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Implementing a digital model for smart space design: practical and pedagogic issues

Do-Young Kim[a], Yoon Choe[b], Sung-Ah Kim [a, b,*]

[a]*Sungkyunkwan University, Department of Architecture, "Suwon", Republic of Korea*
[b]*Sungkyunkwan University, Department of Convergence Engineering for Future City, "Suwon", Republic of Korea*

Abstract

Traditionally, models have been used by designers to represent abstract design ideas or to analyze and evaluate the refined design solutions. The digital model, in particular, represents the logics, process, and intended result of the design in the form of digital information and media. Innovations in Internet of Things (IoT) and 3D printing technologies now enable the various levels of real-world spatial interactions that were possible only when the user becomes an avatar in a cyberspace. This level of model virtualizes the design and the building itself, becoming an organism of information and materials whether it is being digital analogue.
This phenomenon calls for the reorganization of the conceptual framework during the architectural design process where different kinds of models coexist and continuously evolve. Beyond the ad hoc communications between two modes of models, a symbiotic framework is proposed in this paper, where digital and analogue models interact in synergetic ways in the form of design versions and prototypes. This framework is especially appropriate for designing the smart space. It reflects the paradigm of form-finding and prototyping over the traditional counterpart of design process: form-making. The concept of Smart Analogue Model (SAM) is introduced as a main instrument to facilitate this process. The SAM refers to the prototyping of smart space by integrating ICT-embedded components like sensors and actuators. Through the co-evolving process, two models interact in various channels by utilizing techniques from parametric design, design-by-simulation, and physical computing. The impacts on the pedagogy of architectural design studios are discussed within the framework of the proposed symbiotic design process.

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1. Background

Traditionally, designers have used models to externalize abstract design ideas or as a mean to analyze and evaluate the refined design solutions. Models are also used for more tangible communication between designers and clients or collaborating engineers, as in the case where the architect often uses the model to convince or share design problems and propose solutions. The digital model, in particular, represents the logics, process, and intended result of the design in the form of digital information and media. Therefore, the role of digital models may be simplified as a digital representation of physical buildings to be realized in the long run, or a digital representation of a mental image transforming incessantly in the designer's mind. That is, the digital model represents something. With the advances in computer technologies, digital models have evolved into essential tools, expanding the horizon of design languages (Kim 1997, Kim 2012). Experimental and complex geometries became universal vocabularies in architectural design thanks to the generative nature of parametric design models (Shelden 2002). That is, the digital model is able to generate the design or the building. Furthermore, VR technologies facilitate full sensory experiences from

*Corresponding author. Tel: +82-31-290-7566; fax: +82-31-290-7570
E-mail address: sakim@skku.edu

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the design artifacts of a cyber space, by adding more interactive features to the digital model (Singh 2011, Volander 2014, Calado 2013). Fully fledgling technologies, in the field of Internet of Things (IoT) and 3D printing, now enable the various levels of interactions and experience with the space that were possible only in cyber space in the condition that an user limits him/herself as a virtual being (Say 2014). This level of digital model virtualizes the design and the building (Fig. 1).

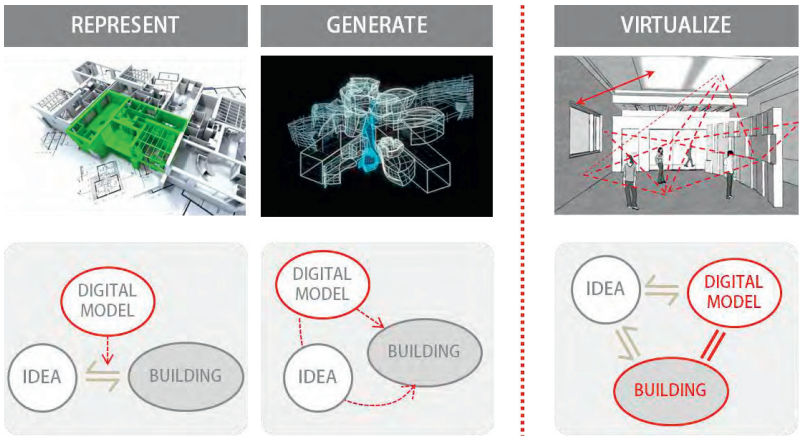

Fig. 1 Evolution of the Digital Model

Not being far different from traditional physical equivalents such as wood model, digital models like 3D geometric model have been extensively used for form-making process. This process involves iterative creating and modifying operations that require manual craft of the designer as a computer operator. Most of digital modeling works are still conducted at this level. This form-making process becomes faster than ever, due to the development of computation design methods such as generative parametric design and digital fabrication. These methodologies are also even better supported by the powerful simulation and optimization tools in combination with accelerating BIM (Building Information Modeling) technology (Oxman 2008). The paradigm of digital modeling is changing from form-making to form-finding as the designers can enjoy the selection of optimum design solutions from myriads of possible alternatives (Carpo 2013).

Analog models, on the other hand, even in the age of computational design, still possess superior merits over digital ones. The pedagogical value of analog models cannot be underestimated as they allow designers to understand the tectonic characteristics through the manipulation of three-dimensional objects (Sun 2013) and to learn the process of construction by physically handling design elements (Cochran 2001). One of the major limitations of the analog model is that it cannot be generated or modified as flexibly as digital models due to its material nature. Thus, analog models tend to be constructed only when the necessity exceeds the limitations of resources compared with the relative flexibility of digital model's unlimited generations and modifications. In other words, few analog models can be created while digital models virtually do not have limitations in terms of quantity in most of architectural design process.

The Smart Analog Model (SAM) can be implemented by the combination of up-to date ICT technology, 3D printing, Internet of Things (IoT) and Smart materials: The form, spatial configurations, and properties of the components can be changed in response to user's information and environment state: The SAM, provided with versatile interaction channels with the digital model, can overcome the limitations of traditional analog models. Furthermore, it augments the form-finding process of the digital model by adding authentic human interactions and real world simulation and optimization operations. The SAM is not modeled, but prototyped as in the case of manufacturing industries: the purpose is to verify the overall performance of the space being designed, not to evaluate only form and shape.

Prototyping with SAM can be of great help to designing a smart space, which should support user's task and respond to the change of environment in real-time. This process allows a kind of Pre-Occupancy Evaluation as the designer is able to estimate user's interactions with the space and the level of performance during the design stage. This nature is essential to the implementation of smart space, as the user feedback can be reflected into the modification of the model from the individual component level. Therefore, when prototyping of smart analog model is applied to educational curriculum, designers can be inspired to follow the architectural trends of future technologies and grasp the concept of flexible space adapting to user's task and environment. Thus, designers can not only generate alternatives rapidly, find optimum alternatives which are satisfied with design criteria, but also verify alternatives by the multidisciplinary approach (Fig.2).

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