Relating to the 'real'

Perceptions of Computer Aided and Physical Modelling

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Designing - giving form to new objects or environments - is largely a question of anticipating the workings of spatial and material environments, which can become 'reality' only by being built. Until 'realized' a design is essentially a figment of the designer's imagination, although his or her ideas may be laid down and conveyed to others via specialized design media. In this way impressions of the design may be shared with clients, colleagues or other 'actors' in the design process.

Such products of the designer's imaging process can be relatively abstract or begin to approach - future - reality. Form & Media research can be 'revealing', stimulating insights concerning preferences, working processes and the effects of products of the designer's imagination. In the past ten years we have gained considerable practical experience with both virtual and tangible (scale) models. We have compared different techniques in conference workshops, within educational settings and in our Form & Media research laboratory. The research projects ranged from the development of practical techniques and working methods to protocol analyses of designing architects.

This contribution draws comparisons between different computer aided modelling techniques, with an indication of their perspectives, making use of the experience gained from various experiments in an educational context, and will highlight the potentials for different combinations of digital and physical modelling techniques.

***Keywords**: Computer Aided Modelling; Rapid Prototyping; Virtual Reality; Education; Perception.*

Introduction

Apart from the drawing – which is essentially a *two dimensional* interpretation or representation of (aspects of) a design – the architectural *model* is an extremely effective design medium. Characteristic of the model is that, like the building itself, it is a three dimensional object which can be perceived dynamically, even though it is usually 'scaled down' to a manageable size. A typical aspect of classic – physical – model making is that the construction of the model is to a large extent a *building process* in its own right. However, because of the scale factor the design has to be 'interpreted' in such a way that it can actually be made and will 'come across' as a model. This involves a level of *reduction* of the total design information, depending on what the *function* of the model is (sketch, design testing or presentation) as well as the level of *precision* afforded by the relatively small scale. Creating models can also be instrumental in design *related* fields such as analysis and research as well as being used to inform a wider audience, via exhibition or – by creating images taken *from* the model – via publications or websites.

Full scale modelling (http: //info. tuwien. ac. at/efa/ May 2002) is a specialized form of such three dimensional representation and also has a long tradition. The products of this type of modelling enterprise may be mock-ups (usually of some part of a building, details or products) or even comprehensive 'model' environments (which can vary from an 'imitation' of the 'real' object, constructed in makeshift materials, to a complete, working building prototype).

Modelling *in* the computer is in some ways similar to physical modelling, yet at the same time significantly different. The computer can of course be used for drawing, but its true potentials lie in creating – virtual – three-dimensional 'environments'. Working in the computer is essentially working 'full scale', a negative aspect to this 'quality' is a lack of 'overview': to get readable detail one needs to zoom *in*, to get an impression of the total it is necessary to zoom *out* – with a serious loss of visual information. To compensate for this there are many positive points, such as changeability, the use of layers and the possibility to view spatial compositions in different ways, such as: in wire, shaded or rendered model formats (using texture maps), as well as the possibility of 'post production' using graphic editing software.

In virtual reality the model is not only full scale, but perceived dynamically in real time and interactively. Steadily improving computer technologies and perfectionistic modelling will enhance the *illusion* of experiencing something close to 'reality'. Certain extensions can contribute to an 'immersive' experience of the model space, however the standard situation is still one of looking at images 'on a screen': essentially a two dimensional projection of a three dimensional model. Another drawback of the *exclusive* use of the computer is that the results are often perceived as being too perfect: too 'clean', lacking individual expression and the charm of a handmade artefact.

One reaction to this is the inclusion of 'filters' in software to give an image a certain 'feel' (however primitive) and the tendency to once again make hand drawn presentations (often using computer models as an 'underground'). Furthermore, *physical* models still prove to be an important asset, in design *processes* as well as design *presentations*.

In which ways might computer-aided methods and time-honoured model making techniques be used in *conjunction*, rather than being treated as *separate* media?

One way is to use physical models as the basis for computer enhanced visualisations. This essentially comes down to the generation of 'views' from design models (using (digital) cameras), which can then be 'worked up' in the computer: cleaning up imperfections, changing colours and lighting effects, adding in 'samples', such as images of people and furnishings etc..

Another approach is to use the computer to generate (parts of) physical models. In this case – two or three dimensional – computer files form the basis for the 'output' of objects, using specialised machinery. When choosing this approach, it once again becomes important to think in the terms of 'scale', as all of the available 'tools' have their own specific possibilities – as well as limitations…

Some characteristic computer supported modelling/prototyping applications are:

- milling machines;
- knife and laser cutters;

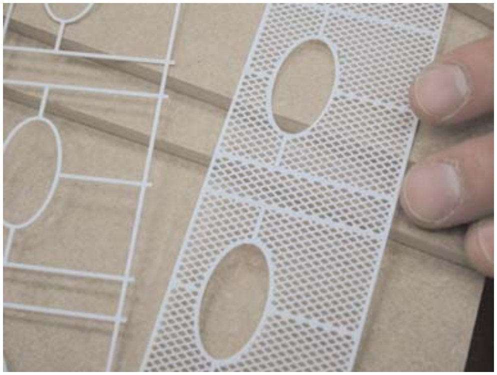

Figure 1 and 2. Milled fencing and window frames (scale 1:50) in 0.2 mm airbrushed plastic.

- bending machines;
- 3d ‘printers’.

The first two categories basically are *subtractive* (taking material away), the third can be said to be *manipulative* (changing the form of an object), and the last is in principle *additive* (usually building up a three dimensional form in layers). 3D printers belong to a field of technical applications also known as *rapid prototyping* (for an overview see e. g. http://rpdrc.ic.polyu.edu.hk/content/rp_for_arch_short_guide.htm May 2002).

The result of such an activity can sometimes be the ‘end’ product, but in most cases there will have to be some form of (manual) finishing work (assembling parts, painting etc.). The generated form can be a ‘positive’ form, but may also be developed as a *mould* in which the objects or components are cast.

The above techniques can be used for making models – to various scales – but also for the benefit of creating *full-scale prototypes*. Of particular interest is the development and testing of building components for designs with *complex* geometries.

Experiments

After performing an extensive ‘market’ investigation for all sorts of rapid prototyping techniques, we have come to consider a selection of techniques as specifically interesting for the *intensive* use in an educational setting.

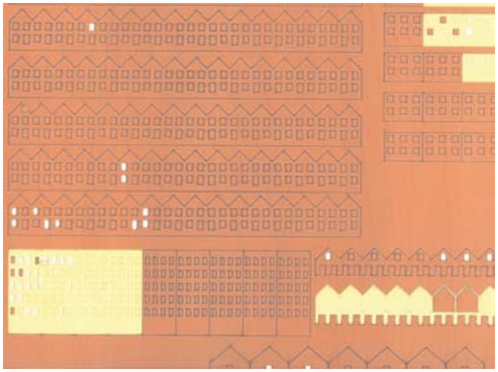

Figure 3 and 4. Laser cut facades (scale 1:1000) in 0.5 mm wood veneer.

A computer driven 2D milling machine can be used for thin plates of plastic, wood, veneer or metal. This technique is specifically useful to prepare the finest parts of a handmade scale-model. Facades and, for example, curved ground plates of landscape models can be prepared much more easily and precisely by computer driven 2D milling machines than by hand (figures 1 and 2).

Another technique for operation of thin plates is laser cutting (figures 3 and 4). This works as simply as a pen-plotter, though care should be taken with the laser light (hazardous for the eyes and the risk of fire) and the proper removal of fumes.

A safe, clean and productive rapid prototyping technique that competes in cost and visual charm is known as 3D printing. The technique from Zcorp which we explored (www. zcorp. com May 2002) works with a water-based liquid deposited (like in a jet-printer) on a thin layer of powder. The powder layers solidify by means of the binder liquid, the unused powder performs as a temporary support for the next layers. A typical 3D-model of a house (scale 1: 50) can be printed in two hours (figure 6). This process also produced particularly interesting results on the level of building components and details (figure 5). The printer can be fed with STL and VRML files from CAD programs like AutoCAD, ProEngineer, Maya and 3D-Studio-Max. This technique allows the designer to explore and adapt both the CAAD model and the printed model. Thus a rapid design cycle can be realized, in which the physical and the virtual model influence the thought processes.

Conclusions and future expectations

CAAD gets an extra dimension when techniques are used to 'relate to the real'. In one way, 'the real' can be involved in 'the virtual' by means of e. g. photogrammetry and texture mapping. The other way round is 'computer aided manufacturing (and *modelling*) '. CAM can make CAD *tangible*. All of these techniques can contribute to a better evaluation of the envisioned design product. Different media 'talk back' in different ways. The *combination* of techniques can make things particularly interesting, giving the designer added insights and more means to (re) consider and refine a design.

In the coming years we intend to incorporate the 2D milling and 3D-printing techniques actively in the educational curriculum. Especially the 3D-printer is expected to provide rapid prototyping means to study architectural concepts using different *scales* and varying *applications*. A step towards preparing the students for a building practice in which (parts of) buildings are increasingly 'computationally tailor made'.

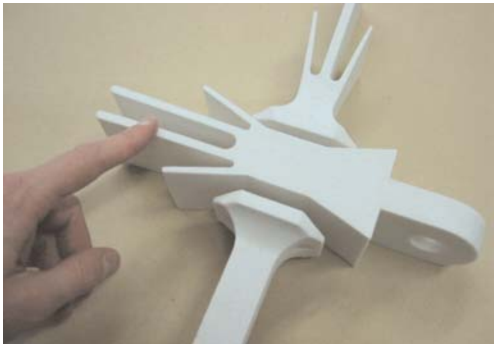

Figure 5. 3D printed construction details (full scale model) from starch based powder.

Figure 6. 3D printed house (scale 1:100) from plaster based powder.

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