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CADCAMing
The use of rapid prototyping for the conceptualization and fabrication of architecture

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Abstract

The objective of the study is to suggest a methodology for fabricating designs, through the use of rapid prototyping, that are innate to this mode of production. It endeavors to do so by involving a more inclusive sensory spectrum as an essential ingredient in the conceptualization and realization of a design.

Keywords: Architecture; Design; Rapid prototyping; Senses; Avaterial

1. Introduction

It is difficult to deny the impact CAD has had on the profession and practice of architecture during the past few decades. As the preferred medium for both technical drafting as well as graphical visualization computers seem today to be the norm. However, in architecture, a discipline in which the visual only acts as a part of the total sensorial experience, the computer has had an unduly confining, even hegemonic, influence and impact.

The use of Computer-Aided Design (CAM) is still a relatively recent phenomenon in the design related fields. Particularly the additive procedure of rapid prototyping (RP) has thus far only been used within certain sections of engineering [1], medicine [2], and, within architecture, for the production of complex scale models of buildings [3,4]. Similar models can be achieved by other means, but it has proven to be comparatively faster and more accurate to produce them through the use of RP to this level of detail. This practice, whilst certainly an adequate means to an end, still does not seem to reflect or aspire to the fullest potential of this mode of production; it still only manages to 'mimic'' designs made by more traditional processes. RP is rarely used for the production of the final, finished article, something the technology today certainly allows for, nor has it really been used as the inceptive catalyst for conceiving a design, something this project aims to amend.

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2. Background

Rapid prototyping falls primary into two main categories: the subtractive and the additive method. The initial entailing a process in which usually a router 'subtracts' material, through the use of a variety of different routing-bits, from a, usually wood or foam, block which is gradually reduced into a physical replica of the original CAD model. Examples of this kind of production are Computer Numerical Control (CNC) milling, routing centers, and plasma and laser cutting.

In the case of the latter, additive, method, a physical model is sequentially constructed, layer by applied layer (a process referred to as 'stair-stepping'), to finally form an analog facsimile of its digital (CAD) origin. It is this latter additive process this study is exploring.

Of the 30 [2], or so, additive RP processes (also termed, perhaps more accurately, Solid Freeform Fabrication, or SFF), four seem to have become more prevalent than the rest. These four are stereolithography (SLA), fused deposition modeling (FDM), selective laser sintering (SLS), and 3D printing (3DP).

2.1. The RP process

In short, the primary steps in the additive process are (http://www.me.psu.edu/lamancusa/rapidpro/primer/chapter2.htm#rapidmfg):

- The production of a CAD model of a design.
- Conversion of the CAD model into a STL format.
- Slicing the STL file into sectional layers.
- Fabrication of the physical model, layer by singular ascending layer.
- Cleaning and finishing the model.

Here the use of CAD solid modelers, which tend to represent 3D more accurately than wire-frame modelers, is a safer bet. Due to the variety of different algorithms used to denote such solid objects, the STL format has been adopted as the standard by the rapid prototyping industry. This format represents the design as an assemblage of connected planar triangles (like the facets of a cut diamond). Since such planar elements cannot represent curved surfaces exactly, one has to increase the number of triangles to improve the approximation of 'smoothness', inevitably resulting in a larger file size. The third step involves a pre-processing program that slices and prepares the STL file to be built. Most of these programs allow one to adjust the size, location and orientation of the design [2]. This ability is important since how, and where the design is placed on the build platform influences both the piece's strength as well as the time required to build the model. The fourth step is the actual construction of the design. This phase is fairly autonomous, needing little human intervention. The final stage is post-processing. This involves removing the design from the machine and the detachment of any support structures. Some of the photosensitive materials need also to be cured before being used. Most objects may also need some additional cleaning and surface treatment.

2.2. The cons and pros of RP technologies

Some of the disadvantages of the additive process are:

- In real time, the build speed is quite slow. Depending on the required level of accuracy and the size of the design, the process can take from a few hours to a number of days.
- Currently, there are some limits to the size of objects one is able to produce. Most machines can still only fabricate items within the 500 mm cubed volume. There are, however, already a number of exceptions to this rule.
- The number of materials available for additive RP is still somewhat limited, particularly in comparison to those appropriate to CNC milling. Again, however, the number of suitable materials specifically designed for the various RP processes is increasing rapidly.
- The final surface quality usually needs some secondary finishing.
- The completed piece is usually structurally less sound compared to a cast component [2].

Some of the advantages of this procedure are:

- The ability to produce complex and detailed three-dimensional forms. The additive process allows for deep undercuts as well as features such as building