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SCHEMING AND PLOTTING YOUR WAY INTO ARCHITECTURAL COMPLEXITY

HENRI H. ACHTEN, JOS P. VAN LEEUWEN
Eindhoven University of Technology
Faculty of Architecture, Building, and Planning
Design Systems - HG 4.05
PO Box 513
NL-5600 MB Eindhoven
The Netherlands

Abstract. The problem of complexity underlies all design problems. With the advent of CAD however, our ability to truly represent complexity has increased considerably. Following the four waves of design methodology as distinguished by Cross (1984), we see changing architectural design attitudes with respect to complexity. Rather than viewing it as problematic issue, architects such as Koolhaas, van Berkel, Lynn, and Franke embrace complexity and make it a focus in their design work. The computer is an indispensable instrument in this approach. The paper discusses the current state of the art in architectural design positions on complexity and CAAD, and reflects in particular on the role of design representations in this discussion. It is advanced that a number of recent developments are based on an intensified use of design representations such as schema's, diagrams, and interactive modelling techniques. Within the field of possibilities in this area, the authors discuss Feature-Based Modelling (FBM) as a formalism to represent knowledge of the design. It is demonstrated how the FBM approach can be used to describe graphic representations as used in design, and how other levels and kinds of design knowledge can be incorporated, in particular the less definite qualitative information in the early design phase. The discussion section concludes with an extrapolation of the current role of design representation in the design process, and advances a few positions on the advantage and disadvantage of this role in architectural design.

1. Introduction

The nature of design has been described many times by various authors. They identify aspects such as complexity, ill-defined problems, lack of evaluation criteria, use of heuristics, and so forth as distinguishing features of design problems. The field of design methodology has been engaged in tackling design problems from the early 1960'ies onward.

Cross (1984) provides an overview of the changing understanding of design problems. In broad lines, the field started with a systems theoretical view which stressed the systematic approach to charting and solving design problems (period 1962-1967). This research yielded insight in the complexity and large scope of design problems.

The focus changed from encompassing methods towards inquiries into the structure of design problems in the period 1966-1973. This work showed how various structures play a role in structuring processes and solution types. In the following period, 1972-1980, attention shifted to the study of designers and their every-day working procedures. Work done in this period highlighted the importance of understanding designers in action.

In 1980-1982, the work to that moment prompted many researchers to rethink their basic stance to design research. Cross (1984) notes a renewed interest in the basic assumptions that found research in design.

From the 1980'ies onward, computation has become a substantial part in research on design, in the cognitive research approach, the field of Artificial Intelligence, and information modeling techniques.

Within this last area, Feature-Based Modelling (FBM) aims to provide semantically rich data structures of design. FBM has been developed initially in the area of mechanical engineering (Shah & Mäntylä 1995). Historically, the starting-point in FBM has been formed by geometry models, from which it was attempted to recognise the semantics of design. These semantics were then modelled using so-called Features. This basic and later developed design-by-Features (DeMartino et al. 1994, Ovtcharova & Vieira 1995) formed a bottom-up approach of information modelling. FBM is interesting with respect to complexity, since Features are defined as relatively autonomous entities of information that are given a position and relationships in the model only at design-time, not at the time of development of conceptual models. Also, the collection of Features available to designers is not assumed to be complete: designers can define and add their own Feature types to their collection of design tools. These characteristics of Feature-Based Modelling are very appealing to the dynamic architectural designer who is struggling with ill-defined design problems at the early stages of design.

Information modelling techniques have become versatile enough to encompass the complexity of information in the architectural design process. Standardized product models and versatile object definitions in CAAD packages are developing in the direction of comprehensive databases. There is however, still a long way to go. Flexibility and extensibility of design data has to be implemented in systems that scale up to realistic size and speed.

No matter what information modeling paradigm is used, complex and huge amounts of information need to be processed by designers. One way of investigating how complexity can be dealt with is by looking at architects, in particular their styles and theories.

2. Architects Dealing With Complexity

Besides being systems for achieving aesthetically pleasing results, architectural styles also provide means to tackle complexity in design. They point to a hierarchy of issues that have to be dealt with first in order to get a successful design. These issues not only concern organization, structure, relation diagrams, but also elements, composition, and order (see for example Broadbent 1990 for an overview of approaches in this area).

Another source that provides information about dealing with complexity, is architectural theory. As Rowe (1987) states, architectural theory (so-called ‘normative positions’) constitutes “a corpus of principles that are agreed upon and therefore worthy of emulation”. Architectural theory often is a mixed reflection on the nature of architectural design, design processes, made in descriptive and prescriptive terms (see Kruft 1985; Lefaivre and Tzonis 1990 for a broad historical overview).

Contemporary architects incorporate the computer in their design process. They produce architecture that is generated by the use of particle systems, simulation software, blobs, animation software, but also the more standard modeling tools. The architects reflect on the impact of the computer in their theories, and display changes in style through using it. In this way, architectural style and theory can provide directions to further develop CAD. Most notable is the acceptance of complexity as a given fact, not as a phenomenon to oppose in systems of organization, but as a structuring principle to begin with. In this paper, we will be interested in precisely this aspect.

Complexity is obviously not a new issue in architectural theory. Since it is an inherent characteristic of design problems, it has been dealt with in many different ways throughout history. Complexity has been picked up explicitly by for example Venturi (1966) and more recently by Koolhaas and Mau (1995). Architects who incorporate CAD in their design process, such as Oosterhuis, Spuijbroek, Lynn, van Berkel (UN Studio), Franke, Kolatan and MacDonald, etc. utilize complexity in their work and also formulate new positions in architectural theory and style.

3. Role Of Design Representations

A key aspect in the combination of CAD, complexity, and architectural design is the role of the design representation. The way the design is presented and perceived during the design process is instrumental to understanding the design task. Lynn (1998) talks in this respect of "ambiguous yet rigorous shapes" (p.), meaning that the design representation can appear to be ambiguous, but is based on a precise and exact definition that can be constructed every time. More architects are trying to reformulate this working of the representation.

Peter Eisenman's working method, for example, as described in Galofaro (1999), relies on a simultaneous production of drawings, scale models, and computer models. The technique of superposition is used to combine historical readings of the site into material that forms the basis of a design (this is very well documented in Bédard 1994). In this way, Eisenman is looking for complexity in material related to the history of the site. In a later phase, this already complex superposition gets an additional layer by means of a diagrammatic model: an image that is associated with the project (e.g. the image of the structure of a liquid crystal display as related to the design task of the headquarters of a software firm). This image is used to distort the current design by making the design follow lines and directions present in the diagrammatic model. This is done either in two dimensions, on the plan level, or in three dimensions, in a computer model.

For computer implementation purposes, the superposition method works with almost any graphics or CAD package that supports layering. The technique of the diagrammatic model can also be 'hand-worked' in such a way, although more sophisticated tools are required when applying it to 3D computer models.

UN Studio, or Ben van Berkel and Caroline Bos, after applying rather traditional analytical techniques on a design task, try to find a diagram that informs their design process (van Berkel and Bos 1999). The diagram is an image of an organizational structure that is related to the core issue in the design task. It forms a metaphor for thinking about the design, and in which direction it should progress (e.g. for the Moebius House, the diagram of two intersecting curvilinear lines is used to characterize the two intersecting sequences of space that form the basis of the house). In their work, the development of the building design and how it relates to the diagram, is an important aspect. The diagram provides a handle on complexity as it hints to directions in which the solution can be developed.

In the work of UN Studio, thinking in diagrams, and the results of the analysis of the brief, is usually translated immediately in 3D forms. Intensities of traffic, use patterns in a site, pedestrian movement, etc. are visualized as volumes, and form a basis for shaping the new design.

Gregg Lynn investigates the consequence of computing space, and how architecture as a reactive element in space can be generated by means of animation (Lynn 1999). His main concern lies in understanding the consequence of making every element of architecture computational. Lynn defines the relations between objects in a brief, their interrelationships, and constraints, and also models the characteristics of space and its influence on the objects. Then, by using the technique of keyframing, Lynn introduces time and animation to the system and analyses what happens when the whole is set in motion. In this way, Lynn can handle an increased notion of complexity through the processing power of the computer.

Lynn's work points to the direction where all pieces of architectural design can be coded in a computational form, and thus proceed through architectural design in a reflective, studied, manner that reacts on emerging events rather than a thought-through process in which the drive behind changes in the design comes from the architect.

Many of these approaches rely on modeling geometry only, where the meaning still has to be inferred from the designer him- or herself. The research area of Information Modeling is aiming to tackle just this issue of semantics. In the group of Design Systems, we are focusing on FBM as developed by van Leeuwen (1998) as the information structure. In order to link FBM with graphics representations, we are aiming to describe so-called generic representations by Achten (1997) in terms of Features.

4. Feature-Based Modeling and Complexity

Many of the approaches mentioned above rely on modeling geometry only, where the meaning still has to be inferred from the designer him- or herself. The research area of Information Modeling is aiming to tackle just this issue of semantics. In the group of Design Systems, we are focusing on FBM as developed by van Leeuwen (1998) as the information structure.

The continuation of the work on FBM has been reported in van Leeuwen and de Vries (2000). In order to understand the dynamics of FBM, concrete design processes have been described in terms of Features (Achten and van Leeuwen 1998), and a first classification of changes in Feature Models has been made in Achten and van Leeuwen (Achten and van Leeuwen 1999).

Broadly speaking, Features Models can be seen as networks of related pieces of information, called Features. A Feature can mean anything, ranging from geometry to property, meaning, annotation, etc. The relations between Features are indicated by roles. Meaning and interaction of Features can be interpreted on basis of the roles. Features are defined on a high level as Feature Types, that describe the general state of an object. A particular model is made as an instance of a Feature Type. Types can contain other Types, thus increasing complexity of the information. The FBM approach developed in Eindhoven allows not only to define Feature Types by the user (or a system in the background supporting the user) but also on the Feature instance level to change roles between Features and make new ones during a design process. In this way, the information model can evolve and develop along with the design.

As can be imagined, Feature Models networks of information can become large and difficult to get an overview of. Work by Coomans (1998; 1999) is directed to visualize Feature Models in a Virtual Reality environment. A first prototype has been finished, and is currently being tested. In this prototype environment, called DDDiver, the designer can choose and manipulate Features in a 3D interactive environment.

In order to acquire larger units of design information in terms of Features, we have been looking at ways to describe so-called generic representations by Achten (1997) in terms of Features. Generic representations are graphic representations that consist of specified graphic elements called graphic units. A graphic unit is a set of graphic elements with a well-defined meaning. Combinations of one or more graphic units constitute a generic representation. On the basis of its constituent elements the meaning and design decisions involved can be inferred from the drawing.

Generic representations can form a bridge between the high level of detail that Features can represent and the designer-units of information that is captured in graphic representations as discussed above. In this way, we hope to encode architectural knowledge in terms of Features; thus providing a computational representation that can be processed by a CAAD package. The work as it stands now has been reported in Achten and van Leeuwen (2000).

5. Discussion

Before any CAAD system can be actively involved in design support, it needs to have a level of understanding of the objects that are represented in the system. At the moment, all CAAD systems understand geometry and offer many sophisticated tools to create and manipulate geometry. Meaning however, still is a difficult aspect, and complexity has not yet been adequately dealt with. The way architects use graphic representations can be informative how units of information can be formed and used in the design process. The study of concrete design processes can point to directions of further development of design information. What is needed, are many more levels of abstraction in information models to capture the different ways of viewing design information as an architect does.

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