Architectural Design Process Simulation And Computer-Based Modeling
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ABSTRACT
Since cognition to solution, design problem statement, has been practiced for a long time, and have opened different variations in design methods. The amplitude of design consists of step by step procedures along with inspiration and creativity. Different theories in design have developed some parts of the subject. Two distinguished viewpoints in design theories can be observed. The first is the systematic approach and the second is the creative design. In systematic approach there are some step by step procedures, which define the act of design. Others, who believe in creative design state that designing is a creative endeavor, which uses inspiration; so it cannot be defined in procedures. In addition, considering design process as progression in problem solving and finding the answer needs illuminating steps of its procedure. But increasing complexity in design subjects and effective ingredients inhibit the human mind to face design process and come up to a mature integrated solution. Design tools like physical models and drafts cannot support complicated configuration anymore. Nonetheless, with growing complexity in design subjects and its components, design tools are developing to follow them. One group of these tools consists of parametric operators, which are based on parametric methods. Three capabilities of parametric methods in making connection between design data are: 1. Creating a hierarchical connection between data, 2. Providing a connection between items (which can make a system), and 3. Control data and relations to compare them with principals. These capabilities prepare three procedures for applying parametric operators: 1.Data-based framework, 2.relation-based framework, and 3.model-based framework. The research question is “Which are guidelines for applying parametric methods in architectural design process”? Research method is based on emancipatory paradigm and analytic-qualitative research method.

Keywords: Design process, parametric methods, problem solving, parametric model

1. Introduction
Increasing presence of digital technologies in architecture has had a considerable influence on various part of design process and provides a computational support of the innovative and creative design. Digital design, particularly parametric methods are new approaches in implementation of CAD tools in architectural design which use different software for problem-solving, integrated design and fabrication. These methods are based on algorithms and step by step orders. Complicated computations become possible by automation potential of computers.
On the other hand, creativity in design process has been neglected in most design process studies. As Dorst (2005) implies, Creativity in the design process is often characterized by the occurrence of a significant event—the so-called ‘creative leap’. Sometimes such an event occurs as a sudden insight (Dorst, 2005) because of this, most design researchers omit this issue. However, digital design tools have had a big influence on design creativity and open a ground for study about digital creative design.

In design, cognitive models of design thinking, which can be empirically verified, constitute one important platform for cognitive psychology in design research. For example, concepts and methods, which have been developed in cognitive psychology, have been applied to design in, among others, the work of Akin (Akin, 1886), and the work of Schon and Wiggins, (1992) particularly on visual thinking through interaction with the conceptual processes of design thinking. Cognitive models of design constitute a general approach for modeling cognitive process in design as global process of thought and reasoning (Oxman, 2007).

Cherry (1999) explain how quantitative methods can make big progress in architectural design process which is a qualitative-quantitative activity. This paper tries to introduce a framework for implementation of parametric methods in architectural design process and answer the following question:

Which are guidelines for applying parametric methods in architectural design process?

After a discussion in design process, and algorithmic simulation of architectural design, an optimized model for parametric methods computations will be propose.

2. Design process in architecture

Proceeding in knowledge and technology, and subsequent forms, materials, structure and etc, design action becomes more and more complicated. If we matter the design process as a problem solving subject, as Lawson (1997) and Mitchell (1977) implied, in this process designer face with two substantial questions. First one is “where we want to go”. This question will be answered after getting acquainted with the discussed problem. In this step the following question “how we can get there” will be next design challenge. This question is discussed in various researches and different answers are provided which are known as design methods.

In 70’s, researchers attend for logical systems and systematical designs approaches in problem solving. But after a while the insufficiencies in modernism and rationalism impact on design process emerged. Critics stated that creative design process is more complicated for declaring as separated steps and components. Most designer believed that design is an implicit creative attempt and studying about it will decrease the effectiveness of innovation in design process. They think designer should be free to act and any process will limit this freedom.

In the other hand, people like (Lawson, (1997); Alexander, (1977); Gero, (2002) presented a model which is based on both approaches. Poincare (1924) and Kneller (1965) describe a process for creative thinking which is divided into different phase’s kinds of thought. First is a period of initial investigation of the problem in hand, followed by a more relaxed period of apparent mental rest. Next, an idea for the solution appears almost unhidden
by the thinker probably at the solution needs elaboration, verification and development. (Lawson, 2007) as shown in Fig.1.

![Creative Thinking Diagram](image)

**Fig.1. creative thinking, by Lawson (1997, p.149)**

There are two general approaches in architectural design process: 1-systematical methods and 2-creative methods. In creative methods, design process articulated in five steps which start from the first line to the end. The steps are: 1-first insight, 2-preparation, 3-incubation, 4-illumination, 5-verification.

Based on this approach, design process is composed of activities which use preliminary data to analyze and describe the final product. This process is characterizing a systematic design process along with creative thinking. In fact, researchers who explain design process as a system are considering the 1, 2 and 5 phases and others are emphasizing 3 and 4 phases.

Designers through these 5 steps answer to different aspects of design problem, e.g. form finding, spatial relations, costs and etc. Bringing these issues in the context of design process, improving in science and technology, make it more and more difficult for human mind to manage data and making integrated relations between components. Therefore, Computational tools can be useful for developing human capacities.

3. Simulation of design process

Since the early 80’s, CAD [Computer Aided Design] tools have provided us with new means of graphic representation in architecture. Contrarily to the usual manner in which spatial forms are represented in 2D “glance” (in section, elevations and plans), but using this 3D drawings software, one is provided directly with a virtual 3D model “constructed” by the computer. (Wetzel, 2006) However, implementations of CAD tools are generally in form finding and drawings documenting, but not limited to these. CAD tools are helping designers
with simulating different aspects of design. One of the most complicated actions in design is problem solving and managing the design process. Computational tools because of theirs characteristics can set designers with various solutions in developing architectural design process.

As it can be observed in parametric projects which are described by Monedro (1998), Gane (2007), and Cardenas (2007), a parametric approach to design process means to establish integrated relations between design data, as a system, in a way which changing one affect other components. This system can keep these relations and conditions without any change from beginning to end. As mentioned before, phase 1, 2 and 5 can be modeled as a system and phase 3 and 4 are inner manners to designer.

But what happen in an architectural design process. In the first phase, designer collects any data which need to know the problem. In the next phase all data analyzed and get the designer information which is needed to solve the problem. And the final phase happen when the answer is provided. This answer will be checked if it is sufficient. Moving between these phases may repeat several times as shown in Fig.2.

In a parametric language, this process should represent as data and relations. It is similar to represented phases with some different. In a parametric approach designer collect data and in the next phase they peruse to find relations between. The result will be a system (components with integrated relations). Therefore in the last phase designer control the system to measure the sufficiency of the system. Fig. 3.

In the next section an optimized model for computational tools will be discussed.
4. Optimized Model for Computing

As mentioned in previous section, three phases can be found in a design process which will be used to make a parametric model and subsequently employ in computational tools. The first one which works with data we will call data-based assistance. The one which use analyzed data to make relations, relation-based assistance, and the last one which take a system to control and verification, model-based assistance. These assistances cover design process in three scales, from local to global issues as in Fig.4.

4.1 Data-based Assistance

Parametric systems may be as data-based assistance for architectural design process. Sometimes the process is in need of vital information and data which should be use in different stages of design process. Data-based assistance are available in different situations and assist the design group when they should be used and prevent ignorance or other disorders in design process.

In this method a hierarchical relation provide which make a system. Each system has sub-systems inside and all sub-systems are connected directly or indirectly. Clearly it is hard to
make such a pervasive model and will take a lot of time. But instead, in such a model, all components are accessible real time and making any change apply to the entire model.

For example, some software like REVIT or ARCHICAD, which are known as BIM software, provide a database of architectural components, wall, floor, window, door and etc. each component can be control with its properties like width, depth, height, material and etc. designer can select components and make them related. For instance, choosing a door to be installed on a wall will be performing with dragging the door on the wall, and the door will connect to wall. In this situation user can move the door on the wall or change the door height and wall will be update with changes, no more need to make a new model for new door.

Another example is software like CATIA or parametric toolbars in other software (VISUAL-ARQ plug-in for RHINOCEROS), which provide menus to define relations between geometrical shapes. For instance, in building footprints which designer is forced to keep definite relations like specific dimensions, parallels and etc, software protect all the conditions which is determined before.

![Fig.5. schematic diagram of data-based assistance, data feed the design, by authors](image)

### 4.2 Relation-based Assistance

In this method designer consider relations between data. Relation-based assistance provides specific connection between data to lead process to design goal. Among relations that can be simulated are geometrical relations, spatial relations, ecological issues, structural consideration and etc.
Each kind of relation needs a specific software or program. For example there are some ecological software i.e. ECOTECT and ENERGYPLUS; or structural one i.e. ETAB and SAP. But there is no specific software for spatial relations. As a replacement some programming decks which are provided in different software can be used. The programming menus and plug-ins (e.g. GRASSHOPPER in RHINOCEROS) give designers a chance to code their favorite’s relations and make a model.

![Diagram](image)

Fig. 6. Schematic diagram of relation-based assistance, specific relations define, by authors

4.3 Model-based Assistance

Most designers in preparation phase of design process use case based methods. The comparison between previous answers and provided answers for design problem is one of the verification methods in design process. In this process it is possible that previous lessons be ignored. Model-based assistance is a prologue to artificial intelligence. It helps designers to keep precedent models in a library and import to current model when needed. This model library develops in time and complete gradually. Each answer which is achieved in a problem solving process records in library and the program will remember it in the future. Also other answers which are provided before by others can feed the current library.
Designer can pick among presented assistances considering the project requirements and design group abilities.

5. Conclusion

Design problem statement, since cognition to solution, has been practiced for a long time and have opened different variations in design methods. The amplitude of design consists of step by step procedures along inspiration and creativity. Different theories in design precede some part of subject. As mentioned before, different viewpoints in design theories can be observed. The present research postulates a coequal method composed of systematic and creative thinking methods based on creative thinking approaches. In this view, five phases can be considered for creative design: 1-first insight, 2-preparation, 3-incubation, 4-illumination, 5-verification.

In this process step 1, 2 and 5 as systematic methods can be modeled in a parametric way. In the first step designer provide data needed to face the problem. In the next step data get analyzed and the answer is found. In the last step designer check the sufficiency of the answer.

To model these three steps in a parametric system, three assistances based on these three characteristics represent in:

a. **Data-based assistance**, designers use methods to manage design data as an integrated system. This method helps them to have a real time access to all components. These components are related each other and any change to one will affect the entire model.
b. **Relation-based assistance**, one system or some sub-systems defines and models. It is easier to model a part of design than the whole.

c. **Model-based assistance**: if we consider data and relation based methods as local approaches; a model-based has a global view. In this method generic models uses for forming and verifying the design.

These assistances don’t cover all the aspect of a creative design; they don’t make an automated design process too. They assist designers to increase their capacity for a creative design. Parametric methods increase the possibility to innovative design with their abilities in responsibility to complicated computations. A human designer can individually produce a creative design with or without using parametric methods or computing machines. But these assistances help to decrease mistakes and increase fabrication abilities. Also, they speed up design process and save time, energy and costs.

**References**


