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Education

RP-aided computer modeling for architectural education

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Abstract

This paper explores the concepts of digital architecture using rapid prototyping (RP) process. A point cloud was given to students and different representational data were substantiated as real 3D physical models. The presence of the RP models and the sequential illustration of working steps in their reports revealed that shape control often differed from what students perceived in the VR worlds. The results confirm that physical models are useful for visualization as well as in design pedagogy. The design development process that students undertook accounted for structure, order, procedure, illustration, and communication.

Keywords: Rapid prototyping; Digital architecture; Architectural design; Pedagogy

1. Introduction

The procedure for creating architectural models begins with defining elements and their operations after inserting and deforming primitives. Related functions include Boolean operations of instances or the extrusions of planar shapes by 3D applications. The computer models are made in a virtual space that is different from traditional physically presented objects made of woods, plastics, or cardboard. The skill of the student and the complexity of the building form may prevent a physical model from being made as delicate as a computer model.

A rapid prototyping or RP machine can fabricate 3D models for visual inspection. Applications in architecture are made in the fabrication of building parts and design concepts [1–6]. RP in architecture is limited by the restrictions on size and time required to output a model. The footage of the model is another limit of an ordinary RP machine. A large model has to be separated into parts and assembled afterward. Another drawback is that the process is time-consuming. Normally, a RP production of an industrial part the size of a cell phone cover may take up to 10–20 h. Ordinary RP materials like polymer can create a thin cover with the strength of plastic. Another disadvantage is that RP models used to be made in white or other plain color. Although color-keyed components have been created recently allowing a uniform color to be assigned to a part [7–9], still, the limited variety of colors cannot provide adequate surface attributes such as the texture that is needed in architecture visualization, whether it is procedure texture (texture allowing for parameter change) or direct image mapping (texture using a predefined image as content).

The data used for RP do not have to be the final visualization results; instead, this stage of application can offer benefits in the early design phases [10]. Similar RP applications in the field of art can be seen in the creation of cartoon characters and visual arts [11,12]. It seems RP has worked well with current modeling

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processes in a specific and purposely integrated manner. But how useful is it in architecture? It is still to be seen whether a direct connection with a modeling process can be established.

The purpose of this study is to present students' fulfillment of an assignment that explores the concepts of digital architecture using rapid prototyping (RP) process. This study explores the modeling process of an abstract form by visualizing it with the assistance of RP models.

2. An assignment

In a course entitled "Digital Architecture" offered by the author, an assignment was given to students to create forms based on any simulated behavior of objects. With the enlightenment of forms manipulated in digital designs, most of the students produced free forms. Fig. 1 shows an object that was transformed from a rectangular tube section by section, for a more dynamic appearance. The texture was mapped by the instructor to enhance its appearance. The computer model was made prior to the point cloud assignment as a warm-up exercise. These outcomes led to a second assignment for which objects were to be created from an ill-defined geometric data structure. Assignment 2 was designed to use smoke particles generated from Hazard II (a fire simulation program) as a raw data set of point clouds. Although each point represented a particle of fire or smoke, the attributes were hidden from the students for a pure geometric study of the potential development of forms.

When the digital architecture trend enlightened student's design with diversified free forms, a new issue was raised regarding the construction of the free forms in practice. As an instructor, two issues are raised: the conceptual development of building forms and the modeling of the forms. So an assignment has to be "designed" to cover these two issues that used both experience with computer models and physical models. The point cloud and the instructor's illustrations of possible developments can be seen in Fig. 2. The same assignment was given in a similar course entitled "3D Modeling" the following semester as an exercise from a modeling perspective of view only.

3. Observation of student work

When the assignment was given to the students, the instructor hypothesized that they had no preconceived notions of tools, data interpretation, and presentation. The kinds of titles students used for the second assignment were "6000 points", "Inside or outside!?", "Combination of three-way frames," etc. Their reports showed they perceived that the points were disoriented and not measurable by size. The 6000 points were considered as a single entity as well as a group of multiple objects. For some students, the points were static, so a "wrap" operation could be made. For other students, in contrast, the points were dynamic, so the connections among them either showed the movement of parts or that their presence enabled turbulence made by other types of geometry. The points were the subjects that "interfered" with a plane in order to reveal their presence in a certain form.

Fig. 3 is illustrated with two columns to the left showing different views of a RP model and a third column listing comments in terms of presentation manner, key component, and modeling process. Rows "a" and "d" are two exceptions that show phases of the creation process and a modification of the original model. The terms are explained as follows.

3.1. Heterogeneous or homogeneous manner

The presentation of elements is classified into heterogeneous manner and homogeneous manner. The former was conducted by applying geometries of different shapes, such as tubes and planes. The latter used the same or very similar shapes throughout the whole model. Either manner was considered as an indication of the elements suitable for the representation of cloud structure.

Fig. 1. An RP exemplification from Assignment 1 and its original digital form. (Jeh-Zen Hu.)