B.I.M. and cultural heritage: multi-scalar and multi-dimensional analysis and representation of an historical settlement.

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B.I.M. and cultural heritage: multi-scalar and multi-dimensional analysis and representation of an historical settlement. The case study of Montemagno, a New Village in Piedmont

Among its many and varied potential, B.I.M. includes those of diachronic and multi-scalar management of digital models. These potentialities have been tested in an innovative way on the case study of a medieval settlement of particular morphology, for its comb-shaped layout interspersed by narrow alleys, placed on a system of three ridges, in Asti territory. This interdisciplinary research, has involved analyses at the urban, micro-urban and architectural levels. The methodology uses tools whose applications to historical buildings is currently object of study by scholars in the field of H.B.I.M . Compared to existing studies, however, the present approach uses some functionality for the control of the time dimension not yet properly explored, interlacing with the archaeology of the elevations and the stratigraphic Harris Diagram (Matrix), in order to facilitate the analysis.

B.I.M. e beni architettonici: analisi e rappresentazione multiscalare e multidimensionale di un insediamento storico. Il caso studio di Montemagno, Borgo Nuovo piemontese

Fra le sue numerose e multiformi potenzialità, il B.I.M. annovera quelle della gestione diacronica e multiscalare dei modelli digitali. Tali potenzialità sono state sperimentate in maniera innovativa sul caso studio di un insediamento medievale di particolare caratterizzazione morfologica, per la sua disposizione a pettine inframezzata da stretti vicoli, collocato su un sistema di tre crinali, nell'astigiano. La ricerca, di carattere interdisciplinare, ha comportato attività di analisi a livello urbano, microurbano e architettonico. La metodologia impiegata usa strumenti la cui applicazione al costruito storico sono attualmente indagati dagli studiosi in ambito di H.B.I.M.; rispetto agli studi esistenti, però, l'approccio utilizza alcune funzionalità per il controllo della dimensione temporale non ancora adeguatamente esplorate, intrecciandole con l'archeologia degli elevati e il diagramma stratigrafico di Harris (Matrix), al fine di agevolarne la lettura.

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Key words: B.I.M., Cultural Heritage, Representation

Parole chiave: *B.I.M., Cultural Heritage, Rappresentazione*

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1. MULTI-SCALAR AND MULTI-DIMENSIONAL INFORMATION MODELS FOR THE REPRESENTATION OF THE HISTORICAL URBAN TISSUE: PHILOLOGICAL-CONJECTURAL SURVEYS, THEMATIC DIGITAL MODELS, ORTHOPHOTO OF THE HISTORICAL CONTEXTS, TO B.I.M. (ROBERTA SPALLONE)

Among its many and varied potential, B.I.M. includes those of diachronic and multi-scalar management of digital models. These potentialities have been tested in an innovative way on the case study of a medieval settlement of particular morphology, for its comb-shaped layout interspersed by narrow alleys, placed on a system of three ridges, in Asti territory. This interdisciplinary research, has involved analyses at the urban, micro-urban and architectural levels, carried out by historical, bibliographic and archival research, cartographic surveys and measurements in situ. The knowledge synthesis model, made by B.I.M. technologies, allowed to appreciate, at different scales, the historical transformations, read with the regressive method, up to the application of stratigraphic analysis methodologies on the facade's surface of an exemplar building, the Accornero house.

The methodology uses tools whose applications to historical buildings is currently object of study by scholars in the field of H.B.I.M . Compared to existing studies, however, the present approach uses some functionality for the control of the time dimension not yet properly explored, interlacing with the archaeology of the elevations and the stratigraphic Harris Diagram (Matrix), in order to facilitate the analysis.

The case study proposed in this article was developed by Andrea and Simona Piano as part of their Master's thesis in Architecture Construction and City, at the Politecnico di Torino, under the guide, as supervisors, of Roberta Spallone and Carlo Tosco. The interdisciplinary approach, now more than ever necessary in the investigation on Cultural Heritage characterized by a high level of complexity, such as urban / architectural one, thus involved the disciplines of Representation and History of Medieval Architecture.

Today's research arises as a progression of a series of methodological proposals and experiences, personally carried out by the author of this paragraph, who supervised Andrea and Simona Piano during their analysis, interpretation and communication of the knowledge process.

One of the basis of the work is certainly constituted by the urban survey methodology, developed by the group led by Augusto Cavallari Murat in the second half of the 60s, which had among the main outcomes, in 1968, the publication Forma urbana e architettura nella Torino barocca [1], in three volumes, and in 1974, the formalization of the standards and symbols for the survey of historical urban tissue, within the standard UNI 7310-74 "Cartografia urbana. Rappresentazione convenzionale di aggregati urbani storici prevalentemente caratterizzati da edilizia multipiana".

The urban survey maps, in scale 1: 1000, based on cartographic offered by the tables of geometrical particle cadastre, made by Andrea and Alberto Gatti, 1823, integrated with the municipal map of the time, represented a selection of data obtained through the archival research on iconographic documents, at different scales, and text, such as censuses.

Dino Coppo remembers that Cavallari Murat had several meetings with Pierre Lavedan and that "with him lasted an interesting discussion of what were the values that characterized the historic city, in particular the Baroque one, and the ways in which these could be represented in a sinthetic drawing, as had happened in some famous maps of the past, in particular, the map of Rome by Nolli" [2].

The problem of balancing the information level, in relation to the scale of reduction, had been one of the critical nodes of the work; in fact, it had to reconcile the freehand ink drawing, with the choice of graphics, symbols, line thicknesses and hatches.

The morphological, typological and stylistic data, were collected in a drawing of the ground floor, where public spaces were distinct to private ones. The goal is to provide, through a plan, a series of information about the three-dimensional character of the tissue, clearly evident by the words "Stereometric symbols", manifested in the drawing of the upper cornices, distinct in their technological and stylistic peculiarities; in the patterning of the different building units, more or less dense depending on the number of floors; in the virtual projection of vaulted and architraved covers; in the indication of the openings axes of the main floor and the vertical distribution systems and access to the housing units in the type plan.

The representation also showed multiscalar intentions, defining not only invariants and variants at the level of urban morphology, but also distributive, functional and stylistic characteristics, for each artifact.

A series of personal experiences in this regard, as the urban survey of Via Pietro Micca [3], under the guidance of Dino Coppo, and the surveys of some Villae Novae in Piedmont - Fossano, Cherasco and Cuorgnè [4] - shaped as smaller urban tissues, conducted with Gianfranco Calorio, Giuseppe Moglia and Marco Vitali, allowed, in the first case, to formulate proposals for implementations to the UNI standard mentioned above, in the second, to deepen the ways for combining the urban survey with the architectural and details surveys, assigning different levels and meaning to the analyses at different scales.

A different approach characterized the three-dimensional digital reconstruction of the historical transformation of the Borgo Po in Turin [5]. In this case, using the tools available in the late '90s for 3D modeling by CAD, the author had developed a method of investigation and set up a synthesis model representing the documentary research and the direct survey made. In particular, the aim was, to recognize, in the present urban tissue, the traces of sedimentation of successive stages of construction, demolition and transformation, through multiscalar archival research, which included the historical surveys, the urban plans and the drawings design of individual buildings with direct metric measurements. The regressive survey method, recorded, in intervals of thirty-year, chosen on the basis of the historical events that had affected the city, the morphological transformations of the tissue, going back to the late

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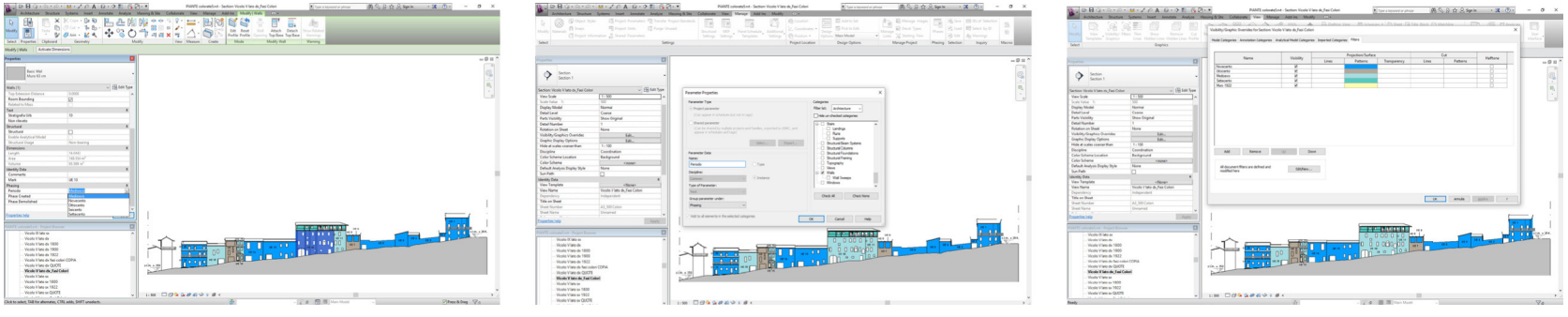
seventeenth century, the period when the first settlements were documented.
The construction of the model, which had affected about thirty city blocks, was drawn to provide a basis on which formulating proposals for volumetric changes within the blocks, compatible with the recently approved General Urban Plan of 1995.
Using the first numerical cartography of the City, realized in the same years, and MicroStation, the hilly terrain, the road system and the volumes of the buildings were modeled, including roofs and dormers, using different colors to distinguish the periodization.
The digital model lent itself to the visualization of the built environment in different periods and the generation of land sections along the streets, which indicated, in the urban continuum, the geometric characterizations of the different units.
The research Napoli in assonometria had been an indispensable reference for such work; it was carried out in the mid-90s by the group of Adriana Baculo [6], tracing a great drawing of the city seen from the sea, proposing a series of conventional signs to characterize the facade schemes in their historicity. Further contribution to the current research is derived from a series of multiscalar surveys concerning streets and squares in Turin and Piedmont [7], in which, the construction of orthophoto, which integrated the drawings, including information on the façade materials, the textures, the colors, has been joined to the direct survey methodologies.
Also in this case the urban survey value was not given by the sum of the individual architectural surveys, but from the reading and identification of variants and invariants constituting the street or the square system. Moreover the apparently predominant role of the facades, as in other contemporaries works carried out in Naples [8] and Cesena [9], had never been separated from plans and sections, which represent the intrinsic three-dimensionality of the urban / architectural system.
Proven methodologies, problems and solutions experimented on built systems similar to the case study proposed in this research led us to ideate a digital informative modeling process referring to the stratigraphic analysis method. The information model display could be set at different scales and in different historical periods and could, once applied the stratigraphic analysis criteria, automatically generate the Matrix diagrams. In addition, the possibility to create animations, now widespread in all the modeling software, could facilitate synthetic communication of research results. To achieve these objectives the B.I.M. seemed to be the most appropriate instrument from among those currently available.

2.THE PROJECT OF KNOWLEDGE IN B.I.M. MULTI-SCALAR AND TEMPORAL MANAGEMENT OF THE FOURTH DIMENSION. (ANDREA PIANO)

The method of research used has been applied to the borough of Montemagno Monferrato (AT). It combined architectural survey and a subsequent data elaboration in B.I.M.
During the survey we focused our attention on spaces and relations between buildings and their background considering the old town center as an urban continuum with a unique morphology. We used images rectification to measure buildings.
Our research approach is founded on a regressive method [10], so we studied the present configuration of an object or a territory in order to gain some information about the more ancient situations. The aim of this approach is the comprehension of the dynamics that brought to the today changes. This method considered the building area as an historical integrated source. Ancient traces on buildings have been catalogued and historical cadastres were analyzed in order to define the construction texture of the old town center in different centuries. The principal cadastres studied were the ancient one of the Savoys' territory (1770), the Napoleonic one (1812) and the one of 1922. We studied the alignments of cadastral units in order to understand unification and subdivision of property, new constructions or other important changes.



1. Screenshots of B.I.M settings.

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2. Construction phases of Montemagno historic urban tissue.

Studying the cultural heritage implies important issues such as the flowing of time and the materials conserved during the centuries. It is very important to consider the relations between the space of the cultural heritage, its materiality, the construction phases, the conservation state etc. structuring and linking information to the represented object trough its semantics. From this point of view, information models (especially object based systems) are the best systems. Multi-scalarity and Multi-dimensionality are very important in the management of the Building Information Models describing historical buildings.
Historical research and architectural survey were organized in three different level of details concerning on B.I.M. characteristics. The analysis was structured in an urban level, a micro urban scale and finally in an architectural level. In the first case, the urban one, our attention was focused on principal buildings types, blocks extension and their density. The stratigraphic analysis was applied in micro urban and architectural studies [11]. The multi-scalar approach is a good method to manage and to compare different information. Constructions are important sources from which it is possible to understand a past event, notions on construction techniques and customs. Interdisciplinary is increased with the contemporary use of different scales of study; but a multi-scalar methodology is also important to find and interpret from various point of view direct and indirect traces of the past, documents, sources. In case of necessity of a more detailed study than the urban analysis, we used stratigraphic analysis at micro urban and architectural levels.
Multi-scalar approach permitted to connect and increase the management of the three scales of study (urban, micro urban and architectural). The three LOD (coarse, medium, fine level of detail) were created corresponding to the scales of the research, 1:1000 for the urban level, 1:500 for the micro urban scale and 1:100 for the architectural one. In a second time families of the digital model were realized according to these levels of detail.
The management of the fourth dimension is another advantage of Software B.I.M. Temporal phases in B.I.M. were initially born to manage the

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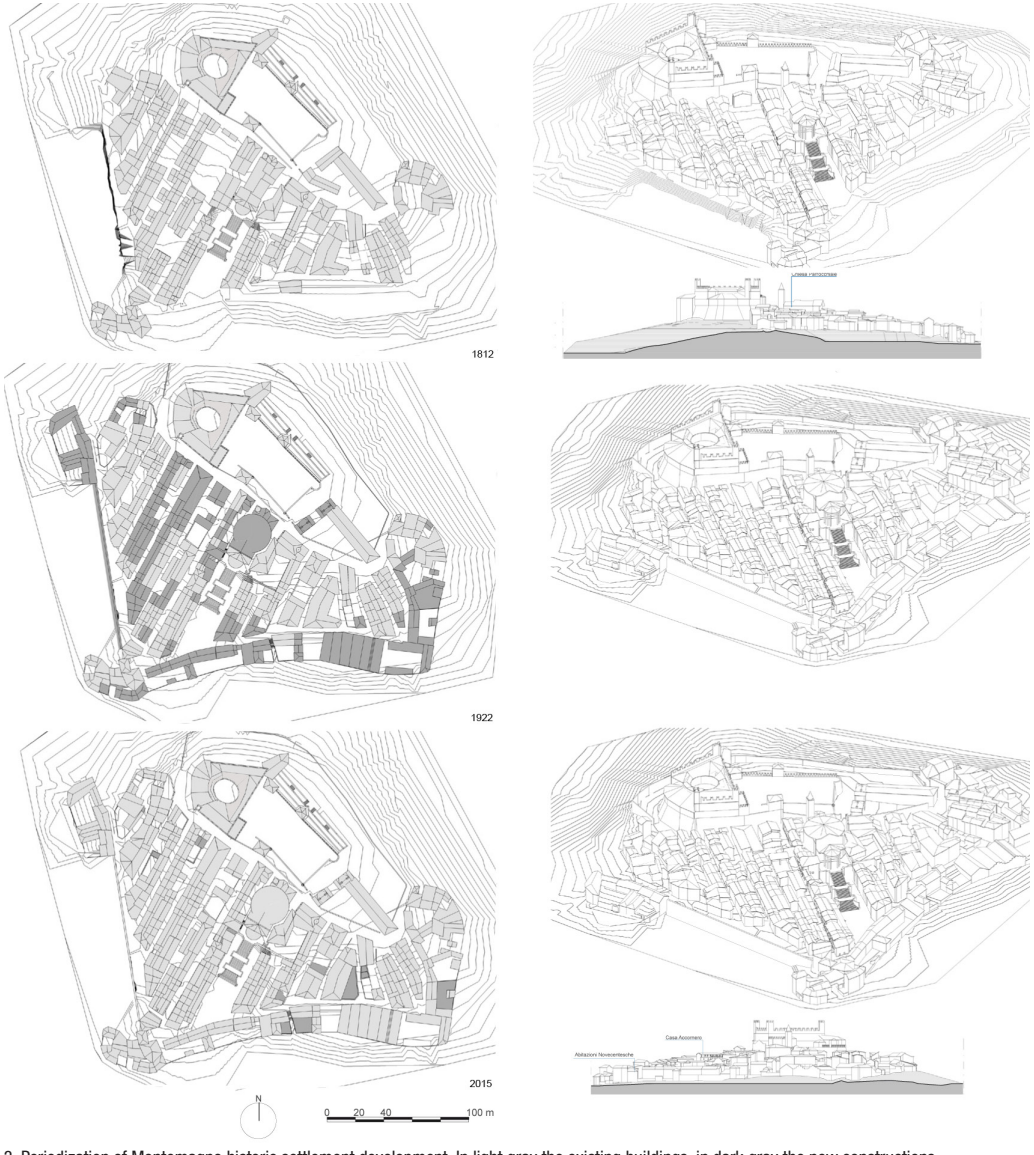
construction site and the construction of a building, later they were extended to the management of the building as built. Organized databases give the designer a greater control, from survey to construction of the building.
We based the digital reconstruction of the historic center of Montemagno on the idea of using Autodesk Revit temporal phases on its history, creating different urban configurations according to the century considered.
We recreated buildings from today's situation to previous centuries overturning the traditional logic of temporal phases that considers the future of the building. In the model temporal phases correspond to the Phase Units characteristic of Stratigraphic analysis. Considering our case study, Phase Units were created in relation with information contained in land registers (French cadastre, 1812, maps of 1922, recent land register, 2002) and understood during direct observation. Temporal phases were realized coherently with the following centuries and years: XV century, period of reconstruction of the borough of Montemagno; XVII century when blocks of VI and VII Alleys and churches were reorganized; XVIII century, age of the wooden balcony of Accornero House and of some elements of the castle and church; the years of 1812 and 1922, when cadastres were drown, and finally 2015.
There is no limit to the number of temporal phases that can be created. The range of temporal phases we adopted is one hundred years (from XV century to 2012) for Accornero House; through those phases a dynamic model was created, in order to show buildings transformations in different periods. Because of lack in documentation to reconstruct Accornero House and understand its changes, direct observation and comparison with other buildings were the principal methods utilized.
Our work continued with the definition of volumes, new constructions, demolitions and new built parts of the houses at urban, micro urban and architectural levels. The study proceeded with the reconstruction of temporal phases, for example the closures of medieval windows. From these wall elements a part was removed and in-



3. Periodization of Montemagno historic settlement development. In light gray the existing buildings, in dark gray the new constructions.

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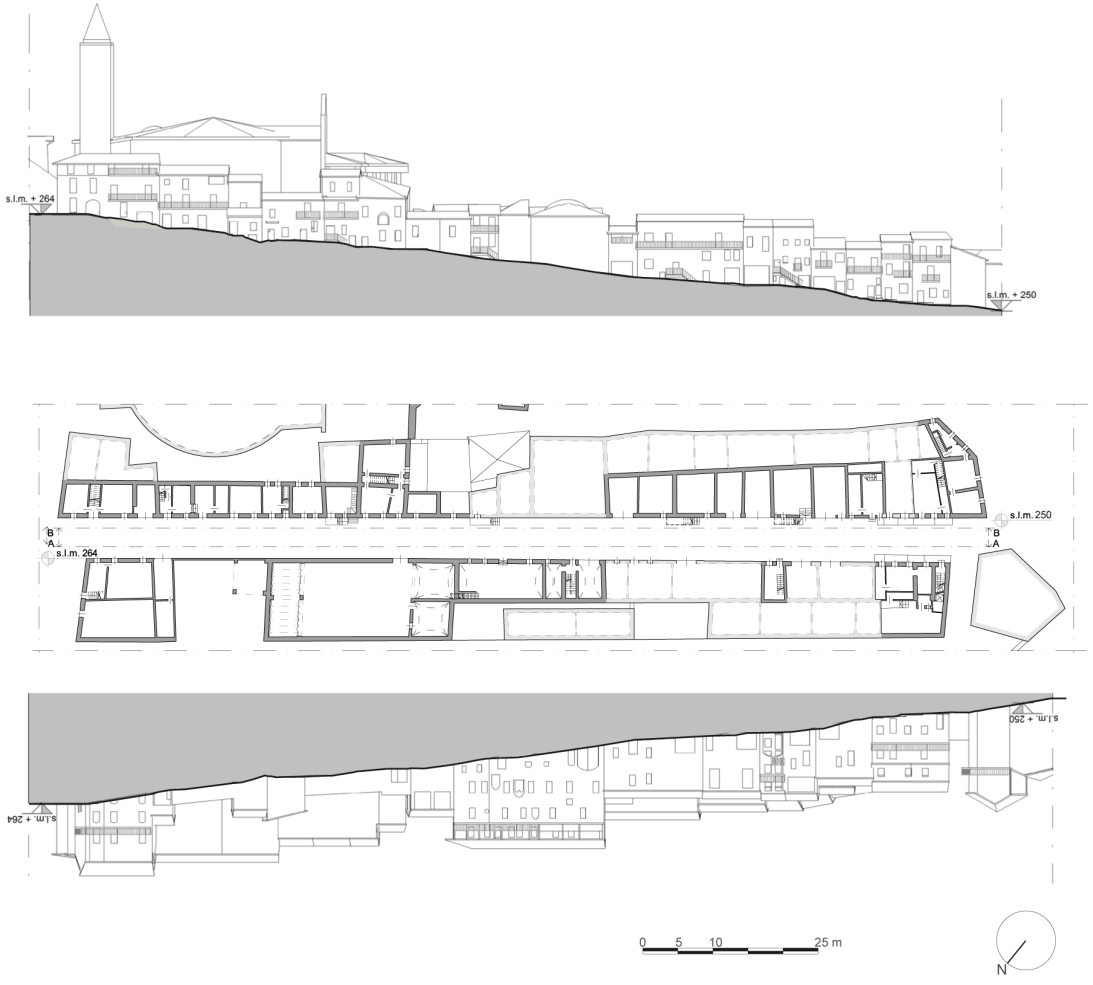
serted in a posterior phase unit in order to create new windows between the closure and the original wall.
At the urban scale our aim was to analyze volumetric details avoiding an excessive geometric simplification of the historical center of Montemagno. At this level our research was focused on chronological development and transformation of the borough. We only studied material at micro urban and architectural scales.
At micro urban level we analyzed Alley V where Accornero House is situated. Through the Stratigraphic Archaeology the building is subdivided in units and in homogeneous proportions characterized with the same construction techniques and materials. Building Units [12] were the Stratigraphic units of micro urban scale. They were identified on the fronts of Alley V observing the Principal Façades which are portions of the entire fronts of the building. In this way the selected wall elements can be considered contiguous and homogeneous proportions and it was possible identify new constructions added to medieval buildings. Building Units are suitable to Revit because they related to the classification of continuous and homogeneous tri-dimensional units with the same characteristics. It is possible create families and types for these stratigraphic units. Obtaining information about the sequence of architectural transformations is the aim of the research at micro urban scale. This analysis is represented through Harris Diagram or Matrix [13] that shows changes of buildings.
Initially the Building Unit was born for the architectural scale [14], but its definition as homogeneous and continuous wall elements permits some changes in its use which are impossible with other approaches. It also considers the object in its context and gives possibility to recognize some Wall Stratigraphic Units present in architectural scale. In our research Building Units are bigger than the others used in similar analysis, because the micro urban level implies a smaller scale than the architectural one. So this study was realized with some simplifications respecting the Level of Detail of the scale. The stratigraphic method was used at micro urban level because there were uniform characteristics in the walls (composed of brick or stone blocks). All this let us propose a study for micro urban scale of Alley V fronts. Sometimes it was difficult because of plastered walls that do not show wall texture and do not understand their construction period. However a relative chronology was defined through the integration of direct observation and cadastral information. Stratigraphic analysis at micro urban level made us deepen the study and understand the relations between different buildings.
At architectural scale, Building Units of micro ur-



4. Micro-urban scale analyses: survey of Alley V in Montemagno.

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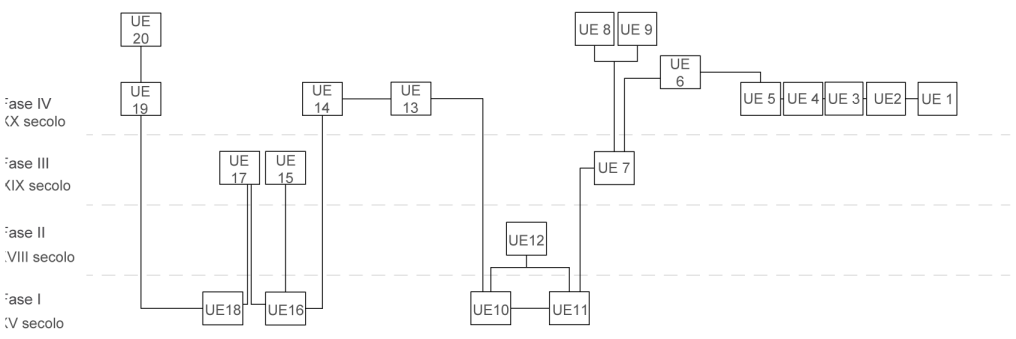
ban level were detailed in Wall Stratigraphic Units [15], in Covering Units [16] and Architectural Elements [17] identifying new openings, closures and new constructions. Wall Stratigraphic Units and Covering Units were identified through the characteristics of homogeneity in materials and construction techniques. The artifacts have been divided in several parts relating to different construction phases. The Harris Diagram is generally created at the end of a stratigraphic analysis in order to show units relationships. It is a method used by archeologists and architectural historians, but is not a dynamic tool. Often it has to be modified by hand with the risk to increase errors. Our proposal is to use the traditional Harris Diagram, thematic representations and schedules realized with Revit. It is possible to manage a dynamic model, its temporal dimension and every view is automatically modified when the model is changed. It is important to use both of diagrams because Revit schedules do not show stratigraphic relationships.
The next step of our research can be the use of pre-set schedules or other solutions designed in Revit as app-ins or to utilize interoperability between software without avoiding comparison with different methodologies.

3. A PROPOSAL OF APPLICATION OF B.I.M. IN THE STRATIGRAPHIC ARCHAEOLOGY ANALYSIS (SIMONA PIANO)

The stratigraphic analysis of the center of Montemagno was realized using the B.I.M. software Autodesk Revit and generating an updatable database about Building Units which were associated to new-created parameters in order to show different views of the them according to the analysis. During the definition of Micro urban units (Building Units) some tags were used to indicate wall elements. These tags are associated to the "mark" of a wall element and they identify every object with a number. The "mark" is an instance property, that means it is a kind of property which is editable by the user and connected to objects but not tied to their categories. In this way, the Building Units of Alley V in Montemagno were numbered following its land profile. Some-



UE Urbane			
Mark	Periodo	Family and Type	Area
UE 1	Novecento	Basic Wall: Muro 60 cm	60.11 m²
UE 2	Novecento	Basic Wall: Muro 20 cm	6.83 m²
UE 3	Novecento	Basic Wall: Muro 20 cm	29.54 m²
UE 4	Novecento	Basic Wall: Muro 20 cm	24.53 m²
UE 5	Novecento	Basic Wall: Muro 20 cm	31.46 m²
UE 6	Novecento	Basic Wall: Muro 20 cm	56.69 m²
UE 7	Ottocento	Basic Wall: Muro 20 cm	33.30 m²
UE 8	Novecento	Basic Wall: Muro 20 cm	5.75 m²
UE 9	Novecento	Basic Wall: Muro 20 cm	5.80 m²
UE 10	Medioevo	Basic Wall: Muro 63 cm	148.55 m²
UE 11	Medioevo	Basic Wall: Muro 63 cm	51.44 m²

UE Urbane			
Mark	Periodo	Family and Type	Area
UE 12	Settecento	Basic Wall: Muro 63 cm	42.72 m²
UE 13	Novecento	Basic Wall: Muro 40 cm	111.70 m²
UE 14	Novecento	Basic Wall: Muro 40 cm	57.00 m²
UE 15	Ottocento	Basic Wall: Muro 60 cm	6.94 m²
UE 16	Medioevo	Basic Wall: Muro 60 cm	13.39 m²
UE 17	Ottocento	Basic Wall: Muro 60 cm	26.38 m²
UE 18	Medioevo	Basic Wall: Muro 60 cm	72.44 m²
UE 19	Novecento	Basic Wall: Muro 60 cm	81.31 m²
UE 20	Novecento	Basic Wall: Muro 60 cm	23.93 m²

5. Orthophotos and Harris Diagram applied to Alley V in Montemagno.

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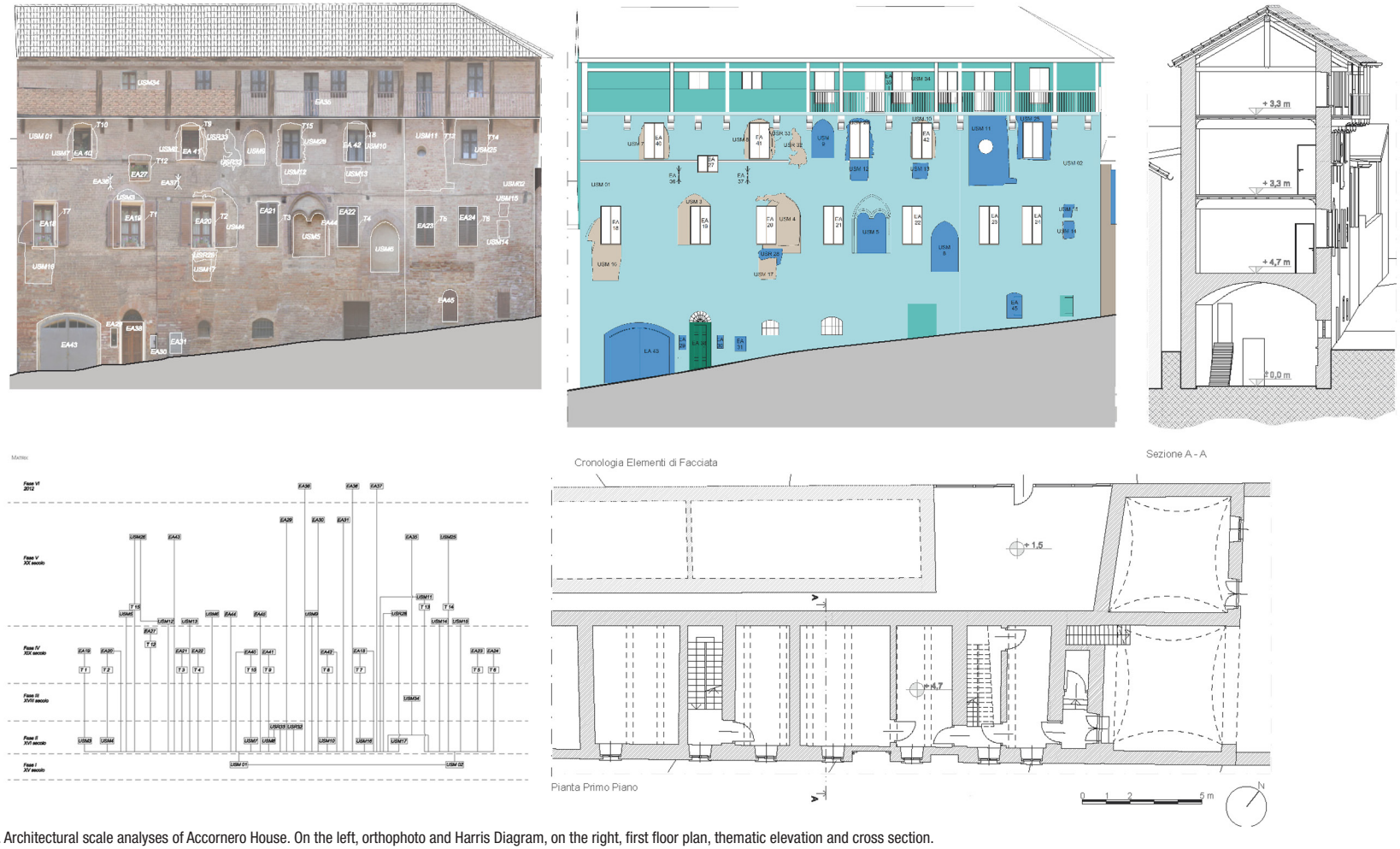
time there were houses with the upper part more recent than their lower portion: in these cases tag numeration continues the one of the older underlying wall. Through this method, we could create thematic representations linked to schedules describing the Building Units' construction period, in order to show their different building phases. Using Autodesk Revit a new parameter called "Period" was created. The schedules are tables containing information about the properties of objects; in the case of the micro urban study they refer to the Building Units. Schedules created with B.I.M. are automatically modified when the digital model and the objects are transformed. The data were been organized following the Building Units numeration order, the aiming was to simplify the lecture of diagrams referring to the drawing of Alley V front.



6. Architectural scale analyses of Accornero House. On the left, orthophoto and Harris Diagram, on the right, first floor plan, thematic elevation and cross section.

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The B.I.M. Software collects and manages heterogeneous information in a unique database: this characteristic is very important to deepen analysis structuring Levels of Details when the digital model is created. The families designed at urban, micro-urban and architectural scales are coherent to the three different LOD of Autodesk Revit ("coarse", "medium" and "fine"). An example is the double-lancet window of Accornero House which is not visible at the 1:1000 scale: we used that level only for volumetric analysis. At 1:500 scale, the two small arches and the shape of mullioned window are visible, while 1:100 scale shows also decorations of bricks.
The stratigraphical study at micro urban scale is not only limited to a classification and chronological definition of Building Units. The "Period" parameter was utilized to generate thematic representations showing with a different color the construction phases for every objects, buildings and elements analyzed. All this was done using Visibility and graphic overrides applied to specific views. The aim of these drawings is to simplify comprehension and to make more visible building periods.
The traditional stratigraphic analysis utilizes Harris Diagram that shows stratigraphic relationships between Building Units such as contemporaneity or posteriority (it is the example of the construction of a new part of a house). For example, considering two Building Units, the more ancient one is put in the lower part of the Harris Diagram and the more recent one is traced over it. They are connected through a line which indicates the relationship of posteriority. It is possible to create with Revit a schedule about Building Units or Wall Stratigraphic Units properties and to relate them to thematic representations. The analysis of Accornero House is an example of that. Despite this method does not show stratigraphic relationships it has the advantage to underline the construction phases (or Phase Units) of Building Units. The Stratigraphic analysis of Accornero House, managed with B.I.M., increased information of the study of micro urban scale, in fact this building is situated in Alley V. Creating the digital model of that building, the openings of the medieval windows were created in the wall of Accornero House (mullioned windows and single-lancet windows, today closed). In these openings other wall elements were introduced in order to close ancient openings, whose sizes were read from an orthophoto image. In these new wall elements nineteenth-century windows were included. At the architectural scale, the approach is comparable to the micro urban because a specific "tag" is associated to the "mark" of an element and it indicates the name of a Wall Stratigraphic Unit. In this way it is possible to define stratigraphic units analyzed with B.I.M. with the same name of the ones studied with the traditional approach.
B.I.M. was created to design new construction or to describe recent buildings. Our method is a little bit different because we try to use an historical approach to understand construction phases, periods and changes of the building. Advantages of Building Information Modeling are important and useful for the comprehension of Cultural Heritage from a management, reconstructive, performative point of view.
The main advantage of Building Information Models is the possibility to constantly classify information and data as well as to manage the model through Revit phases. This function is utilized by designers in relation to construction and demolition phases with specific graphic overrides. The pre-set phases of Revit are "existing" and "new construction", some graphic overrides, modifiable by the user, are associated to them. In Revit every object has a phase. However the designer can create a construction or a demolition phase. Combining particular phases designers can use specific graphic overrides on the objects of the digital model in order to underline some characteristics of elements. Phase Filters create a homogenous graphic which is not connected to the category of the element (door, window, wall etc.). Using them it is easier to choose what objects you can see in a specific view. The situation that shows all phases displays recent and ancient construction periods in the same time, but not the demolished objects. In addition to these filters there are other ones that show only new construction element or older building objects without referring to new constructions. The user can create these filters without any limit.
Phasing graphic overrides are other important functions of Revit, the designer can modify them, but he cannot create new ones. They refer to what the Software indicates as "new", "demolished" and "existing". It is possible to change the type of lines (continuous, dashed etc.), the color or the thickness of Graphic overrides, in the same way the hatching of objects can be modified.
In the digital model of Accornero House the choice was to use black and continuous lines in every construction phase. This solution was useful to accurately show objects in the phase chosen because Revit generally utilizes different colors and line types for elements built and demolished in the same phase, considering them temporary elements.
An Harris Diagram must be created in architectural stratigraphic analysis too, as well as the micro urban study. In the same way of previous analysis new schedules about Stratigraphic Units were realized and associated to thematic representations. All these units were connected to the "Period" parameter with the aim to show the correspondent age of the elements in the digital model of the house. Investigating Accornero House it was not created a unique schedule for different Stratigraphic Units, as the Building Units, but we collected similar objects in the same table. For instance Wall Stratigraphic Units and Architectural Elements are in different schedules (Table 1). Revit filters objects relating to user's selections: in this case we identified architectural objects focusing on the respective stratigraphic unit. Wall Stratigraphic Units correspond to wall elements whether they are closure of ancient windows or wall of the building. Architectural elements are doors, windows, niches; every type of these objects has a specific schedule.
The elements of the model are divided in classes; an acronym (USM or EA) is associated to every object, it was possible through the utilization of the semantics of Revit.
The methodology described uses Building Information Models in stratigraphic archeological analysis. Nowadays applications of Building

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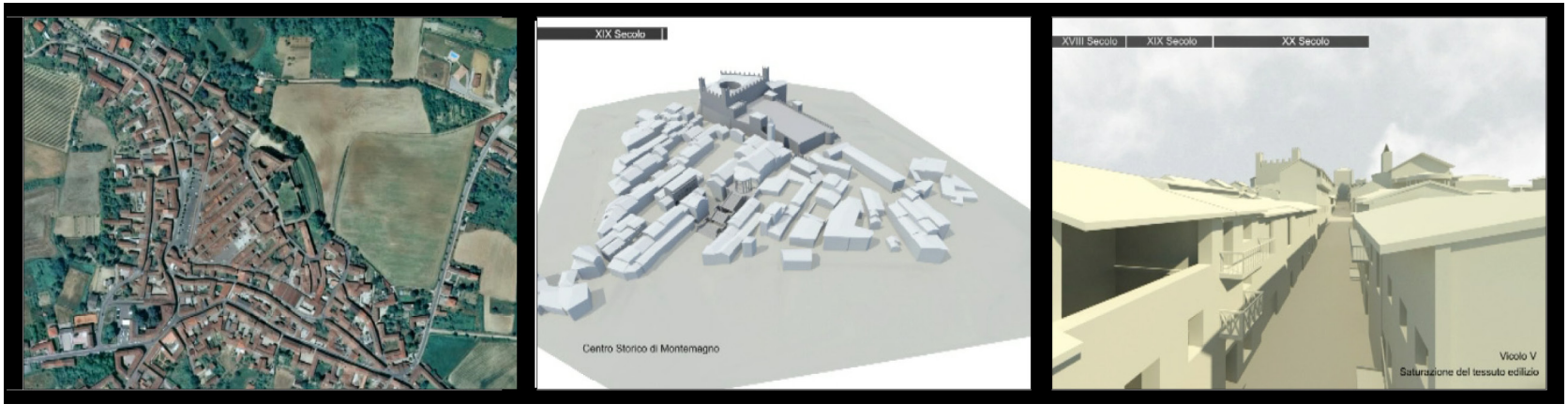
Information Models in archaeology concern the realization of digital models in order to represent objects and then to export them in IFC, DWF or ODBC formats. The recent studies do not explore all the advantages of temporal management of B.I.M.; they created only a database of the model. Our research goal is to evaluate the use of B.I.M. in stratigraphic archeological analysis to test the use of temporal dimension through phases of Revit both in the urban scale on the borough of Montemagno and in micro urban and architectural levels. In the case of Montemagno, the temporal range considered is one hundred years, from XIX century to nowadays, but for the one for the previous period is larger because of the lack of information on the borough for XVI and XVIII century.

4. CONCLUSIONS (ROBERTA SPALLONE, ANDREA PIANO, SIMONA PIANO)

The advantages of the approach just described are manifold, starting with the ability to directly create a series of reconstructions of the borough's morphology during the centuries, in the model of the existing. This method could also be applied to the study of other historic towns or small urban settings and, if you have access to historical documents in higher quantities, you can create more detailed temporal phases of the town, with fewer time intervals.
You can better manage the fourth dimension in the case of architectural scale deepenings, as it is also possible to detail the definition of the temporal phases of individual buildings, as we have begun to experience regarding Accornero house.
In the present research this has been applied on all three levels of analysis, urban, micro-urban and architectural, assuming phases with shorter intervals depending on the reduction scale (1: 1000, 1: 500, 1: 100). The application of stratigraphic approach at different scales using B.I.M. would be desirable in the future to create a immediately upgradeable database and digitize the data and information collected. The B.I.M. model, in fact, allows to carry out various kinds of study firstly investigating the evolution of the heritage over time.
However, the most interesting potentiality, not yet been adequately explored, because of the limited accessibility of the building and the unavailability of non-destructive survey tools, which would allow to overcome the limit of a study circumscribed to the "skin" of the artifact, is the interlace of the stratigraphic analysis with the three-dimensional model, creating a wealth of information that fully represents the morphological and material characteristics of the building, in its constitution and transformation over time.
The digitization and the representation of the survey data directly into Revit allows multiple uses of the multiscalar model, creating a knowledge base on which to plan requalification and restoration, from urban to architectural scale.
The database thus obtained can be also used as a starting point for further studies on historic, sociological, economic fields.. with the aim of passing from the archaeology of the components to "an archaeology of the complexity of relations, whose chronological limits are not defined a priori, but depend on the quality of the available sources and duration of single phenomena" [18].



7. Screenshots from the video realized for communicating the analisys on Montemagno.

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NOTES

[1] Cavallari Murat, A. (1968), *Forma urbana e architettura nella Torino barocca*, Utet, Torino.

[2] Coppo, D. (2006), *Ragioni e significato di un metodo di rilievo urbano. La norma UNI 7310 a quarant'anni dalla sua prima applicazione*, in Ikhnos. Analisi grafica e storia della rappresentazione, pp. 193-212.

[3] *Coppo, S. Spallone, R. (1995), Rilievo di via Pietro Micca*, in Dipartimento di Ingegneria dei Sistemi Edilizi e Territoriali, *Torino nell'Ottocento e nel Novecento. Ampliamenti e trasformazioni entro la cerchia dei corsi napoleonici*,Celid, Torino, pp. 534-538.

[4] Calorio, GF., Moglia, G., Spallone, R., Vitali, M. (2003), *Il disegno dei portici nei centri minori in Piemonte. I portici delle Villae Novae piemontesi: Fossano, Cherasco, Cuorgnè. Il disegno dei "percorsi coperti" per la valorizzazione dell'immagine urbana*, in Cundari, C., Carnevali, L. (edt.), *Il Rilevamento urbano. Tipologia, Procedure, Informatizzazione*, Kappa, Roma, pp. 497-518.

[5] Spallone, R. (1999), *Lettura e rappresentazione della trasformazione storica del Borgo di Po a Torino dall'età neoclassica ad oggi*. In Coppo, S., Novello Massai G., Bisceglia, L., Davico, P., Spallone, R., *Borgo Po 1999. Un'esperienza di rilievo della trasformazione*, Levrotto & Bella, Torino, pp. 21-42.

[6] Baculo Giusti, A.(1994), *Napoli all'infinito/Naples in progress. Napoli in assonometria… e Napoli nel data base*, Napoli, Electa. Baculo Giusti, A. (1995), *Napoli in assonometria*, Napoli, Electa.

[7] Spallone, R., *Corso Vinzaglio*. Spallone, R., *Via Cernaia*. Carrozzo, A., Spallone, R., *Via Pietro Micca*. Calorio, GF., Spallone, R., *Piazza Bodoni*. In Coppo, S., Davico, P. edt. (2001), *Il disegno dei portici a Torino. Architettura e immagine urbana dei percorsi coperti da Vitozzi a Piacentini*, Celid, Torino, pp. 131-155, pp. 157-173, pp. 347-355, pp. 391-399.
Spallone, R., *I mercati di Fossano*. Spallone, R., *La provincia di Novara*. In Coppo, D., Osello A. edt. (2007), *Il disegno di luoghi e mercati in Piemonte*, Umberto Allemandi & C., Torino, pp. 262-272, pp. 273-295.

[8] Baculo, A., Campi, M.,di Luggo, A., Florio, R., Maglioccola, F. (2006), *I fronti urbani di Napoli. I grandi assi e le strade maggiori della città*, 1, Electa, Napoli. Baculo, A., di Luggo, A., Florio, R., *I fronti urbani di Napoli. I quartieri degradati e le piazze della città*, 2, Electa, Napoli 2006.

[9] Apollonio, F. I., edt. (2007), *I colori di Cesena. La scena urbana della città*, CLUEB, Bologna.

[10] The regressive method investigates the nowadays situation in order to study more ancient facts and territories shapes. In this way we can know how contemporary landscape has been modified. Tosco, C. M. (2009), *Il paesaggio storico. Le fonti e i metodi di ricerca tra medioevo ed età moderna*, Editori Laterza, Roma-Bari, p. 6.

[11 Stratigraphic analysis is a method of study applied to buildings. It is derived from geologic and archeological analysis. This approach identifies the construction and demolition actions and recognizes stratigraphic relationships of anterioriy, posteriority understanding their sequence. Brogiolo, G. P., Cagnana, A. (2012) *Archeologia dell'architettura. Metodi e interpretazioni*, All'Insegna del Giglio, Firenze, p. 7. Lo scopo di tale metodo di studio è individuare la sequenza delle fasi intervenute sul costruito nel corso del tempo.

[12] The so called Building Unit is a reference unit defined as a whole of continuous and homogenous wall elements, which are tied in only one executive intervention. This is a 3D unit generated within an intentional and continuous construction process which can be clearly detected on the conserved structures. Tosco, C. M. (2003), *Una proposta di metodo per la stratigrafia dell'architettura*, in Brogiolo, G. P., Cagnana, A. (2012) Archeologia dell'architettura, cit., p. 19.

[13] The Harris stratigraphic diagram, or Matrix, shows the relationships that make up the stratigraphic sequence. The matrix construction is coherent to the units sequence and the first unit that has to be write down is the one which initially covered all the other units. On the horizontal axis line you have the location of the units in space, while on the ordinate axis there is the relative time passed between a stratigraphic unit and another one. The Harris diagram shows the physical relationship existing between the parts of the building, indicated as stratigraphic units. Beltramo, S. (2009), *Stratigrafia dell'architettura e ricerca storica*, Eurolit, Roma, pp. 18-19.

[14] Tosco, C. M. (2003) cit., p. 19.

[15] Stratigraphic wall units are defined as building actions (positive interfaces) and as destructive actions (negative interfaces). Their limits are objective and they depend on the details we want to describe. Stratigraphic wall units are defined through stratigraphic relationships. A single stratigraphic wall unit is an homogenous whole built during one working day. Brogiolo, G. P., Cagnana, A.(2012), cit., p. 29.

[16] Among the wall stratigraphic units there are the Covering Stratigraphic units, identifying plasters and other types of coverings which can be decorated or directly built on site. These units have the advantage of containing numerous information about materials (pigments necessary for decoration or plaster) or surface treatment. Sometimes the traces of the tools used to spread the plaster or finish them are still visibles. Brogiolo, Cagnana, (2012), cit., p. 29.

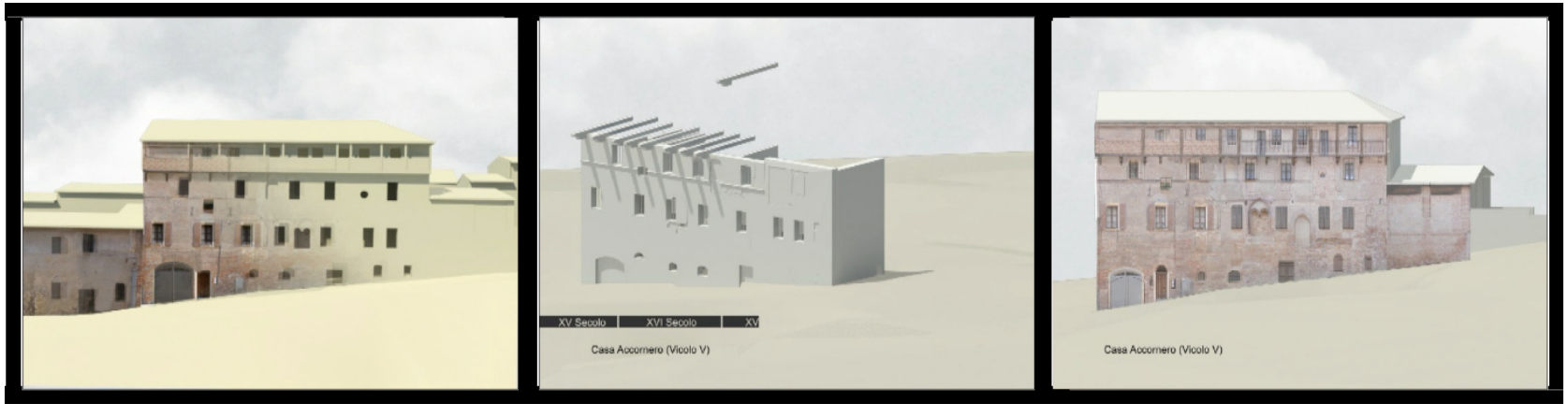
[17] Architectural Elements (EA) are identified with the vertical connections (pillars, columns, pilasters, stairs and ramps), the horizontal ones (cornices string courses etc.), and the openings (arches, lowered, pointed, with architraves, lintels). Brogiolo, Cagnana, (2012), cit., p. 27.

[18] Brogiolo, Gian Pietro (2007), Dall'Archeologia dell'architettura all'Archeologia della complessità, in Pyrenae. Revista de prehistòria i antiguitat de la mediterrània occidental, Università di Barcellona, vol. I, n. 38, p. 33.

REFERENCES

Adami, Andrea, Guerra, Francesco, Stevanin, Cecilia (2004), *Il modello urbano tridimensionale quale supporto per la conoscenza: il caso del borgo medievale di campo*, in Malinverni, Eva (edt.), *e Arcom – Tecnologie per comunicare l'architettura*, Portonovo, Ancona, 20-22 Maggio 2004, Ancona: CLUA Edizioni, pp. 1-5.

Affleck, Janice, Yehuda, Kalay,



8. Screenshots from the video realized for communicating the analisys on Montemagno.

ISSN 1828-5961

Kvan, Thomas (2008), *New Media and Cultural Heritage*, Routledge, Londra.

Apollonio, Fabrizio Ivan, edt. (2007), *I colori di Cesena. La scena urbana della città*, CLUEB, Bologna.

Baculo Giusti, Adriana(1994), *Napoli all'infinito/Naples in progress. Napoli in assonometria… e Napoli nel data base*, Napoli, Electa.

Baculo Giusti, Adriana (1995), *Napoli in assonometria*, Napoli, Electa.

Baculo, Adriana, Campi, Massimiliano, di Luggo, Antonella, Florio, Riccardo, Maglioccola, Francesco (2006), *I fronti urbani di Napoli. I grandi assi e le strade maggiori della città*, 1, Electa, Napoli.

Baculo, Adriana, di Luggo, Antonella, Florio, Riccardo, *I fronti urbani di Napoli. I quartieri degradati e le piazze della città*, 2, Electa, Napoli 2006.

Beltramo, Silvia (2009), *Stratigrafia dell'architettura e ricerca storica*, Eurolit, Roma.

Bertocci, Stefano, Bini, Marco (2012) *Manuale di Rilievo Architettonico e Urbano*, Città Studi Edizioni, Novara.

Brogiolo, Gian Pietro (2007), *Dall'Archeologia dell'architettura all'Archeologia della complessità*, in Pyrenae. Revista de prehistòria i antiguitat de la mediterrània occidental, Università di Barcellona, vol. 1, n. 38, p. 7-38.

Calorio, Gianfranco, Moglia, Giuseppe, Spallone, Roberta, Vitali, Marco (2003), *Il disegno dei portici nei centri minori in Piemonte. I portici delle Villae Novae piemontesi: Fossano, Cherasco, Cuorgnè. Il disegno dei "percorsi coperti" per la valorizzazione dell'immagine urbana*, in Cundari, Cesare, Carnevali, Laura (edt.), *Il Rilevamento urbano. Tipologia, Procedure, Informatizzazione*, Kappa, Roma, pp. 497-518.

Cavallari Murat, Augusto (1968), *Forma urbana ed architettura nella Torino barocca: dalle premesse classiche alle conclusioni neoclassiche*, UTET, Torino.

Chiavoni, Emanuela, Docci, Mario, Filippa, Monica, (2011) *Metodologie integrate per il rilievo, il disegno, la modellazione dell'architettura e della città*, Gangemi Editore, Roma.

Comba, Rinaldo (1985), *Le villenove del principe. Consolidamento istituzionale e iniziative di popolamento fra i secoli XIII e XIV nel Piemonte sabaudo*, in *Piemonte medievale Forme del potere e della società. Studi per Giovanni Tabacco*, Einaudi, Torino.

Coppo, Secondino, Spallone, Roberta (1995), *Rilievo di via Pietro Micca*, in Dipartimento di Ingegneria dei Sistemi Edilizi e Territoriali, *Torino nell'Ottocento e nel Novecento. Ampliamenti e trasformazioni entro la cerchia dei corsi napoleonici* ,Celid, Torino, pp. 534-538.

Coppo, Dino (2006), *Ragioni e significato di un metodo di rilievo urbano. La norma UNI 7310 a quarant'anni dalla sua prima applicazione*, in Ikhnos. Analisi grafica e storia della rappresentazione, pp. 193-212.

De Luca, Livio (2011), *Verso la caratterizzazione semantica di rappresentazioni digitali di artefatti architettonici: linee programmatiche di ricerca / Towards the semantic characterization of digital representation of architectural artifacts: programmatic lines of research*, in DISEGNARECON, Università di Bologna, vol. 4, n. 8.

Docci, Mario (2007), *Virtuale, Rappresentazione*, in Enciclopedia Italiana Treccani, XXI secolo, settima appendice, volume terzo, Istituto Enciclopedia Treccani, Roma, pp. 448-450.

Docci, Mario, Maestri, Diego (2009), *Manuale di rilevamento architettonico e urbano*, Editori Laterza, Bari.

Dore, Conor, Murphy, Maurice (2012), *Integration of Historic Building Information Modeling and 3D GIS for Recording and Managing Cultural Heritage Sites*, 18th International Conference on Virtual Systems and Multimedia: "Virtual Systems in the Information Society", 2-5 Settembre 2012, Milano, pp. 369-376. <https://www.academia.edu/2099498/Integration_of_Historic_Building_ Information_ Modeling_HBIM_and_3D_GIS_for_Recording_and_Managing_Cultural_Heritage_Sites> ultima consultazione: 17 Luglio 2015.

Dore, Conor, Murphy, Maurice (2012) *Integration of BIM and 3D GIS for Digital Heritage Modelling, Digital Documentation*, Edimburgo 22-23 Ottobre 2012.<http://arrow.dit.ie/beschreccon/71/> ultima consultazione: 17 Luglio 2015.

Garagnani, Simone, *Building Information Modeling semantico e rilievi ad alta risoluzione di siti appartenenti al Patrimonio Culturale*, in DISEGNARECON, Università di Bologna, Numero Speciale, DoCo 2012 – Documentazione e Conservazione del Patrimonio Architettonico ed Urbano, vol. 5, n. 10.

Longhi, Andrea, (edt.) (2008), *Cadastres et territoires : l'analyse des archives cadastrales pour l'interprétation du paysage et l'aménagement du territoire = Catasti e territori : l'analisi dei catasti storici per l'interpretazione del paesaggio e per il governo del territorio*, Alinea, Firenze.

Marotta, Anna, Novello, Giuseppa edt. (2015), *Disegno e città*, in Atti del convegno dell'Unione Italiana del Disegno "Disegno e Città", Torino, 17 – 19 Settembre 2015, Gangemi Editore, Roma.

Migliari, Riccardo (2012), *Geometria, Costruzione, Architettura,* in DISEGNARECON, Università di Bologna, IX, n. 9.

Murphy, Maurice (2012), *Historic Building Information Modeling (HBIM), For Recording and Documenting Classical Architecture in Dublin*, Tesi di Dottorato, Department of Civil, Structural & Environmental Engineering, Trinity College Dublin. <https://www.academia.edu/8237173/Historic_Building_Information_Modelling_HBIM_PhD> ultima consultazione: 19 Novembre 2015.

Murphy, Maurice (2014), *Semi-Automatic Techniques for Generating BIM Façade Models of Historic Buildings, Virtual Cultural Heritage in Ireland* 2014, Dublino, 27-28 Febbraio 2014.

Simeone, Davide, Cursi, Stefano, Toldo, Ilaria, Carrara, Gianfranco (2014), *BIM and knowledge for building heritage*, in ACADIA 2014 Design Agency: Projects of the 34th Annual Conference of the Association for Computer Aided Design in Architecture, ACADIA/Riverside Architectural Press, Los Angeles,13 Ottobre 2014, pp. 681-690.

Spallone, Roberta (1999), *Lettura e rappresentazione della trasformazione storica del Borgo di Po a Torino dall'età neoclassica ad oggi*. In Coppo, Secondino, Novello Massai Giuseppa, Bisceglia, Leonardo, Davico, Pia, Spallone, Roberta, *Borgo Po 1999. Un'esperienza di rilievo della trasformazione*, Levrotto & Bella, Torino, pp. 21-42.

Spallone, Roberta (2001), *Corso Vinzaglio*. Spallone, Roberta, *Via Cernaia*. Carrozzo, Antonio, Spallone, Roberta, *Via Pietro Micca*. Calorio, Gianfranco, Spallone, Roberta, *Piazza Bodoni*. In Coppo, Secondino, Davico, Pia edt. (2001), *Il disegno dei portici a Torino. Architettura e immagine urbana dei percorsi coperti da Vitozzi a Piacentini,* Celid, Torino, pp. 131-155, pp. 157-173, pp. 347-355, pp. 391-399.

Spallone, Roberta (2007), *I mercati di Fossano*. Spallone, Roberta, *La provincia di Novara*. In Coppo, Dino, Osello Anna edt. (2007), *Il disegno di luoghi e mercati in Piemonte*, Umberto Allemandi & C., Torino, pp. 262-272, pp. 273-295.

Tosco, Carlo Mario (2003), *Una proposta di metodo per la stratigrafia dell'architettura*, in *Archeologia dell'architettura*, All'Insegna del Giglio, vol. VIII, p. 17-27.

Vigliano, Giampiero edt. (1969), *Beni culturali ambientali in Piemonte contributo alla programmazione economica regionale*, Unione Regionale delle Camere di Commercio, Torino.