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Reconstruction beyond Representation in Notre-Dame de Paris

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***Abstract* – Despite their aesthetic expressivity, realistic images of reconstructed pasts tend to withhold the scientific work of reconstruction and fail to provide scholarly reusable documentation. The contribution examines the operative role of (3D-)representations in the context of archaeological reconstruction. We propose a semiotic framework to look at reconstruction images. A semiotics' analysis (aesthetic, technical and analytical attributes) of practical examples of reconstruction images from the Notre-Dame de Paris arch reconstruction shows that there is a double effect of compression in the reconstruction and its representation. To alleviate these compressions in discourse and meaning, we focus our effort on the argumentation patterns and the conflict of interpretations as foundations of reconstruction scholarship. If we consider the 3D-reconstruction not in its illustrative image of reconstruction, it becomes an inherent part of the reconstruction data. We demonstrate how the argumentation can tie together the visualizations and the reconstruction. The linking of representation and reconstruction is possible through consistent documentation practice using CIDOC CRMinf to elicit the reasoning and the argumentation in the reconstruction process.**

I. CONTEXT

There is a saying, a picture is worth a thousand words, meaning that the images have the power of conveying realistic, spatial, social information implicitly. Despite their aesthetic expressivity, hyper-realistic images of reconstructed pasts tend to withhold the scientific work of reconstruction. While the study of reconstruction is based on archaeological evidence and argumentation, the produced visualizations fail to provide scholarly reusable documentation [16, 19]. This contribution builds on a previous reconstruction work of the authors on the archaeological reconstruction of the collapsed arch of Notre-Dame de Paris' cathedral [11] after the spire collapsed on the nave, sweeping the vaults away at two places during the fire on April 15th 2019. The object of this article is to look specifically at the role of scientific visualizations in the reconstruction argumentation and hypotheses.

II. PROBLEM

A common pitfall of 3D visualization democratization is that a 3D model of a reconstruction is too often reduced to an illustration. Traditionally drawings or engravings used to accompany the reconstruction publications as visual aid and illustration of the argumentation in the text. With the accessibility of 3D modeling tools and the development of virtual archaeology, the representation of reconstruction is dissociated from the reconstruction hypothesis formulations. The image of reconstruction is decoupled from the scientific research that produces it. The interpretive and analytical informative elements present in a scientific image are sacrificed for the sake of cultural consumption for their aesthetic quality. Looking at different visualization outputs in relation to the reconstruction project, we demonstrate the two-edged sword of visualization in reconstruction research. What makes a visualization a good scientific visualization of a reconstruction? What are the potential and limits of such a representation? How to overcome or mitigate these limits?

First, we porpose a method for a visual semiotic analysis for reconstruction images. Second, we will apply this semiotic framework to reconstruction images from the case-study of Notre-Dame de Paris to show the dissociation reconstruction-representation. The semiotic analysis of reconstruction images from the authors' previous work shows that no matter the medium used for the visualization, representation and reconstruction are problematic. Third, from a theoretical perspective, the double problem of reconstruction and representation is unraveled looking at the compressions in the reconstruction discourse and representation. They are both based on compressions of meaning and discourse. Finally, we argue that the linking of representation and reconstruction is possible through consistent documentation practice. We will show that it is possible to enrich the metadata and paradata of the reconstruction following the method in [3, 13]. The argumentation developed in the reconstruction can be linked to its representation using Linked Open Data and mapping with CIDOC CRM and CIDOC CRMinf.

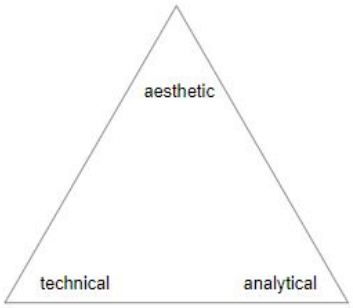

Fig. 1. Triangle with criteria for visualization analysis based on Fritz and Tosello's work [8]

III. METHOD

This part will define the analysis method we will apply to analyze reconstruction representations. We borrow from the theoretical framework of semiotics [**barthesChambreClaireNote1980**]. We reclaim the distinction between (1) aesthetical analytical representation and (2) technical analytical representation that Fritz and Tosello use to describe survey as process [8, 9]. We choose to adapt it for the analysis of reconstruction visualizations. The former (1) uses the morphology and geometry of the reconstructed object as a starting point. In this case, the illustration becomes an end in itself: the graphical expression conveys the interpretation. In the latter (2), the illustration is built as an open medium for discussion and interpretation. While the first is an accurate witness of the interpretation about a reconstructed past reality, the second is rooted in an accurate record of reality (ie. measurement). The two types of representations present different sets of qualities: aesthetic, technical and analytical. We propose to synthesize and reformulate Fritz and Tosello's approach in [Figure 1] as an abstract triangle representing the 3 opposed qualities.

This simple framework allows to highlight qualitative key points for the assessment of reconstruction representation:

- the role of information interpretation and curation in image production;
- to expose the image production bias;
- the volume and the diversity of information carried by the image regarding the original data. Conversely, it allows us to weigh the risk of information overload and evaluates how the interpretative layer filters the noise it builds up in the original data;
- the fascination for the visual and aesthetic value of reconstruction.

IV. RECONSTRUCTION IMAGES ANALYSIS

In this part, the analysis through practical examples [Figure 2, 3, 4 and 5] will show different roles that visual-

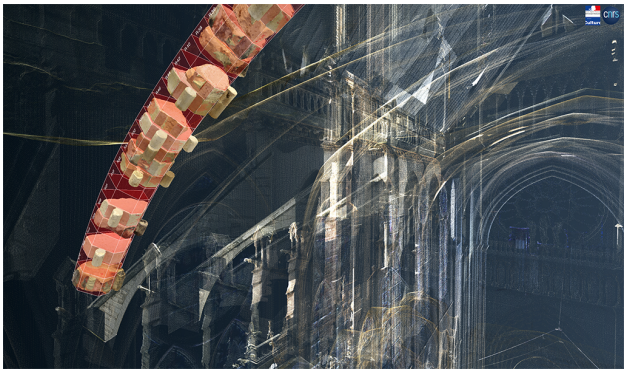

Fig. 2. The hybrid hypothesis on the online 3D viewer [1]. The arch and the cathedral are represented by point clouds or meshes that evoke placement of voussoirs in the reconstruction. This image is technical and aesthetic.

izations assume in the reconstruction study. We purposefully choose to look at visualizations separated from the reconstruction data. The semiotic analysis of these decontextualized visualizations will demonstrate how the visual representation bears specific aspects of the reconstruction process and reasoning. Let us consider 5 different images about the reconstruction of the collapsed arch of Notre-Dame de Paris [11] through the lens of the semiotic framework described in the previous part. The objective is to analyze qualitatively these images according to the aesthetic, analytical and technical criterias [Figure 1] presented in part iii..

In the case of 3D photorealistic images, we can argue that the decontextualization of the signifier and its separation from the signified is the reason that visualization tends to supersede reconstruction. Using Fritz et Tosello's terminology, the visualization can be characterized as both aesthetical and technical but it has lost its analytical end. The visualization becomes the object of understanding before what it represents. In contrast, the use of the schema like in figure 4 abstracts the signifier, focusing on the signified. It avoids shortcuts to the aesthetical value through the schematic representation. Inversely, figure 6 illustrates the archaeological predicates that guide the reconstruction hypothesis. The figure leans towards the aesthetical and analytical sides of the triangle. The analysis of the figures 4 et 5 shows that aesthetics is uncorrelated with the curated documentation of reconstruction. Between aesthetic-analytical and techincal-analytical, there is an array of scientific visualization and data visualization with the possibility of interaction and the capacity to aggregate large volumes of information.

The triangle for representation analysis helps clarify to what degree each representation eludes aspects of the reconstruction by its aesthetical, analytical or technical quality in the representation. It is because of the fundamen-

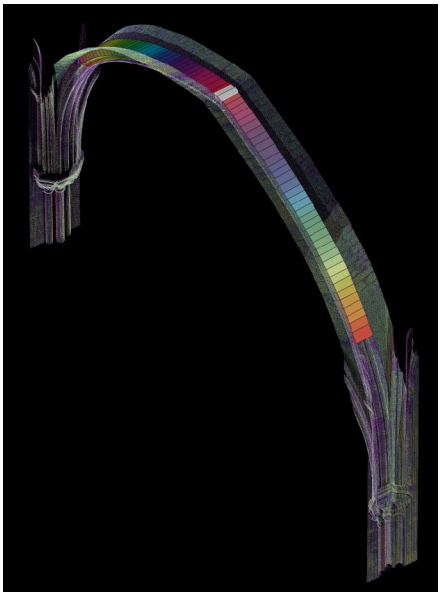

Fig. 3. An excerpt from the cathedral point cloud provides support for a parametric volumetric model of the arch with arbitrary colors. This image is technical and aesthetic.

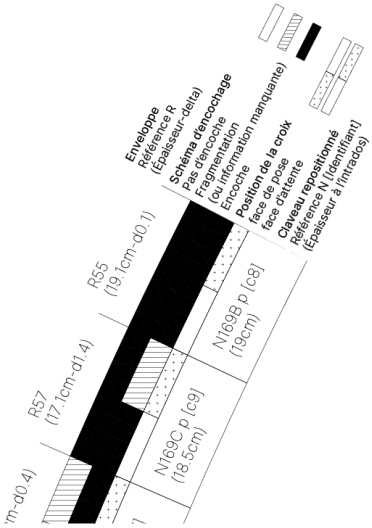

Fig. 4. The schematic representation filters the information represented towards the analytical elements and exacerbates its technical character.

tal opposition of the tops in the triangle that it is difficult to find an equilibrium. The representation rather tends to favor 2 attributes on the 3 possible: aesthetic-technical, technical-analytical, or aesthetic-analytical. Each image shown is the product of a specific moment in the reconstruction study, ie. a momentum in the reconstruction hypothesis formulation and formalization. The analysis of reconstruction images shows in negative both the limit and the potential for the reconstruction images to implicitly transcribe the underlying curation work on the reconstruction data and mediation role of the image. Without their context, all the reconstruction representations fall short to represent the reconstruction as a whole. They only present facets of a reconstruction hypothesis.

V. THE DOUBLE PROBLEM OF RECONSTRUCTION AND REPRESENTATION

The problem around the question of reconstruction has been clearly identified and stated in [4]: "reconstruction" is problematic as a term itself and as what it means in the practice of archaeology. Although the problem can be intuitively appreciated, it has rarely been detailed, and even fewer propositions and tangible research have ensued. Why is this problem still open? The aspect of argumentation in the reconstruction exercise has proved all the more crucial [6] with the evolution of 3D modeling tools and virtual archaeology. The question of argumentation or documentation of the reconstruction did not follow the same pace as the increasing interest for virtual archaeology. Then, the literature in archaeology related fields identifies the problem, but it is necessary here to make a little digression in philosophy to dig deeper. Building on the chapter "the construction of the unreal" [7], the exercise of reconstruction can be defined as the shift in the object of study from the "actual" (ie. archaeological remains) to the "unreal" and "counterfactual conditionals" reasoning (reconstruction hypothesis of what a past might have been). The methodology about reconstruction sends us back to a fundamental open philosophical question that Goodman formulated as follows:

> "The analysis of counterfactual conditionals is no fussy little grammatical exercise. Indeed, if we lack the means for interpreting counterfactual conditionals, we can hardly claim to have any adequate philosophy of science" [10].

If we identified the root of the problem, how does it apply in the practice of reconstruction? Fauconnier and Turner give some insights:

> "But as Goodman first recognized, changing any one element opens up complicated questions of what else would need to be changed in order for that one to differ. Counterfactual scenarios are assembled mentally not by taking full representations of the world and making discrete, finite, known changes to deliver full possible worlds but, instead, by conceptual integration, which can compose schematic blends that suit the conceptual purpose at hand" [7].

Hence, reconstruction can be defined as examples of intricate counterfactual blends that are built on compressions

of space and time. Counterfactual is defined by Fauconnier and Turner as when "one space has forced incompatibility with respect to another" [7].

The reconstructions in archaeology are then tied both in the "actual" of archaeological data and "conditional scenarios" as a compression between fact and hypothesis in the discourse about the past. If the reconstruction is a hypothetical compression, the reconstruction images showed that there is a second level of compression in the act of representation itself as well. The analysis of reconstruction representations in part iv. led us to consider the different qualities of the image in their ability to convey some analytical, aesthetic or technical information. We will explore here 3 possible aspects of the representation compression.

First, to understand the compression happening because of the representation, the work of Barthes' on the analysis of photography in [2] shows the "duplicity of this medium, which is able to function in both registers of memory: the first being the capability to suspend and embody the moment in the time and space of the photograph and the second being the capability to bring a dead past to life" [12]. This duplicity in photography explains why the representation gives almost life to what it represents. The representation becomes the condition of existence of the represented. The representation can be understood as a compression that allows something unreal (it is only represented) to become a new incarnated existence through the representation.

Second, the representation compression goes beyond the representation process and the creation of images. The act of reading is another compression aspect. In the decoding of the visual information, the interpretation of the meaning is left to the person looking at the image. The reading of an image is not univocal [18]. The compression of reading happens between the reader and the image in the appropriation and interpretation of the image.

Third, this aspect is a common compression for both the reconstruction and the representation. The double meaning of representation is useful to understand this aspect:

> "Representation in the humanities rests on a denotative philosophy of language according to which names represent things and maps represent territories. There is a second meaning of representation, more common in the social sciences, used to refer to persons speaking or being in place of others" [17].

The reconstruction aims at building knowledge about a lost past, but we do so from our present time, our own cultures, societies, communities, and bias. Doing reconstruction, one speaks for people and communities who are long dead. It informs about the us/here/now more than the "other"/there/past [21]. The decolonial studies were precursors for these questions and critical postcolonial thinking and theory can be applied to reconstruction works.

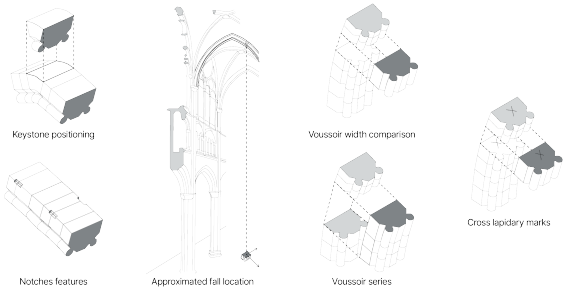

Fig. 5. Illustration of archaeological predicates for the reconstruction. This figure is analytical: it synthesizes the criteria for the reconstruction. The representation has an aesthetical value (architectural line drawing).

We showed here that the problem of reconstruction and of representation operate like a double layer of compression: the one due to the layers of representation and the ones of the reconstruction itself. The next part will tackle some proposition to unblend what is of representation and what is of reconstruction and how it can be documented. The counterfactual or the analytical elements of images are part of the argumentation and need to be decompressed and documented as such.

VI. ARGUMENTATION DOCUMENTATION AND REASONING

Secondary questions arise at this point: first, do the visualizations have this ability to convey explicitly the reconstruction study process? Second, what is this process made of?

To push the boundaries of reconstruction study and discipline bias, one needs to understand how scientific visualization is defined in so-called hard sciences [15]. The challenge related to the quality of information can be formulated as the need to make visible something that is currently invisible in the amount of data. In the case of reconstruction, the expressivity of uncertainty and degree of fuzziness applied to the data is what makes the quality of the argumentation deployed in the reconstruction process, and it is expected in the resulting visualization. The granularity of data becomes a top-notch challenge: researchers differentiate what data is considered as certain, from what is questionable or what is an object of conflict of interpretations [20].

The conflicting interpretation of the same element is rather a common issue in the study of the past. This entanglement of adverse interpretations is a central part of the research in reconstruction: it constitutes its scientific, ethical, and epistemological dimensions. The intellectual probity of the archaeologist or historian is at play. The entanglement of interpretations intertwines argumentative

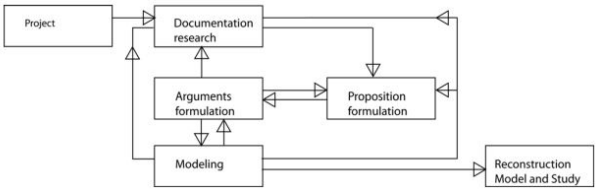

Fig. 6. Workflow diagram in the reconstruction reasoning and documentation [13].

threads that come from the same observations. Then the interpretations and analyses differ thanks to methodological reasons or to equal probability of opposite solutions [Figure 6].

The presentation demonstrates through the case of Notre-Dame's arch how the reconstruction argumentation can be tied together with the visualizations and the research process [Figure 6]. The goal is to document the reasoning and hypothesis in the process of reconstruction as in [3, 13]. Traditionally a text accompanies the visualization to support the reconstruction argumentation, but in our case, the documentation of the argumentation targets the metadata enrichment, mapping with CIDOC CRM, and transformation in LOD [14]. The methodology of documentation is complementary to the approach developed by [5, 22]. The main difference is that the focus of our modeling is on the argumentation patterns and the conflict of interpretations rather than the geometry reconstruction. The reconstructions in archaeology are then linked at the data level both with the archaeological data and reconstruction hypothesis using CRMinf for the mapping of the arguments. The semantic nodes are mapped in order to make explicit the links between the data of reconstruction, the visualizations produced and the documentation of the process. Our contribution aims at leveraging documentation of the conflicts of interpretations in relation to the visualization and the reconstruction argument and data.

VII. DISCUSSION

In the previous part, we showed research directions towards the argumentation documentation of reconstruction to overcome the entanglement of representation. Make explicit both the geometry creation and the reasoning process about reconstruction. Working on paper or with 3D modeling software does not change the underlying problem. Once again Fauconnier and Turner are helpful in this discussion. By asking about *modus tollens*, it applies nicely to our problem of argumentation about reconstruction:

> "Question: Isn't all this just the simple logical operation of *modus tollens*, in which, given that p implies q and given that not-q, then it follows that non-p?
>
> [Fauconnier and Turner's] Answer: It is true that if an assumption p implies a contradiction q [...], it follows that non-q is true tautologically and therefore non-p is true, by *modus tollens*. Clearly, in that sense, the logical law of *modus tollens* captures something true and important. But *modus tollens* has nothing to say about how q could possibly be found. This is where the counterfactual blend is crucial, and it takes considerable running of the blend before q pops out. [...] The long work of the mathematician or logician who finally finds the contradiction q can, in retrospect, be compressed into a *modus tollens* statement, but the logical law of *modus tollens* is not in itself a way to discover contradictions. In fact, even more simply, inference, as in 'p implies q' is after-the-fact shorthand for what may be a long, difficult, imaginative cognitive process. Constructing the contradiction is a cognitive achievement. [...] The *modus tollens* formula is only a superficial report that such a process has taken place (somehow) and delivered a certain result" [7].

The documentation of the proposition sets, arguments and inference logic that were used in the argumentation of the reconstruction is, as Fauconnier and Turner put it, "a long, difficult, imaginative cognitive process". This effort of formalizing these arguments using an ontological model like CIDOC CRMinf opens the possibility of reasoning and querying the reconstruction arguments.

VIII. CONCLUSION

Paradigms of representation are inherited from Renaissance knowledge and scholarship. The technological shift (2D to 3D) perpetuates the way one reads, understands and produces representations. It ensues the continuing challenges of linking argumentation, reasoning and visualization in the making. The issue is rather not the medium as signifier (3D or not 3D) but the documentation of scientific context and reasoning (ie. signified) in which the visualization is produced. We need to be able to operate a reduction on the overwhelming aesthetic information present in 3D realistic images to be able to let appear the relevant argument aspects of the reconstruction. Doing so, the visualization moves away from a static and finalized illustrative output of the reconstruction study and toward an open dynamic visualization of reconstruction data.

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