Digital prototyping in the architectural design studio

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This paper describes the inter-related use of three digital prototyping technologies by undergraduate students in the Department of Architecture and Building Science at the University of Strathclyde. These are: virtual reality computer graphics (CG), rapid manufacture (RM) of physical scale models from digital data, and acquisition of digital data relating to the shape of a physical object by some form of laser scanning (LS). The paper describes two experiments – one relating to housing, the other to a transport museum – to determine how seamlessly, accurately and usefully the (student) architect can move from one technology to another in the course of design.

Computer graphics, rapid manufacture, laser scanning

The technologies

The use of computer graphics (CG) in schools of architecture is now ubiquitous and some are acquiring advanced virtual reality (VR) facilities which afford a highly realistic simulation of being present within the virtual building. 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 wide by 2 metre high screen The effective use of this facility in the context of the design studio has already been reported (Petric, 2002).

The use of rapid manufacturing (RM) technologies in engineering design is well established and their use in architecture is growing (Ryder, 2002).Students from the Department of Architecture and Building Science have access to technologies, the a which 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.

A number of technological variants exist to capture digital data from an existing physical object (sometimes known as “shape grabbing”), most involving some kind of scanning process. For the purposes of the experiments, the company Kestrel 3D agreed to make its highly sophisticated laser scanner (LS),

The experiments

The intention of the experiment was to determine, within the context of the design studio, how feasible it would be for the designer to enter the technology cycle illustrated in Figure 1 and with what degree of verisimilitude (and ease) the design concept could be passed around the cycle. Figure 1 places the designer or design team (D) at the centre of a triangle of the 3 technologies; computer graphics (CG), rapid manufacture (RM) and laser scanning (LS); the number 1 and 2 indicate the starting points for experiment 1 and experiment 2, described below.

The first experiment, using a brief for urban housing in Edinburgh, involved the student creating a CAD model (in ArchiCAD) for display in the Virtual Environment Lab; Figure 2 shows the visual impact analysis of the proposed scheme on the urban site.

The digital data from the CAD model was then passed to the 3D Printer After a few hours an accurate, if delicate, physical scale model was produced by the 3D printer (Figure 3).

The physical scale model was then taken to the premises of Kestrel 3D. With a model this complexity, the operator must reposition the model on the table and re-scan, a number of times, to ensure that parts of the geometry are not occluded. The outcome is shown in Figure 4.

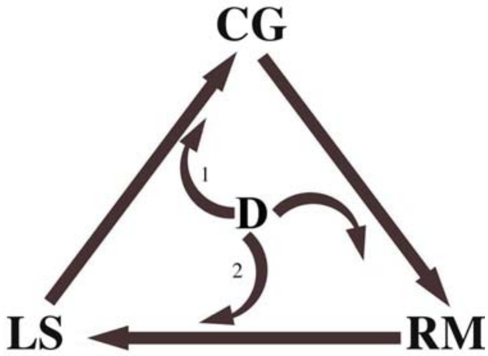


Fig 1. Relationship of designer (D) to the technologies

Fig 2 Computer graphic of housing scheme

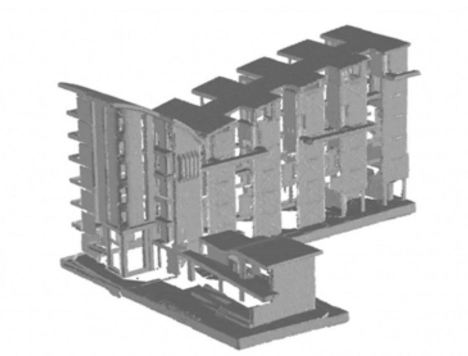


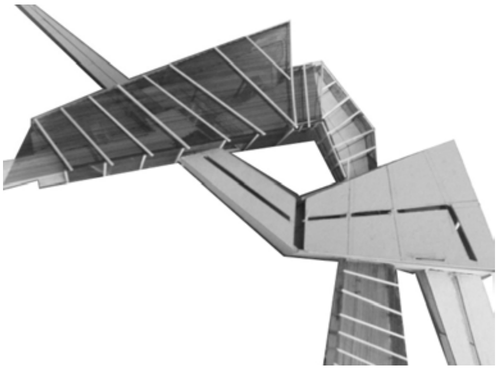
Fig 3. Model produced bu rapid manufacture

Fig 4. Computer graphic image of scanned model

In comparing Figures 2, 3 and 4, the visual likeness of the model in its different manifestations is quite striking, although clearly some geometry has been occluded during scanning.

The second experiment featured a different design brief and had a different starting point. The brief was for a Museum of Transport and the starting point was a cardboard model of a complex geometry proposed by the student (Figure 5) which was then laser scanned (Figure 6)

Comparison of Figure 5 with Figure 6 again shows some verisimilitude between the cardboard model and the image produced by the laser scanning.althoug again geometry has been occluded.



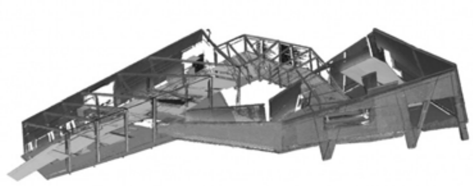


Fig 5. Cardboard model ofTransport Museum

Fig 6. Computer graphic of scanned model

Discussion

The initial intention in both experiments was not only to view, as a computer graphic, the data captured by the scanning process but to pass the data on to the rapid manufacture facility, thereby completing the cycle. To date however incompatabilities between the data format produced by the scanner (IGES) and that acceptable to the 3D printer (STL) are significant and work is on-going to solve this problem.

The other problem is occluded geometry; this may be obviated by constructing the geometry in parts to reveal interior spaces

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

Acknowledgements

The authors gratefully acknowledge the help of Kevin Steele of the Rapid Design and Manufacturing Centre at the University of Strathclyde, Kevin Harvey of Kestrel 3D and two able students Ross Marshall and James Munro.

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