This essay discusses the dichotomy between visual, animated images and the abstract computer program that generates them. This digital and numerical base adds an extra dimension to the animation, whereby the creative experience is divided into a number of different levels.

Abstract

Digital images are informed by the status of their algorithmic source, creating in the viewer a kind of numerical perception, thereby introducing scientific knowledge into our understanding of the visual. But because of the computer's formalism and arbitrariness, the relation between algorithmic source and the electronic visual effect is not stable. Imagery is of a different experiential type to logical structures, and this causes their disjuncture or alienation, although they are logically and deterministically connected. Thus synthetic images do not appear "human" or manmade but objective or "natural," like photographs.

The underlying algorithm is so contingent that in terms of being an accessible entity it hardly exists at all without reference to its sensory manifestations. The actual substance of the animate is diffused into so many different levels at once, it loses its ontological identity. These effects lead to a description of a computer animation as an object able to vitalize both tangible and intangible spaces and become a super-animate.

Superanimism:
The practice of formalised imagery

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Introduction–The Word Made Flesh

Through computer modeling, a type of animation has evolved that does not depend on the result of the manual dynamics of traditional animation but on a construction of multidimensional objects in symbolic space. This new kind of animation exists on more than a visual or poetic level and can be thought of as having the status of "real" and objective entities with ontological depth and, in some contexts, being able to function as bodies of knowledge.

As an example of the changing critique of the image, consider three possible ways of representing a common cloud. To begin with, take a painting of a cloud formation by an artist such as the eighteenth-century landscape painter John Constable (Figure 1). This painting tells us as much about how the artist painted the cloud as it does about the cloud itself. The fluffy brush marks and impasted surface encourage the eye to delight in the variety of the technique for its own sake, almost as a distraction from the idea of "cloudness" or at least a redefinition of it. The painting is an impressionistic rendering of a meteorological condition, not designed to provide us with more information.

In comparison, photography is considered a transparent medium. A photograph of a cloud gives us pretty much a one-to-one correspondence with its referent (Figure 2). It provides us with accurate information about a portion of the sky at a particular moment in time. But the information is still limited to what a cloud looks like, and it is not clear how this representation can be expanded without moving into diagrammatic representations and compromising visual realism.

Computer renditions of synthetic clouds are now visually indistinguishable from photographs (Figure 3). But in the case of a digital image we can extend our critique beneath the surface of the image to examine the rationale of the algorithm that generated it. We can ask the same question concerning the realism of this

Figure 1. *Cloud Study: Horizon of Tree*, John Constable. Oil painting, 248 mm x 292 mm. London, Royal Academy, 1821.

algorithmic model as we can concerning the realism of the image—whether it is a fractal or impressionistic self-model,[1] a textured morphological model,[2] or a physically based model composed of differential equations.[3] Furthermore, this digital structure or algorithm might allow the imagery to be animated, not just passively like recording a film, but moving in a dynamic interactive space.

We can compare algorithms like this with the knowledge we have about the nature of cloud phenomena and evaluate the result according to our priorities. That is, even if the picture does not look like what we think a cloud should look like, an appeal could be made to the accuracy of its mathematical basis to secure its legitimacy. We would not, for example, be dismayed to hear someone argue for the validity of an unfamiliar looking cloud picture by referring to the means by which it was modeled. Armed with this means of perception we might then go into the nearest street and carefully examine the sky overhead for shapes that correspond more closely with our new conception of clouds.

Thus, the popular scientific discourses of chaos and fractal theory are mediated through imagery to the public and are able to exert an influence on perceptual habits, producing an almost numerical perception. Digital images have depths and attendant processes that cannot be clearly demarcated and instead diffuse their being and meaning onto many levels. Let us take a closer look at the dynamics behind this process.

Animating Information

Traditional animation has been limited to morphology. Whether we are drawing figures by hand or manipu-

1. R. P. Voss, Fractal Forgeries, in R. A. Earnshaw (ed.), *Fundamental Algorithms for Computer Graphics*, Springer-Verlag, 1985.

2. G. Y. Gardner, "Visual Simulation of Clouds," in *Proceedings of SIGGRAPH '84*, 1984, pp. 11-20.

3. J. Kajiya and B. P. Von Herzen, "Ray-tracing Volume Densities," in *Proceedings of SIGGRAPH '84*, 1984, pp. 165-175.

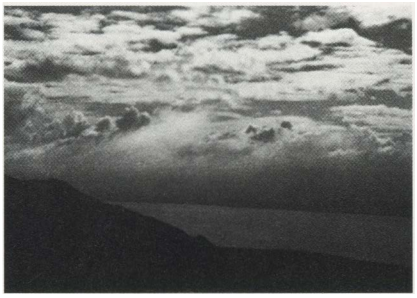

Figure 2. *Sea Fog Turning into Cumulus Clouds*. Photograph.

lating models during stop-frame recording, we are basically animating shape, whereas we can now talk in terms of animating information. Although commercial animation systems still mainly imitate manual methods, such is the potential of the computer that animating by mathematically controlled methods is an irresistible lure.

This kind of computer animation begins life as no more than implicit or latent in digital memory, like a digital muse waiting to be algorithmically unfurled. The animation is constructed by formal rules acting on a symbolic structure, and its realization as videographics can take on any one of a limitless number of forms depending on the animator's interest or intentions. Because of the lack of uniqueness or authenticity in the representational format chosen, computer animations are properly referred to as visualizations — our ability to create that which is visible. A computer animation exists informally in an intuitive space with other visual objects, but it is derived from a formal space within the computer's memory. By substituting the term *visualize* for *represent* we create a context in which the animate can exist as an independent visual object in its own space while at the same time retain a formal relationship with the virtual world of digital sequences defined inside the computer.

Deterministic Alienation and the Numerical Image

The formal, logically defined relationship between the image and its model can serve to rupture their intimacy, as much as to structure it, by both the sheer algorithmic complexity that accompanies the transition from data to model and/or algorithm to image and the constant element of arbitrariness in its conventions. Suppose we try to formalize this stratification of the logistics of digital creativity, using the following classification.

Ideal Space. This is the lowest level at which mental objects might be conveniently formalized. It simply refers to a more or less coherent abstract idea like "there are five regular tessellations in the plane," or perhaps a platonic object like a sphere, theoretically defined.

Figure 3. Still from animation by Semmania Cheung, 1988. Copyright CASCAAD, Middlesex Polytechnic.

Logical Space is where abstract ideas are transformed into formal notation, usually mathematical. In our context, the notation is probably an algorithm or program, such as encoding a sphere to be represented by a center of origin (*x y z*) and a length of radius (*r*) or the procedure by which it is illuminated and rendered.

Symbolic Space. Objects exist in symbolic form, in our case as digital symbols or numbers, like a data file for a three-dimensional model or the representation of a picture of a sphere stored as a file of pixel values that could be further processed or edited.

Sensory Space is generally the space of everyday experience or perception, such as when a picture of a sphere displayed on a monitor. For computer animation, at present this space has two main aspects, which we can call electronic space (on a TV screen) and interactive space.

This contrived taxonomy is not meant to function as a simple hierarchical ordering of conceptual and perceptual modes. That is, a space described lower down the list is not always defined and directed by the one immediately preceding it. This is partly because earlier stages are constantly suffering feedback from their effects on later stages (such as debugging an algorithm by inspecting an image it has generated). But also, each perceptual space is engaged on so different a level of experience as to require vastly different ways of coming to terms with the objects that dwell there. This frequent inability to relate the objects of one space to associated objects in another can lead to effects we might term *deterministic alienation*.

The most obvious causes of deterministic alienation are the mathematical characteristics of algorithms described as chaotic or nondeterministic systems in which future states cannot be predicted from their starting conditions. For users there is a feeling of dislocation between the simple and uninteresting looking mapping function that exists in logical space as only a few dozen lines of programming code and the intricate and changing patterns of dots and clouds of color that continuously dance in front of their eyes on the video display unit (VDU). Although this particular experience is limited to the mathematicians who study such dynamics or the computer enthusiasts for whom it is a recreational pursuit, the same effect of alienation is a general occurrence among computer graphics programmers.

Startlingly exotic graphics are possible because the computer is divorced from physical limitations and often becomes isolated from common aesthetic idioms.

Most programs written for serious applications are several thousand lines long and contain many separate functions and algorithms. To make the job practical, they are usually written by a team of programmers under the supervision of a software architect who lays down the basic structure of the project, assign portions of it to various team members, and ensures compatibility between their contributions. It is plain to see that no one person can grasp the operation of such a complex piece of software and that individual programmers can quickly lose track of the detailed flow of their own particular module without constantly refreshing their memory. Users of a computer graphics package can have only vague ideas about how the images they design are actually produced.

In addition to the considerations of software construction, there are the workings of the graphics hardware, the processors, memory architecture, display controller, and so on, that have to remain shielded from the quizzical gaze of the user. The fact is that computer science has now become such a highly specialized field that no one person can really say how a computer–either hardware or software–actually works. Some people do have knowledge of the general principles involved, for example, the binary operators, scan converters, or z-buffers, like any modern scientific discipline, but if we compare this kind of specialized knowledge that scientific practice entails with the physical production of drawings and paintings and sculptures, we see that large areas of the working processes of computer media will always remain veiled. The introduction of scientific techniques to the arts supplements the hallowed mysteries of creativity with bland wonderment at the power of mathematics and electronics.

Apart from the practical and technical hindrances to a complete understanding of the generation of a numerical image, there is a huge difficulty in trying to switch one's level of awareness from the visual space of the electronic image to the logical space of the program, to the ideal space of the concept. Each shift involves a complete change in perception, and each transition from one space to another can be achieved by a number of different routes. Trying to retain one's feelings of admiration when describing a Vermeer interior in terms of radiation interchange can be like trying to describe the feelings of first love in terms of hormonal chemistry. Each class of experience operates in a different space, independent of any necessary basis for comparison.

The complexity of the process of rendering a simple combination of geometric primitives using even a mathematically straightforward algorithm leads inevitably to lighting interactions of inscrutable subtlety. The density of interreflections and shadowing in such images can often be so great that it is difficult to discern whether they are legitimate or the result of some error in the calculations. Usually if the algorithm appears to work for simplified test lighting conditions, we allow ourselves to trust that the algorithm works in more complex situations as well, unless our eyes detect something quite obviously wrong.

These issues, as potent as they seem at present, will doubtless shift their emphasis as future computer graphics users, who have known little else, find it easier to familiarize themselves with the operation of these systems unlike the problems older generations have had in changing from traditional media. It can be surprising how the wonderment of a newcomer to computer graphics can change to a casual acceptance of the behaviour of the computer as it scans down the screen, automatically shading in assorted geometries. New methods of modeling and rendering are constantly being developed which may require the continual acquisition of new artistic practices. Startlingly exotic graphics are possible because the computer is divorced from physical limitations and often becomes isolated from common aesthetic idioms. There is a point at which the workings of the computer itself are no longer questioned, no longer an issue, and bewilderment at its idiosyncrasies is replaced by a submission to whatever system of operation the computer has been designed to offer. In this way the effects of creative alienation become internalized and implicit, with the result of a fragmented relationship between the means and ends of digital media.

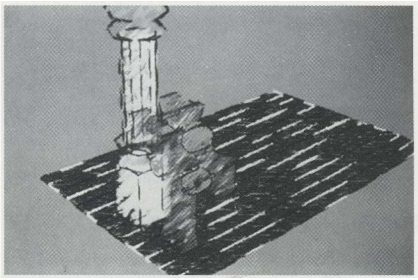

Figure 4. *Cross and Column.* Simon Schofield, digital image, 1989. Courtesy of the artist.

One of the aims of the process of scientific visualization is to try to overcome this stratification of experience, or in this case, of knowledge by using visual perception as a way of accessing, or perhaps, of reintegrating knowledge. Interactive visualization spaces are especially efficient in attempting to compensate for the cognitive schism by articulating a space that allows an intuitive understanding of an abstract object to be moulded. But this process does not directly bridge the gap between our perceptual spaces. Rather, it allows us to come to terms with them by replacing the old static object that was so difficult to get to grips with, with a completely new interactive object programmed specifically to be more responsive and accessible. Easier "understanding" can now be a design feature of scientific visualization.

Synthetic Realism

The synthetic image itself is by nature phenomenologically autonomous. Electronic imagery is by definition not created by any mechanical or physical process. On examining a synthetic image we see it is too detailed, too precise to have been executed by the human hand. But it does not look "mechanistic" either; it does not

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have the regularity or symmetry we associate with graphs and chart plotting. In fact, we generally cannot make out how the image has been made; there is no evidence of craftsmanship, no brush marks. This leads to an associated phenomenological effect of synthetic imagery–that it has not been made, that it has somehow occurred naturally without human intervention or volition, like the swirling patterns of oil in a puddle.

Photographs are perceived in the same way. People feel the photographic method to be defined and mechanica–although not entirely inaccessible–and that its results are objective and able to function as statements of fact.[4] Although this judgment is generally true, it is often reduced to a triviality. All photos tell us is that a scene once existed. They are a mute witness, they do not help us understand, and we usually end up reading our own stories into the pictures. Recent photographers have tried to subvert this acquiescence to photographic veracity by constructing and photographing impossible scenes, liberally employing special effects and compositing.

If this can be a strategy in photography then it is doubly possible as a strategy in synthetic photography. Photographic realism is now exploited as a style to validate and confirm the fantastic. In computer graphics this stance is given added impetus by the fact that realistic rendering is but one alternative to visualization and frequently not the most efficient for communicating the desired information. For this reason realism as a method has no claim to truth; the pluralism of computer graphics reduces it to a specialized technique mainly appropriated to disciplines such as architectural simulation.

New rendering systems currently being developed can subsume synthetic photography into a wider language of pictorial styles and visualization techniques, deliberately forging the styles of other media and appropriating their modes of perception. For example, a picture rendered with stochastically shaded patches provides all the cues for its reading as painterly brush marks (Figure 4). The recognition of this familiar process allows the viewer to empathize with the supposed means of production expressed in appearance if not in fact, and this in one sense reduces the alienation caused by the usual pristinely shaded artifacts.

The realism of synthetic photography is exposed as one of a wider catalogue of styles. A computer is in principle capable of simulating this or any other definable process and possesses no intrinsic "style" or language of its own, or any of which is relevant to this context. This freedom enables the computer to make its completely arbitrary connections between digital constructs. Some of these connections can be functionally specialized as in three-dimensional rendering and, although still strictly deterministic, can become inaccessi-

4. R. Barthes, *Camera Lucida*, Flamingo, 1981.

ble and alienating. Some others can appear straightforward like diagrams and other more complex visualizations can be disguised at later stages and at different levels to control their perception and their understanding.

The Computer as a Mediatory Fabric

It is better to think of the abstract digital structures that form the basis of the animation discipline as merely a coding, a raw unformed state, rather than as the complete embodiment of the images that arise from them. It is even possible that the data could be completely random and still be rendered into some meaningful form, such as in synthetic texture generation. The animations generated create a new sensory electronic object so they only seem existent when in this tangible state and previously seem quite dormant. But although this appears to be restricting our conception of animation to the level of the visual, the computer expands the definition of animation by providing schemata of correspondence between different visualizations of data. In fact, the source or data and their attendant processes are now nothing more than a mediatory fabric from which their diverse materializations can extrapolate themselves. The database can even be said to remain undefined as an accessible object until a process to externalize it has been applied. It is only then that it is made real, perhaps in visual terms, so it can be apprehended at a human level. Using this fabric as an internal abstract medium, one animate can be said to represent or revisualize another, initiating a self-reflexive loop linked in a logical or symbolic space. It is in this space that animates may be said to talk to each other.

In the environment of an animation production company we have a situation where the predefined procedures to create photosynthetic effects are still not flexible enough to produce the desired kind of rendering of each object efficiently without extensive editing of the scene description and/or software package. Although the advanced global lighting models that architectural scientists are developing for fast parallel processors would give animators the ability to just about build their own movie sets inside the computer, now that designers have discovered the power that mathematical modeling gives them, it seems unlikely that they will want to stick to the specialized methods others have provided for them.

Imaging software is now habitually customized for many jobs in a kind of mathematical montaging until the desired effect is achieved. The freedom this offers encourages effects that are straying far from previously accepted styles. After the algorithmic base has been refreshed many times, the coherence of the

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mathematical structure "behind" the imagery begins to recede until we reach a stage when an endless chain of visualizations have no obvious "real" referent, only a clearly and logically defined yet purely conventional and mutable internal fabric.

The wider variety of rendering systems will tend to bring computer animation in the media industries closer to the practice of visualization graphics, especially now that the novelty of conventional three-dimensional rendering has worn off and new stylistic devices are sought. In the developing use of computer graphics, distinctions between "image" and "model" will continue to shift erratically, as they have in the dichotomy between form and content. Although strictly deterministic, numerical images are indeterminable; generally speaking, they cannot be studied to uncover the functions by which they were formed. They are phenomenologically autonomous and generatively inscrutable.

The form of output for computer graphics may itself be seen as an extension of the visualization process. Because computer graphics has no innate language, many different media can be used to externalize imagery, and we can compare realizations with photographic techniques, pen plotters, video, hypermedia, and interactive systems. The variety of final output is linked to an underlying logical fabric in the computer, but this fabric is just as fluid and contingent as the images it produces.

The diversity of the relationship between digital images and computers in the dynamics of visualization can help reinforce the experience of the visual as an independent class of objects rather than define them as a mere reflection of abstract mathematical forces. The capability for interactively accessing the image space does not recover this intimacy because each time it is engaged, it redefines the object under scrutiny. The computer both constructs a formal relation between logical space and the animate and at the same time undermines it by its arbitrariness and by effects such as deterministic alienation, producing a fluctuating dynamic space rich in conceptual ambiguity.

As articulated by popular alchemical metaphors, the origin of the art of animation are the beliefs of animism — the attribution of the qualities of life to inanimate objects.[5] But the kind of computer animation discussed here substitutes the transmutable metaphysical substance of alchemy for a digital metaphor, a universal formalism that is both always applicable and yet purely textual. It is a superanimism, not just synthesizing the appearance of living things but a simulation possessing an internal relational fabric able to generate infinite realizations of itself.

5. R. Cardinal, "Stirrings in the Dust," in *Animating the Fantastic*, *Afterimage* No. 13, Autumn 1987.