

As happened in 2009 for the village of Castelnuovo (Di Mascio, 2010), also even for Caporciano was organized a workshop (by the Faculty of Architecture of Pescara and coordinated by Prof. M.C. Forlani), to reflect and develop various ideas and proposals for the reconstruction and the recovery of the village in a sustainable way. The event involved students, PhD and professors belonging to the technological area of several Italian Faculties of Architecture. Our work is part of this event/research. All the scientific contributions have been collected and recently published in a publication only in Italian (Forlani, 2010).

OBJECTIVES OF THE PROJECT
To work adequately in a complex and fragile urban context like the one of the small historical towns, it is necessary to know this context extensively. The first step related to the knowledge of the building, as indicated in the ReLuis Guide Lines (ReLUIIS, 2010), is
represented by the survey that should interest both the whole geometry of the buildings and the single decorations and the constructive elements.

One of the main purposes of a survey, there is the creation of a metrically precise documentation (plans, elevations and sections), useful to document the geometric, spatial, proportional and formal characteristics of a building.

The various recovery and refurbishment interventions in the historical centers often show the lack of an adequate basic technical documentation. It follows that there are alterations of aesthetical, constructive and functional aspects. These errors are not caused only by the cultural unconcern of those who work in these contexts, but also by the high economic expenses of the interventions that have to be done by expertise.

The survey of this “minor” historical-artistic heritage presents also a series of new problems. In fact it does not deal about surveying and documenting the squares and the monuments of the big cities, often surrounded by a wide and comfortable area to make all the measurements. On the contrary, the small towns are characterized by a complex, densely built center. The buildings are next to each other and the main facades often overlook on narrow, irregular and uphill roads (figure 1).

This is one of the main reasons why it is difficult to survey the buildings and to make pictures. We can find the same characteristics in the village of Caporciano, as well as in the narrow road, on which we focus in this study. On this road there are abandoned buildings, with opening sides, and buildings classified unusable after the earthquake of April, 6th 2009.

**METHODOLOGY**

The survey techniques that we know, are often too expensive and unworkable in the previously described situation. We are referring, for example, to the use of photogrammetry and 3D laser scanners. The costs related to a photogrammetric survey are high not only concerning the preparation phase of the stereographic couples, but mainly for what concerns the rendering phase that requires specialized technicians.

Even the use of the 3D Laser Scanner, considering the conditions described herewith, does not seem to be the best approach for the survey of minor historical villages, because of the many reference points needed to scan the examined context. The work could be too long and complex.

The main objective of the research we are presenting in this paper is related to the elaboration and the testing of a method that, could be fast,
precise, cheap at the same time and able to employ possible technologies and the software at our disposal in the best way. The desire to create a three-dimensional model and not simply the traditional two-dimensional drawings (plans, elevations and sections) is born both from the major precision of the final drawings, that all come from the same model, and from the possibility of making deep analysis concerning technological and constructive elements of architectural features.

Instruments and methods of Information Technology (IT) applied to digital reconstructions and critical analysis widen and improve the quality of the information if compared with the ones acquired through traditional systems (Di Mascio, 2009). Moreover, the studies on the three-dimensional models could include also the morphologic-spatial aspects. To deal with the problems presented previously and to reach the set goals, we have used a method of technological 3D survey of the architectures called “Ad Oggetto” (research by Prof. P. Palka).

In computer science, around the 60s, a new type of programming paradigm called “Object Oriented Programming” was developed. This paradigm, unlike the procedural, considers a software modular, in other words made up of single independent elements. With the procedural language the software carries all the routines necessary to perform various tasks on objects; with the object-oriented language, it uses only the elements it needs at that precise moment, and later it releases them. In architecture, we could compare the object-oriented language to prefabricated buildings, where each part of a building is independent and can be replaced without interfering with other components. The concept at the basis of the survey “Ad Oggetto”, takes its inspiration just from this aspect of the programming. Each architectural element (walls, doors, windows, etc..) can be measured independently, and hence, every variation on the same element does not require changes to other objects, except in the connections. All the elements are then reassembled to form the final object.

The LEICA 850 provides both azimuth and zenith angles, as well as the distance between the collimated point and the optical center of the station. The traditional topographic methods use these variables to determine the position of objects in the plane (cadastral plans, layouts, etc.) The method presented here instead, uses the so-called derived quantities, i.e., known angles and distance, the instrument in real time, and on a second display, is able to provide the spherical coordinates of a collimated object. Thus the set of the 3D points of the various objects create a 3D scene.

The obtained coordinates have been reported in real-time in a drawing software (AutoCAD), differentiating the objects by category and placing them on different layers. Within the CAD package, we have linked the single points identified through lines, splines or arches. The final result is a 3D model.
in wireframe, that permits to appreciate the outlines of the facades taken into consideration, the connections on the ground and the openings. In this way, we have obtained a background that, provides us with the first spatial information (figure 3).

PHOTO RECTIFICATION IN FOTORAD
The following passage has been fundamental for a detailed representation of the architectural and technological/constructive details. In this phase we have used the homography, an invertible transformation from the real projective plan, instead of the expensive and difficult photogrammetry.

A homographic transformation changes a figure into another figure, it even produces the deformation, so the angles of the two figures don’t remain constant. In such a case you need to know the plane coordinates of a minimum of four points on two levels of transformation.

Eg. Transforming a square into a trapezoid (needs to know 4 vertices of a Square and 4 vertices of a Trapezoid).

Differently an “affine” transformation does not take into account the deformations, therefore, the angles remain constant. In this case it is sufficient to know the plane coordinates of a minimum of three points on the two levels of transformation.

Eg. Transforming a square into a rectangle (needs to know 3 vertices of a Square and 3 vertices of a Rectangle).

The pictures have been elaborated with the FOTORAD software (research by Prof. P. Palka), ™ UD’A 1996. In this way the representation has been enriched by windows, doors etc. (figure 4)

NURBS AND 3D MODEL
The information obtained with FOTORAD has been positioned inside the wireframe cage, made exclusively by lines and points. Since we are dealing with irregular walls subject to various deformation such as the bulging, it is not possible to obtain adequate sections in every point of the façade, with the only geometric elements available. For this reason we have decided to create some surfaces using NURBS (Non Uniform Rational B-Splines), to represent both the walls that overlook the narrow road and the floor surfaces. In fact, until a few
years ago, in the CAD software packages it was possible to obtain sections only by solids, while now we can also section the surfaces. We believe that in the survey field, in some situations, it is better to use surfaces generated and composed by complex curvilinear profiles. Therefore, it is important to critically identify the surfaces adequate to represent the different elements and the architectural details, such as walls and columns, portals and windows. For example, for the creation of the facades it is important to choose the outlines of the single wall surfaces of each building, in order to obtain results as much as possible geometrically corrected and easy to manipulate and to analyse within the digital working environment.

The overlapping of the wireframe model on the surfaces has allowed us to understand the relations between the irregular wall surfaces and the surveyed architectural/decorative elements. (figure 5)

Afterwards we have chosen a surface that represents the façade of a small building and we have made parallel sections, both vertical and horizontal. The sections so performed are the basic, useful documentation to demonstrate and analyse the deformations of the walls. (figure 6)
CONCLUSIONS AND FUTURE DEVELOPMENTS

The 3D survey “ad Oggetto” has proved its usefulness and validity in other studies (Palka, 2010), in which the various models were used to extract elevations, plans and sections, with cuts made at any level, as well as to do more accurate calculations of surface areas and volumes. Producing all drawings by a only one 3D model helps to avoid the typical errors that can occur when making individual drawings as in traditional practice. However this approach is not suitable by itself to represent complex three-dimensional decorations, and in this case it could be integrated with a laser scanner or a modeling application such as 3D Studio Max.

The method and tools described in this paper are intended to provide a valid choice for surveying and representing a small villages. The entire process leads to metrically precise results, achieved in a short time and with less cost in comparison to other technologies such as photogrammetry and laser scanning, which in this context are also difficult to use.

Research is still ongoing. We are experimenting various techniques of representation and analysis of the digital model taking into account the new opportunities offered by newer versions of various software package such as 3dsmax or rhinoceros. New tools for creating and modifying NURBS surfaces allow further analysis of three-dimensional models, a few years ago impossible to put into practice. The research doesn’t stop at a three-dimensional model only, but it also includes textures, produced by the photo-plans created in Fotorad, useful to represent different materials, and animations that help to better understand some spatial characteristics.

In the following stages, through some expedients in the creation of elevations and their objects, like portals and windows, the 3D model provides the opportunity to analyze the individual parts of a building even in a “net” environment, to query the cards collected in a database, which contain various characteristics of the elements.

The survey and the three-dimensional representation so far have concerned the facades of buildings facing the little road of Caporciano. Because of the damage caused by the earthquake or the absence of the owners in the village, it wasn’t possible to make any survey into the houses. We will be examining, in the next phases of the research, the opportunity to get inside in some of the buildings so as to make a survey and thereby create a complete three-dimensional model useful for analyzing other characteristics such as relationships between inner and outer spaces, functional aspects, structures and energy consumptions.

ACKNOWLEDGEMENTS

Danilo Di Mascio: I would like to thank Professor Maria Cristina Forlani for permitting me to study this subject and my sister Ilaria Di Mascio for helping me with the translation of this paper from Italian to English.

REFERENCES

Ammeraal, L 1993, Programmazione grafica in C++, Tecniche nuove, Milano, Italy.
Bezoari, G, Monti, C, Selvini, A 1992, La fotogrammetria per l’architettura, Liguori editore, Napoli, Italy.
CANTU’, M 2003, Programmare in Delphi 7, Apogeo, Milano, Italy.
Caterina, G, Fiore, V (eds) 2002, Il piano di manutenzione informatizzato. Metodologie e criteri per la gestione informatizzata del processo manutentivo, Liguori editore, Napoli, Italy.
CRESA (Centro regionale di studi e ricerche economico-sociali) 2002, La montagna abruzzese: Indicatori di marginalità, L’Aquila, Italy.


Forlani M C (ed) 2010, *Cultura Tecnologica e progetto sostenibile. Idee e proposte ecocompatibili per i territori del sisma aquilano*, Alinea editrice, Firenze, Italy.


