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TEACHING RAPID PROTOTYPING IN CAD STUDIOS FOR CREATIVE DESIGN

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Abstract. This paper is intended to study the characteristics of digital tools and applying the rapid prototyping (RP) technology to the architectural design studio. The examples and experience of using RP are presented.

1. Introduction

The term "rapid prototyping" is a relatively new expression for the generation of three-dimensional models manufactured without the need for machining or tooling. CAD/CAM (computer aided design and manufacture) is graduate emerged for better data integration. The concept of rapid prototyping (RP) as an extension of CAD/CAM, is recently introduced to the design professions by the well-known architects such as Frank Gehry and Peter Eisenmann. Applying RP to design and modeling enables designers have the ability to rapidly produce accurate, tangible models of products designed on a CAD system. Designers can also visualize the design outcomes and examine the feasibility of design approaches and consequent development. As new technologies developed, it is important to explore how to use and teach the technologies in design studios.

Therefore, this paper attempts to explore the interactions among RP digital tools (including software and hardware) and the design process, i.e., to study how digital tools affect the process. Furthermore, it is to explore whether new digital tools such as RP can be the impetus for creative design.

2. Processes and Tools

To study the capability and potentials of RP, our CAD studio adopts the CAD/CAM approach at the graduate level, especially focusing on the possibility of animating forms and integrating digital tools with the modeling process. In order to enhance the idea, the studio conducts case studies to

understand why and how to apply RP in design, provides tutorial lessons of software and hardware, and processes design projects.

2.1. PROCESSES

The studio first examines the role of design tools in design projects from the design projects by Antoni Gaudi to recent projects by Frank Gehry (1999), Peter Eisenmann (1999) and Greg Lynn (1999); and summarizes the basic operational requirements. Meanwhile, a top-down process of design development is used for design exercises and discussion. The basic design scenario consists of "Think, Design, Print, See, Hold, Feel, Show, Try". Designers generally implement two basic design processes: (1) the forward process consisting of "think, design, CAD model, 3D print"; and (2) the reverse process that adopts the reverse engineering concept, consisting of "think, design/sketches, scale models, CAD model".

2.2. TOOLS

New development of digital tools has open a new way for designer to use iterations between handmade and digital media (Herbert, 1995). Therefore, the studio has built a design platform shared with other institutional units, and adopts both conventional and digital tools for enabling the interactions, including:

(1) Hardware: The studio is equipped with a desktop digitizing system (MicroScribe 3D). The 3D Modeling & RP Lab at Department of Aeronautical and Astronautical Engineering, NCKU, provides the RP facilities including selective laser sintering (SLS) by DTM and a 3D printer by Z-corp. While various technologies and tools are introduced, the studio applies the 3D printer in the forward process, and the desktop digitizing system in the reverse process based on the feasibility and economic reasons. The studio covers the cost of RP production if the RP model is necessarily required.

(2) Software: The studio adopts Form-Z, Rhino-3D, and 3D Studio Max with the capability of solid modeling and deformation functions such as Non-Uniform Rational B-spines (NURBS) operations that uses mathematical formula to define curves. All model files have to be converted the lithography format (.stl) for RP production.

3. Operational Studies

Previous design studies focus on the design process and its relationship with design thinking. However, different tools have different strengths and restrictions, and consequently influence how people use these tools. Meanwhile, the complexity of forms also affects designers' choice of tools.

Various design concepts require different computational operations, such as folding (Deleuze, 1993), deformation, and fractals (Chiu, 2000).

In the studio, each designer applies various concepts of deformation to their exercises and realize in a design project. For example, Figure 1 illustrates possible approaches of using a 3d-printer in the forward process, including: (1) solid / void, (2) parts / assembly, (3) prototype / deformation, and (4) iteration / generation. While free form or non-orthogonal forms can be sketched in 2D, but is more feasibly modeled by NURBS operations in 3D and generated by RP. The provision of models is important for initiating conception and refinement. Designers can visualize the design outcomes and examine the feasibility of design approaches and consequent development. Computer rendering often cannot reveal possible faults of modeling. During the process, RP facilitates the understanding the complexity of geometry, and detect the possible problems in the early stages. However, the 3d-printer has to be used appropriately because of the restriction of scales (8”x10”x10”) and economics. Each RP production finished in less than two hours will cost about US$100. Therefore, careful plans of RP production are required, particularly at the preliminary design stage. Designers tend to generate small-scale models, then assembly into large models.

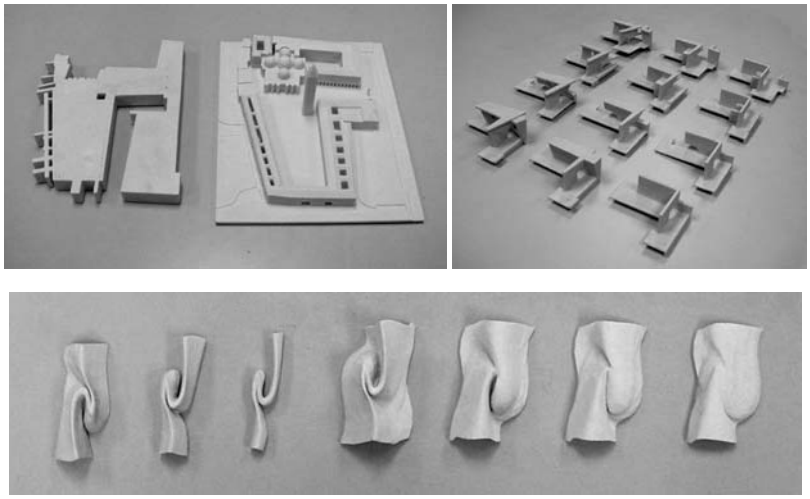

Figure 1. Design examples of using RP

4. Discussion

The above exercises provide the foundation in response to the questions such as: What should design studios be equipped and provided? How the use of

digital tools can be structured into the curriculum? Are conventional tools or scale models still required for design representation?

It is found that designer's intention and the characteristics of design are the main consideration for choosing the approach of modeling and tools. The approach of producing forms by RP in studio requires minimum resources to support creative thinking and generate design. While traditional tools or scale models still can be complement to the digital tools, the potential for increasing the degree of design freedom and the ability of design integration become the main strength for using RP. Indeed, it appears that interactions between handmade and digital media are a complex mixture of the artifacts. If the new artifacts created in the process force the reinterpretations that generate design information, then media interactions amplify the designer's opportunities. Ideas of new tools such as "digital clay" foster the potential for exploration (Schweikardt and Gross, 2000). The curriculum have to be structured into a good combination of the process, availability of digital tools, and supporting design theory and methods, then designer's intentions enhance the opportunities of design creation.

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