MULTI-DIRECTIONAL INTERRELATIONSHIP APPROACH FOR HYBRID INTERACTIVE DESIGN TOOL FOR HIGH-RISE BUILDING

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Abstract. The role of computers in architectural design is constantly increasing, as may be seen in the efforts to develop generative design tools which are focused on helping create innovative results. Some of these are generated by sets of rules, constraints, theoretical models and algorithms, for which the computer is used as the implementing tool. This research introduces a new approach in hybrid interactive design tools, which are focused on the clustered and hectic urban context in the modern age, meaning that architecture is continuously developing vertically, in high-rise buildings. The main point in this research will be the abandoned gap in connecting the internal functions and external appearance. This is another main point which cannot be ignored in designing high rises, which ideally contain both internal and external perceptive aesthetics. The scope of this research will cover three aspects: Function, Perception, and Proportion. Therefore, the work flow of this design tool will be a multi-directional interrelationship between these three steps: 1) internal function and external form generation by various types of constraints, 2) internal function and external form inspection, and 3) internal function and external form modification by the users.

Keywords. Generative Design, Interactive Design, High-Rise Building, Multi-Directional Interrelationship, MAX Script.

1. Introduction

During the early phases, designers explore many design alternatives, which can be supported by generative design systems. These systems can assist designers in creating feasible design solutions rapidly through generative mechanisms, such as design heuristics, shape grammars, constraint solving. Recent advances in this area, such as SEED-Pro (Ak n et al., 1995), SEED-Layout (Flemming and Chien, 1995) and SEED-Config (Woodbury and Chang, 1995), Floor Layout and Massing Study Programs (Harada, 1997), and Performance Simulation Interface (Suter, 1999) have been able to provide extensive support, through sophisticated generative mechanisms and evaluation functions, with which designers are able to investigate different formulations and decompositions of design problems and to explore alternative design solutions.

These generative design systems may be typically divided into two approaches, some focused on generating forms, such as Cellular Automata (John von Neumann, 1951), L-Systems (Smith 1984; Prusinkiewicz and Hanan, 1989; Prusinkiewicz and Lindenmayer, 1991), FormWriter, (Mark D. Gross, 2001) while the others emphasized functions, e.g., SEED-Layout (Flemming and Chien, 1995) and Architectural Layout Design Optimization (Jeremy J. Michalek). Various groups of researchers have made attempts to combine both approaches to create hybrid methods in order to generate architecture that can focus on both form and function, such as Harada (1997) and Suter (1999).

Due to the clustered and hectic urban context in the modern age, the increasing trend of architecture in the present has been to develop vertical, high-rise buildings.

Historically, the development of high-rise buildings has been dependent on technological advancements. As the continuous advancements of technology impacted high-rise building design and planning, the architectural profession also changed to keep up with the rapid technological progress. One of the more remarkable technologies is the use of the computer to analyze complex structural systems and to produce construction documents.

However, digital tools to assist in architectural design to generate innovative high-rise building forms have not progressed at a comparable rate.

The goal of this paper is to propose the multi-directional interrelationship method as an alternative approach to explore the abandoned gap in connecting the internal functions and external appearance, in addition to the recent research into the high-rise building generated design, which has led to methods focused on developing external form and structural core shape, e.g., Tall Building Form Generation by Parametric Design Process (Sang Min Park, 2004), Embedding Methods for Massing and Detail Design in Computer Generated Design of Skyscrapers (Shouheng Chen, 2006), and Design and Development of a Fish-Skin Double Facade System for Freeform Super Tall Building using Parametric Design Tools (Sergio Araya Goldberg, 2005).

2. Approach

This research paper focuses on three aspects: Function, Perception, and Proportion, essential factors in generating the design of high-rise buildings in the multi-directional interrelation approach that correlates the internal functions and the external appearance, with the user interaction as a catalyst.

2.1. HIGH-RISE BUILDING

In the development of high-rise buildings, the overall building form should be one of the major elements that impacts building aesthetics and behaviour. However, architecturally, structurally, and aesthetically, it is a complex task to develop an optimal form for high-rise buildings due to the interrelations of large numbers of components, taking into consideration that one change can affect many other factors when developing a project. The use of digital tools in the schematic design phase of high-rise building design is still quite limited. The computer-aided design includes using a computer not only for visualization, analysis, and evaluation, but also for the generation of designs or, more accurately, for the rapid generation of computable design representations describing conceptual design alternatives. Potential design alternatives are generated and evaluated in order to obtain the most promising solution. The advantage of the method studied in this paper is its ability to communicate internal functions with the external perceptive aesthetics. An apartment building is selected as a implementation model as it best represents high-rise buildings with form that follows function.

2.2 FUNCTION

In the phase of Function, we implement the tool for an ability to generate the design of the apartment building by the following variables.

2.2.1. Internal Variables

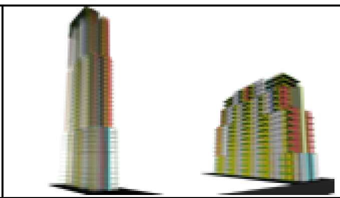
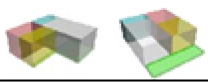
The **Room types** variable scales the number of each type of room, comprising studio, one-bedroom, two-bedroom, and three-bedroom, which affects the overall building layout and external appearance.

The **Types of access** variable represents vertical and horizontal access, which cause changes in the building's height and layout.

The **Size of spaces/internal open space** variable restricts the dimensions of each room's internal functions, which are sleeping area, living area, working area, dining area cooking area, bathing area, and internal open space. It also has a great impact on the overall building layout and external appearance.

The **Space layout** variable creates a sense of privacy by the arrangement of a room's internal layout.

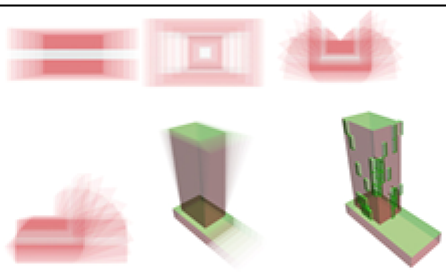
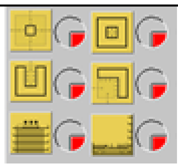
TABLE 1. Internal variables and user interaction.

Types of access		
Size of spaces		
Space layout		

2.2.2. External Variables

The **Open space / Green space** variable affects the building shape and overall layout by one or a blending of six types of open space forms.

TABLE 2. External variables and user interaction.

Open space / Green space		

2.3 PERCEPTION

In this phase, the ability to work three-dimensionally, from four viewpoints – implementing both internal and external perspectives – creates the potential to inspect both internal and external functions and forms (see Figure 1).

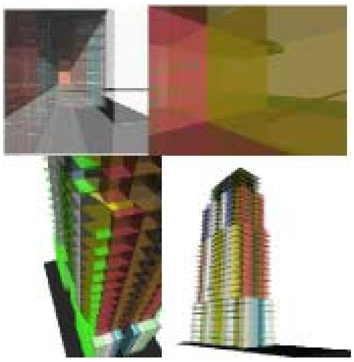


Figure 1. The potential to inspect both internal and external functions and forms.

2.4 PROPORTION

We develop the interaction with the users in this phase, allowing architects to adjust the forms to meet their aesthetical, proportional needs (Figure 2).

Figure 2. The interaction with the users.

2.5 MULTI-DIRECTIONAL INTERRELATIONSHIP APPROACH

The work flow of this approach is outlined in three steps: 1) internal function and external form generation by constraints, 2) internal function and external form inspection, and 3) internal function and external form modification by the users (Figure 3).

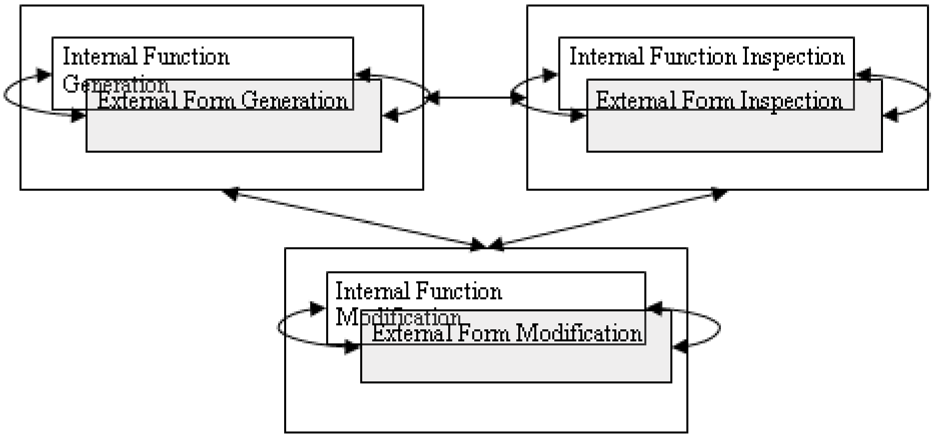


Figure 3. Multi-Directional Approach.

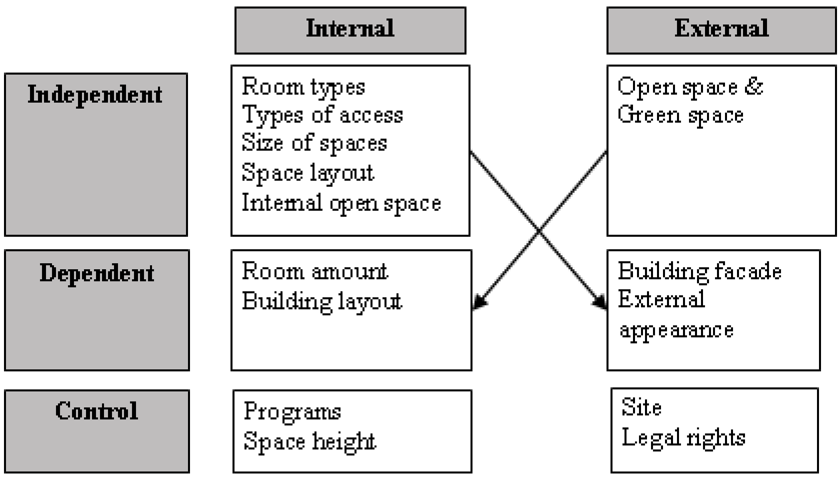


Figure 4. Diagram of interrelationship.

3. User Interface

Two types of user interface are provided: basic and advance modes. Basic mode provides simplified variables for typical users, and advance mode is for those who prefer a parametric method (Figure 5).

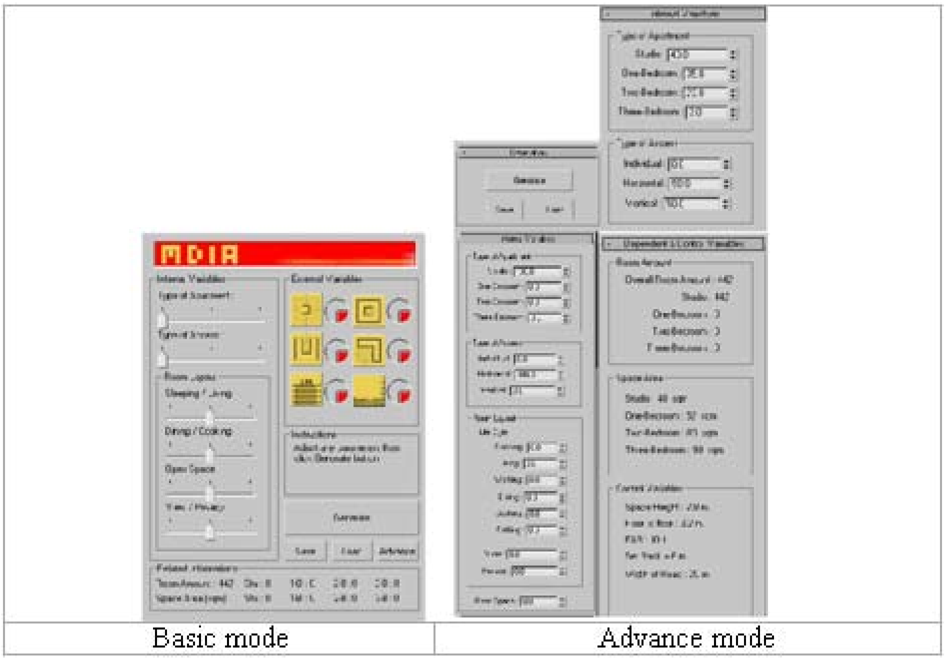


Figure 5. User Interface.

4. Evaluation

In this phase, by providing a function to save or load generated models, the explored, potential high-rise building forms can be chosen by the users to further develop.

Since the forms are developed completely with digital models from the very beginning, the outcome of this research is therefore three-dimensional generated building forms that can be constructed as three-dimensional surfaces for rendering.

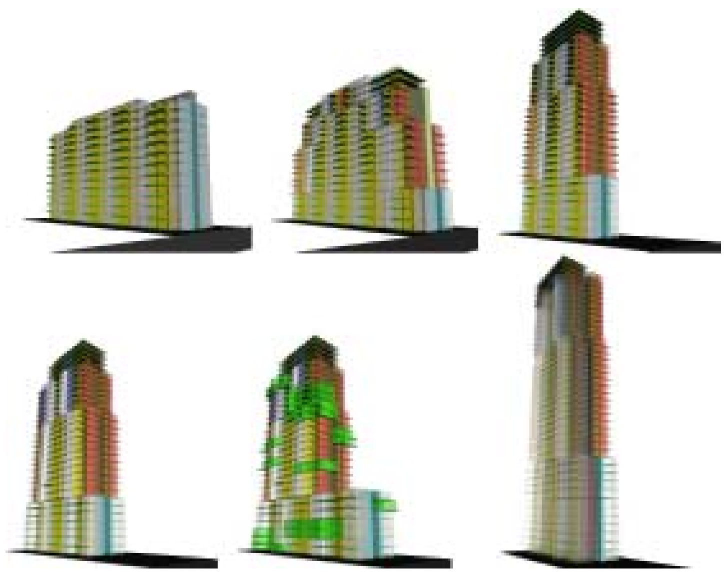


Figure 6. *Design evaluation.*

5. Implementation

We focus on using MAX Script as the Application Programming Interface in development of our design tool. As 3DStudio MAX is the most widely used object-oriented CAAD tool, especially in Thailand, through all educational and organizational levels, it has potential for further development into the most practical tool.

6. Conclusion and future work

The purpose of this research is to inspire more interest in the innovative concept of designing high-rise buildings through the integration of architecture and digital technology. The focus of this research is to suggest the generative forms that are applicable to architecture by means of architectural evaluations and the form generation process. This research will contribute to the development of high-rise building forms. Technology can be used as an architectural tool to produce not only better performance design but also generative and innovative concepts. The improvement of design quality and design process using advanced technology is a practical and challenging task for professional development. By integrating digital tools based on design criteria rules and design requirements with new concepts in high-rise building forms, the generative potential forms can be determined. Development of such a method enables designers to apply their designs in a unique fashion.

On a large scale, this paper shows the importance of automating certain portions of the design process and the benefits of doing so: architects can avoid repetitive work and concentrate on more creative issues. Also, the paper demonstrates that architects can construct better digital systems to handle their particular design tasks instead of relying on other systems that have been developed by engineers and computer scientists.

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