The Application of Color-image-mapped Rapid Prototyping in Architectural 3D Modeling

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Abstract. The purpose of this study is to present an application of an RP machine in the substantiation of architectural design concepts, using color image mapping to enhance visual details. Related visualization leads to the exploration and comprehension of shapes. Exemplification can be seen in the verification for proofing or documentation of as-built models, such as paper architecture, process modeling, furniture, partitions, and construction details. The influences on architecture reveal issues related to pedagogical exploration, interdisciplinary exploration, reality management, and visual detail and structural detail.

Keywords. rapid prototyping; 3D printer; 3D modeling

Introduction

A rapid prototyping (RP) machine can fabricate 3D models for visual inspection. Related applications in architecture are made in the fabrication of building parts and design concepts (Krishnamurti and Earl, 1992; Novitski, 1999; Rotheroe, 2000; Ryder & etc., 2002; Streich and Weisgerber, 1996; Wang and Duarte, 2002). RP in architecture suffers the restriction of size and time required to output a model. 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 it is time-consuming. Normally, an industrial part the size of a cell phone cover may take up to 10-20 hours. Ordinary RP materials like polymer can create a thin cover with the strength of plastic. Most RP models are made in plain or white color. Color-keyed components could not be created until recently so that a uniform color can be assigned to a part (Karapatis & etc., 1998; Ming and Gibson, 2001; Pham, and Gault, 1998). But the variety of colors still cannot provide 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).

Purpose

The purpose of this study is to present an application of an RP machine in the substantiation of architectural design concepts, using color image mapping to enhance visual details. Related visualization leads to the exploration and comprehension of shapes.

RP Modeling Process

This study shows an application of an RP machine in architectural model-making. In addition to commonly used modeling functions, the color image mapping and modeling tools are two features particularly distinguished from others. What is different from an ordinary RP process is that now a model can be applied with color image mapped in JPG or PNG format. A model can thus be created with more visual details that are very helpful in showing the materials of building parts. The process is rather straightforward. Instead of
choosing a commonly used STL format, a model is exported in VRML 1.0/2.0 format and is sent to an RP machine along with the images to be mapped. The process is almost application-independent as long as the corresponding format can be translated. The study used ArchiCAD, TrueSpace, or 3D Studio Viz to create models and Deep Exploration to translate files. Some problems with normal vectors were encountered and fixed. The VRML format enabled a direct connection between a virtual world and a real world. All the operations were done on Pentium III 850/IV 2.53 MHz PC with 512/1280 MB of RAM. A Z-Corp. model 406, also called a 3D printer, was used.

**Color image mapping**

The cube shown in Fig. 1 was created and mapped with an image in TrueSpace 4.0. The size of the image was 62 KB. Like most of the 3D application GUI, image mapping comes with sphere, cube, and cylinder types. Wrap over effects represent the method applied by the program. The output results correspond to what they look like in a browse mode. Change of the normal vector direction can be made either in 3D application or using an RP system.

**Exemplifications of Design projects**

A “Photo Studio” project was given to students to design a space with images or video projections as background for customers to take pictures (see Fig. 2). The configuration of spaces and associated image mapping created specific design vocabularies of forms. Similar project was given to design a building complex at street cor-
ner with advertisement display integrated (see Fig. 3). Enlightened by digital architecture, final results came with free forms and images carefully mapped.

Texture is one of the most important visual factors in illustrating an object’s appearance. A realistic rendering of 3D scenes is appearing with visual details provided. Those design models were very difficult to make. So the demand is to make models of free forms and surface attributes. Before a color RP was applied, the realistic images or objects only exist in a virtual world. A RP output became a solution to create physical objects with the forms and the surface attributes included.

The physical form of a design improved the comprehension of the relationship between forms and images, since the visual depth of both eyes enhances the perception of a 3D form more directly. This visual perception not only makes models out of free form and surface attributes that can be difficult to make manually, but also is important to instructor-student communication in a more realistic manner. The efficiency, which comes from a direct feedback of realistic output, makes design intention clearly defined and straightforward.

A CAAD model output and two rendering modes is shown in Fig. 4. This model, which measures about 6.5x6.5x8 cm, is used to see how much detail a building component can achieve. The RP output is compared with renderings and a filtered image to differentiate their appearances in a real world and a virtual world. The model is also reviewed in an auto-stereographic environment.

**Influences on architecture**

The RP application in architecture is not only a modeling issue, but also plays a role in connecting the virtual world and the real world. It seems a regeneration of virtual design in a physical form can help both students and instructors understand design studio works better. Because the RP process provides a view with a better sense of depth, a combinational experience can be acquired, especially as students can physically touch the models to examine dimensional or textural relationships.

A traditional RP application represents a closed domain in an STL-oriented software environment and model-making process. Formal RP mainly exists in the fabrication of parts in industrial design. But in an open community, RP becomes part of a design visualization system that combines auto-stereographic LCDs for HMD-free display and 3D scanners for data retrieval. Examples show that, in architectural fields, RP is available for different areas of study, such as design theory, construction details, urban environmental models, etc.

The switch between a virtual world and reality enables a two-way channel coming from either side periodically. The geometric objects used to visualize ambiguous spatial relationships can now be presented through the RP process. A direct connection between a virtual world and reality can be achieved. The immersive experience in a virtual world can now be an explicit experience of a physical model too. We believe it
would be valuable to use the neutral characteristics as a physical model for an unbiased representation of virtual artifacts.

The restriction of size and dimension of members in the RP process can be compensated by the visual detail applied through images. The shape of a model is created by binding layers of powder together. The material strength is different from that of a normal linear member made, for example, of wood or steel. So is a two-dimensional surface like a polygon. Delicate part of small or thin size may not be structurally strong enough for supporting itself. A combination of grids with thin panels may enhance the strength of members. However, the lack of delicate details needed for linear members restricts the scale of details that can be produced.

Conclusion and Future Works

The application of a 3D RP machine is part of a design visualization system study that includes a 3D HMD-free auto-stereographic display and a 3D scanner. Future works could emphasize the substantiation of digital data retrieved from most architectural fields for the purpose of object identification, geometry description, and digit reproduction for data referencing or changes in verification purposes. More specific applications of architectural studies would include the preservation of traditional architecture, scientific data substantiation, interference checking, or artistic illustration. It is hope that, with the development of printing technology, a 3D RP machine will be available for common use for fast, low-cost, large-sized concept substantiation.

Acknowledgement

The original models in Fig. 2 & 3 were created by undergraduate student T. J Chang in plain color. The contents of Fig. 4 were made by graduate student J. I. Cheng.

References


