DIGITAL MODELS OF BUILDING FORM

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SUMMARY

Some characteristics of digital 3D models of building form are discussed. There are aspects of materiality and location-in-context in making digital models that are more developed than in conventional physical models. Site, light and shade, texture and pattern, and colour and translucency can all be expressed more convincingly than in physical models. This leads to the emergence of symbol systems that map differently on to the building being modelled. There are also fundamental differences in the way digital and physical models are presented and viewed. A physical model is available in its totality for the viewer to shift attention rapidly from detail to whole. A digital model is typically represented in a narrative, where a story is told by the model builder using images and animations, or as a space to be explored, where the viewer builds up a mental picture of the modelled building through interactive manipulation of the model.

INTRODUCTION

I enjoy drawing. I take pleasure in the feel of the pencil in the hand, the action of making a mark, and the subtlety of control through pressure and angle that can be exerted on the tool to vary the character of the resulting line. I also enjoy making rough but crisp form models with cut and glued card to test design ideas, watching the model take shape and lifting it to eye level to explore the emerging form. But I do not enjoy the mess that always seems to result when I make a model, or the difficulty of cleanly altering one of my drawings.

Figure 1

Making digital models (figure 1) has different pleasures. There is a ‘glass wall’ between the physical and digital worlds, and making objects in the digital worlds lacks the tactility and immediacy of making objects in the physical world. We have to operate through instructions, selecting tools while frustratingly never being able to directly ‘grab hold’ of the object we are making. In this different craft I still enjoy watching models take shape and seeing form in projected light and shade. The relative safety offered by the ‘infinite undo’ command by which changes can be undone encourages risk taking and exploration. And when I am making a digital model the mess I make is neatly contained within the digital world, not on the table and floor.

In this paper I draw attention to aspects of the ‘materiality’ of digital models. I argue that in several respects the digital model, perhaps unexpectedly, makes connections with the ‘real’
physical world that are stronger than those of physical models. These include the presence of site and sun context, the depiction and understanding of space, materiality, a sense of construction, and connections with ‘reality’ in the way that a model is presented to viewers. It is important to note that drawings and physical models are re-created as a design develops, whereas digital models are edited. Drawings and physical models in design are episodic; they contribute to and record a stage in the design process and are then replaced by further drawings and models. Producing the next generation takes a similar time whether changes are major or minor. In contrast, digital models evolve. They are edited and added to rather than recreated, so that somewhere in the late-stage model data may be remnant elements from the earliest exploratory stages. Minor changes are easy, but major changes are hard.

While quick ‘studies’ of the form of building elements have a role in designing with digital as well as physical models, I shall concentrate in this paper on the modelling of a building as a whole.

**DESIGNING IN CONTEXT**

The ‘always available’ site model is the first component in the connection between models and the ‘real’ world (figure 2). While a site model can and often is made for a physical model, its fixed-scale nature means that a site model at, say, 1:500 can only be used with an outline form model of the building design at the same scale, not (self-evidently) with more detailed models at 1:100 or 1:20. Because digital models are not made at any predetermined scale but use ‘real’ dimensions and are viewed to fit the purpose, the site context is always available. A designer using digital models will change the scale of views frequently, checking the effect in the context of the site of changes made to aspects of the design. Context is also important when views into and out of the building, urban or landscape design, shading and insolation are considered. This ease of seeing the model under sunlight conditions, with shade and sun patches, is a second connection with the ‘real’ world. This is particularly important in teaching building design, where students often appear to design buildings-as-objects divorced from their environmental context.

![Figure 2 Site context model for designing a house](image)

Context extends to the detail. In the same way as the building can be seen in the context of its neighbours or surrounding land form, a model of a detail can be seen in the context of the building as a whole. When students are making CAD models of their designs, they are often encouraged because of limited time to model only a fragment in detail while providing an outline of mass of the rest of the building. This ‘sampling’ is akin to the careful rendering of only a segment of a hand-drawn elevation. Strangely, both hand drawing and image of computer model often look better when the detail is rationed.

**ALTERNATIVE WORLDS**

A record of the state of the design can be made and stored at any time, and models can be duplicated so that the record of design development can fork, with two models being used as the basis for different design moves. Cloning physical models is difficult. More interestingly, within a single digital model can be alternative representations of the same building or part, and alternative designs for the building or part. The former is useful as a means of making representations of ‘pure’ form while also making representations of surface qualities. The
latter is useful in exploring design options (figure 3) or keeping models of the design as it develops. Both may be useful in constructing a narrative about the scheme, as described later in this paper. The digital model, then, has (in the terminology of CAD) multiple layers of representations which may map on to multiple layers of meaning.

Figure 3 Models of alternative building forms for a house, seen from the street

SPACE AND VOLUME

A first point concerns the ‘creation’ of space in a model. In a digital model it can be (and often is) represented directly as an entity, as a volume instantiated through parametric primitives. In a physical model it is almost always defined implicitly by making and positioning the bounding surfaces. This direct ‘working with space’ facilitates an abstraction which ignores the nature of the boundaries and concentrates only on the spatial geometries and intersections. The Boolean operations available on solid modelling systems make such play with volume models of space quick and fun. It is particularly useful when students are learning about space and volume.

A second point concerns the way space is perceived in the representation. Renderings of digital models are poor in depth cues; the distant object looks as clear and close as the near object. Vision provides natural depth cues when looking at a physical model, where depth is quickly established by stereoscopic vision and enhanced by moving the eyes slightly relative to the model. Manual renderers of perspective and elevation views use relative line weight and colour intensity to indicate distance. One would think that it would be a fairly simple programming task to make renderings of model views that ‘fuzzed’ the more distant objects, but I have not seen such a system. This makes the images curiously flat.

Figure 4 VRML model of an urban neighbourhood (model by Tapani Launis) where exploration is driven by the viewer using controls at the foot of the screen.

There are other aspects of digital models, though, that work to enhance the sense of physical space as experienced in a ‘real’ building. Animations can constrain the view to eye level and direct a realisable sequence, such as moving towards and into a building. A VRML model is better in shifting control to the viewer (figure 4). Such images lack content at peripheral vision, so that the experience of space is different to reality and is itself a representation. VR models seen in a ‘cave’ or through ‘VR goggles’ provide more peripheral vision and a real sense of three dimensions, but the convincing visual depiction of movement while the body is
still does not mirror the physical experience of space and is, for most people, distinctly unpleasant.

**MATERIALITY AND SURFACE**

My own favourite material for physical models is white or brown card. I do not attempt to model the texture or colour of surfaces; doing so tends to result in something which looks as if belongs in a model railway set rather than an architect’s office. Other than what can be expressed as form and volume, materiality is left out of the modelling agenda. In a digital model, however, I do use and exploit representations of surface textures, colours and transparency. These are employed as a coding for another level of design information in the process of developing a design. Using this coding emphasises the notion of making a building out of real, physical materials with their own characters. It begins to indicate the contrasts and balances achieved when different materials are placed together. Typically, the surface rendering overstates the degree of colour and texture that would appear in a building, and this, too, has to be read as a symbol system rather than as a ‘photorealistic’ image (figure 5).

![Figure 5 Materiality: a ‘pile’ of building materials, and the Pittwater House (architect Richard Leplastrier) modelled to emphasise surface texture (model by Henry Williams)](image)

Coupled with the representation of surface qualities is the modelling of light transmission and reflection in a CAD systems. Beginning students experimenting with a CAD modelling program such as FormZ seem to be particularly keen to use highly reflective and translucent surface qualities, producing glossy images of models with high degrees of inter-reflection. Used well, qualities of surface and form can be apparent in digital models that cannot be approached in physical models. If used with restraint, an apparently photo-realistic image can be obtained (figure 6) – although ‘realism’ is not necessarily an indicator of accuracy in the representation.

![Figure 6 Model of entrance with surface texture, light transmission and reflectance approaching ‘photorealism’ (modeller Adrian Price)](image)
CONSTRUCTION DETAIL

Surface qualities and materiality leads to a sense of making, of construction, in the model. In the card physical model, little sense of construction is generally desired or achievable. In the digital model, construction can be modelled in great detail, literally adopting a ‘nuts and bolts’ approach if desired (figure 7).

Figure 7 Model of the Manson House (architect Rex Addison, modeller Jamie Gill) with cladding ‘turned off’ to reveal timber studwork, and extract from a model of the Mackerel Beach House (architects Allen, Jack and Cottier, modeller Peter Charles) where bolts are part of the aesthetic – and part of the model.

Modelling a building at this level of construction detail requires almost as much construction information as physically building the same building. Even with a set of working drawings, the modeller must interpret 2-D information into coherent 3D form. The modeller has to make sometimes arbitrary decisions; both builder and modeller had, for example, to decide exactly where to place noggins on the wall of the Manson House shown in Figure 6, and the chances of builder and modeller making exactly the same decisions are remote. In this sense, too, the digital model is using a symbol system to represent a stud wall, but a system apparently closer to ‘reality’ than in conventional working drawings. As more 3D ‘working drawings’ are used in the construction industry, we can expect the development of code systems which will indeed probably be ‘closer’ to built form than is used in 2D drawings, but still recognisably codes of some kind. A builder will come to understand what in the model corresponds geometrically to the expected built form, and what is symbolic. In student work, representing construction in a digital model of their designs can be immensely time consuming but is highly effective in promoting an understanding of ‘making’ architecture with its interrelationship of aesthetic and construction issues.

NARRATIVE AND EXPLORATION

The perception of space has been discussed earlier in this paper, with reference to animation and VRML as modes of describing space. An animation is a narrative, in the sense that the author (director) of the animation decides how to tell the story of the building which is featured. A common narrative theme is the ‘visitors experience’, where the animation begins with an approach to the main entry and then moves through the doors to the entrance hall, then on through the main rooms. This ‘walk through’ may be accompanied by a ‘walk around’ or a ‘drive past’, and often by a ‘fly by’ showing overhead views – not commonly seen by a human experiencing a ‘real’ building, but useful in imparting a sense of the whole and serving the same kind of purpose to looking down on a physical model. The noteworthy issue here is the much greater control of the presentation of the model by the author than is possible with a physical model placed before an audience.

A Microsoft Powerpoint® presentation is also a narrative (figure 8). Like an animation, it tells a story about the design and model using images – some at scales to suit an appreciation of how the building fits into its context, some at scales to suit an appreciation of the building form as a whole, some showing details, mixing external and internal views. Images may also show options, and a drama in which the designer enacts the story of deriving a design, as in a flight simulator the user "enacts the storey of one particular flight." (Ryan, M-L. 1994, para 25)).
Some images may be overlaid with diagrams and annotations. Some may show different representations: images of the model showing only volumes, images showing various stages in a construction sequence, images showing isolation of the building or its overshadowing of neighbouring properties at critical times. There may be images showing overlooking into or out of the building site. The point I want to make is that this narrative is constructed from the elements of the single digital model, through a careful control of what is ‘turned on’ or ‘turned off’ in the model image, type of rendering, viewpoint and scale.

Figure 8 Sequence of images in a Microsoft Powerpoint® presentation (Jamie Gill)

While narrative is one metaphor for showing a digital model, exploration is another. Given the model itself opened in a CAD system, the operator will come to understand it by selecting views at various scales from various positions, and ‘turning on and off’ the various layers of which it is structured. More commonly, the model is translated into a VRML format, leaving viewers to ‘look around and walk around’ under their own control. A web site typically combines aspects of exploration and narrative. The site itself is a tree or net to be explored, and may contain VRML models which are also to be explored. It may also contain narrative, where a sequence of pages on the web tell a story, perhaps with animations. A Powerpoint® presentation may also contain animations or VRML models.

Once made, a physical model is ready as an object to be viewed. A digital model is just the beginning; how it is viewed needs to be designed, scripted and directed.

CONCLUSION

I have argued in this paper that digital models can be more effective in representing and suggesting materiality than physical models. This is due to the overlaying of multiple representations in a single model, the ability to ground the way that it is seen from eye level, the simulation of sunlight and shadow, and the rich mapping of surface qualities. But digital models do not replace physical models. Both the quick, cardboard design model and the precise, detailed presentation model have an immediacy and presence that eludes their digital counterparts. My impression from visits to the offices of ‘leading’ design architects suggests that many, but not all, use both computer and traditional model making techniques. We encourage students to do the same. It is also notable that the making and presentation of digital models reveals individual styles and character in the results, akin (although often not as marked) as the development of individual styles in making physical models and drawings.

I noted early in this paper that while physical models and hand drawings are episodic (each stage of development is re-presented in new models and drawings), digital models and drawings evolve through editing and changing of a continuing file. Minor changes to a digital model require correspondingly minor work (how much depends on the nature of the modifications), whereas major changes may involve daunting amounts of work to create a wholly new model. There is therefore a tendency to inertia when a complex digital model has been created. It is not uncommon to find a student radically redesigning a project in the last moments of a design studio, when she or he has finally come to grips with the issues and found a ‘better way to do it’. Such radical change can be accommodated with manual media, but not with digital media. Interestingly, this is also an issue with the development of 3D working drawings. While the notion of building a complete digital prototype before attempting
to build ‘on site’ is attractive, one of the difficulties is handling late and on-site changes – rife in the development process.

Using both digital and physical models, then, is not merely a temporary transitional stage but likely to be a permanent situation. The two come together with ‘rapid prototyping’ techniques, where digital models are the source of data for the automated machine production on physical (nylon) versions. Still little used in architecture, the relaxed mixing of digital and manual techniques in the creation of parallel manual and digital models is a likely feature of future practice – but then the physical version takes on the character of physical models, and leaves behind the qualities of digital models. It is equivalent to a printed 2D image, useful but not replacing the digital version.

In this paper I have concentrated on the modelling of buildings which are intended to be buildable on ‘real’ sites. In digital modelling the surreal is never far away (figure 9). Modelling the un-buildable (with elements that do not join, structure that ignores gravity, different elements occupying the same volume, and more than three dimensions) is indeed easier than modelling the buildable. Sometimes the surreal is intended, a play on design ideas, but often it lurks in the apparently ‘real’. Virtual architecture for its own sake is a fascinating topic – but beyond the scope of this paper.

**Figure 9** Towards the surreal: model of the Israel House (architect Peter Stutchbury) transposed from eucalypt hillside to glassy lake (modellers Basil Genimahalixiotis, Jarad Wilson and Jamie Gill)

**REFERENCE**