# Proposition of a model using parametric operations as an aid to the creation of architectural forms

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**Abstract.** In the early stage of creation, the architect tests his working hypotheses by making many adjustments while designing. During the sketching phase, the existing modelling tools are not compatible with the iterative nature of this process. So the challenge lies in the definition of a model which will allow the whole creative process with its various coming and going during the phase of conception. In this article, we are going to define a data structure model allowing the simultaneous exploration of several possible solutions, which seems more in line with a creation process.

**Keywords.** Decision tree, historical operations of forms.

## Introduction

More and more architects exploit the possibilities of three-dimensional modelers in order to create new forms. But the work on these forms, particularly for their realization, often requires many adjustments incompatible with a linear approach of geometrical modelling. But work on these forms, in particular in view of achieving them, often requires many adjustments, which are not compatible with a linear approach of geometric modelling.

In a conception approach privileging the plastic quality of an object, the genesis of these forms results from successive operations of processing forms. These operations have semantic targets and are guided by one or more mental image(s). Thus, the designer proceeds from source forms borrowed from various fields (geometry, nature, mechanics…) to target forms enable to which are able to accommodate the program of the owner's building. This journey consists of many trips back and forth (Zeisel, 1984) and significant variations between different stages of the form. These characteristics make it an iterative and parametric process which allows the designer to consider an important number of formal solutions.

In this article, we will introduce the specificities of the architectural conception as a form-creation process and the representation of the conception activity as a decision tree. After an analysis of historical functions implemented in current softwares, we will introduce the concept of conception tree as a principle of formal progress. Finally, we will suggest a model using the conception tree in an approach of iterative conception.

**Architectural design process**

Various research works on design activity define the architectural conception process as a complex and slow one aiming to bring a satisfactory answer to a badly formulated problem (Simon, 1969). It is complex because it considers a high number of parameters which have degrees of importance with several levels (Prost, 1992; Simon, 1969) but also because it presents a randomness and an uncertain nature (Morin, 1990). It is also described as slow because it correspond to an iterative process answering various questioning in order to obtain an "acceptable" solution (Asimow, 1962; Conan, 1990).

During creation, design is a "speculative" activity (Estevez, 2001) which finds in drawings, photography, modelling or 3D model representations of one or many picturing(s) of the designer in relation to the project. These representations are fragments of the creative process which constitute the multiple intermediates steps which help the designer to make a choice among his ideas and reduce his uncertainties (Lebahar, 1983).

These various representations are materialized ideas which become "marks of creation" (Porada, 1994). In this manner, the designer keeps traces of his cognitive activity and has a kind of data base he can search in during all the conception phase.

**Architectural design process and decision trees**

A project process results from a set of choices and actions. According to Santiago Calatrava, the creative process is a stratification of figurative elements of a mental picture. These elements are organized between themselves and permit to follow the cognitive progress of the designer. « To begin, we visualise the thing mentally ; it does not exist on the paper, but we begin then to make simple sketches and to organize things, and then, we proceed layer after layer… this is really a dialog » (Lawson, 1994).

It would be possible to represent this progress with a decision tree as that describes by P. Rowe (Rowe, 1987).

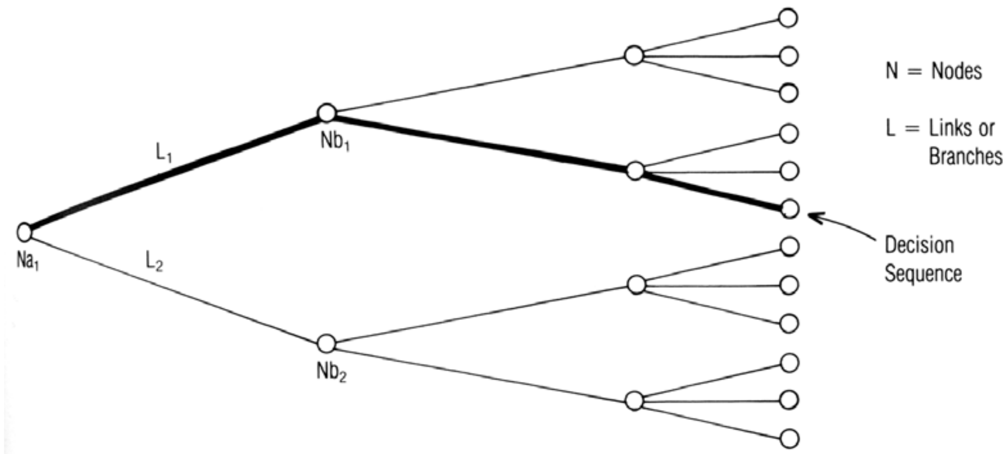


*Figure 1*
*Decision tree (Rowe, 1987).*

This graph traces the project evolution, from the initial state to the final one, through several intermediate states (figure 1). Each node represents a project state and each link an action transforming the current state into the next state. In every state (node), the question of the choice between several solutions (link) can arise. The final state of the project is represented by a unique way, a succession of nodes and links. This type of graph is in general a tree because it has neither cycles nor convergent links.

Every production work, well beyond the architectural conception domain, contains back and forth steps, in order to develop an alternative solution from a previous state. That is the reason why almost all softwares contain history allowing this navigation in the current way.

The more specific need in a conception initiative is to make several alternative solutions coexist , because each has its advantages and disadvantages, and it is often necessary to develop them in parallel before being able to opt definitively for one or an other. It requires maintaining, simultaneously in the decision tree, several potential ways, representing the variants of the project. We will call this representation a design tree.

**Iterative geometric modeling**

We are interested here in the modeling methods that can show, in the history of an object or a project, how it was manufactured.

In all cases, an object results from the succession of operations on its previous stages. But the peculiarity of these approaches is that it allows a retroactive action on prior stages and / or operations so that the result can be implicitly modified. In a way, the object is granted a historical asset.

*Solid modeling*

The solid modeling, also known as modeling CSG (Constructive Solid Geometry) is probably one of the first methods based on the principle of historical assets.

The objects are geometric primitives, on which basic geometric transformations are applied. The use of Boolean operations (union, intersection, subtraction) can create - from two existing objects- a new object, and so forth.

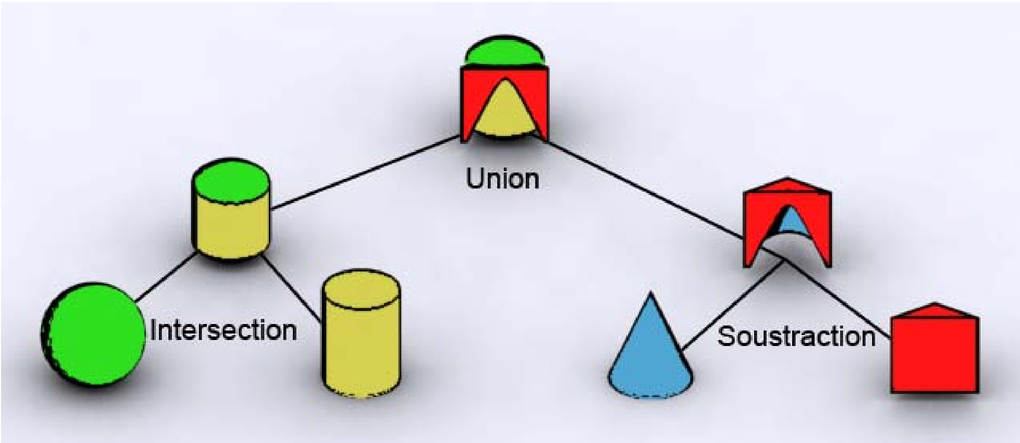


*Figure 2*
*Exemple de modélisation CSG*

The object is represented by a modeling graph. The replacement of a primitive or a Boolean in the graph changes the geometry of the resulting object.

The operations of current solid modelers inherit this approach. They allow for some editing primitive, but in most cases, the resulting object is described only by its borders without it being possible to return to the nodes of the tree construction.

*Modeling by constraints*

This term covers a variety of methods, sometimes grouped under the name of parametric modeling (Monedero, 2000). These approaches share the principle of dependency between objects. The graph of dependency is not represented but the modification of an object source to update dynamic objects sources that depend on.

Among the applications of these methods, systems geometric integrated to SolidEdge and some modelers and software for dynamic geometry such as Cabri Surveyor and Cabri 3D.

*Modeling history*

A history of orders, software, is the portion of the decision tree limited to the current path. Most often, this history is invisible to the user, who has access through the actions of cancellation and recovery. In some software, it is possible to display it in order to facilitate navigation.

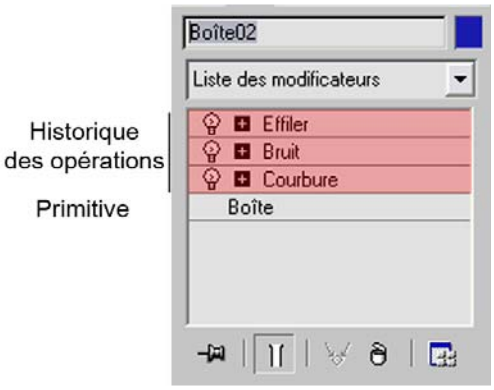


*Figure 3*
*3DSMAX stack modifiers*

This history becomes a tool for design when it is editable. In this case, the user can change the parameters of a previous operation or the attributes of an existing object and assess its impact on the current result. In fact, the user publishes the nodes and arcs of a construction path that remains unchanged.

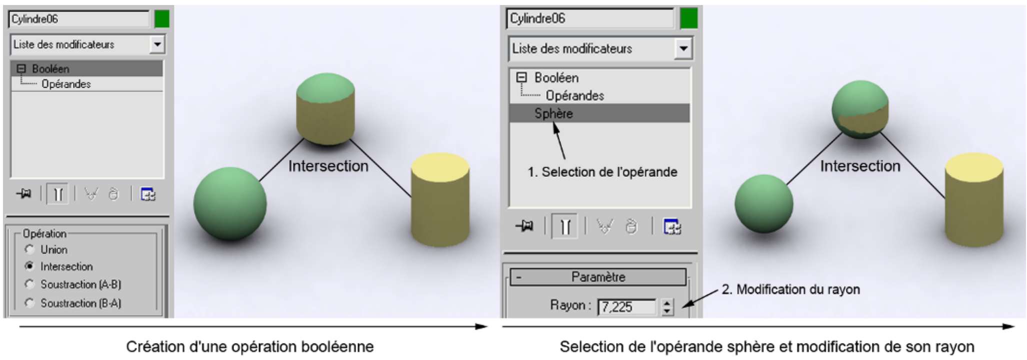


*Figure 4*
*Editing a primitive in 3DSMAX stack modifiers*

**Towards a modeling environment iterative**

*Design tree*

Based on previous observations, we propose here a structure of data derived from the decision tree and historical modeling software. We call it a design tree.

The particularity of this tree lies in the conservation of multiple simultaneous design paths. These paths are as many variations in gestation, which seems much more suited to a creative process.

A node of the tree represents a state of the project and an arc outlines the transformation, through one or more morphological operator(s) that we model and define further (Wetzel et al., 2006), from one state to another. The designer can document a state or a series of states by metadata (words, pictures, sound or video) to clearly identify the main idea behind the designer choice to perform these operations. We distinguish four specific states of the project in the tree:

- An intermediate state is a step in the path of the project.
- A state of choice is a state in the project at which several solutions are developed, a node of this type contains several outgoing link.
- A relevant state represents a partial result, held interesting by the designer, but not necessarily definitive; we can consider that the current status of the project is a state (temporarily) relevant; a node of this type is terminating a path in the tree.
- A stable state is regarded as definitive; nodes upstream are not stored;

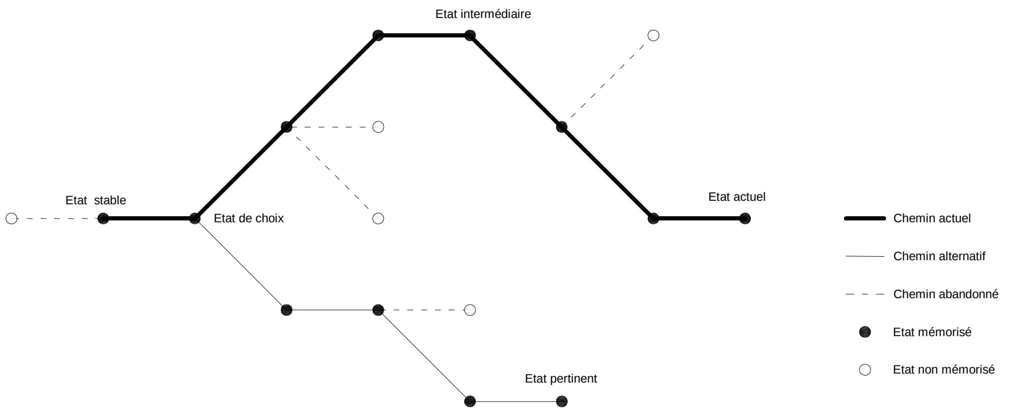


*Figure 5*
*Tree design.*

This data structure takes into account two characteristics of the design activity:

- The back and forth in the draft are not relevant, so states considered and then abandoned are not stored.
- At a given level of progress of the project, some initial choices are no longer questioned; statements prior to a stable condition are no longer stored.

*Principle display stages of design*

From the point of navigation in the tree, a hyperbolic representation (figure 6) (Spence, 2001) following the context would allow the display of information of a current state compared to the previous and following statements.

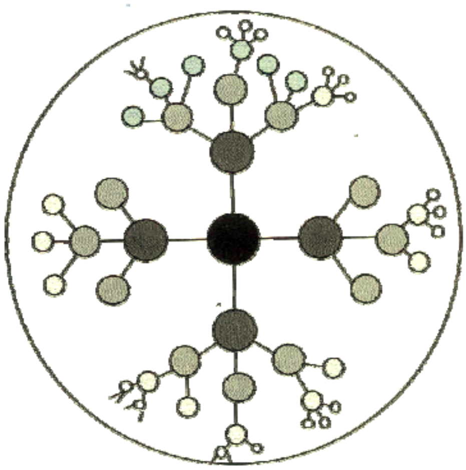

*Figure 6*
*Hyperbolic representation*

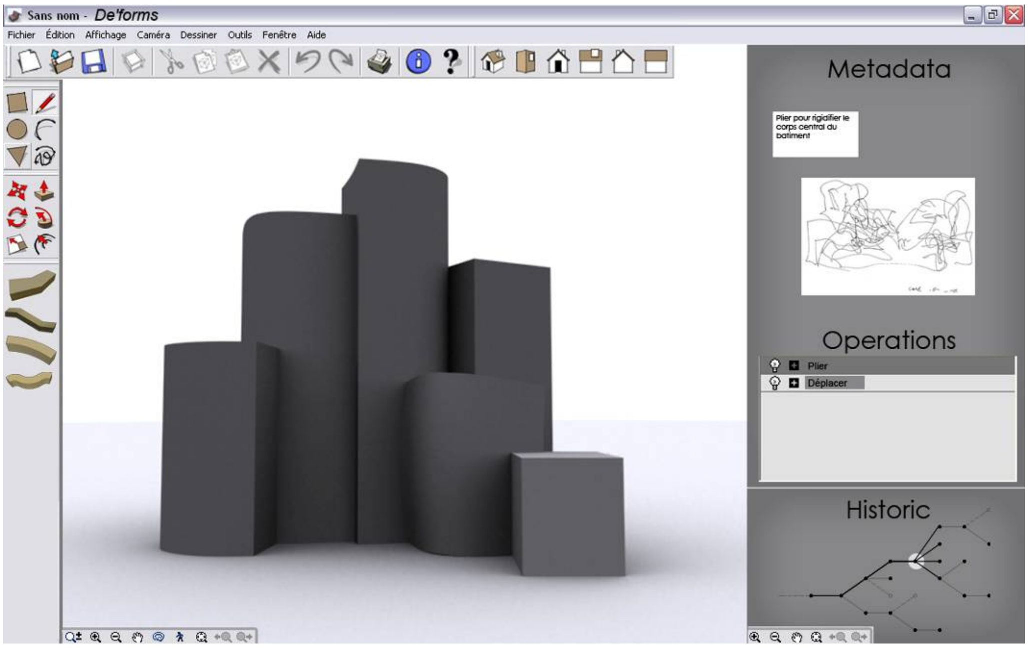


*Figure 7*
*View of an active node.*

The designer could - by using an interface with this system- work on a node. Then from this node, it navigates to other nodes using a hyperbolic view of the whole tree. Specifically, each node would have a sticker relating changes made by the designer who would be in direct relationship with near stages. These morphological changes would be brought to light in an automatic way by a system highlighting the affected area. The designer could navigate through these vignettes to return to previous operations or create a new branch.

With this principle, the designer may at any time view and act on all transactions carried out in a research phase. Moreover, this model allows data to undertake, in parallel, several formal solutions for the same project.

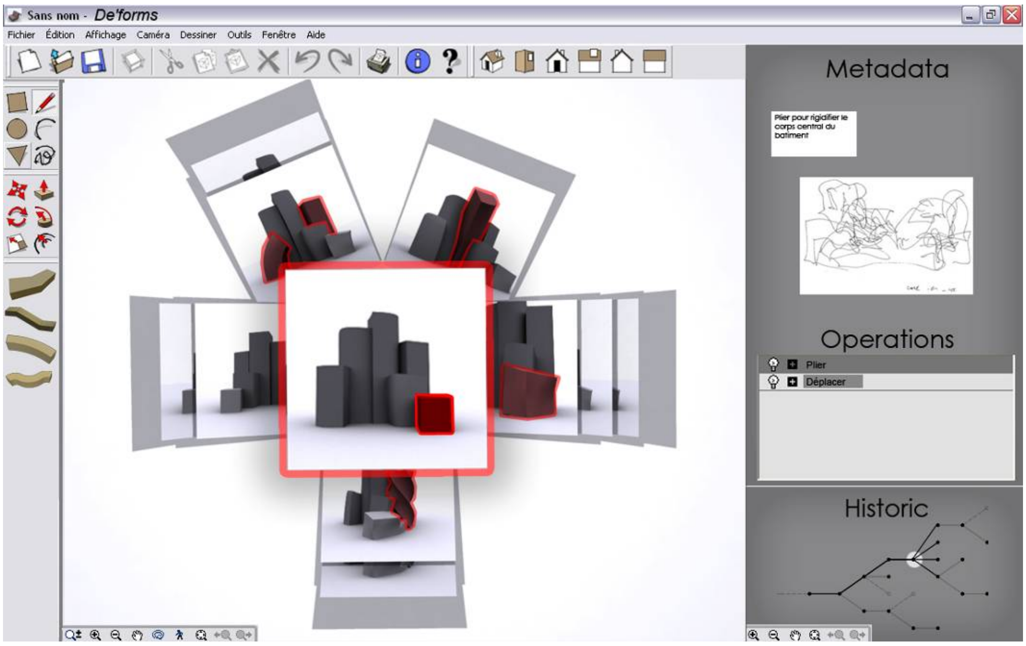


*Figure 8*
*View of nodes related to the active node using a hyperbolic representation.*

## Conclusion

In this article, we have tried to show the relevance of a data structure which reflects stages of design. This design tree allows for representation and changing transformations, used in a process of creating forms. In addition, the simultaneous representation in this structure, of several possibilities for the project gives the designer more freedom in its formal research.

Along with this model, we are currently working an analysis of a formal research on a real case in order to sketch a likely design tree of the project.

The result of our work will focus on a more advanced modeling of the design tree and an extension of the corpus of morphological operators, to develop a 3D modeling environment, allowing new morphological expressions.

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