



**POLITECNICO
DI TORINO**

Honors thesis

MASTER OF SCIENCE IN ARCHITECTURE HERITAGE
PRESERVATION AND ENHANCEMENT

Abstract

**Analyses in the Valperga castle site using UAV
Photogrammetry, Laser Scanning (LIDAR) and GPR
techniques (Ground Penetrating Radar)**

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This Thesis is the result of the elaboration of a study around the thematic defined by the student project called 4Dilan (4th Dimension in Landscape and Artifacts Analyses), created and developed by a group of students with professors, doctorand students and internships of the Geomatics Laboratory and Geophysics Laboratory of the Politecnico di Torino. The 4Dilan project looks into knowing, analyzing, acquiring data and elaborate information with an academic aim. The project also quests to deepen in the study of an architectural building with a great cultural and historic value, guided by some disciplines in the Engineering and Architecture fields. Therefor the main purpose of this Thesis is to present and analyses the principal methodologies of 3D metric survey and the integration between those methods, those applied in the Valperga castel site located in the province of Torino.

The main objectives of this work are:

- KNOWLEDGE – Developing Geomatic and Geophysic surveys for study a cultural heritage with an elevated historic and cultural value which has never been studied with these innovative scientific technics
- STUDY – Studying the particularity and the features of the Valperga castle, based on the analyses of the historical documents and the contribution of the Geophysics field with a Georadar survey.
- 3D METRIC SURVEY – Create a methodological model to manage similar studies and researches in the Geomatic field, applying some of the most innovative techniques like the UAV Photogrammetric technique, Digital Photogrammetric (Photo camera) and Terrestrial Laser Scanner (Lidar)
- ENHANCEMENT – Restore the current situation or the Valperga castel through the planimetric representation of the architectural complex and the synthesis of the architectural qualities for its enhancement and diffusion
- PRESERVE AND PROMOTION – Promote the knowledge and preservation of the heritage currently located in the Valperga castel executing a survey of an element with a high artistic and cultural relevance: the Affresco Arduinico (13th century)

The technological revolution and the development of the informatics science during the last decades has brought so many scientific advances in the field of the study, analyses and documentation of the territory. These used also for the analysis of the natural phenomenon and the architecture context, allowing the application of new surveying techniques in the build heritage and cultural landscape, this innovation consented to improve of these techniques of metric survey, for example the Fotogrammetric process and the terrestrial scanning (LIDAR).

Nowadays, these techniques part of the Geomatics field constitute a scenario with a huge potential for the study of the build architecture but also for the various natural and pantropical phenomenon in a determined territory. Thanks to the most important software, instruments and device's development which also involve other scientific fields, allow an integration between them looking for best and more accurate results. In this way, a systemic, multidisciplinary and innovative approach is conceived, which seeks to address the data generated by surveys and surveys (whether terrestrial or airborne) and to achieve optimal

results that contribute to knowledge, study, analysis, protection and promotion of the Built Heritage and the Territory.

It is very important to note that for the study of any type of architecture, and even more for conservation and intervention through enhance and restoration projects, it is necessary to undertake an in-depth analysis and documentation of them. This kind of studies permits to know the different relationships between this and the environment in which it has been established, as well as the various study disciplines that can provide useful information for an overall understanding of the good at different scales.

For this reason, the approach to the study and the architectural and territorial analysis of the Castle of Valperga and the surrounding area is defined in three different stages of study, carried out by the prospects of three thesis of the thesis, called "*3D Models, GIS Instruments and Sources cartographic. Diacronical Interpretation of Valperga Castle Territorial Context written*" by Nany Matamoros, "*Valperga Castle site analysis via Unmanned Aerial Vehicles (UAV) and Land Scanning (LIDAR) integrated with Ground Penetrating Radar (GPR)*" written by Vivian Camila Pinzón Mejía and "*Using drone photogrammetry and laser scanning techniques in a constructive analysis of a late medieval tower at Valperga Castle written*" by Julian Chaves, all three students of the Master's Degree in Architecture Heritage, Restoration and Enhancement.

The contents of the first thesis correspond to the broader and general scale of study, which deals with the diachronic and present analysis of the territory of Basso Canavese and the territory of Valperga through the use of the GIS platform, emphasizing in a historical study on important events that have transformed the Castle of Valperga and the context in which it is located.

The second approach scale (Valperga castle complex) described in this thesis has resulted in the elaboration of an Ortophoto of the Castle area as well as of other descriptive and representative products of the architectural complex and surrounding areas such as a dense dot cloud that describes tridimensional morphology, a 3D mesh or 3D model of the terrain and also the DEM (Digital Elevation Model), among others. The point cloud obtained is a descriptive material of the artefacts and of the anthropic and natural elements of the study area, from which it could create so many other contents of analysis and study both from the architectural perspective, the description of the materiality of the buildings, of its volumetric composition, of elevation and of interaction with the others built inside the Castle complex and many others. At this second scale, a geophysical survey will be carried out using the technique of Georadar in order to analyze the possible traces of buried structures hypothesized based on historical investigations and the analysis of historical documentary sources found in antique archives.

The third and last scale analysis will examine the ancient of the Fabbrica Thones through an analysis of the materiality and structural conformation in detail, starting from the elaborations obtained from the previously described hypothesis in the other thesis. In this thesis, the techniques, tools and methods will be presented in the logic of the previously

defined intermediate scale of the study, applied in this study to the castello di Valperga Fabbrica Thones.

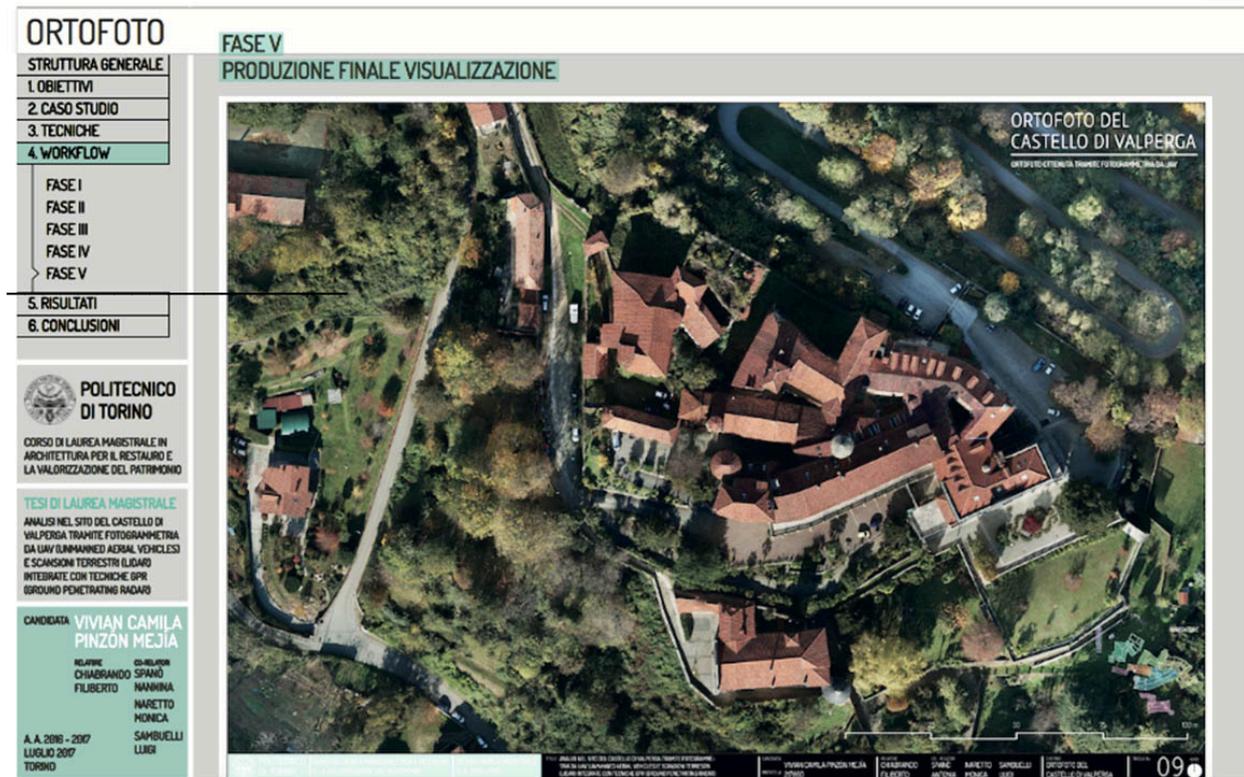


Figura 01. Orthophoto of Valperga Castle elaborated on Photoscan and obtained by photogrammetry from UAV. Drone UBIK DIATI MK 01.

The material developed in this Degree Thesis as The Orthophoto of the Castle has been a fundamental part of knowledge and in designing an architectural heritage that was never viewed from a perspective as a whole due to its complexity and characteristic location on the territory, giving us the possibility to rebuild the history of a Castle that is made up of a variety of fragments that throughout history have become autonomous but have always formed a set. Using the Fotogrammetric technique from UAV using a non-commercial platform belonging to the Geomatics Laboratory for Cultural Heritage of the Politecnico di Torino, it was possible to overtake this area and find the object of study in an innovative, fast and very fashionable way effective in comparison with any other traditional technique. Thanks to the shooting of frames from different angles (nadirali 90 and inclined 45) from the top it was also possible to do with the planimetric restitution of the whole area of the architectural complex with the help of CAD tools, unpublished product that had never been made and constitutes a technical material of high value and importance for future interventions, research, studies, surveys or initiatives of space transformations directly on the architectural body. In addition, the high-precision altimeter restitution of each building and open areas of the complex was carried out, such as terraces, access roads, terraces and meadows, walls, ruined buildings and buildings through quoted sites, information obtained directly from the 3D model of the Castle elaborated through the 3D metric survey carried out during two campaigns at the castle. This plan is therefore a scientific material that faithfully describes the morphology and composition of an architectural good that has a long history and particular features but which had never been studied at this scale.

o this overall survey of the Castle is added also the most detailed one made in the Fabbrica Thones area, through another metric 3D metrology technique that today is one of the most innovative in the industry, which is performed through the Laser Terrestrial Scanner (LIDAR) and has resulted in a cloud of even more detailed points. Counting on results at different scales made with different methodologies and the application of different techniques, which also describe different levels of accuracy but complementary to each other, allowed to integrate data in such a way to obtain various digital products such as the 3D model of the various areas around Fabbrica Thones such as the Contrada leading to the Chapel of the Consortile / Sant'Anna located in the northernmost part of Fabbrica, the courtyard of the core of Fabbrica itself and also the building of the Fabbrica in its entirety.

The integration of the survey with Georadar is one of the key aspects in the realization of this thesis given the relevance of the application of a geophysical method for reading and analyzing the possible buried elements particularly studied in this case study. The motivation to integrate this discipline has given interesting results for the development of this thesis, as from an analysis of the historical documents (XVIII century architectural plans) of the Castle, and more specifically of the Fabbrica Thones, the ancient structures which were searched through the georadar. This survey resulted in a ground reading near the Fabbrica Thones and gave us indications of the truthfulness of the found documents, which also constituted the basis for future archaeological investigations and excavations in the area.

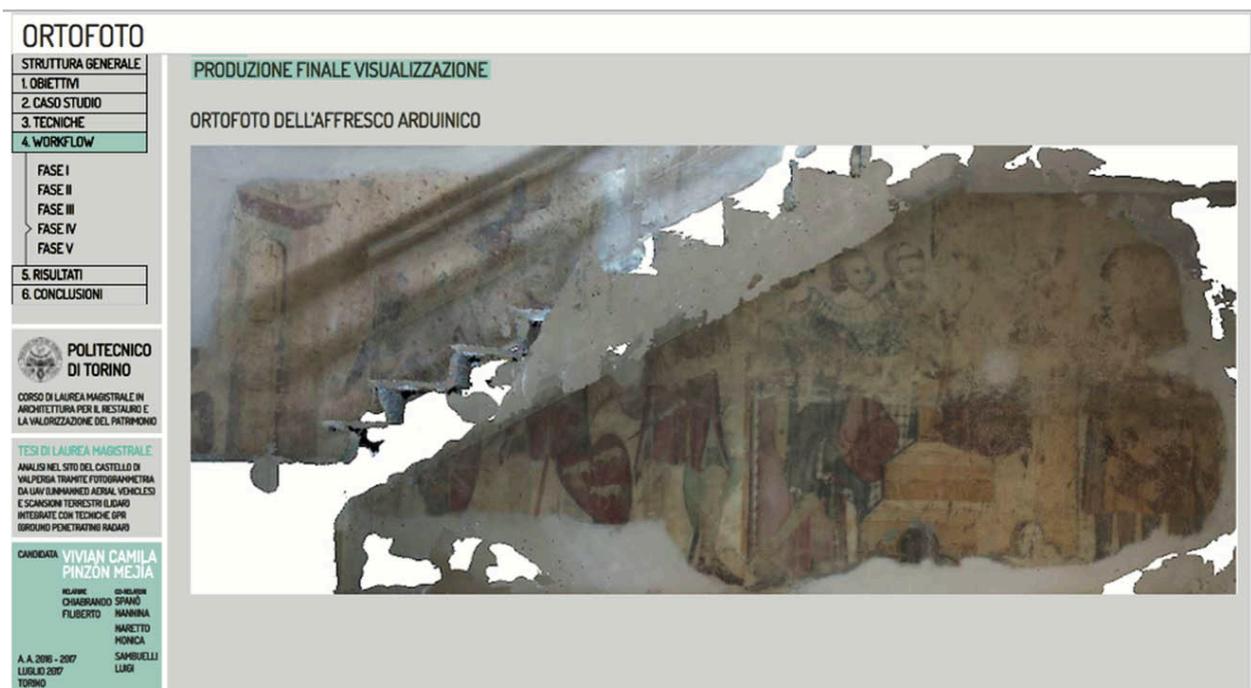


Figura 02. Orthophoto of Arduinic Fresco (XII century) obtained by Digital Photogrammetry (Camera)

The digital photogrammetric survey of the Affresco Arduinico realized in this thesis and the elaboration of the Orthophoto of this artistic work dating from the thirteenth century, rediscovered in one of the renovations in the 1970's in the southern wing of the castle belonging to the barons of Civrone , represents an initiative in the deepening and knowledge of artistic works of high historical and cultural value in Canavese. The study and unpublished documentation of a work of this character and antiquity shows the interest of this thesis in the promotion and enhancement of this medieval symbolic element which must be recognized as a distinguishing element of great value and protagonism in the historical events of this architectural good little studied and in the history of the territory. So the result obtained highlights the vast potential for future efforts to recover and safeguard the cultural and artistic heritage found within this architectural complex.

In addition, there are procedures, methodologies and instrumentation, emphasizing the techniques employed in the different phases of this study, in particular explaining the application of the LiDAR Earth Scanning Laser Scanning Technique and the UAV Photogrammetry with the aim of generating the Orthophoto of the Castle of Valperga and its surroundings, as well as the processing of the data in such a way as to obtain clouds of descriptive points and meshes of the complex in general and the Fabbrica Thones on an architectural scale. Subsequently, a planimetric restoration of the 1: 200 Castle Castle complex and the Prospectus and Coverage of the Fabbrica Thones at 1: 100 scale will be realized. Starting from the point cloud of the Castle and the immediate surroundings drawn from the aerial photogrammetric survey made by the Drone, the descriptive 3D polylines will be restored to the most important map elements with the aim of generating a 3D model of Valperga Castle. The results of the geophysical survey carried out at the castle will also be studied and the study of a work of high artistic and historical value will be introduced. The Affresco Arduinico of the castle of Valperga present in one of the Castle buildings detected by Digital Photogrammetric technique with camera with the aim of promoting and enhancing.

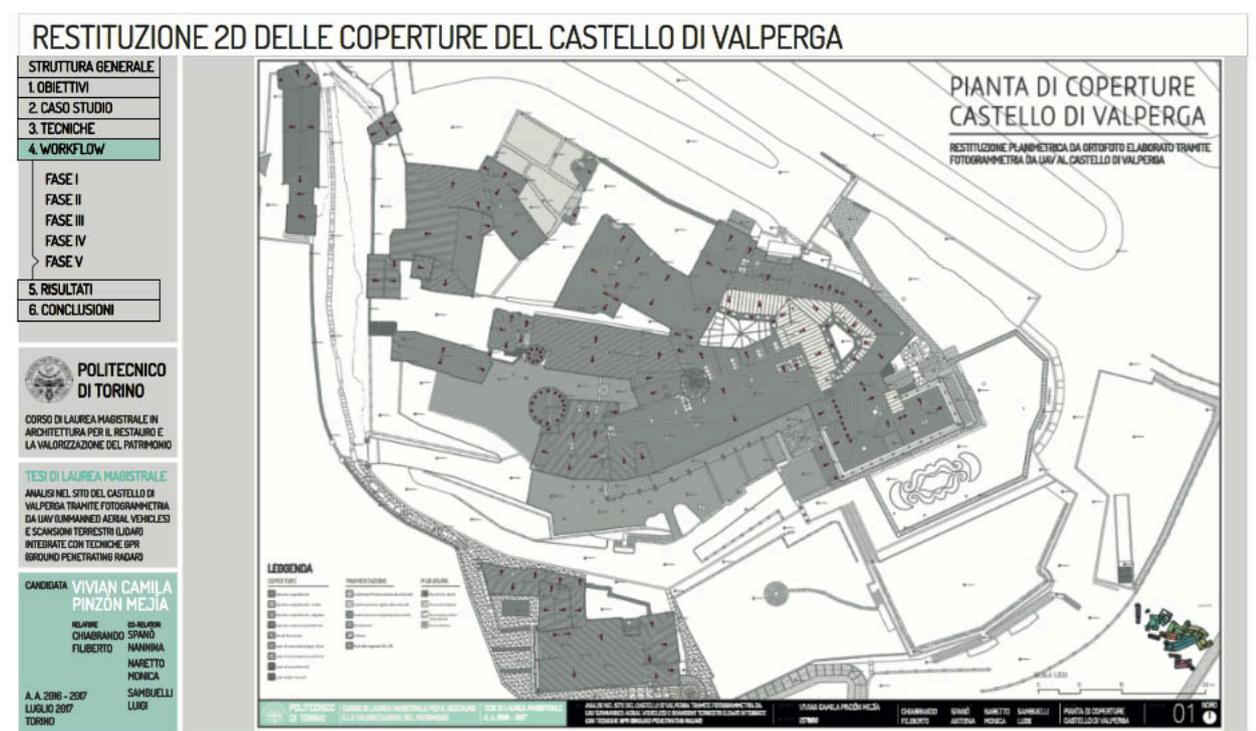


Figure 03. Valperga Castle Coverage Plant. Original processing at scale 1: 200.

The ultimate goal of this theoretical and practical study is to contribute to the knowledge of the Castle of Valperga and to develop material that serves as a basis and study material for future developments and research. The same methodology used to address the architectural and territorial study through the relevant techniques will serve as a starting point for other possible developments and insights on this architectural good of cultural interest and of great historic value in the Basso Canavese.

In conclusion this thesis presents:

- A MULTISCAL APPROACH - A path of knowledge, study and analysis of the Castle of Valperga has been carried out from a multi-scale overview which has made it possible to integrate aspects from the widest scale, the territorial one, and then to increase to the scale of the architectural complex of Castle seen as a set and reaching the materiality and peculiarity of the individual constructive elements.
 - METHODOLOGICAL MODEL - This thesis provides a methodological model for dealing with the study of similar Architectural Heritage by presenting a correlated Workflow between different types of investigation, theoretical studies such as cartographic and historical, and getting to know the materiality and constructive details of the individual architectural elements.
 - INTEGRATION OF TECHNOLOGIES - Integration scheme of several of the most innovative techniques of Geomatica and geophysical surveys with the aim of obtaining a mark of study and analysis of the whole of Valperga Castle.
 - METRIC 3D RATIO - Creation of unprecedented three-dimensional scientific material that has been the focus of the work of the three theses that has specified a metric basis for the elaboration of different analyzes, 2D and 3D products and providing a basis for future further design and interventions on architectural good.
 - PLANIMETRIC RESTORATION - Creation of a detailed and scientific three-dimensional representation of the architectural complex of the Castle of Valperga, providing a scientifically reliable planimetric base at scale 1: 200 for the implementation of any project of knowledge and intervention.
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