THE USE OF INTEGRAL IMAGING TO REALISE 3D IMAGES, IN TRUE SPACE

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Intoduction

For the past two decades my work as a fine art sculptor has been largely based within the cyber environment. I first used CAD as a tool to design actual objects, but more recently I have come to see it as a medium in its own right. Unlike traditional media the trans-physical aspect of the cyber environment provides new possibilities for sculpture and radically changes traditional modes of expression that were defined by gravity, scale and material limitations. Sculptors are now free to build objects that defy natural laws. In this paper I shall explain the advantages of using integral imaging to view objects in true space.

Context

One of the main differences between modeling in the cyber environment and traditional means of modeling is that objects and their surfaces are able to pass through each other without resistance. It is not possible to push a plastic material through another so that they both share the same x, y, z, location in space. This possibility facilitates a completely new way to conceive of form, thus constituting a paradigm shift in the design of three dimensional objects. One central theme in my use of the cyber modeling environment has been to explore the possibilities of the torus knot. This generic primitive is more versatile than others since it has a variety of adjustable parameters. I have used a variety of solid imaging devices to output objects produced in this way and although they are able to replicate the outer surface of the form of the sculpture, the inner workings of the topologies of the form are obscured, even when using transparent materials in the manufacturing process.

In Fig. 1. the surfaces of a torus can be seen to pass through itself because the sum of the diameters in the cross section is greater than the overall diameter of the torus.

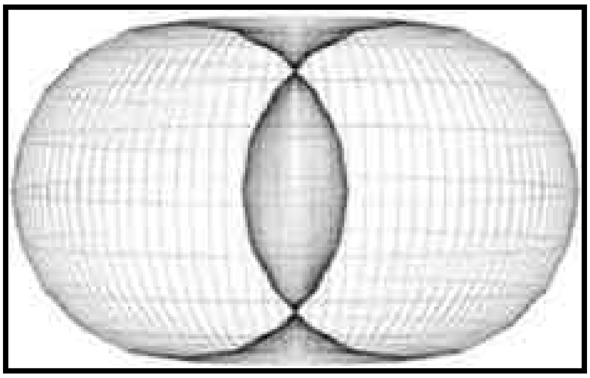

Fig.1. Illustration of a torus with intersecting surfaces.

Fig. 2. Rapid Prototype

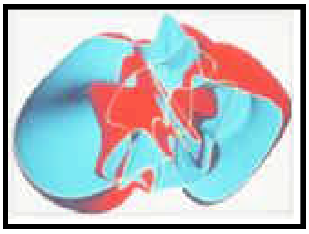

Fig.3. Cross section

In Fig. 2. elements of the object can be seen to pass through each other but the opaque nature of the material prevents the interior to be seen. A cross section, showing the interior of the object using a computer program called Solid View reveals the complexity of the internal topology Fig. 3. Even with transparent resins such as stereo lithography, as shown in Fig. 5, solid objects don't display the internal geometry as seen below in Fig. 4.

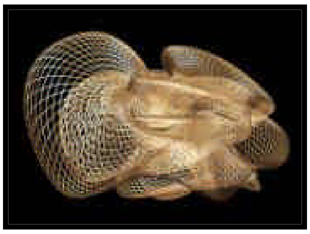

Fig. 4. Wireframe render

Fig. 5 Stereo Lithography

Screen Based Integral Imaging

Three dimensional image display systems give a sense of improved realism over conventional two-dimensional systems, by offering both psychological and physiological depth cues to the human visual system. The addition of parallax information creates binocular disparity, giving rise to depth perception. Most three-dimensional display systems use stereoscopic techniques to stimulate binocular disparity and binocular convergence. Stereoscopic systems, however, do not always offer comfortable or natural viewing; additional cues such as motion parallax and accommodation should also be exploited. Integral Imaging is a three-dimensional display technique, first proposed by Lippmann in 1908, and further developed by others since that time, which overcomes the limitations of purely stereoscopic systems by including these additional cues.

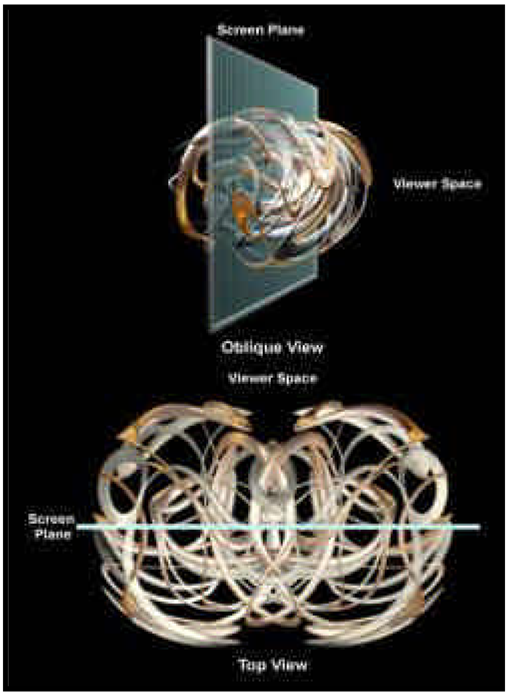

Fig. 6. Screen plane showing the position of the integral image

In the above diagram, Fig. 6, the integral image can be seen to reside on either side of the picture plane, with 50% in front and 50% behind. This generates a full three dimensional image which can be viewed in true space without additional apparatus. This technique facilitates the display of objects of complex topology and with varying degrees of transparency, and which allows the viewer to see into the interior of the sculptural object and to examine it from a variety of viewing positions and from different angles.

In more recent experiments, in conjunction with the company Create 3D who specialize in the research and development of integral imaging, it has proved possible to position the entire integral image in front of the picture plane presenting significant philosophical and psychological implications.

In the example below, Fig 7 & 8, all of the three dimensional information can be seen to exist in real space, not pictorial space, and where light is seen to reflect from a three dimensional entity without a physical body. In the actual integral image it is possible to place your hand into and amongst the objects that appear to float weightlessly in front of the picture plane.

Integral Projection Systems

In addition to the screen based techniques experiments with integral projections systems have also proven to be very successful. The first of these systems was developed in collaboration with the 3D Imaging Technologies Group at De Montfort University (DMU). The prototype projector was built at Manchester Metropolitan University (MMU) using specifications provided by the 3D Imaging Technologies Group and exhibited in MMU's Righton Gallery as part of an international exhibition of digital sculpture called Intersculpt 2001.

Having first seen photographic integral images projected in the laboratory at De Montfort University, I realised the potential of this technique for use in sculpture-installation and proposed to make an installation using a computer cyber-object. After discussion with the 3D Imaging Technologies Group, it was decided to aim for an object 1.5m x 1.5m x 1.5m using the in-house hardware and software at De Montfort University. This necessitated the design of apparatus to accommodate both the requirements of the technology, spatial logistics, and the aesthetics of the installation.

For the computer generation of the source image to be used in the large screen integral installation, the scene data has to be transformed (scaled) by a large aperture objective lens. This “virtual” objective lens was created with the same parameters as the “real” projection lens used in the integral projector, see Fig. 9. This ensures that the projected image is correctly scaled back to full life-size. In this it would be possible for the viewer, looking through the beam splitter, to see people walking through the cyber-sculpture, appearing to occupy the same space as the floating sculpture. A CAD simulation of the sculpture installation is shown in Fig. 10 below.

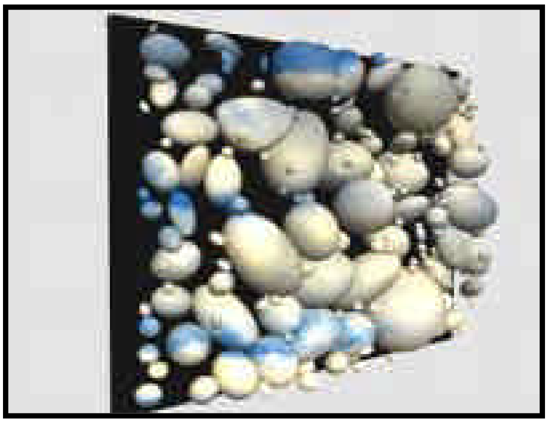

Fig. 8. Integral print (3/4 view).

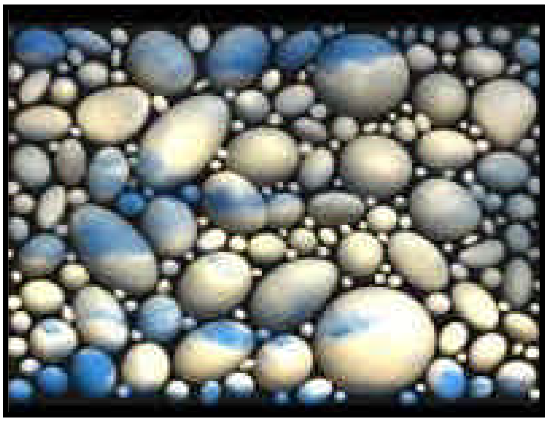

Fig. 7. Integral print (Front view).

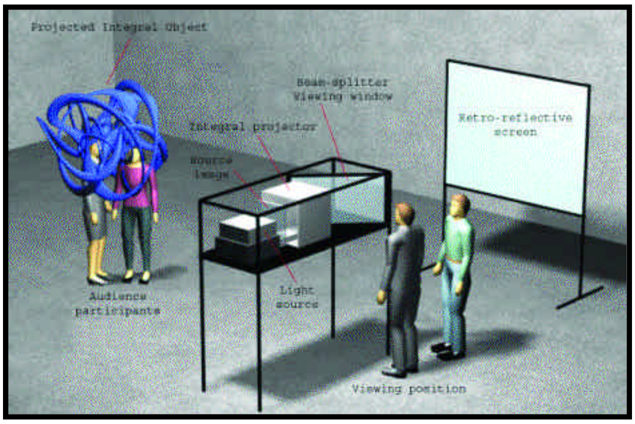

Fig. 10. CAD simulation of the cybersculpture installation

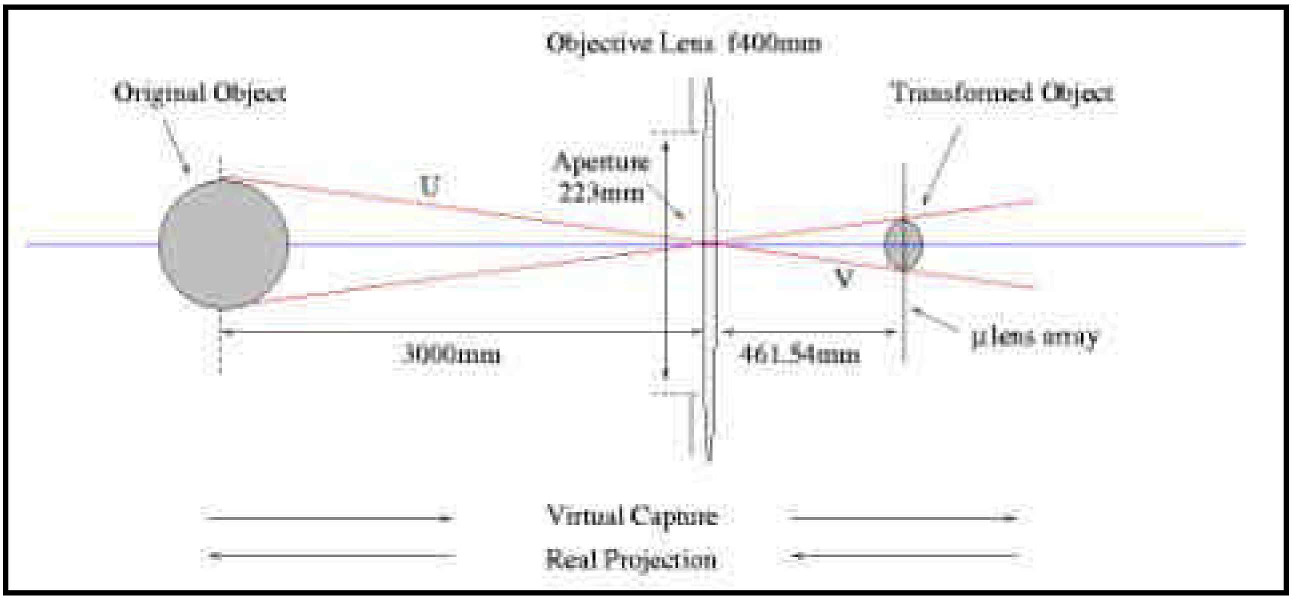

Fig. 9. Objective/projection lens parameters

After trying different levels of resolution and printing techniques, it was found that a 10" x 8" colour transparency generated on a Fire 800 produced the best results. This printing process achieves a resolution of 1270 dpi, and contrast ratios comparable with film transparencies. Also, several different camera models were explored, offering different scaling factors in the projected image. The most impressive of which created a visible depth of 4 meters, fulfilling both the scientific and artistic expectations.

Developing the Integral Projector for Architectural Applications

Although the first prototype projector proved to be a success it still had the look and feel of a piece of laboratory apparatus and the viewing area was also very limited, Fig.11. In order to develop this equipment I wanted a larger viewing area but according to the optics experts in the DMU group this was not possible using this particular objective/projection lens because of the parameter limitations. The reason for this was due to the size of the aperture through which the integral cybersculpture could be viewed. Although I desired a larger beam-splitter viewing widow, it seemed that no matter how large the viewing window the aperture would remain the same size, limiting the actual viewing area to 10" x 8". This being the case, I began to experiment with different design possibilities to make the projector appear less like laboratory equipment, Fig.12.

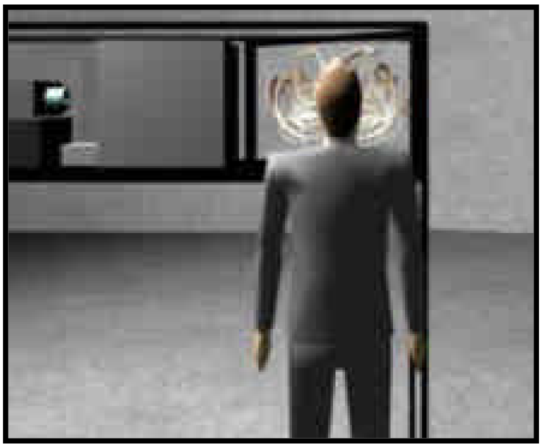

Fig.11. Small viewing window

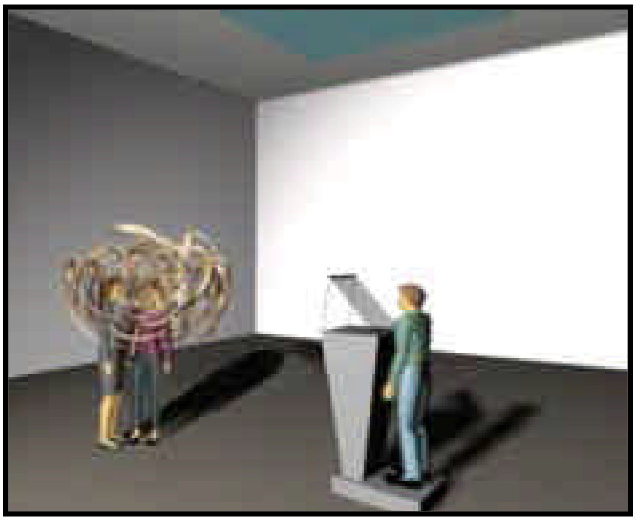

Fig. 12. New design for small window

In the new design for the small viewing window the retro-reflective material has been suspended from the ceiling and the projector has been housed in a vertical position. The viewing platform contains the viewer in the desired location giving the optimum viewing position to look through the beam splitter at the full size integral cybersculpture beyond. Whilst experimenting with different possibilities for the projectors, retro-reflective screen and beam-splitter, I was determined to try the large window possibility, even though it had been rejected on the grounds that it wouldn't work. I took a large format beam-splitter, 6' x4' tall and placed it at what seemed an appropriate distance from the projector on legs to bring it to the correct height for viewing. I turned on the projector and stood in front of the beam-splitter only to discover that the optics specialist had been correct in his prediction that the viewing area in the window could not exceed the 10" x 8" aperture of the projector. I took a step backwards and the integral cybersculpture filled the entire window. It was slightly out of focus but that was easily remedied by adjusting the position of the apparatus. One further development was to add a second window at ninety degrees to the first so as to project the 3D image on both sides of the viewing windows, Fig. 13, below.

In Fig. 14, the design for the installation of the projector has been arranged to be as unobtrusive as possible. The projector has been embedded in the

Fig. 13. Large scale projector with double 6’ x 4’ window beam-splitter

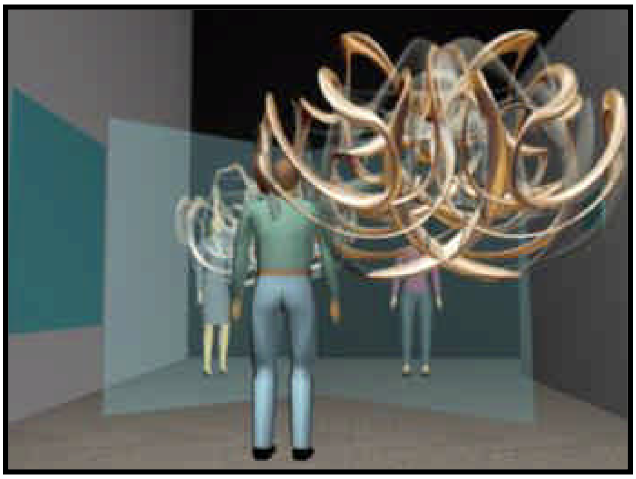

Fig. 14. CAD simulation of ideal configuration for two-sided projector.

wall, the retro-reflective material attached to the wall opposite, and the double beam splitter windows stand directly on the floor. To all intent and purpose in this configuration the cybersculpture can be encountered and navigated in an apparatus free environment where only the beam-splitters, in the form of two sheets of glass each 6’x10’ are encountered with the integral cybersculpture existing in true space on either side.

Acknowledgements

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