WHITE PAPER - BEYOND PHOTOREALISM

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Computer rendering has come a long way, in the last twenty years. But is it going in the right direction? Is the glossy photo-realistic image the only goal worth pursuing? And does the process of making it contribute enough to the design, or the ongoing dialogue with the client?

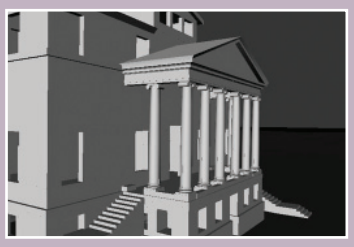

Fig. 1

There certainly are alternative modes of image-making. Frank Lloyd Wright, according to legend, could conceive a whole building in his head, and set it down rapidly, in plan and section. He would leave these drawings overnight to his assistant, who would set up a perspective. In the morning, FLW would spend an hour or two completing the rendering, ready for a lunch-time meeting with his clients. Today, many architects use their computers in the same way as FLW used his night-staff, to set-up an outline perspective, over which a rendering is produced by hand. Students, we observe, will often attempt to complete the rendering using a paint program such as Photoshop to apply textures and entourage in a kind of electronic collage.

Fig. 2

These familiar processes differ from photo-realistic rendering in three important ways. First, the process is split into two - perspective projection (which deals with geometry) and rendering (which deals with surface appearance). Second, the aim is to make a picture, not a simulated photograph. Third, the final rendering stage involves direct manipulation of the medium employed, with immediate hand-to-eye feedback. This is qualitatively different from laborious process of setting up material parameters for photorealism, waiting for a trial rendering, seeing what is wrong, adjusting the parameters, rendering again and so on.

Fig. 3

Figures 1-3:
The geometrical part of rendering results in three channels of information - the rendered image, the Z-buffer, and the material buffer which distinguishes visible elements, here ground, sky and building.

The Martin Centre has been investigating an alternative approach for several years. The result (known as Piranesi) can be regarded as a three-dimensional paint program, or alternatively an interactive renderer. Though capable of photo-realism, it places no emphasis on the physical simulation of light, but offers a much wider gamut of representations.

To use Piranesi you first set-up a model and render it simply, without textures. The result is saved, usually as a monochrome image, in an extended TIFF file, which includes two extra channels. One of these channels is the Z-buffer, which expresses for each pixel how far it is from the observer. This information is calculated by most renderers, but is usually discarded. The second channel is a Material buffer, which codes the layer, object class or material type of whatever surface has been rendered at that pixel.

Piranesi itself loads this file, displays the image, and presents an interface similar to a paint program, with familiar tools such as the brush and the paint-bucket. A less familiar feature is called Matting, which replaces the laborious use of selection masks necessary in conventional paint programs. If Material Matting is switched on, a brush stroke is confined to pixels of

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a single material. If Plane Matting is switched on, the stroke is confined to pixels lying in a single plane - for example a single face of a cubical object. This astonishing trick is done by reference to the Z-buffer, from which the orientation of the surface at any pixel can be deduced.

The three-dimensional nature of Piranesi, as opposed to a paint program, is most vividly shown by the way it pastes in elements of entourage, such as trees or figures which we term cut-outs. A cut-out is a separately scanned image, which might be a photograph or a drawing, provided with an alpha-channel, which specifies its shape and transparency. When a cut-out is positioned, its size is modified according to the Z-buffer value of the pixel at which it is placed. So near trees are large, far ones small. Furthermore, if the tree is partly obscured by other elements in the scene, the hidden parts are suppressed correctly.

Cut-outs can be planted frontally, like trees, or oriented onto a surface like a creeper growing up a building. In either case, the cut-out modifies the Z-buffer and the Material Buffer, so that it can be over-painted selectively, and can hide or be hidden by cut-outs introduced later.

Painting with Piranesi is largely a matter of painting with textures. Like cut-outs, textures can be scanned from photographs, but hand drawn textures are often superior, and natural materials have interesting possibilities. Alternatively three-dimensional solid-noise textures can be generated procedurally. The way textures are defined is much the same as in a conventional renderer, but the way they are applied is quite different, as they are painted onto surfaces directly, and can be faded, rescaled, overlapped and otherwise modified in a way which is completely impossible with a batch-mode program.

Textures can be mapped into perspective (again using the Z-buffer for the essential information), but equally they can be applied in a two-dimensional sense, flat on the image. So, for example, brickwork might be hatched by courses correctly oriented in perspective, while shadows are superimposed at a conventional 45 degree angle. The two-dimensional texture can also be used to simulate the “tooth” of paper or the weave of canvas.

Textures can have alpha-channels like those in cut-outs, giving them variable transparency. These can be used for glazing-bars in windows, palings and balustrades.

We have a special interest in the grossly neglected area of black-and-white rendering, corresponding to the traditional techniques of ink drawing, etching and engraving. Here the colour of marks is constant; light and shade is obtained by altering their thickness or density. Piranesi has a special way of applying textures (called thresholding) which gives just this result.

In addition to these basic painting techniques, Piranesi has three “special effects”, not obtainable in ordinary painting programs because they are

Fig. 4

Fig. 5

Figures 4 and 5: Alternative renderings of the same model of Palladio’s Villa Malcontenta, using multi-layered textures, cut-outs and partial demolition.

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based on the Z-buffer:

- Edge drawing looks for discontinuities in the Z-buffer, and makes a mark according to how great they are. This results in a "hidden line" drawing of great sensitivity, as contour edges are emphasised, while changes of orientation are lightly indicated, and shadow edges do not show at all. This is commonly used on a blank screen, as a way of starting a rendering, or alternatively towards the end of a rendering, to emphasise edges.

- The "Kango" tool is used to alter the Z-buffer, making it rather easy to demolish part of a building, to render ruins. It can also be used to fill-in missing planes - for example to put glazing in openings, which can then be overpainted, perhaps with reflections.

- The Fog brush gives a density of effect which is related to distance. Usually this is measured into the picture, giving a conventional fog effect, thought it can be brushed and textured. But it can be reoriented, for example to give an effect like mist rising from damp ground.

Once an image has been rendered in Piranesi, it can be re-input and rendered again. For example a fairly bare CAD model might be rendered once to get some distinction between materials, add a sky background, and insert some figures and planting, all done in grey scale. Then the image can be re-input and rendered in a black-and-white style, using thresholded textures and the Edge effect. The cut-outs added at the first stage make their mark in the Z-buffer, and so are included in the second render.

Photorealism has been espoused by the computer graphics community because of its determinacy. If you specify all the light sources, the optical characteristics of all the materials, and simulate the physics of light with the utmost fidelity, then the resulting image is fully determined; there is nothing left to the imagination, and it is the ideal subject for a computer program of the old-fashioned kind. But this hardly meets the needs of a visually oriented profession, which is accustomed to using images day in and day out, and sweating the maximum benefit from each one. Imagination has to be let back in. This Piranesi does, with a considerable number of benefits.

The photorealistic image tends to be read as a complete, definitive statement. It is non-negotiable. Sometimes this is appropriate, but there are many times when something fuzzier, more tentative is called for, either because ideas are only partially worked out, or to encourage discussion. Piranesi images can contain any amount of "noise" which people will tend to interpret according to their own predilections. Such images stimulate the imagination, rather than suppress it; and as an added benefit, require less geometrical detail in the original CAD model, and so are both economical and especially appropriate at the early stages.

Photorealistic practice ignores the selectivity which is fundamental to all

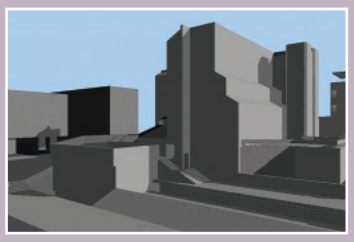

Fig. 6

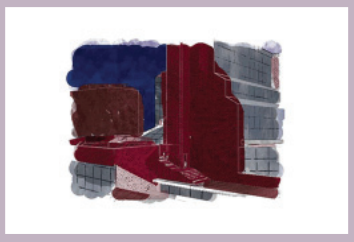

Fig. 7

Fig. 8

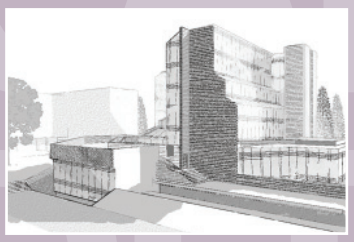

Fig. 9

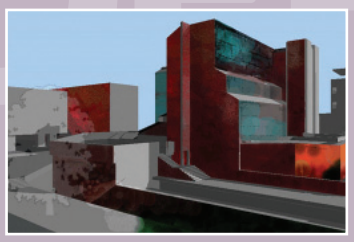

Fig. 10

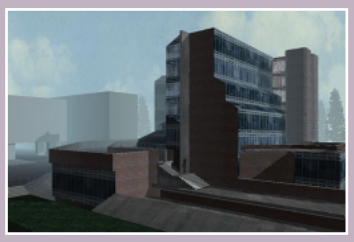

Fig. 11

Figures 6-11:
From the same basic rendering (Fig 6) of Stirling's History Faculty, Piranesi can produce a range of treatments varying from the abstract to the semi-photorealistic (Fig 11).

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kinds of drawing. Everything is rendered in the same way, with the same amount of detail. Piranesi offers infinite ways of foregrounding the subject, by modifying its weight, colour or textural detail, and reducing background by fog, blur or vignetting; and this hardly requires conscious effort. The way we judge these renderings has shifted – we are no longer talking about technical virtues such as the smoothness of shading, the sharpness of textures, or the size of highlights, but are concerned with their pictorial qualities, of how they focus an issue and stimulate the imagination or support an argument.

Fig. 12

Office interior using photgraphic textures and cut-outs mixed with painted light and shadow, and some heightening of edges, taking a few hours. Setting up textures in a photorealistic renderer to get a similar effect would probably take as many days.

Piranesi uses the computer as a medium - not a simulation of a traditional medium, but something unique and new, a three-dimensional paint-box. Behaving as a medium is quite different from behaving as a heavy duty analytical engine, which is what the normal photorealistic renderer is. The fundamental difference is that there is an immediacy to the result, you see the effect not a few minutes or a few seconds after you make a move, but continuously, within milliseconds.

This effect, of a complete connection between what you are doing and what you are seeing, is even stronger if you use a tablet with a pressure sensitive stylus. You now focus entirely on the image, rather than on the process of making it, and the work flows. With traditional paint programs this flow keeps breaking down, because you have to make selection masks for nearly every operation.

Fig. 13

London street scene rendered in black and white using hand drawn and as-found textures, some applied in perspective, some in screen space.

Piranesi uses Matting, and does not even have a selection tool. It also avoids any kind of numeric input (sliders or direct manipulation instead), and is very close to being keyboard-free. The consequence is that Piranesi is a fast, expressive, absorbing, and uniquely enjoyable way of rendering images on a computer.

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This article was first published in the Architects Journal, 12 June 1997. At the time of writing, Paul Richens was Director of the Martin Centre for Architectural and Urban Studies at Cambridge University. He is now Professor of Architectural Computing, and Director of Research for the Centre for Advanced Studies in Architecture at the University of Bath's Department of Architecture & Civil Engineering.