# REDUCE TO UNDERSTAND: A CHALLENGE FOR ANALYSIS AND THREE-DIMENSIONAL DOCUMENTATION OF ARCHITECTURE

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## Introduction

For nearly thirty years, the digital phenomenon has integrated many disciplines. Those involved in the image processing and analysis took advantage of this major technological breakthrough to revisit the tools and methods of their discipline. In this context, the architectural field, and more specifically the one of heritage analysis and documentation, have greatly benefited from the development of acquisition and visualization techniques. Today, it is no longer unusual to document a building with millions of three-dimensional spatial coordinates. Whether in the context of archeology, history of art or architecture, digital documentation of built heritage is becoming a major contemporary challenge[1]. AlICe laboratory (Computer Laboratory for Image and Conception in Architecture) from the Faculty of Architecture of the Université libre de Bruxelles (ULB) investigates this field for many years through a research and education program. In terms of architectural design, the practice of graphic representation firstly involves the definition of an idea by drawing exclusively relevant information. The architect draws only the lines he considers necessary for the transmission of the idea of its project. This "graphical economy" is therefore for the benefit of didactic quality. But what does this issue become when the matter of representation is not the prescription but the description of an architectural object? Until the last century, documentation by drawing corresponded to a work of reverse engineering in which it belonged to the architect to understand the object and to represent its key feature. Today, 3D data acquisition technology promotes an increasingly "figurative" representation of architecture. In this paper, we will try to consider some epistemological avenues for the integration of those new approaches to the requirements of architectural representation through the lens of student's works.

[1] Marinos Ioannides and Ewald Quak, (eds.). *3D Research Challenges in Cultural Heritage*, Vol. 8355, Lecture Notes in Computer Science, Berlin, Heidelberg: Springer, 2014.

## Figurative information vs. architectural representation

At the level of the three-dimensional documentation of built heritage, the visual fidelity of perceptual features is more promoted than a representation where the graphic figure is considered as mediator of architectural knowledge. The democratization of photogrammetry and other acquisition techniques permits the creation of digitization composed of several millions of data having a great visual and metrical coherence with the observed artefact[2]. However, these techniques constitute, for the field of the architectural study, new arguments in favor of an essentially figurative documentation at the expense of a representation integrating the codes and the language of architecture. This architectural representation paradigm shift raises the question of cultural and cognitive issues of architectural representation.

Whether it is digital acquisition of an existing architectural building or restitution hypothesis of a disappeared state of a building, the three-dimensional documentation requires a critical and reflexive attitude. The management and the processing of big data (such as point clouds, polychromatic data or alteration data, ...) compel reduction of these data to retain only those likely to be used in the construction of a graphic discourse about the object. The graphic transmission of an intelligible knowledge presupposes taking a stance downstream of the acquisition work. Until the last century, the architectural survey was based on onsite observation work during which the architect represented, through drawing, the information he regarded as most relevant to make explicit knowledge about an object. Contemporary acquisition devices require us to take a contrary attitude. The act of architectural representation no longer resides at the drafting level of a specific selection of information, but in the ability of the architect to sort, set aside and / or to connect large amounts of digital data. Its ability to handle (sometimes heterogeneous) data is decisive for the knowledge enhancement at the level of the representation.

Although architectural representation is essentially seen as a cultural vector, we will firstly try to consider it through its heuristic function[3]. This involves understanding how digitization efforts (understood as a process passing through the acquisition, the processing and graphic representation of produced information) allow to build an analytical discourse embodied in the representation of the object under study. However, to justify our judgment on the discursive value of graphic documents, it is essential to understand how the information on geometry, dimension, color, etc. is consolidated. In this paper, we will to consider how information workflow culture of architectural representation establish a critical and opposable discourse in two Master student's works.

[2] Marc Pierrot-Deseilligny, Livio De Luca and Fabio Remondino. "Automated Image-Based Procedures for Accurate Artifacts 3D Modeling and Orthoimage,", in: *XXIIIth International CIPA Symposium*, 2011.

[3] Robin Evans. "Translations from Drawing to Building", in: *Translations from Drawing to Building and Other Essays,* London: Architectural Association Publications, 1997, pp. 153-93.

## Observed criteria

If we cannot speak of an observation method in the strict sense of the term, we estimate the informative value of the student's works following three different criteria: reduction, absence and extrapolation. They are established in order to evaluate each step of the reconstruction process, passing through the reduction of digitization data acquired on site, the reconstruction of architectural elements with few or devoid from historical sources, and the extrapolation of fragmented information to the whole composition.

***Reduction*** – Starting from big data, the criterion of reduction is intended to highlight the manipulations (discrimination, linking, ranking, etc.) performed on the original data (photogrammetric acquisition or other.) so as to keep only the information able to refer to a specific architectural knowledge.

***Absence*** – In the case of three-dimensional reconstructions of disappeared or altered objects, it is not uncommon to have to rely mainly on textual or graphic material. However, these sources offer piecemeal information about the building. The geometric restitution work (in other words, the formulation of hypotheses) requires a high degree of interpretation. In this context, it is necessary to make clear the nature of information at the level of representation. From this criterion, graphic contrivances are set up and evaluated in order to account for the level of knowledge or certainty present in the representation.

***Extrapolation*** – Finally this criterion implicitly refers to the two previous ones. Architectural documentation (produced by a survey of an existing state or a restitution hypothesis) includes by nature a vacuum of information. The research of a visual consistency imposes to complete the digital instance with information arising nor from the "real" (data acquisition work), nor from specific documentary sources (textual or image archives). The part of interpretation to complete these "gaps" can be decisive. Indeed, whatever the reconstruction methods mobilized, the level of interpretation, and thus the value of the representation, are mainly determined by the degree of architectural knowledge of the student.

## Restitution hypothesis of the cloister of the Villers-la-Ville Abbaye

The Villers-la-Ville Abbey is a Cistercian abbey dating from the 12$^{th}$ century and located in the Walloon region of Belgium. The building was partially destroyed during the French Revolution, only ruins remained. The cloister is one of the major elements of the site. Only five vaults along the southern gallery of the cloister are still in place today. The aim of this work was to propose a hypothetical modeling of the cloister during the 15$^{th}$ century starting form remaining architectural fragments, the doctoral research of art historian Thomas Coomans[4].

[4] Thomas Coomans. *Abbaye de Villers-en-Brabant: Construction, configuration et signification d'une abbaye cistercienne gothique*, Bruxelles; Brecht: Éditions Racine & Cîteaux, 2000.

Within that context, student Vanessa Lardinois conducted a photogrammetric digitization of walls and remaining spaces of the cloister. In such a process, millions of three-dimensional coordinates were extracted from photos, creating an accurate geometric shape associated with color values of the photos (Fig. 1). The mass of data of the imprint describes well the physical complexity of an architectural object but fails to build a model of knowledge, or to consider the object through its architectural features. Digitization should not be considered as an end in itself but as a starting point of an architectural study. A point cloud – where every points have the same value – does not evoke the intersection of two cylinders forming a rib vault when architectural drawing does. Therefore, the process that turns digitization into restitution hypothesis can not only rely on mixing digital 3D imprint and documentary sources. It has to be founded upon a reduction process based on a cognitive analysis of the building in order to bring out its characteristic lines.

Examination of the work of reduction, extrapolation or production of information is essential to understand the degree of cognitive involvement of an author in a modeling process. Cognitive involvement is made explicit by a layer of graphic schemes that extends graphic representation of the building, and accounts for relative levels of knowledge. For Villers-la-Ville Abbaye, the work of reduction, extrapolation or production of information (absence) developed as follow:

**Reduction**: The student has undertaken a simplified polygonal reconstruction based on the point cloud of the cloister (Fig. 2). This involves to reduce the amount of data to the characteristic lines of the building, or in other words: to establish a reverse design process based on the analysis of generic elements (vaults, pilasters, bays, etc.).

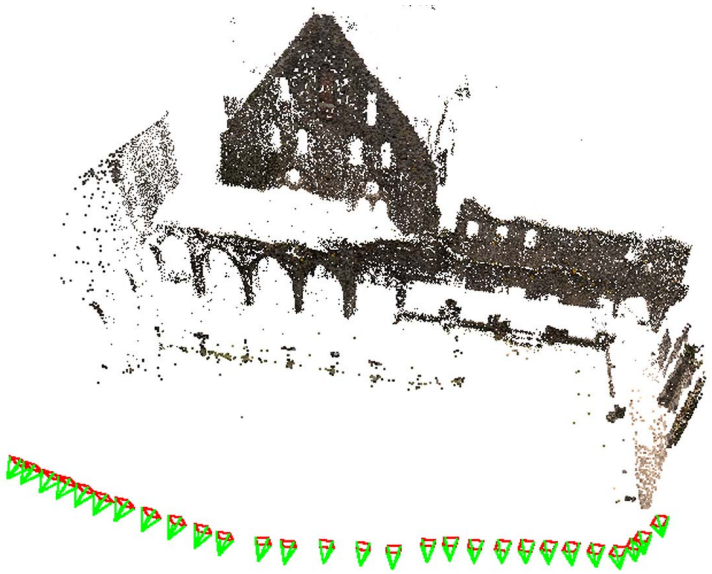

Fig. 1. Photogrammetric acquisition of the south wing of the cloister. Preview of the point cloud
*Source: Vanessa Lardinois, AIICe laboratory, 2012.*

This implies to deliberately deviate from the complexity of the cloud to establish a geometric representation consistent with the formal vocabulary of architecture. The use of a worm's-eye axonometric projection is part of that very analytical approach. The axonometric view creates a distance to the object that helps to mobilize the codes of architectural representation for analytical purposes. In rejecting the embodied viewpoint out of the graphical space, the student redefines a new space that opens opportunities for comparison between the studied objects (Fig. 2).

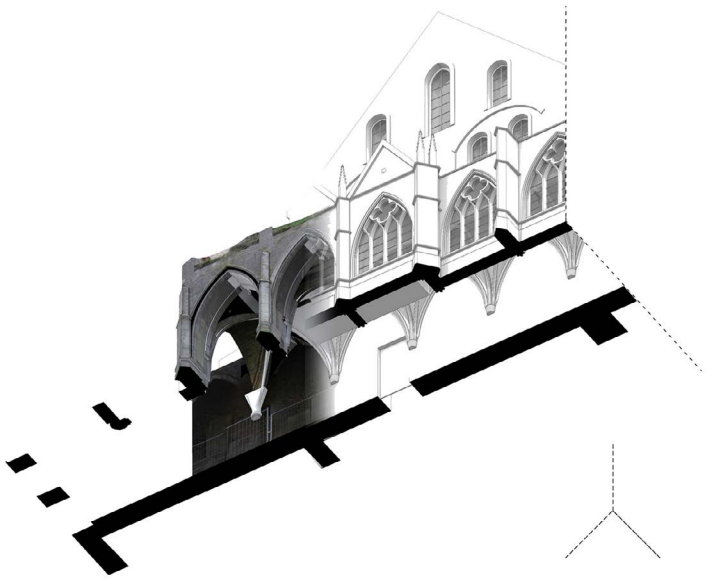

Fig. 2. Digitization confronted to the restitution hypothesis (Axonometric worm's eye view)
*Source: Vanessa Lardinois, AIICe laboratory, 2012.*

**Extrapolation**: The few architectural elements still in place (vaults, transverse arches, etc.) as well as the fragments and the primers visible on some walls offer an unquestionable support for the digital reconstruction of the building. The study of composition rules, proportions and bay rhythms provides a set of indices from which one can extrapolate the entire site (Fig. 2). However, extrapolation unavoidably leads to take positions from which distance to historical reality is difficult to estimate. But a restitution process is considered reversible: graphic codification identifies parts related to the existing state and parts related to extrapolation. Based on the *informative modeling*[5] concept, the student has developed a color chart to visualize the distance between 3D modeled geometries and data coming from the digital acquisition.

**Absence**: The only traces of architecture still visible on the site are not always sufficient to consider a complete restitution hypothesis. Thus, historical researches on the abbey, literature on Cistercian architecture and student's own knowledge were added to the digital sources acquired on site. Yet, if knowledge about a place

[5] Jean-Yves Blaise and Iwona Dudek. "Informative Modelling", *MIA Journal*, No. 1. 2006, pp. 143-54.

will always be fragmentary, restitution hypothesis integrates absence with great difficulty. Gaps have to be filled with extrapolated parts based on external sources. The expression of a historical reality by graphic means is then illusive or misleading The expression of a relative state of knowledge seems more appropriate[6]. For this reason, the student has proposé a hypothesis integrating missing parts, where the degree of certainty is represented by three separate criteria (shape, location and dimensions). Each architectural element is associated to a color indicating its proximity to those criteria (Fig. 3).

Whether it is about filling the lack of information by generic architectural knowledge or discriminating big data to get only main lines, the author's involvement in the restitution hypothesis guides the quality of the result. But, is the result opposable? In a quest for scientific objectification, digital survey tools provide a fragmentary answer to an essentially cognitive analytical process. In that context, the intersection between data visualization devices and the paradigm of architectural representation outlines a first response to that epistemological problem.

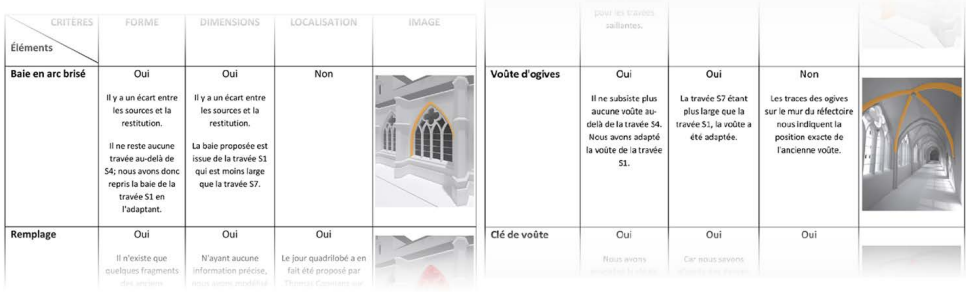


Fig. 3. Characterization of the restitution hypothesis. Graphic codification of geometries according their proximity to the documentary sources in terms of shape, location and dimensions
*Source: Vanessa Lardinois, AllCe laboratory, 2012.*

## The Bessonneau building in Casablanca – 1918 restitution hypothesis

Built in Casablanca, Morocco in 1918, the "Bessonneau" (also called "Lincoln Hotel") is a valuable witness of architecture dating from the French protectorate. Its facade presents exceptional characteristics mixing neo-Moorish ornaments and European modern composition that led the city to list the building. But the Bessonneau sits on a land with an increasing worth, and listing the building did not prevent its deterioration. Since 1990, it is abandoned and caught up in a conflict between worth of land and worth of cultural heritage. Nowadays, the building is a ruin surrounded by scaffoldings, with no possibility to access it for security reasons. Adding the fact that it exists no well-organized archives about the Bessonneau, this architecture and its historical and cultural knowledge are about to permanently disappear.

[6] Aurélie Favre-Brun. "Architecture virtuelle et représentation de l'incertitude", Aix-Marseille, 2013.

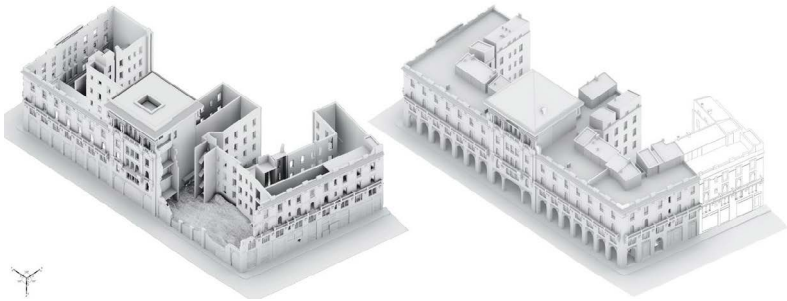

Fig. 4. Bessonneau building: actual state vs. 1918 restitution hypothesis
*Source: Youssef Oueld El Hachemi and Omar Essaadouni, AllCe laboratory, 2014.*

Supported by the local association Casamémoire, students Youssef Oueld El Hachemi and Omar Essaadouni undertook to document the building and to survey its existing sate. The objective was twofold: to propose a restitution hypothesis of the Bessonneau as it was in 1918, and to create a file for its protection and a possible restoration (Fig. 4).

Students proceeded to an investigation on the field so as to discover the very few historical documents related to the building: plans on microfilm, pictures, old postcards, newspaper articles, official city reports, oral testimony, etc. Simultaneously, they collected geometrical and colorimetric information of the current state of the building by mean of two different digital sources: a laser survey of the facades[7] carried out in 2009 before the placement of scaffoldings, and serval on-site photogrammetric surveys of interior spaces and courtyards. The core of the work becomes then gathering information of these manifold sources in a common 3D space, and extracting meaningful graphic representation that acknowledges different analytical understandings of the architectural object under study. This procedure necessarily complies with the 3 previously identified steps, and develops as follow:

***Reduction***. Lasergrammetry and photogrammetry produce point clouds that are very rich in terms of figurative information but unsubstantial in terms of intrinsic architectural meaning. Those big amount of information have to be reduced to a set of relevant architectural information. Such a reduction is about understanding specificities of neo-Moorish and European styles so as to extract from the point cloud only main lines of generic architectonic elements (pilasters, arches, bays, lintels, moldings, etc.). Those elements are organized in a 3D polygonal model that conveys cognitive knowledge. The cognitive approach globally prevails in a point cloud reduction process, but the shift between architectural scale and ornament scale must be taken into account. Sculpted or highly complex artifacts that cannot be easily synthesized in a set of lines must be identified. For those artifacts, a direct transfer from the point cloud information to the 3D model is needed for reporting their complexity. This results in a multi-scale 3D model that accommodates with the level of detail required by various architectonic elements, from structure to ornament (Fig. 5).

[7] This laser survey was completed by ETAFAT, an engineering and topography company based in Casablanca.

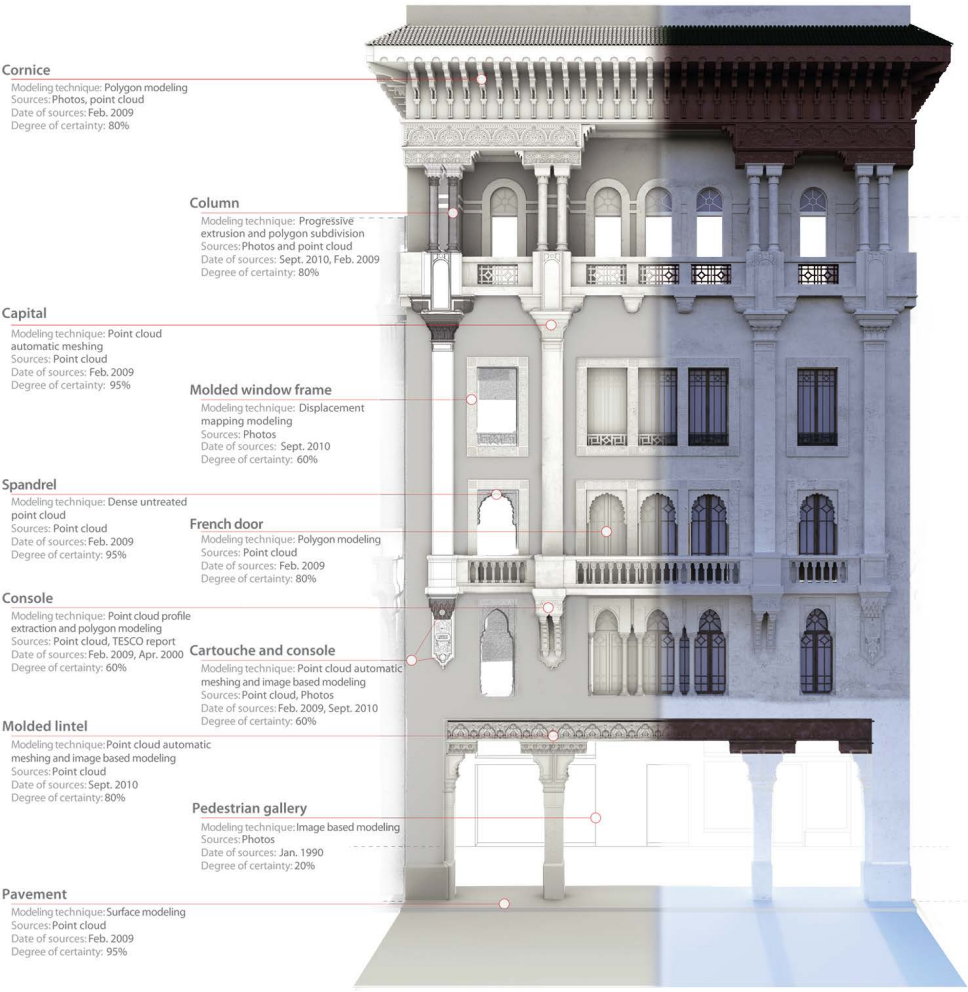


Fig. 5. Central part of the Bessonneau building: 1918 restitution hypothesis stating sources, modeling techniques and degree of certainty for several architectonic elements
*Source: Youssef Oueld El Hachemi and Omar Essaadouni, AIICe laboratory, 2014.*

***Absence***. Mixing information sources and media types into a single 3D graphic space necessarily prompts interpretation. As we have seen, an overload of information must be filtered, but some *gaps* have to be filled as well if one aims at continuity and visual coherence.

Some parts of a restitution hypothesis are highly speculative. For the Bessonneau, geometrical information extracted from the point cloud and matching with pictures dating from 1920s is considered as the most reliable, a unique oral testimony as the less reliable. Degrees of certainty are attributed to the parts of the building according to the richness and accuracy of their documentation. To become a valuable source of knowledge, it is paramount that the 3D model specifies interpreted parts and their degree of certainty (Fig. 5). A color code was also used in several instances of the 3D model for acknowledging degrees of certainty.

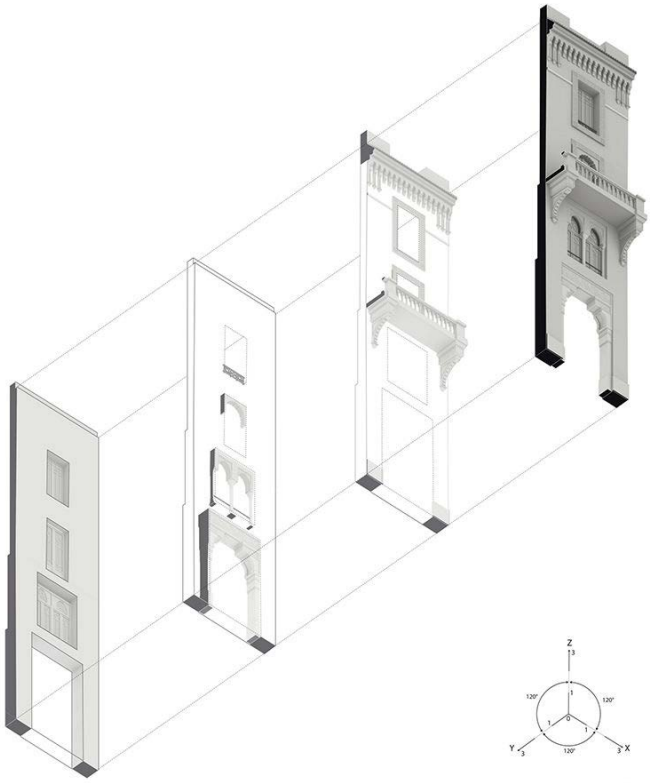

Fig. 6. Main bay of the Bessonneau building: exploded axonometric worm's eye view
*Source: Youssef Oueld El Hachemi and Omar Essaadouni, AllCe laboratory, 2014.*

***Extrapolation***. The facades of the Bessonneau are made of repetitive bays. Therefore, the analysis and digital reconstruction of one bay can extrapolate to the others that are similar. The less deteriorated bay was isolated and served as a base in the restitution hypothesis for the transformation of raw information of the point cloud into a cognitive 3D model. This model deploys in the building, and serves as a base for the reconstruction of the most altered bays. This process points out an interesting swing between raw information reduction and architectural knowledge expansion that takes advantage of graphic representation. The building was reduced to its very basic architectonic entity: the bay. The complexity of the point cloud of this bay was reduced to a few meaningful lines. These lines were represented by one single paradigmatic figure combining plan, section and elevation: the *axonometric worm's eye view.* The bay, now represented in the homogeneous infinite of axonometric space (Fig. 6), includes inherently its potential duplication[8].

[8] We refer here to the work of Auguste Choisy, whose architecture understanding as a system of repetitive structure for lowering loads led him to systematically synthesized historical buildings into a single bay represented by an axonometric worm's eye view. See Mandoul, Thierry. *Entre raison et utopie. L'Histoire de l'Architecture d'Auguste Choisy*. Wavre: Mardaga Editions, 2008, p.112.Thierry Mandoul, *Entre Raison et Utopie. L'Histoire de l'Architecture d'Auguste Choisy*, Wavre: Mardaga Editions, 2008.

## Conclusion

This paper has exposed the result of discussions held at both levels of education and research. Those results relate to the digital documentation considered through the prism of the architectural representation paradigm. Within a context where the heritage documentation increasingly complies with information technology, the main issue of this paper was to suggest an epistemological response to a discipline that is undergoing profound changes.

Firstly, it is necessary to distinguish architectural representation from data visualization. This implies on the one hand to understand the cultural and cognitive value of architectural representation and on the other hand to determine the nature and quantity of information produced during the digitization phases. Through the observation of those two digitization projects, we tried to understand how information is processed, manipulated and often reduced to construct representations able to refer to a realm of architectural knowledge.

In continuation of this first issue, the second was to discuss different positions about architectural documentation. Considering built heritage documentation through the lens of analysis and communication, the idea was to observe several students approaches about the representation of existing buildings, the representation of hypothetical states, the representation of certainty and the representation of temporal information. Beyond communication and cognitive issues, our purpose also attempted to understand how the digital representation of architecture could become a scientific tool for knowledge sharing.