Transition between architectural ideation and BIM:

Towards a new method through semantic building modeling

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Faced with the challenges of the actors' coordination regarding the increasing building complexity, the new digital collective approaches of advanced design raise the problem of the transition between collaborative ideation (first creative moments of deployment of ideas) and the following phases of digital production (including the formalisation of building specifications in BIM models). In response, we aim to develop a digitally instrumented method for moving from conventional architectural graphic documents to the 3D digital models characteristic of BIM. We propose here a detailed formalisation of the ideation-BIM transition problem and a method for managing building information to improve this transition.

Keywords: *Building Information Modeling, Architectural Ideation, Digital representation, Media architecture, Semantic model.*

CONTEXT

The complexity of buildings is growing, and the performance requirements are increasing too. A need for coordination between the various actors (project manager, architect, engineers, builders, etc.) is gradually becoming apparent (Hubers, 2009). To meet this need, a transformation of practices is taking place in favor of collective approaches (Comtet, 2007).

BIM (for Building Information Modeling) constitutes one of these transformations. This work method is characterised by the sharing, between the actors, of a 3D digital model of the building. The model collects graphical and non-graphical information, throughout the concept design and construction phases (Celnik & Lebègue, 2014; Hijazi & Omar, 2017). BIM indeed claims to support the process of data management and actors' coordination all along with the building life (Daniotti et al. 2020). It seems promising to enhance exchanges and improve performance (NSCSC, 2010; Celnik & Lebègue, 2014). It is the sign of a real asset in the construction phases as well as in building site management (NSCSC, 2010). However, it is hardly transposable in the ideation phases, creative moments of idea generation and deployment, and in the preliminary design phases (LIST, 2015) where it is nevertheless present and sometimes already imposed (Dautremont *et al.*, 2020).

This raises the issue of handling the transition from the early phases of architectural design to BIM.

ISSUE

Currently, the transition between ideation and BIM appears to be inoperative (Forgues, 2017). It is a source of additional work for architects

(Calixte, 2021). It also creates several splits in practices (Baudoux & Leclercq, in press) and often leads to information loss (Rahhal, 2020).

Our aim is therefore to develop a digitally instrumented methodology for moving from conventional architectural graphic documents (Safin, 2011) to the 3D digital models characteristic of BIM. This method must consider the already complex processes of designers, meet the current BIM requirements and usefully convey the necessary information between ideation and explicit BIM visualisation.

STATE-OF-THE-ART OF THE CURRENT TRANSITION

At this point, we provide a brief state-of-the-art of the above-mentioned gap situation. It is based on the literature and on observations made in the context of an integrated design project later subjected to BIM modeling and evaluation (the context is described and qualified by Baudoux and Leclercq, 2021 and in press). We will therefore describe the conceptual design process, the BIM approach and the transition between them as it is currently achieved.

Design process

Once the architectural program has been defined, the design process begins with a creative design or pre-design phase (point 1 in Figure 1) where ideas are generated and where the main constraints emerge (Leclercq, 2005; Safin, 2011; Dautremont *et al.*, 2020). These ideas are discussed, adapted and new ones are generated. This is followed by a design concept phase in which the building forms. The designer geometrically solves the project. (Safin, 2011; Dautremont *et al.*, 2020).

These two design phases are iterative and convergent activities (point 2 in Figure 1) that progressively lead the project, through constructions and transformations of representations, towards an increasingly precise characterization of a solution (Goel, 1995; Visser, 2006; Darses, 2009).

These design activities are supported by media, thus employing different design tools (hand-drawing, 2D CAD, prototyping, etc.) and mobilizing different external representations (reference images, sketches, plans, physical models, etc.) (Joachim *et al.*, 2012; Baudoux & Leclercq, 2021 - point 3 in Figure 1). Let us recall that these external representations are in fact already codified (Leclercq, 1994; Joachim *et al.*, 2012). The characteristics of the project are indeed represented according to predetermined codes and symbols, understandable by all the construction actors.

Transition

Depending on the project's time constraints, the creative activities of idea generation and modification are stopped. The deliverables production phase should start (point 4 in Figure 1). This phase is different from the design phase (Safin, 2011): it consists in the production of a first rough BIM model of the project. This cessation of activity constitutes the first split observed in the current transition (point 5 in Figure 1). We note that this first split is threefold.

Firstly, the nature of the activities changes from design to production. This phenomenon initially linked to the timetable is consequently reinforced by the nature of the following BIM process, which calls for a precise and most exhaustive definition of information, whereas the sketch does not explicitly address a quantitative approach or all aspects of feasibility. There is therefore a contradiction between the level of precision given to the design, which aims to accentuate the guidelines of the project and its identity, compared to that of the BIM models which specify the building in detail.

Secondly, a change of media, imposed by the BIM method which employs specific tools such as IFC (Industry Foundation Classes) mock-ups and BIM protocols, is opposed to conventional tools such as sketches, CAD and geometric models used in the design phases (Hoscheid, 2018; Dautremont *et al*., 2020). Specify that the term "sketch" is used in this paper going beyond the paper sketches and rather to designate an abstract and moving representation of the project, by opposition with a detailed executive plan, regardless of the medium being paper, CAD or parametric tools.

Thirdly, we observe a loss of information during this first step of transition (Baudoux & Leclercq, in press). Indeed, in his observations, Rahhal (2020) identifies 6 types of information conveyed in the BIM process (*i.e.* understanding the project, modeling the project, exploiting the model, detecting geometric conflicts, organizing collaborative work and assimilating the tools) and shows that the coordination information predominates over the others. Other architectural information, such as ambiances, qualification of spaces and information concerning the motivation of certain choices, is therefore lost in this transition, as revealed by Mer (1995).

Once the initial split is crossed and the rough BIM model is produced, it, unfortunately, appears to be hardly usable (Calixte, 2021). It constitutes a deliverable in itself, which is now required in many situations, particularly in large-scale public procurement competitions. This model shows that the project manager is competent in BIM, but it does not serve as a basis for the rest of the BIM process and must be manually remodeled (Calixte, 2021). This is the second split observed in the Ideation-BIM transition (point 6 in Figure 1).

BIM approach

The BIM process has several limitations too.

Although the BIM is declared as the single baseline for all actors (Kensek, 2015) and despite the fact that all information and data are theoretically compiled in a supposedly single digital model (Chone et al, 2016), practices show that the BIM process is nevertheless complemented by other information and exchange media, such as additional perspectives, diagrams, texts, tables, but also independent communication (Rahhal, 2020) or alternative collaborative spaces mobilizing conventional tools (Calixte *et al.*, 2019 - point 7 on figure 1).

Furthermore, while this process is presented as a collaborative way of working, actors often still work individually on separate project parts that are then linked in the model during a few moments of cognitive synchronisation (Calixte *et al.*, 2019 - point 8 in Figure 1).

Schematization

The transition is depicted in Figure 1 as a progression, from left to right, through several states.

The convergent loops of ideation and rough design are followed by the first split, aimed at producing the rough BIM model. Then comes the second split, when this rough BIM model is taken over by hand to provide the basis for the initiation of the BIM formalisation stage. During this stage, several digital models are created and then modified, which therefore coexist. They are also supplemented by several complementary documents of various kinds, which evolve in parallel.

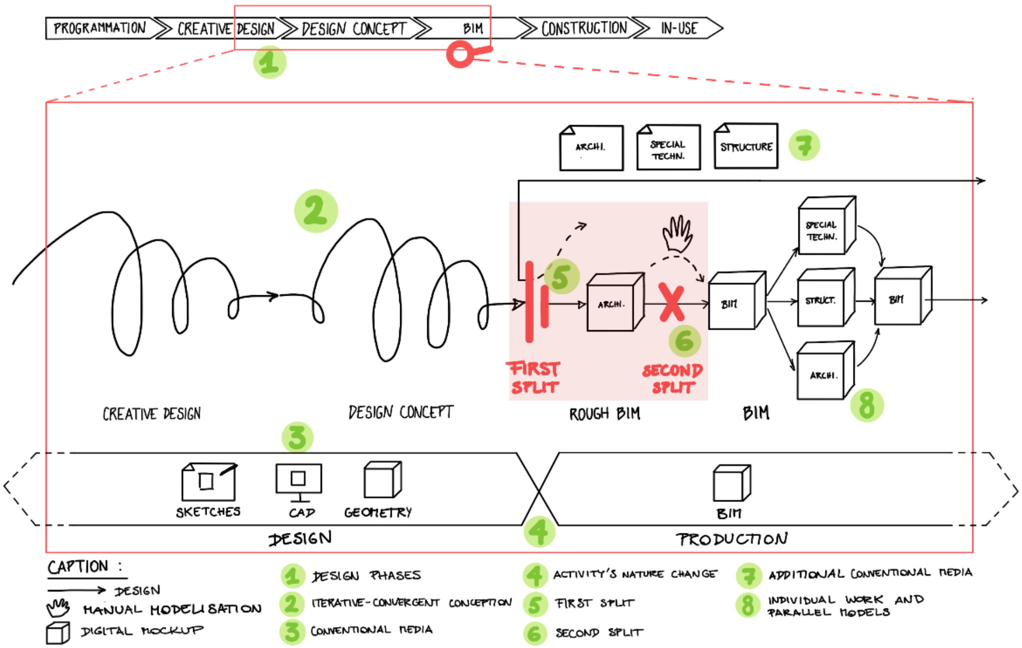

Figure 1
Modelling of the current transition

DISCUSSION

In this section we focus on the transition from the architectural design process to the BIM process, to propose an alternative method for making this connection. It should be specified that the problems of the BIM process itself, such as IFC interoperability and synchronicity issues, are not covered in this article.

Our reflection is the continuation of several research works addressing the issues of sketch interpretation. Leclercq, Azar and Jumches developed the EsQUIsE software, capable of interpreting architects' sketches using a multi-agent system to provide a semantic model of the sketched plan intended for the building evaluation in a construction application (Leclercq & Jumches, 2002; Jumches, Leclercq & Azar, 2004). Subsequently, Demaret and Leclercq (2011; 2012) overcame the limitations of EsQUIsE by developing the NEMo software (for New EsQUIsE Modeler), which is able to interpret a hand-drawn sketch to generate a 3D model by recognizing the different architectural symbols instead of forcing the architect to use a specific mode of representation. It can also handle the existence of incompatibilities in the representations.

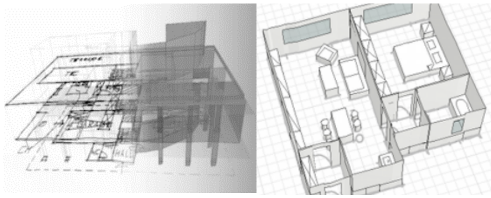

Figure 2
Visuals of EsQUIsE (left) and NEMo (right)

Furthermore, other research shows the possibility to generate 3D models from semantic representations with, as an example, the automatic semantic modeler Isom (Inner Space Organisation Module - Jamagne, 1991).

We are reactivating those searches at a similar detail level to the Nemo software and, instead of focusing on building applications as in EsQUIsE, we are adding a layer of meta-level information with the provision of architectural meaning.

Proposed method

Without interrupting the architect's design activity and without changing its iterative-convergent nature, the objective of our method is to automatically collect, throughout the process, useful information from graphical traces such as sketches and CAD plans (point 1 in figure 3). We rely on the plan and section graphic representations because they are naturally codified and the BIM is based on plans and cuts. Moreover, the architect may or may not be aware of this collection since the information is extracted from the naturally drawn traces.

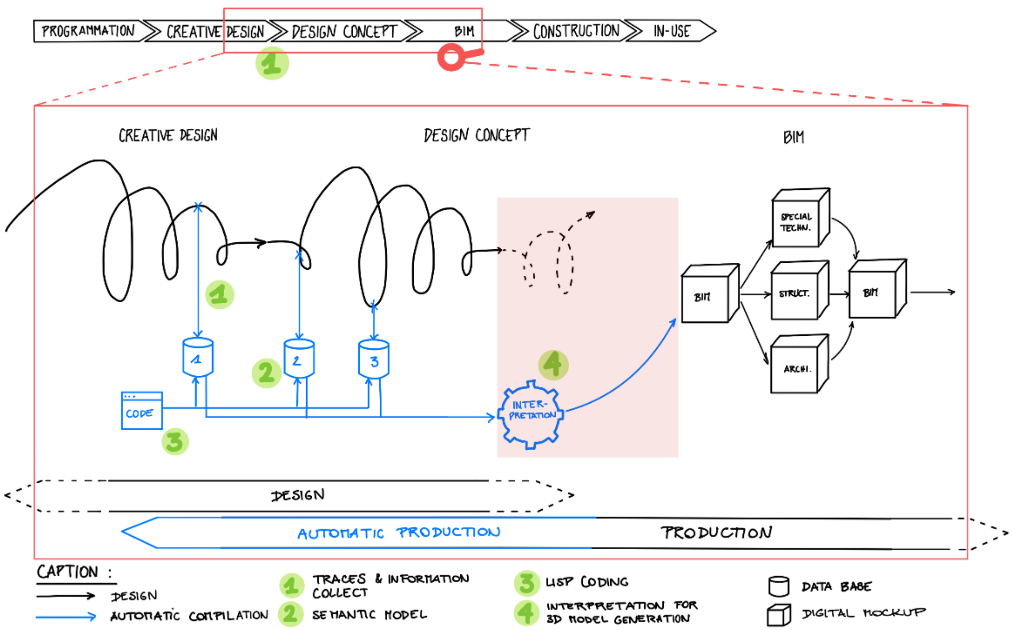

Figure 3
Modeling of the proposed alter-native transition

The information from these graphical traces can be automatically modeled in a semantic model (point 2 in Figure 3). This model includes amongst other things the set of spaces and boundaries designed, their relationships, characteristics, etc., adding a layer of meaning to the formalized information. Using a semantic model makes it thus possible to go beyond plane representations and to integrate in addition other aspects equally important, deduced from the plans or manually added, as well as materials, daylighting, etc.

Another benefit of this semantic representation of the building under design is that it makes a new representation possible at a high level of abstraction, essentially topological, but nevertheless detailed and complete, highlighting the qualitative relationships between the elements of the architectural project and not only the metric data quantitatively characterizing the building.

Interpreted by MAS (Jumches et al., 2004), it is not an additional task for the architect, thus not constituting an additional and time-consuming cognitive load.

From a technical point of view, several researchers had already developed methods allowing the collection of meaningful information from combinations of strokes from graphical traces such as sketches and plans and the implementation of these representations in semantic models (Leclercq, 1994; Jumches & Leclercq, 2002; Elsen & Leclercq, 2007; Demaret & Leclercq, 2012).

New transition

To achieve the transition to BIM, we start from the graphical traces and the automatically generated semantic models.

A software could interpret the information which characterizes the project to automatically generate a 3D model of the building which can be implemented in the BIM digital model since it will already contain all the attributes of the project (point 4 in figure 3). These attributes can be for example a floor covering, the height of a bay, or the adjacency of two function spaces, ... These attributes are already codified in the external representations of the projects in the design phase in the form of annotations, openings' height labels, hatched lines, ...

In addition, this allows additional information to be imported from the meaningful semantic model into the BIM model.

Below is an illustration of how the model is applied to a concrete case. We implemented this transition proposal with an architectural project.

We started from the intermediate sketch in Figure 4, representing the ground floor of an urban dwelling. Form associations and architectural codes are then interpreted to understand the graphic document. Thus, the software can recognize among other things the walls of the house, the positioning of tables and chairs, or the stairs.

A semantic model is generated, containing all the information about spaces, boundaries, and pieces of equipment with their relationship and characteristics. Based on the interpreted plan, a 3D model of the building can also be generated.

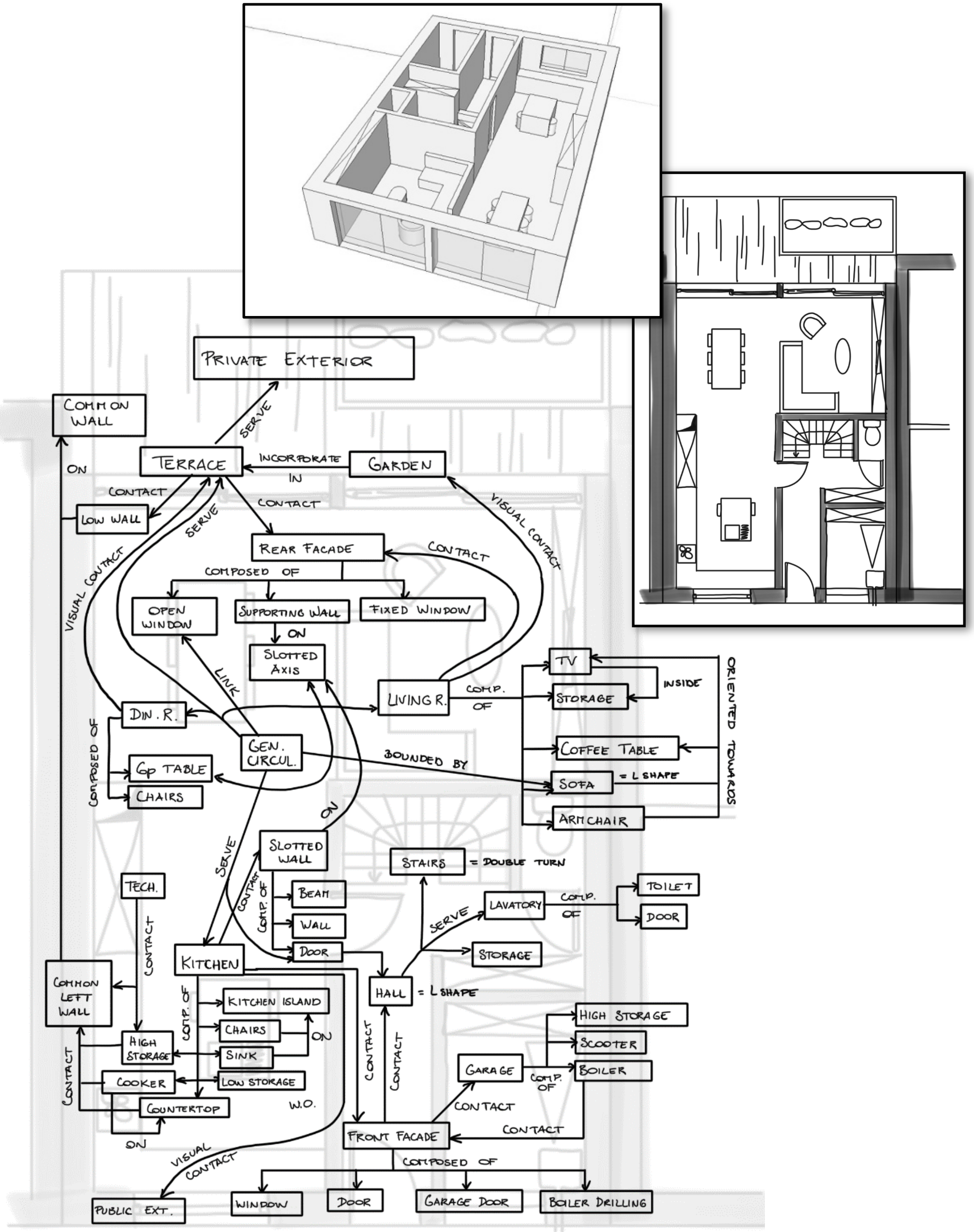

Figure 4
Example of semantic modeling and 3D model generation

Benefits of the proposed method

With our proposal, the first split can be avoided since the design can continue while automatically feeding the production. The conventional media normally used will no longer be arbitrarily and suddenly replaced but can be retained for the remainder of the design. And the necessary information will be anchored in the semantic model that feeds the BIM model.

The second split will also be avoided as the semantic model will be automatically generated from the graphical traces captured throughout the design process. This model will then be automatically interpreted by software generating the 3D semantic model, feeding directly the BIM model.

This will make the transition smoother, without activity interruptions and without information loss. In addition, the cognitive load of the designer will not be altered, allowing him to focus his attention mainly on the design itself.

CONCLUSION

Overview

The new digital collective approaches to design raise the problem of the transition from collaborative ideation to the subsequent phases of digital production. In this paper, we therefore explore the handling of this transition from the early phases of architectural design to BIM.

We have highlighted the various limitations of the current transition. First of all, it presents a first split. Firstly, there is an imposed change in the nature of activities from design to production. Secondly, a change of design media is imposed. And thirdly, there is a loss of information, which is only partly offset by the addition of complementary information and exchange media in parallel with BIM models. Once a rough BIM model has been produced, a second split arises as it is hardly usable and has to be manually remodeled to serve the rest of the BIM process.

We proposed an alternative to this transition through a method of semantic formalisation of the building feeding the BIM. We will automatically collect, throughout the process, useful information from the already codified graphical traces of the designers. This information will be automatically modeled in a semantic model, rich in meaning. Based on a specific ontology, a software can therefore interpret these project’s attributes to automatically generate a 3D model of the building under design that can be more directly implemented in the BIM digital model.

Limits

The main limitation of this research is that the model is so far assumed since it has not yet been implemented in real testing, in BIM contexts. However, it derives from concrete research (Jamagne, 1991; Jumches, Leclercq & Azar, 2004; Jumches & Leclercq, 2012) that has already led to semantic modelers and software that can interpret architects' sketches to produce digital 3D models capable of evaluating the performance of the designed building.

Furthermore, ideation sketches are highly personal. We will therefore need to investigate the possibilities of AI to interpret these sketches universally.

Prospects

Now that the benefits of such a transition are identified, we will be able to set up experiments to implement this method with expert designers from the professional sector to compare our proposals with real-life practices.

Our method also raises the question of the relevance of the information to collect. In the future, we will have to identify precisely the information and attributes of the project that are necessary to collect, to feed the BIM process but also to serve the design process.

We are furthermore in a research process with laboratory experiments to collect via the traces present in the architects' sketches the characteristics of the project and to articulate them in a semantic model.

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