Procedural Model and Intelligent Design Assistant, Vitruvius' Ideas in a Space Shuttle

A new Approach that considers Semantic Operators to produce Geometric Models

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ABSTRACT

The goal of this paper is to present a new method of design in Architecture. This method uses the computer as a tool of producing an intelligent model. In order to present this method, we analyze the distinctive characteristic of Architecture as a dialectic link between the functional and the operational. We examine the results of some case studies on the possibilities to use computers in design. By making a semantic design-assistant act on a procedural model, we use the computer in order to obtain configurations controllable by a functional language, with the purpose to be able to express new concepts. For example, the operator of the Visibility of the Roman theatre can be integrated by the "intelligent" assistant in a structure producing a new concept, like a space shuttle.

In this research paper we suggest an approach that encourages design, based on semantic operators, rather than on geometric primitives. We propose a method of design using

procedural models and structured with the help of an “intelligent” design assistant. Thus, we foresee a re-evaluation of the current architectural representation practice.

This research fits into a paradigm that leads to representation of the building through functions that can be called with parameters and encapsulated in an algorithm, making it possible to create procedural models that assist the design process. This mechanism is extremely powerful. It helps establish relations between the functions, contributes to a better understanding of the project's aim and encapsulates the building's properties by recalling characteristics of common classes which give rise to a new configuration and a completely original design.

If we consider Architecture as a complex set of procedural models, we can describe the architectural process algorithmically, creating variables (called "attributes" in object-oriented programming) that distinguish one object from another by describing its state and its appearance. These characterizing variables, which we can qualify as behavioral, are modified when the object interacts with another one. This means that we can model a set of actions on a class or a set of properties.

This approach makes it possible to construct a volumetric model by adding a fourth dimension, that is to say, a new dimension consisting of all the events entering into the construction of a building. This permits us to generate a model based on specified parametric functions which we call generic parametric functions. In this way, the computer-based tools make it possible to add a new dimension to the classical architectural description, giving the architect more freedom in the creative process than allowed for by the simple use of geometric points and lines.

In the end we can explore the properties of the object to be created : light, harmony of forms and space-composition, and we can explore our object until its final realization, while keeping in mind its constructive genesis. This makes us think of the etymological meaning of the word “symbol": *symbolum*, which represented a clay object that was broken in two by the host upon departure of his guest and which would provide lasting proof of the relationship between the

owners of the pieces. In a similar way today, we define a symbol as being a figurative sign that represents a concept, its image, its attribute in accordance with a logical correspondence.

The history of architecture and its teaching clearly reveal how representations of the image and drawing have changed over centuries. Our objective is to propose a model for describing an architectural concept that meets the needs of architects to handle semantic properties and links and not only to look at a “picture” or to “experience” a “virtual image”. This has led to the idea to consider the process of design as acting on and/or with object’s properties. The method of computer-assisted design, proposed in this paper, makes use of procedural models organised by an “intelligent” computer-assistant. These procedural models consist of geometric operators and operators that define the properties of a building. We have named these operators “semantic”. The “intelligent” assistant consists of a functional “engine” that is able to handle the semantic properties of the model and to produce its geometric form and visual representations.

An example of a procedural model of Vitruvius’ Roman theatre and the different faces of a functional model of stairs, show how we can use a generic model to produce a volume model preserving all the determining characteristics of the given family of objects. This type of models can serve not only to illustrate the result of a process, or to establish connections between buildings on the basis of their construction process, or to test the validity of a rule typical of a set of objects, but also to integrate, through a functional language, semantic operators which to date have been excluded from the initial design phase. This descriptive mechanism is extremely powerful in making it possible to establish relationships among the functions and properties of a building and the purpose of the architectural project.

The scientific contribution of this research is to test the hypothesis that we can use computer tools to manipulate operators which enable the architect to re-appropriate a complex approach to design, and to open up new perspectives for integrating geometric and knowledge-based systems into a unified representation.

Keywords: architecture, computer, design, representation, modelling, CAD, geometric operator, semantic operator, procedural model.

The linear approach that permitted the development of the first systems of computation didn't allow a full development of a computer architectural language that takes into account the complex approach, an architect must develop, in phase of design. This method followed the same simplification in the representation used in architecture since the Renaissance: making drawings be just a part of the information that we want to symbolise, but not expressing the design process. Thus a drawing became only a geometric representation of building with more or less details.

These considerations allow us to affirm that, in order to obtain a real aid to the design process, the computer tool must not be used like a tool to resolve problems, but like a creation tool in design situation. This approach permits all the actors of an architectural project to call for the presence of the computer tool in conceptual understanding.

We are going to present our experiences that suggest a change of paradigm for the architectural figuration and the utilisation of the data processing during the phase of design. We demonstrate that the computer, by the slant of the utilisation of semantic operators, is not only a tool of aide in design situation, but also a tool to develop an understanding of the building's properties in collaborative design.