Virtual Reality, Rapid Prototyping and Shape Grabbing

A New Generation of Tools in the Architectural Design Studio

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Abstract. Virtual Reality (VR) and to some extent Rapid Prototyping (RP) are established in the design studios of the more progressive Schools of Architecture; Shape Grabbing (SG) - i.e. the capture of digital information from a physical 3D model - much less so. This paper recounts an experiment conducted by a third/fourth year student which explores one Shape Grabbing technology as a means of closing the VR/RP/SG cycle.

Keywords. Shape grab, laser scan, rapid prototype.

Terminology and technology

Virtual Reality, at its simplest, is the visualization of the 3D form of a building design in a photo-realistic way, which is well established in the design studios of progressive Schools of Architecture. In the Department of Architecture and Building Science at the University of Strathclyde, the VR facility available to students is quite sophisticated: the Virtual Environment Laboratory is a "reality room" similar to a 15 seat theatre with a 5 metre wider / 2 metre high screen curved in the horizontal plane to subtend an arc of 160°. The SGI supercomputer which drives it, generates three views of the virtual world which are "edge-blended" to offer viewers a seamless and dynamic, immersive experience of the virtual world. Students have access to the facility and, increasingly, present their design projects, interactively, to peers and tutors in this immersive environment. The effective use of this facility in the context of the design studio has already been reported in Petric (2001).

Rapid Prototyping technologies have been deployed in a number of engineering design contexts over the last decade. Students from the Department of Architecture and Building Science have access to three alternative RP technologies, the most relevant of which is known as 3D Printing operated within Strathclyde University's Rapid Design and Manufacturing (RDM) Centre. 3D printing works by "drawing" with latex on successive layers of powder in much the same way as a 2D plotter draws with ink on successive sheets of paper. On completion of the operation, the powder which is not bonded by the latex is blown away to reveal the 3D object. The use of this technology by Strathclyde students is described in an earlier paper (Petric, 2003).

Shape Grabbing is a relatively new technology and its potential application in architecture is as yet untested. Technologies exist to scan, with an appropriate laser lens, existing buildings. In this case, a very sophisticated laser scan technology, developed by the National Research Council of Canada and operated by a commercial company Kestrel 3D, is used to scan, by vertical repetitive "slices", a physical 3D model of maximum dimensions of one metre cube.

Concept

The central issue which this paper addresses is the inter-operability, within the architectural design process, of these three digital technologies. Can the designer, from any starting point, move through the VR/RP/SG cycle, as represented in Figure 1?

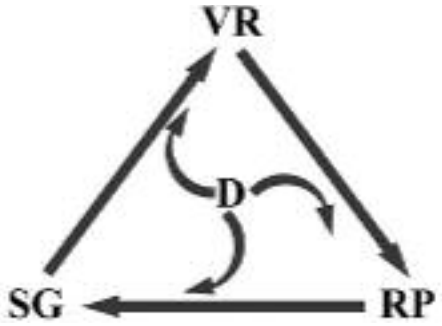


Figure 1. Relationship between VR, RP, Shape Grabbing (SG) and the Design Team (D).

To test the concept, two design ideas were selected with two very different starting points. The first was the student's design for housing in an urban context modelled in Archicad. The second was a fellow student's cardboard model for a transport museum, again in an urban context. The ambition was, starting from these two points of departure in the design process, to progress around the cycle in Figure 1 and to compare the outcomes at each previous and subsequent stage.

Experiments

Under the supervision of the authors the 4th year student undertook two experiments.

First Experiment

In the 3rd year of his BSc (Architectural Studies) course the student had designed a housing complex on a site in Edinburgh Old Town. As a matter of course, he used Archicad to visualize the scheme on a standard workstation monitor and in the Virtual Environment Laboratory. Figure 2a shows the visual impact analysis of the proposed scheme in the context of the existing site.

The digital data relating to the scheme was then passed to the Rapid Design and Manufacturing (RDM) Centre, a facility which is co-located to the Architectural Department. The Centre can accept digital data from a number of 3D modelling packages including Archicad, 3D Studio, Rhino and FormZ; in each case the data is converted into the STL (Surface Triangulation Language) file format, otherwise referred to as stereolitography file, suitable for rapid prototyping. Within several hours a delicate but accurate physical scale model of the scheme had been produced by the 3D printing facility in the RDM Centre (Figure 2b).

This physical model was then taken to the company Kestrel 3D. A number of passes through the laser scanner produced a data file in IGES (Initial Graphics Exchange Specification) format which, when viewed, revealed the image in Figure 2c.

Second Experiment

A fellow third year student had produced an elegant cardboard model in response to a brief for a transport museum in Glasgow (Figure 3a).

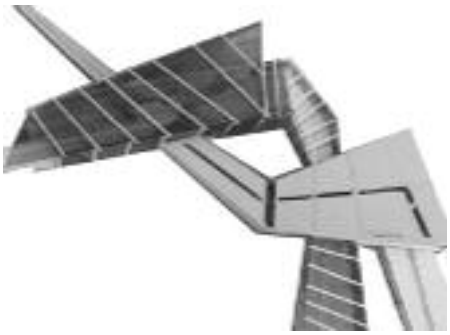
Figure 2a. Photomontage of housing design in Edinburgh

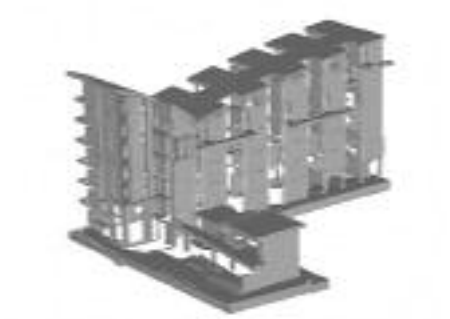
Figure 2b. RP model of housing

Figure 2c. Image of housing from Kestrel 3D scanning

Figure 3a. Cardboard model of a transport museum.

Figure 3b. Kestrel image of a 3D scanned cardboard model.





This model was taken to Kestrel 3D and scanned. Again, a number of passes through the laser scanner produced data in IGES format which, when viewed, revealed the image in Figure 3b.

Remaining Experiments

Viewed in IGES format, the laser scans of the RP model of the housing and the cardboard model of the transport museum re-produce images which have high verisimilitude with the original source of the analogue/digital data.

Regrettably, incompatibilities remain between the IGES data format and those acceptable to other facilities; while images from the 3D scan can be viewed, the data is too "cloudy" to be easily used for rapid prototyping in an STL environment. This issue is well addressed in the paper by Remondino (2003).

Software links are on their way from Kestrel and the last part of the experimental linkage will follow.

Conclusion

The experiments establish that:

1. Starting with a conventional CAD model (Figure 2a) a delightful 3D physical scale model can be produced (Figure 2b); and that such a physical scale model can be scanned (before or after design intervention), to reproduce a viewable digital reconstruction (Figure 2c).

2. Starting with an analogue model (Figure 3a), the scanning process produces digital data which can generate VR images (Figure 3b).

Apart from the problem associated with conversion of IGES to STL data formats, care has to

be taken in two other matters:

i) Data created in a CAD environment using FormZ, 3D Studio, Archicad or similar may have to be modified to ensure that no geometrical member is thinner than is appropriate for the structural integrity of the material being used in the RP process. In the case of the 3D Printer, this threshold is 1mm.

ii) Parts of any RP or hand-crafted model may be occluded in the scanning process, however many "passes" across the object are taken (note the white areas in Figure 2b); this problem may be obviated by constructing the model in parts which make it possible for the scanner to "see" internal volumes.

The concept represented in Figure 1 is, the authors believe, realizable and will offer architects a rich set of opportunities within the design process.

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