Ways of Seeing: Visualization of Artificial Life Environments

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Abstract

This paper investigates the significance of cultural assumptions associated with the methodology and epistemology of visualization in simulations. Starting with ideas from art theory on 'ways of seeing' in the context of painting, we look at the concepts of truth and representation in the visual image. Example images on the subject of evolution and artificial life are examined to reveal the assumptions and implicit knowledge used by the creators and viewers. We use examples of visualization from other cultures to clarify the means by which knowledge influences conventions in representation, and how alternate modes of visual representation may offer new insights for visualization of artificial life systems.

Keywords: Observation and Representation, Visual Simulation, Philosophy of Artificial Life.

Introduction

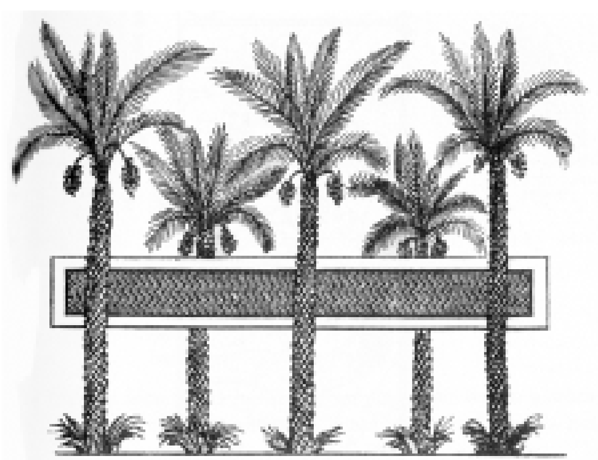

Figure 1: Egyptian representation of a water tank with a row palm trees on either side.

"Seeing comes before words. The child looks and recognizes before it can speak." — so begins the introduction to the classic book by art critic and theorist John Berger, *Ways of Seeing* (Berger 1972). Berger's book, a long time prescribed text for undergraduate art students, draws on the theory and writing of Walter Benjamin, particularly *The Work of Art in the Age of Mechanical Reproduction* (Benjamin & Arendt 1968). Berger and his colleagues examined how the made image captures the way of seeing of its creator and how the culture and values of the viewer influences what is 'seen' in the image. That is, *seeing* in Berger's sense is not a mechanical process of undisputed regularity. The way we see things is affected by what we know and believe. The act of seeing is a selective one, implicitly a relation between the things we see and ourselves.

For those of us who create images for scientific purposes, it may come as a surprise to find that in art, images may reflect many things, but are never seen as a single *truth*. The real is seen as an excess, something that the production of truth draws upon, but can never exhaust or contain.

According to Berger, 'Images were first made to conjure up the appearances of something that was absent. Gradually it became evident that an image could outlast what it represented; it then showed how something or somebody had once looked — and thus by implication how the subject had once been seen by other people.' (Berger 1972, page 10) The book deals in the main with art images, but it is interesting to see how such ideas might be applied in the context of scientific visualization in general and visualization of artificial life in particular.

In this paper we will look at some examples of visualization, both recent scientific visualization and the alternate 'visualization' of other cultures. Our goal is not only to critique, but also to look in a general sense at issues regarding seeing, assumed knowledge, and representation. We will introduce a number of theories from the art world, and see how these theories might inform our understanding of the visualization process in Alife simulations. Hence, we will examine the assumptions that many researchers have made, often implicitly, in visualizations of their work. Later in this paper, we will briefly look at how other cultures visualize their worlds, with a view to determine if there is anything in these particular ways of seeing that might be beneficial to artificial life simulations.

When other disciplines 'examine' science or scientific culture, those under scrutiny often become defensive or dismissive of such examinations. There are many reasons for this, such as a lack of detailed understanding of the particular discipline under examination, a lack of rigor in detailing the arguments, or implicit assumptions about actions and meanings. It is also natural to become defensive when your work is questioned by those from outside your own discipline. In many cases, such a response may be justified.

It is not the goal of this paper to create boundaries between disciplines, expressed by the generalization of C.P. Snow's 'two cultures' (Snow 1959; Cordle 1999). We will do our best to offer beneficial insights and critical analysis for those who are interested in new ways of visualizing and *thinking* about their artificial life simulations. This thinking should be cognizant of the extent to which culture, convention and learned systems play a role in the research process.

The Scientific Image and Representation

In this section, we will look at some example images and discuss how understanding and knowledge are expressed in the constructed image. The acts of creating and viewing necessarily involve a series of assumptions. Many of these are established by cultural convention, others by our own physical experience and the physical configuration of our bodies and the systems they contain. It is our view that no representation can be 'value-free', even in the case of the scientific image, where often much effort is invested in obtaining clarity and literalness of representation. This contrasts directly with modern art, where there may be deliberate play between literalness and representation (for example in the photorealist painting of Richard Eastes' *Double Self-Portrait)*.

Visual Representation of Evolutionary History

Let us look at an example of representation in an image dealing with evolution. Figure 2 shows a section of a large mural found at the George C. Page Museum of La Brea Discoveries, in Los Angeles, USA. The museum is devoted to the preserved remains of a number of animals from the Pleistocene Epoch, between approximately 15 and 30 thousand years ago. Animals in the area became trapped in the local tar pits ('Brea' is the Spanish word for tar), and their bodies preserved as the tar solidified due to changing climatic conditions. This image supposedly depicts a typical scene from the Pleistocene of the landscape that is now the museum area — with a wide variety of animals found in the museum's collection depicted. In this case the image is an 'artist's impression'. Images such as this are based on scientific information drawn from the remains of the preserved animals and plants that were believed to exist at that time.

Why did the artist choose to illustrate this particular

Figure 2: Wall mural (detail) from the George C. Page museum, Los Angeles, California.

scene in the way it is shown? What is the goal of such an image? It might be to communicate to the museum's audience science's view of the Pleistocene landscape that is now downtown Los Angeles. However, the image contains several narratives[1], one particular narrative is that of conflict — the ground sloth and the sabretoothed cat are caught in attack, about to fight to the death of one (or both) as the expectant vulture looks on voraciously from above. They are all precariously positioned over a tar pit and one imagines as the fight ensues, they will be consumed by the tar, and the rest as they say, is history.

A popular understanding of evolution in Victorian times was the concept of 'survival of the fittest' — that fundamentally evolution was driven not only by competition, but species were actively engaged in aggression to eliminate competition. The only victors were those who survived to give rise to the next generation (implicitly by wiping out the competition). This belief encouraged people's skepticism towards evolution, particularly the morality of competition for survival. If evolution explained life as survival (and only survival), and humans were a product of evolution, how could any claims of morality, friendship, altruism, etc. be justified? William James referred to this as 'the strangest intellectual stopping-place ever proposed by one man to another'. Such skepticism persists to the present day; its adherents include academics from the left, who see evolution as scientistic support for capitalist ideologies (Singer 1999).

This thinking about evolution and nature, 'red in tooth and claw' is shown literally in the image of Figure 2 — the sloth has claws with blood on them[2] and the tiger (by a fortunate coincidence) has teeth large enough for us to see the details. This image suggests the (incorrect) understanding of evolution exclusively as conflict, and hence reinforces the validity of the concept of 'civilization' where educated human societies are above the landscape of evolution because of our morality.

Of course, one might criticize the reflections above since this example is not really a scientific visualization — rather a decorative display in a museum that is not presented in the context of a scientific paper or journal.[3] So let us now turn to a visualization from Alife.

Visual Representation in Alife Simulations

Figure 3 shows a screen snapshot from Larry Yaeger's *Polyworld* — a typical artificial life environment (Yaeger 1994). The representational scheme used and the assumptions it draws upon are of particular interest here. Since the coining of the term by Langton, *artificial life* (Alife) has contributed to the idea that *life* may be possible in human-made media, such as computers. For artificial life to exist, a redefinition of what was traditionally understood to be life is necessary (Langton 1989). Debate continues within the Alife community as to the possibility of 'strong' and 'week' artificial life (Pattee 1988; Boden 1996).

In everyday reasoning, people have little difficulty with the concept of life — we have no trouble distinguishing *life* from *non-life* when the life we are addressing is at the normal scale of human perception. There are many common properties and behaviours that we intuitively associate with living things: mobility (in the case of animals), reaction to stimulus, apparent agency, reproduction, and so on. These features are common to most forms of 'life' that are observable to the naked eye.

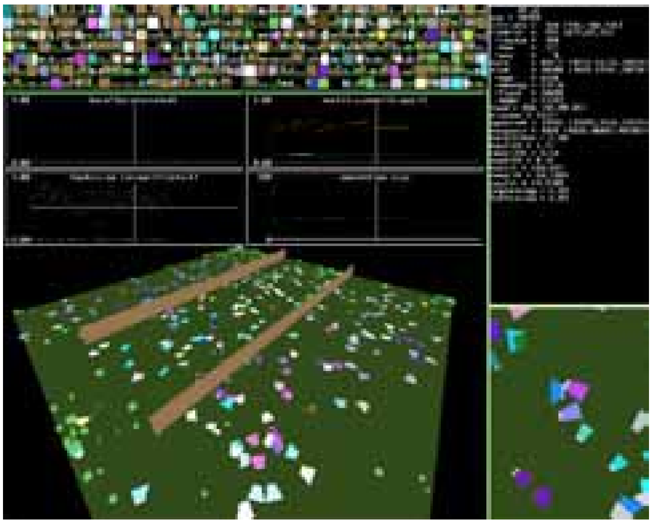

Figure 3: Visualization of *Polyworld*, described in (Yaeger 1994)

A key element of the model visualized in Figure 3, is the manner in which parts of the dynamic data of the software are represented as a virtual world. This world is illustrated in familiar terms — objects in a three-dimensional space with a ground plane. While the representation does not aspire to the visual realism that is possible with modern computer graphics, many visual cues are apparent in the representation that make it clear to the viewer that this is a representation of an environment expressed in terms of our own world (or its interpretation at least).

Polyworld depicts a series of symbols: the ground is symbolized by a horizontal plane; food/plant matter is depicted in green; barriers as high walls. In Polyworld the symbol for an organism is a flat trapezoid in space. Its aggression is visualized in red. All of these symbols are presented using a conventional representation for space and the objects within it — the linear perspective projection — that is read transparently by the skilled viewer. After an initial explanation, the viewer leaves behind the idea that Polyworld is only a representation, 'Those things are grass', 'That creature is angry', 'That is the ground and those are walls'. In doing this, we overlook the fact that

1 Further analysis of this image can be found in (McCormack 1998)

2 It is believed that ground sloths were herbivores, but had many small 'skin bones' deep under the skin around the neck, shoulders and back, possibly used for defense against predators.

3 Although this image does appear in a number of undergraduate books on biology, e.g (Raven&Johnson 1986, pages 444-445), which arguably makes its analysis even more crucial than were it to appear in a scientific paper for experts.

there is no three-dimensional space here, that there are no objects and that there is certainly no food, nor any organisms. The viewer accustomed to reading the symbols extends the rules of physical space to the represented space. The perceptual system succumbs to the illusion because it is accustomed to doing so, and additionally, it is powerful as an explanatory strategy. With this stance comes the ability to make predictions about how the dots on the screen will behave. This comes at the expense of being able to view the system as only dots flickering on a screen. The viewer can't simultaneously be inside the world and external to its apparent logic.

In the case of Polyworld, the perspective projection lends an authenticity to the 'creatures' it apparently contains. This is brought about by our implicit acceptance (acquired through training by repeated exposure to similar images) that linear perspective somehow shows the world the way it really is. In addition, we believe that any representation using linear perspective is somehow 'realistic' (even more so if the dynamics are consistent with folk physics).

A constructed, perspective image is not rendered in stereo (as the world we view through our eyes is rendered), and we cannot move around this represented world, nor put our hand in it to touch a creature. Much of what we know about objects and organisms is not denoted in the image 'world', and yet we dismiss these inconsistencies as irrelevant if we notice them at all. We also avoid asking, how can a small flat shape scoot around in space without some means of locomotion? Where are the creature's eyes? Why can't we see the creatures eating each other and how is it that some of them just disappear? Where is the light source and why are no shadows cast by the barriers in this world? What is holding up the ground plane? We are willing to set aside all of these things and treat them as 'unimportant', despite our knowledge that real organisms and physical objects must meet all of these requirements.

The reason we are able to set aside these requirements and suspend our disbelief is that we have been trained to understand this kind of image. This is not a special means of representing a world 'realistically'. The understanding we gain from this visualization comes about through our transparent interpretation of the symbols depicted on the screen.

A representation conveys the assumptions of the creator and is subject to interpretation by the viewer. There will be a (hopefully meaningful) relation between the machine states and visual representations that show those states. However, objects, even abstract, coloured squares, moving in space over a ground plane imply all kinds of physical associations and intuitive knowledge that we all possess, as we too are agents in a three-dimensional environment.[4] Some aspects include: the physicality of a body in space; our folk physical knowledge; assumptions about direction, movement, location, mass, volume, navigation. A representation such as appears in Figure 3 implies those things, however none exist in the simulation.

Suppose we wish to demonstrate that life is possible in non-biological media. An important aspect of convincingly establishing the validity of a model is the production of an effective representation that looks and behaves in ways that meet our intuition and expectations about artificial life. In addition, this representation should correspond to our knowledge and experience of living things. Polyworld confirms its position as being an exemplar artificial life environment via its visual representations realized in this manner.

We are not claiming that Polyworld attempts to deliberately mislead its audience, or that it is in some sense 'bad science'. Polyworld is an important and significant contribution to the field of Artificial Life. It, and simulations like it, help to confirm that many of Alife's basic tenets and goals are valid — that it may be possible to broaden our definition of life and our knowledge of living systems via simulation.

However, what is highlighted here are the 'ways of seeing' of the author and audience. As stated in the introduction, Berger's theory states that seeing is selective and is always enacted in relation to us, the viewers. Our understanding of Polyworld as a dynamic space is based on the same epistemology used to understand our own perceptual space. Hence, we intuitively make many assumptions about the nature of Polyworld the artificial life world, that have no corresponding ontology in Polyworld the computer program.

Visualization and Knowledge

To further this argument, let us look at how visualization may reflect, even limit a researcher's approach and thinking with regards to a given problem. Many Alife simulations make the distinction between *genotype* and *phenotype*. The genotype is commonly referred to as the 'code' that creates the phenotype in an interpretation analogous to the view of DNA as a 'code'. *The code generates the phenotype*, and in the range of 'genetic' approaches to simulating evolution, such as the genetic algorithm or genetic programming, codes are subject to operations such as mutation and crossover.

In these approaches, genotype and phenotype are commonly distinct: distinct conceptually and hence distinct in representational terms. The data structures that represent genotypes are kept separate from the data structures that represent phenotypes. Phenotypes are seen to exist in the world, whereas genotypes are not visualized in the same space. They typically remain hidden as part of the inner workings of the computer program and are not subject to direct visualization.[5] In cases where they are shown, their

[4] This is not an exclusive definition. We are many other things as well.

[5] Genotype visualizations may include statistical visualization, topological or schematic diagrams. In these cases, the visualization style is highly abstracted, often symbolic or numeric (shown as a graph, for example), further confirming its status as code that exists *in abstracta*, rather than in the virtual world.

representation is usually highly abstract, since they represent code, not life. For example, you would not expect to see Polyworld's genotypes represented in the same three-dimensional space as its phenotypes, complete with ground plane and walls. Alife simulations of simulated organisms in a virtual space are in conceptual terms viewed as having separate ontologies for genotypes and phenotypes.

In recent years, researchers have been frustrated by the lack of progress with such models in developing genuinely novel behaviour, particularly at multiple levels of hierarchical inter-relations (Bedau et al. 2000). In short, these Alife simulations don't really display anything resembling the novelty that we see in life on earth. A number of researchers have suggested this may be due to this conceptual separation of genotype and phenotype (Taylor 2002).

In wet biology, DNA exists in cells. In cellular mitosis, cell differentiation is a physical process. DNA, 'the code', is subject to the same laws of physics as any other molecule, including the molecules that compose the cell. The genotype and phenotype are part of the same physical substrate, and the decoding process is embedded in the same physical arena as this material. Visualizations that focus on the phenotype as an entity, detached from the code that created it, operating in a culturally-constructed space, make it difficult to illustrate this observation. It is interesting to ask in relation to the goals of such simulations: how does the visualization inhibit or discourage certain ways of thinking about the processes it represents?

Visualization and Cultural Epistemology

In this section we will briefly introduce a number of alternative visualization systems, drawn from the art history of different cultures.

Figure 4 shows an image of two people fetching water from a pool. The pool contains lotus flowers and around its edge are reeds and trees. One of the figures is kneeling at the edge of the pool; the other is standing within it. The symbols in this image neatly convey the scene without the use of perspective projection and without depending on visual likeness. The image is built of canonical forms — typical views of objects with which people are likely to be familiar (Solso 1994, page 240). The typical Western observer treats this image as 'unrealistic', although the conventions it applies to create the mapping from the physical world to the image plane are no less realistic than conventions used in linear perspective.

Supposing instead we were to use linear perspective to render the scene depicted above. The trees around the edge of the pool might obscure the view. Supposing the view point were to be elevated above the trees, then the lotus flowers may become too small to see and would be presented from an awkward angle. This image would be difficult to interpret since most people do not view lotus flowers, trees and human figures from the top. Additionally, the strong graphic form of the line drawing is an effective way of visualizing the scene, distilling the key information the creator wishes to convey. To a viewer who understands the

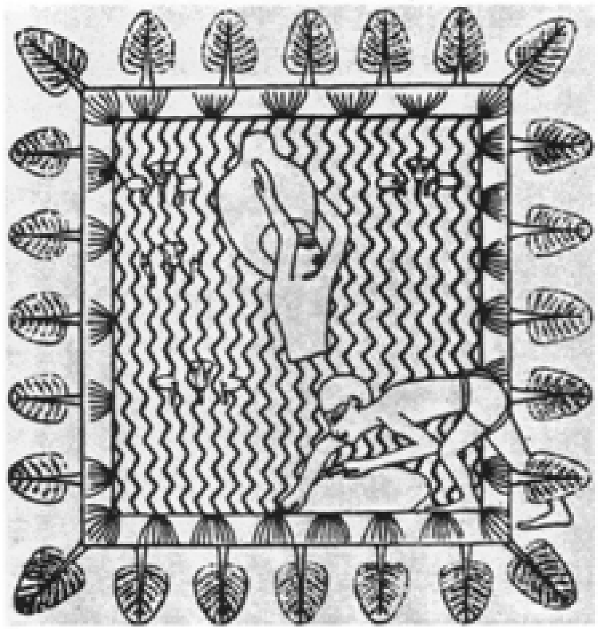

Figure 4: Egyptian style of representing a pond, trees, and people. From (Solso 1994, page 240)

symbols, the Egyptian image is extremely easy to interpret through its use of carefully arranged canonical forms. This clarity would be lost in a perspective drawing (c.f. the drawing shown in Figure 1).

Figure 6 shows an Australian aboriginal depiction of a kangaroo. It shares the clear graphic qualities of the Egyptian drawing and it reveals much about the creature that would be invisible in a photo-realistic image. This drawing is not concerned with surface appearances, but with inner workings and the essential elements of the organism — its spine, stomach and entrails, lungs and so forth. This is a different truth to that depicted in a photograph, but it is no less realistic. Doctors take X-ray photographs, engineers utilize the *exploded view* and the *cross section* in an effort to depict more than what is visible to the superficial eye. Each of these specialists would concur that their image is a realistic representation of the structure it depicts.

The image on the blanket shown in Figure 5 depicts a stylized sea-bear or perhaps a standing eagle. The large circles at the top represent the animal's eyes. Its claws, symmetrically arranged, are visible at the bottom. A geometric transformation or *mapping* used in the image allows an expanded view of the animal: a configuration impossible with conventional perspective. This blanket was designed to be worn over the shoulders and therefore an 'inverse' mapping is performed when the blanket is worn, redefining the three-dimensional form of the image. We can compare this representation to that of the kangaroo (Figure 6). Each highlights different facets of an organism's composition and structure, hence revealing the creator's 'way of seeing' and expressing their understanding of what was important to depict.

A second Australian aboriginal image of relevance to

Figure 6: Aboriginal depiction of a kangaroo. Unknown artist in Arnhem Land (Northern Australia).

Figure 5: Chilkat blanket: Tlingit, before 1928.

this discussion is included also (Figure 7). Here is an extract from a description of the image:

> "The painting seems entirely abstract, but it actually conveys a complex narrative involving two ancestors. One of these men came to Pupunya in search of honey ants; the white U shape on the left represents him seated in front of a waterhole with an ants' nest, represented by the concentric circles [to his right]. His digging stick lies to his right, and white sugary leaves lie to his left. The straight white "journey line" represents his trek from the west. The second man, represented by the brown-and-white U-shape form came from the east, leaving footprints, sat down by another waterhole nearby. He began to spin a hair string (a string made from human hair) on a spindle (the form leaning toward the upper right of the painting) but was distracted by thoughts of the woman he loved, who belonged to a kinship group into which he could not marry. When she approached, he let his hair string blow away (represented by the brown flecks below him) and lost all his work…" (Stokstad 1995, page 907)

This picture, to one fluent in its symbolism, contains information that is not typically included in a static photo-realistic image. A series of temporal events, including paths of travel are depicted. It is also interesting to note that the viewpoint of the image shown may be beneath the earth looking upwards (Stokstad 1995, page 907). This is counter to our Western convention, which may lead us to interpret this image as a bird's-eye-view.

These examples are only a brief selection of the myriad ways in which artists of non-Western cultures have visualized space and the organisms and inanimate objects within it. It is worth noting that twentieth century Western artists have, to varying degrees, explored ideas similar to those addressed above. These same earlier cultures, especially during the Renaissance, were considered 'primitive' and yet their ideas have re-emerged in the form of Cubism, Futurism, Neo-Plasticism, Abstraction etc. The view that there are many visual perspectives other than those perceived directly by the eye is something from which Alife researchers may potentially benefit. As we grapple with definitions of life and its essential properties, it is clear that whatever forms the sufficient and necessary conditions for 'life' take, they will not all be apparent to the eye. Hence, if our simulations are to be at all useful in assisting us to understand artificial life, perhaps some of the techniques employed in the examples above will be of assistance.

Conclusions

Even with this brief discussion of creating and seeing in the context of visualization, we have demonstrated that all visualization necessarily shows *symbols* subject to *interpretation* (Goodman 1968). When those symbols attempt to capture certain aspects of perceptual realism, the viewer may make assumptions that confuse symbols that look 'real' with the perception of reality.

Figure 7: Clifford Possum Tjapaltjarri, *Man's Love Story,* 1978. Papunya, Northern Territory, Australia.

We have looked at visualization examples from several different cultures. The examples highlight two important points of this paper. Firstly, that art theory and art history may offer some important ideas concerning the creation and understanding of images for the purposes of scientific visualization. By acknowledging alternate interpretations and by presenting different juxtapositions and relations other than a naive realism, important relationships and knowledge may be revealed. The techniques could be applied to static and dynamic visualizations.

Secondly, it should be clear that all visual representations express a particular 'way of seeing' of the creator, and are subject to an interpretation by the viewer. What is considered 'true' in an image needs to be questioned. Applying this process of questioning to visualizations enhances the rigor of our research, and may potentially provide new insights into our domain of enquiry.

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