BEVERLY JONES

Cultural MAINTENANCE & *Change*

> Technology is ... no mere means. Technology is a way of revealing. If we give heed to this, then another whole realm of the essence of technology will open itself to us. It is the realm of revealing, ie, of truth ... There was a time when it was not technology alone that bore the name *techne* ... Once there was a time when the bringing forth (*poieses*) of the true (*aletheia*) into the beautiful was called *techne*. And the *poieses* of the fine arts was also called techne.
>
> M Heidegger in *The Question Concerning Technology*

In two prior papers I have emphasised cultural continuity within computer graphics, based in aesthetic theories and technological origins and practices (Jones 1989, 31-38; 1990, 21-30). Viewing cultural maintenance and change as interactive and concurrent, this paper addresses areas of knowledge and belief in which computer imagery and cultural change come together. I will attend primarily to the ways in which computer graphics (as *techne*) reveal or bring forth (*poiesis*) a new view of truth (*aletheia*). As Martin Heidegger states: 'It is in revealing, and not as manufacturing or making that *techne* is a bringing forth ... Technology is a mode of revealing. Technology comes to presence in the realm where revealing and unconcealment take place, where *aletheia*, truth, happens' (Heidegger 1977).

Heideggerian breakdowns, deconstructionist boundaries and implications of connectivity implied in recent computer models of complex phenomenon are used to examine simultaneous continuity and change in culture and high technology. Electronic imagery is examined without separating technological, artistic and popular uses of the imagery to reveal larger cultural patterns.

I have assumed that humans embed their world views in all symbolic and material culture including art and technology. In light of this assumption I have examined four world views that have shaped and are shaped by contemporary symbolic and material culture:

- premodern,
- modern,
- late modern or postmodern, and
- a new paradigm suggested by contemporary computer models of complex phenomenon.

In spite of the terminology used, these world views are not to be regarded as chronologically ordered. Rather they continue and co-exist in the present. They influence and are influenced by electronic art and scientific models.

Cultural change

Computer technology originated conceptually and technically in the period of transition within modernism, postmodernism and the contemporary. Consequently computer-generated artistic and scientific imagery reveal characteristics associated with these world views and the transitions marking their differences. Computer input and output moved from complete reliance on alphanumeric symbols to greater emphasis on graphic representations. Even alphanumeric textual symbols became represented as bitmapped graphics.

During the last decade computer graphics have become ubiquitous. Originally available only in large mainframe computer environments in government and corporate research institutions, computer graphics are now evident in computing environments

Simultaneously Existing World Views

Premodern

Mystical world:
- Known through ritual, meditation, spiritual practice
- Purpose: communion with mystical world

Human as spiritual entity in harmony with larger cosmos/deity/world design
Cosmic continuum of time & space/cyclical or pulsing time
European seasonal cyclical festivals
Indian cycles of creation and destructions
Graphic symbols: cycle, spiral, wave

Modern

Rational predictable clockwork world:
- Known through observation and logic
- Purpose: description, generalisation, prediction and control

Mechanistic human as separate discrete entity, generalisation, averages, statistical prediction sought
Emphasis on universality
Linear sequential time
Cartesian grid of time and space (myth of progress)

Late Modern or Postmodern

Relativistic world:
- Known through observation of the breakdowns of the modern paradigm
- Purpose: liberalisation from the universalised world view and concomitant human consequences

Human unique, alienated, no generalisation or universality possible across humanity
fractured and reassembled grid of time and space
Electronic pastiche

New Paradigm

Integral World:
- Complex, non-linear, self organising, self regulating
- Known through observation and systemic models and simulations
- Purpose: generation of organic process-oriented view of natural world with human as integral part

Human phenomena may be modelled but not predicted
Simultaneous unity and diversity
- Studies in cognitive sciences, biology, weather & origins of universe reveal similar forms
- Butterfly effect: small variation yields large effect

Time and space no longer separate (unified field)
Computer graphics of dynamic complex systems
- Simultaneously regular and unpredictable

across the globe, including the microcomputing environments of daily life (ie home, business, education, medicine, and government).

Computer graphics are employed to create new forms of human machine interface designs, as symbolic representations to facilitate navigation through databases, expert systems, hypermedia systems and other forms of information systems. With this shift in symbolic representation some aspects of information form, content, and design have become emphasised. Others have been de-emphasised. Within virtual reality environments a further shift in symbolic representation is gradually occurring. These environments are being altered to include more audio, kinaesthetic and tactile representations.

Here I want to trace shifts in world views, from modernism through postmodernism to the new paradigm of connectivity. Examples from various aspects of culture including scientific, artistic and popular electronic imagery will be presented to illustrate these shifts.

Cognitive science models of mind and development of neural net computer architecture are illustrations of recent theory and computer models of complex, dynamic, self organising phenomena. Models of these phenomena provide an impetus to a new world view characterised by connectivity. This view has stimulated a new approach to research. This approach is beyond both the prediction-control model of modernism and the relativistic model of postmodernism.

Shapes of time, change and ways of knowing

Modernism broke with the cyclical or pulsing time of Ancient Europe and Indian mythology and instituted regular linear, progressive, incremental time. The mystical world, known through ritual, meditation, and spiritual practice, was replaced by a clockwork world known through observation and logic. The clock and calendar used to assist in ritual practices contributed to the development of the modern world view. The purpose of knowledge shifted from communion with a mystical unified world to description, generalisation, prediction and control of a clockwork universe. The computer was developed to support this view which is based on the model of Cartesian logic and scientific observation. However, it has pushed the edges of this view by revealing blind spots, assumptions and inadequacies.

Postmodern relativism fractured modern regularities of the grid of time and space. A combination of this fragmented view with continuing modern assumptions reigns in most disciplinary areas of studies. However, generation of an organic process-oriented view of the natural world is becoming more evident. This view emphasises humans as integral with nature. It also tends to break with the division of body, mind, and environment.

Beyond modernism

The roots and characteristics of modernism have been discussed by scholars from many disciplines. In *The Technological Society*, Jacques Ellul (1964) builds a case for the pattern of the modern world being exemplified by characteristics of mechanical technology. These are present in industrial manufacture and information-based cultural institutions such as schools, hospitals, and government. This view of technology as dehumanising has been the basis of much literature of anti-technology. The terms componentiality, replicability, uniformity, universality, objectivity and reductionism are frequently associated with this view of modernism. These terms can be associated with many aspects of modern life. Among these are:

- experimental quantitative research in the behavioural and social sciences that stress the measurable and the norm,
- art criticism based on elements and principles of design, typography as a communication technology, and
- minimum standards for production in factories and schools.

Dependence on a single conceptual design of information, hierarchical and grid-based, is a prevalent characteristic of the modern world view. This design is found in the division of disciplines in universities, classification in scientific fields such as biology, categories used in museum collections, library indexing systems and corporate personnel charts. It is the same structure that determines the structure of standard written documents (Flower 1989). It also exists in simple computer menus, organisational strategies for

computer files and addressable memory in most computers. Characteristics of hierarchical classification include the assumption that all the subject space is covered equally, that all categorical divisions are equal, discrete, and mutually exclusive.

The general or larger structure of all knowledge has been presented in a grid with each disciplinary division of knowledge as separate and exclusive. This structure works very well with a subject space that is well known. It is least effective when the subject space is innovative, unfamiliar or evolving. Even so, this is the underlying structure of both Library of Congress and Dewey Decimal indexing systems. This reflects the historical roots of this knowledge structure in seventeenth-century Cartesian logic, eighteenth-century enlightenment (growth and form of classification) and the nineteenth-century conception of science (Newtonian clockwork universe). Abstraction from the immediate sensuous world to a formulated canon of perception and knowledge became the underlying legitimated intellectual mode in modern industrial society. These underlying concepts and structures combined with the privileging of sight as perceptual tool and strong belief in the power and efficacy of alphanumeric symbols marked cultural modernism. Although computer technology developed in this atmosphere, important differences with potential for change were present quite early. The use of analog sensors, analog to digital converters and digital to analog converters, randomisation, limited stochasticism, and interactivity appeared in computer input, processing and output. Another crucial difference was the underlying structure of Boolean logic as an alternative conceptual design for information systems.

Computer generated art made use of all of these differences. Examples from early computer graphics include Bonacic's interactive computer controlled sculpture, the Automatic Painting Machine of the Computer Technique Group of Japan, and Myron Kruger's early interactive environments that he labelled 'artificial realities'. Some artists integrated other computer science domains in their work. Both Ihnatowitz's interactive kinetic sculptures and Cohen's drawings, generated by his intelligent drawing machine, utilised concepts from artificial intelligence.

However, many works retained a visual similarity to modernist art works and could be described and criticised using formalist or empiricist theories of aesthetics and criticism. Lucas (1986) attempted to derive aesthetic criteria for computer generated art via the Delphi strategy. His study of prominent computer graphic artists indicated their agreement that criteria based on elements and principles of design were primary. They also agreed that computer art did not require anything beyond artistic modernism as a theory base. Even so, interactivity was mentioned several times. Interactivity is an important variant in changing the relationship of artist and audience.

In contrast to the experts in Lucas's study, some computer artists and theorists stress the discontinuity of their art with modernism. These individuals stress the ephemeral, changing, interactive, electronic aspects of art. These characteristics could be more closely linked to a reaction against modernism. In this reaction the boundaries between art and other aspects of life break down, uncertainty reigns and art as object dematerialises. Art may be dependent on intertextual reference to historically validated art objects or other art or non-art referents from popular culture.

These characteristics are associated with postmodernism. Examples of some works from the 1990 SIGGRAPH art show illustrate these characteristics. Lane Hall's 'Decaying Infrastructure' crosses the boundaries between art and other aspects of life. Vera Molner's 'Letters of My Mother' uses controlled stochasticism to convey an emotionally charged life experience. 'Robert Mapplethorpe/The Nineties' by Randy Johnson, Stephen Meyers, Ellen Sandor, Dan Sandin, Tom DiFanti, Donna Cox, Bernard Rolzmann, Patricia Spear, Paul Neumann, and Maggie Rawlings comments on a controversial art exhibit and its relations to AIDS. Troy Innocent's and Dale Nason's work 'Cyber Dada Manifesto' links itself to an earlier art movement. Richard W Maile's 'The Birth of Elvis' appropriates an historically validated art work, Botticelli's 'Birth of Venus'. This double appropriation is an intertextual comment. Venus is replaced with an image of Elvis Presley appropriated from a beach movie. The electronic image is ideally

suited to a postmodern view of art and culture (*Leonardo*, 1990).

However, the underlying grid structures inherited from Renaissance perspective (Ivins, 1973) is embedded in camera, video, and computer graphic imagery. This may suggest that the postmodern remains an extension of the modern. The invocation of and stress upon relativism and context in some works, however, mark a separation from the aspects of discreteness, originality, universality and objectivity that clearly mark modernism.

Early breakdowns

Very early breakdowns in the arts are characterised by randomisation, emphasis on context or recombination of fragments. These may be seen in the various art movements. Examples include cubism, collage, dada, and surrealism in the visual arts, John Cage's use of random, naturalistic sounds and silences in music, William Burrough's cut-ups in literature and Maurice Cunningham's choreography and performance art. These early breakdowns continue to influence contemporary electronic art.

In the theoretical world of pure science and mathematics this move toward relativism and uncertainty (ie, away from the limits set by modern nineteenth-century science), had also occurred early. Einstein's theory of relativity, Heisenberg's uncertainty principle, and quantum physics marked the decline of certainty in the physical sciences. The work of Kurt Godel suggested the limits of logical systems in pure mathematics. Thoughtful writers from multiple disciplines have increasingly focused on changing patterns of human belief. Philosophers of science have written about paradigm shifts and the limits of rationality. Computer scientists have found the limits of the nineteenth-century views embedded in hardware and software conceived by technicians creating practical applications. John Von Neumann has been cited as stating:

> The sciences do not try to explain, they hardly ever try to interpret, they mainly make models. By a model is meant a mathematical construct which with the addition of certain verbal interpretations describes observed phenomena. The justification of such a mathematical construct is solely and precisely that it is expected to work (Gleick, 1987).

An earlier physicist, Sir James Jeans, has been cited many times as saying, 'We do not make mathematical models of the world because we know so much about the world, but because we know so little'. Views such as these show clearly that mathematicians, physical scientists, and computer scientists are well aware of the thinness of their models. Breaks between the theoretical and the practical and between the sciences and the arts, humanities, and social sciences have led to misunderstandings and incomplete criticisms of the aims of theoretical and applied work in computer science as well as vice versa.

Breakdowns and continuity in computer graphics

Quite early researchers utilised computer graphics to make mathematical formulae visual. John C Mott Smith's attempts to simulate the movements of subatomic particles in a force field are an example of this. His enjoyment of the visual image and his production of photographs of a nonfunctional nature have led to the inclusion of his work in the realm of computer art. This fits quite well with the dictum of modernist aesthetics that art remain separate from the utilitarian. Simulations at Lawrence Livermore Laboratories of the energy patterns of below ground atomic blasts, simulations of structural stress for engineering done at the University of Utah, and the simulation of a four-dimensional object rolling through a three-dimensional world done at Bell Labs are also examples of relatively early uses of computer graphics to represent mathematical formula. Computer graphics have been used in many fields of science, engineering and design as a metaphoric visual aid to represent conceptual models. Using computer graphic imagery without hidden line algorithms, William Fetter produced an image of the fifty-first percentile pilot of the US Airforce. This image had seven movable systems to facilitate the functional design of cockpits for the Boeing corporation. This fits well with the prevalent modern model for research in the social sciences (ie, quantitative and normative). All of these works done in the 1960s and 1970s reflect a modern perspective.

The limits of this model have become evident both in attempts to simulate human motion in computer graphics, and in attempts to construct inclusive quantitative, logical or structuralist views in the social sciences. More recently researchers in both of these areas have turned their attention to variants, uniqueness, individuality, and context. This reflects a break with modernism. The computer graphic imagery of David Zeltzer goes beyond the normative mathematical construction of human form and movement to add these elements (1985, 105-115). Later deliberately exaggerated animations not based on visual realism stressed these variants even more (Turner 1986, 79-82). These examples show the need to consider human responses to normative simulations of visual realism. These include responses that these are unrealistic as well as emotionally and visually boring. In contrast, caricature-like models (ie, unique variants not based on simulative visual realism), appear to be more successful in stimulating the desired human response. These models exaggerate human movement and expression to create identification and response in the audience. Other breakdowns of the nineteenth-century modernist paradigm of science and technology are numerous. Prominent among these is the human response to visual simulation of reality based on three-dimensional grid space and mathematical formulae for light source, intensity, surface textures, etc. Until the problems of generating good models of these were solved in computer graphics, the degree to which humans require variants from uniformity and certainty to accept a depiction as realistic had remained invisible. It is the discovery of breakdowns such as these that lead to the potential for cultural change.

A similar breakdown occurred as desktop publishing became available to those untrained in the graphic arts. When bitmapped graphic representations of text became available on microcomputers, the design conventions observed by graphic artists had not been learned by new users of this technology. Consequently many unreadable and visually disturbing fliers and corporate reports using multiple unrelated fonts and shading patterns appeared. Those creating them and viewing them knew something was wrong, but had difficulty understanding exactly what it might be. A customary knowledge structure, the formerly invisible canons of typographic design, became apparent by their absence (Lichty 1989).

Formerly separated computer applications are beginning to merge. For example, artistic packages and visual data representation packages are becoming less and less distinct. These include image generation, digitised image capture, processing, analysis, visualisation, simulation, artistic manipulations and retouching. These applications serve a wide variety of purposes in many disciplinary areas. Computer graphics are used to create and present structures representing new concepts of information design derived in the various domains of computer science. For example, these are used in cognitive science in constructing metaphoric visual models of human cognitive processes. These models show cognition as dependent on flocking patterns of neuron firing, a dynamic connective process. This associative process dependent on neural net activity was found using simple digital computers. However, in combination with connectionist computer architecture, it is providing new ways of studying human intelligence. The massive parallel computing capacity of connectionist and neural net computers is pushing the limits of the possible.

Human visual image processing is capable of simultaneously extracting large amounts of data from an image. This ability has not been sufficiently studied in areas other than cognitive science and the visual arts. Computer visualisation laboratories are experimenting with compacting large amounts of quantitative data in graphic form. This is intended to take advantage of the capabilities of human experts to process visual graphic (not alphanumeric) information. Areas formerly considered beyond the realm of reasoned understanding are yielding to human pattern finding and interpretation via computer graphic displays.

New models of reality from computer graphics

A major breakdown/boundary appears present in work on chaos and autopoietic systems. James Gleick's statement describes

the surprise that this research held for scientists from many fields: 'The apparent paradox that simple systems give rise to complex behaviour. Complex systems give rise to simple behaviour. And most important, the laws of complexity hold universally, caring not at all for the details of a system's constituent atoms' (Gleick 1987). This violated the taken-for-granted attitudes that simple systems behave in simple ways, complex behaviour implies complex causes, and different systems behave differently. This research surprised and has proven relevant to neurobiologists studying the chemistry of the human neuron, engineers studying aerodynamic problems using wind tunnels, and economists analysing psychology of purchasing decisions. This research upsets the reductionist program in applied science (separating disciplines and focus on smallest units of study). Curiously, it also upset relativists in many disciplines who have based their positions on the laws of thermodynamics.

Primarily, it has been the second law of thermodynamics that has supported relativism for the nonscientist. It implies there is a necessary tendency toward disorder (ie, a postmodern perspective). Entropy must always increase in the universe and any hypothetical isolated system within it. This law had entered the taken-for-granted realities of those in the humanities and social science. It had been used to explain disintegration of societies, economic decay, breakdown of morals and manners and other decadent or postmodern variants. This was brought into question by the work in chaos theory.

This work was given visible structure on computer graphic displays. Consequently former areas of chaos could be viewed, discovered to have patterned form and conceived to have many potential applications. Researchers from many disciplines viewed the data structures and read reports of research in other fields. They reconsidered problems they had faced unsuccessfully that they felt intuitively might be solved in this way. The crucial role that the growing availability of computer graphics held for this breakdown of old conceptual views is evident in the following example of the 1970's work of Ronald Fox, a young colleague of Joseph Ford (lecturer in chaos at the Georgia Institute of Technology).

After a short time 'playing' with an Apple II computer, Fox wrote a program that allowed him to represent graphically Feigenbaum's universal laws guiding the behaviour of feedback functions. This was at a time when no self-respecting scientist would play with such a 'toy'. (It had been purchased for Fox's son.) The immediacy and structural visibility given to conceptual structures by computer graphics have made an important change in the way of thinking of researchers in many disciplines. The work in chaos and in autopoietic systems has provided a basis for a new approach to unity in diversity as a structure of knowledge of the world. It supports a new frame of reference used by biologists describing evolution and human knowledge, ecologists theorising about the earth as a self-contained self-regulating system (an *autopoietic* system), by some cognitive scientists theorising about humans as self-contained self-regulating systems, by computer scientists involved in developing neural net systems and by physicists creating a model of the evolution of the universe.

An important human activity involves seeking, creating, and symbolising patterns to represent the world. Whether the new connectionist paradigm based on technologically generated imagery is an improved aid for accomplishing this activity remains to be seen. However, it shows continuity with the premodern world in stressing the harmonious connected wholeness of the world. It breaks with both the modern reductionist perspective and postmodern relativistic fragmentation.

It is also in harmony with a view of human knowing that stresses continuity with other natural phenomena. Models of quite different phenomena exhibit striking similarities. A dramatic example of this would be the computer model of the Post Big Bang Universe that is dependent on the connection of sentient entities as the key element of evolution. This model, created by Doug Seeley and Michael Baker at the South Australian Institute of Technology, is named from the premodern Indian myth of cosmological play that rhythmically creates and destroys the universe, LILA. This joining of the ancient with the most recent is also

characteristic of several artists and groups involved in contemporary electronic arts (technopagans, feminist goddess centred artists and those interested in expressing a Dionysian perspective in virtual reality environments).

There is a striking similarity between this model and the model of cognition that depicts intelligence in brain and machine as a relational function. In this model of the brain, neuronal firing patterns act as connecting entities to make sense of the world. A third piece of research that is interesting in this light is the controversial work of a sleep researcher featured on a recent public television series. He speculates that dreams are generated as a result of electrical stimulation from the pons or brain stem every 90 minutes or so during the night, and that this stimulation exercises the connectivity functions of the brain. This results in our making sense of senseless or random input, and in meaning being generated for dreams. Since mammals and some birds undergo similar phenomena during sleep this stimulates interesting speculation on the evolutionary value of human associative and alogical pattern generation. During the modern era this form of pattern generation has been generally devalued. It has remained valued primarily in the arts.

The research connected to the new connectivity paradigm stresses connectedness of mind/body, of mind and body with environment and interconnections of phenomena within the environment. In the modern model these connections and interdependent influencing would have been viewed as harkening back to a premodern 'magical' model. A concern with the magical, spiritual and shamanic characterises the work of many contemporary nonelectronic artists and theorists.

Conceptual view: philosophical and technological

Like Terry Winograd and Fernando Flores (1986) one can 'take action as primary, [and] ask how computers can play a role in the kinds of actions that make up our lives – particularly the communicative acts that create requests and commitments and that serve to link us with others'. Like them and other contemporary theorists I question the embedded 'everyday rational' attitude that is frequently associated with technological systems. Not only Winograd and Flores but Jacques Derrida (1989) cite and comment on Heidegger's important critique, *The Question Concerning Technology*. Winograd and Flores stress Heidegger's view that we always act within a situation without the possibility of disengagement. Consequently acts cannot be understood as the results of a process of representing, planning and reasoning. The readiness-to-hand of the world is revealed through our actions. 'We are always engaged in acting within a situation, without the opportunity to fully disengage ourselves and function as detached observers.' Winograd and Flores propose that a similar view characterises the work of biologist, Humberto Maturana:

> ... our ability to function as observers is generated from our functioning as structure-determined systems, shaped by structural coupling. Every organism is engaged in a pattern of activity that is triggered by changes in its medium, and that has the potential to change the structure of the organism (and hence to change its future behaviour) (Winograd & Flores 1986, 71).

Consequently, we may be viewed as *autopoietic* systems. Maturana takes the position that we may be easily led into fruitless quests for corresponding mechanisms if we believe representations are present in the nervous system (Maturana & Varela 1987). This implies a misplaced concreteness. In this he explicitly rejects the stance of objective realism, for example Putnam's early work on computability of mind (Putnam, 1975; 1980, 464-82).

Similarly Heidegger's critique questions the distinction between the knowing subject, the knower, and a separable object, the known. Heidegger sees representation as a derivative phenomenon. In his view knowledge lies in the being that situates us in the world not in a reflective representation. It is this view that has been embodied and developed in later phenomenological, existential, hermeneutic and speech-act philosophies. An even more radical position regarding knowledge of reality is proposed by Derrida (1989). In his reading of Heidegger, he stresses the importance of conceptual structures, patterns and systems of knowledge. He regards those

structures eluding modern rationalism as most revealing.

Hypotheses regarding knowledge and representation are key in the design of information based technology. This form of technology serves as tools for knowledge amplification and manipulation. Our understanding of what knowledge and representation are, how they are related or how they may be used, is crucial in shaping design decisions for information based technology and consequently in the design decisions made in other domains. These include the conventional design domains of graphic design, product design and architecture as well as the more recent design domain of knowledge systems. Computer graphics plays an important role in all of these.

In *Patterns, Thinking, and Cognition* Howard Margolis (1987) takes a conservative view. This early work reflects the view that patterns derive their existence from interest plus logic thus remaining rooted in the modern. An historical view of representations of various forms of logic and their relationships to technologies of communication leads to views such as that of Walter Ong's theory of transformative technologies (Ong 1971). He maintains, for example, that the development of typography and printing led to the rise of modern logic, that is, it amplified the cultural impact of the logic of Ramus via printed texts of his lectures (Ong 1958). For the first time language could be put in the form of modern industrial design emphasising efficiency, standardisation, replicability, and componentiality. Jacques Ellul (1964) extends this view to show how human organisations and institutions have been shaped by the same factors. Consequently both symbolic and material culture may be seen as expressing the structures and logic of modernism. Like Ellul and Ong, I agree that technology may amplify or de-emphasise factors and thus shape symbolic and material culture. This, in turn, shapes the larger conceptual view of reality in a given culture and time. This concurs with the more colourful view of Holbein on design:

> Design as process, and design as product, encompass practically any aspect of life. Design can be urban design or architectural design or product design or dressmaking, but it can also be cooking or singing or making war or making love (Holbein, 200).

In short, our way-of-being in the world shapes and is shaped by design (of symbolic and material culture). The philosophical argument for the existence of God called Argument by Design could exist only in a certain culture and time. Because it is based upon the concept that the design embodied in the physical world could come only from the mind of God, it is culturally and historically bound to a premodern world. Likewise, only in the modern world did it become possible to purchase rationally constructed, published or broadcasted recipes for music, cooking, dressmaking, conducting war, or making love. However ubiquitous their publication and distribution, their origin and design remained rationally oriented, expertly designed and hierarchically controlled within the modernist industrially designed culture. Electronic information processing and distribution have the potential to alter this emphasis on hierarchical structure in simple and complex ways. Computer graphic models have emphasised some views of order and revealed the limits of others. Consequently, they alter our way-of-being in the world. A cynic might state that if order did not exist in the world we would be forced to invent it. We may be said to be constantly inventing ourselves, our symbolic relations with the world, and the form of material culture that expresses these relations.

Many research and applied domains are using computer graphics in a variety of ways without concern for the research behind the creation of computer graphics. I have chosen to join computer graphics and design (in the broadest sense) with other domains to illustrate the interplay of design of symbolic communication, patterns of knowledge structures and breakdowns of conceptual limits. This is intended to illustrate their shared ground in changing the limits of how we may view the world. In this regard I cite the work of Winograd and Flores. They critique discourse in the cognitive sciences that centres on understanding human thought, discourse and action. They state that it is determined by a 'taken-for-granted attitude shaped by the underlying assumptions of the rationalist tradition'. They further state: 'Implicit in our critique is a statement that the cognitive science research program ... will

have important limitations in its scope and in its power to explain what we are and what we do'.

This limitation of truth and belief based upon a socio-historically embedded world view is also explored by Margolis (1987). He traces the difficulties of changing from Ptolemaic to Copernican astronomy. He also cites the difficulty Kepler had in giving up the perfect form of the circle for planetary orbits for the less perfect ellipse. Joseph Weizenbaum (1976) also traces the impact of technological invention upon the conceptual definitions of aspects of life. For example, he cites the invention of the microscope as shifting disease from defined as supernaturally caused (God's wrath or test of strength, a la Job) to being attributed to natural causes (germs). These examples are interesting in that they indicate breakdowns of taken-for-granted cultural constructs. The French Annales historical research group and ethnomethodological researchers in anthropology and sociology have attempted to elucidate our understanding via focus on areas of breakdown in understanding as they occur across history and across cultures (Clifford 1988). The hermeneutic philosophy of Gadamer (1976) includes the concept of a personal horizon. Both of these approaches to research draw upon his concept (Gadamer 1975) which represents a limit of the possible due to historically and socially constructed beliefs.

Breakdowns and borders

Breakdowns are described as interrupting our habitual, standard, comfortable being-in-the-world. They reveal to us the nature of our practices and equipment, making them 'present to hand' (ie, available for our examination), perhaps for the first time. New design can emerge only in the awareness that comes from breakdowns and the borders which they reveal. It is these borders that are the focus of schools of thought such as hermeneutics, post-structuralism, and deconstruction. Viewed using these philosophical contexts, contemporary computer graphic simulations of chaotic systems and strange attractors may be said to illuminate and alter the borders of our understanding.

The rationality of Descartes is embodied in the grid system underlying computer graphics. It is also present in the standard retrieval systems in many of our socially constructed information systems such as library catalogue systems and computer menu structures. However, Boolean logic underlies many electronic structures and provides a less rigidly structured view of information. The weighted or fuzzy logic of Zadeh allows logical structures of less certainty. Bayesian decision structures include statistically specified stochasticism. Within a relatively short time these conceptual structures have become part of the daily lived experience of many individuals who had experienced or studied only Aristotelian and Cartesian logic. Included among these individuals are artists, designers and users of contemporary products. Household appliances have chips with fuzzy logic embedded in their control mechanisms. Video game players of all ages experience the branching patterns of programs built upon Boolean logic and designed stochasticism. Children and executives choose from computer graphic diagrams representing models of knowledge for navigation in hypermedia information systems. These models of knowledge may be based upon design of a virtual building, a path describing a knowledge construct, a smart filter determined by user interest or others (Dede 1988). In short, the ways we describe and negotiate information has been changed by the combination and intervention of computer graphics and structures derived from research in artificial intelligence, information retrieval, and other areas of information-based technology (Fairchild, Poltrock & Furnas 1987). These conceptual structures enter and change the lived experience of more and more individuals and contribute to culture change.

Many of the very young seem quite able to negotiate these conceptual spaces with relative confidence and certainty. However, some users report disorientation and failure to make sense of *the* structure, not realising that they may choose from several potential structures. Complaints are raised such as, 'I can't find my way back to the beginning of this', which implies belief in the universality of a linear and probably hierarchical structure. Researchers in the humanities and social

sciences often request, 'Can we put this in a matrix for easier understanding?'. Legitimation of prior structures is revealed by their absence. Here an area of breakdown and borders is brought forth. It reveals culture change being wrought by widespread use of a new form of communication employing information based technology.

Deconstruction and knowledge systems

These factors support the view that a plurality of cultural worlds exists in which we participate. Deconstruction focuses on illuminating the existence of the unexpected in the taken-for-granted. The embedment of prior architectures of thought in new technological or scientific or artistic forms is accepted as fundamental by deconstructionists. Focus on the frame or the border is characteristic of this school of thought.

In *Truth in Painting*, Derrida reveals the 'framing' discourse of post-Kantian aesthetic theory (1987a, 33). This 'framing' discourse has been aimed at legitimising its own existence by fixing the boundary between art and other modes of knowledge, including paradoxically, art history and theory. In this work, Derrida demystifies the notion of the aesthetic as a realm of purely disinterested values, one in which conflicts are laid to rest through the free play of harmonised faculties.

An information system that calls into question similar assumptions is Ted Nelson's Project Xanadu (1987; 1988) This system is built upon his desire to democratise not only the distribution of information, but the authoring of information. It allows any user to change any information in any way, so multiple concurrent versions exist. It also allows the tracing of all changes and variations. Although the system itself is constructed by an expert, the information included in it, and the manner of its usage leads to a form that is self-constructing and self-regulating. In essence, this system could take the author from authority and reveal taken for granted canons of design. This is the same spirit as deconstructive theorists in literature and visual artists using appropriated images from art history and popular culture. Interestingly, 'close reading' (ie, critical deconstructive viewing to reveal breakdowns and borders), demands extensive knowledge (Eco 1979). For less knowledgeable readers or viewers, all that exists is a feeling that something is not quite right; clarity and understanding are not complete. Again, invisible taken-for-granted structures are revealed by their absence. Literary deconstruction also breaks another modernist boundary related to hierarchy. For example, there is frequently a blurring of the boundaries between writer and critic. Implied in this is the end of literature in the sense of the end of any special status accorded to it.

Webs of meaning and implications

In the arts, humanities, social sciences and philosophy of science the value of plurality of views is being recognised. A 1988 conference in the sociology of science held in Bielefeld, Germany, presented a research program stressing changes in premises resulting from models based on dynamic, self-regulating, self-organising systems. These systems reflect a new perspective derived from computer generated models displayed graphically. This research program is based on the following assumptions:

1. Complexity as a genuine irreducible phenomenon. This was made evident via computer models of deterministic-recursive systems in which simple mathematical equation systems provide extremely complex behaviour.
2. Irregularity of nature is normal, not an anomaly, and forms the focus of research. Non-equilibrium processes are recognised as the source of order and the search for equilibrium is replaced by search for dynamics of process.
3. Self-regulating model of systemic closure replaces the classical system-environment model based on external control. Effects produced by the system are the causes of systemic organisation and maintenance. In sufficiently complex systems internal self-observation and self-control form the basis of cognition. Any information a system provides on its environment is a system-internal construct. The 'reference to the other' is merely a special case of 'self reference' (Krohn et al, 1990).

The importance of interactive computer graphics becomes evident in depicting simultaneous multiple relations and versions,

making visual sense of chaos and multidimensional statistical structures and offering individualised choices and routes through learning materials. The privileged position of alphanumeric representation is being questioned, the grid has become insufficient as a structure in which to place knowledge. Visual electronic images have begun to take a prominent role in re-visioning knowledge construction in the arts, humanities and social sciences, as well as in the natural sciences. The boundaries between these disciplinary views of the world are becoming blurred by the transformability of digital information.

In the world of the visual arts, reconstructionists such as Suzi Gablik and artist-theorist Heide Abendroth Gottner appear to be moving in the direction of the new paradigm of connectivity. They link their perspectives to a revival of the premodern rather than to electronic imagery. They are interested in relationships of the aesthetic to social, spiritual and ecological issues and see art as playing an active role in these realms. Another group, also interested in the re-enchantment of art and its link to the spiritual, stresses the integral connected role art should play in all aspects of life. This perspective is reflected in David Ray Griffin's collection of essays, *Sacred Interconnections: Spirituality, political economy and art*. Many artists and theorists who belong to this group are concerned with the relationship of mind/body, human to human, human to nature and the underlying spiritual connections between these.

The recent work of theorist and writer Helene Cixous (1990), especially her readings of Lispector, provide an analogy in literature to the conceptual patterns described in this paper. Her work does this in several ways: at an abstract level of 'life affirming rather than negating' (parallel to discussion of the second law of thermodynamics), joining of formerly separate concerns (ie, 'aesthetic, social and corporeal'). She strives toward a mode of revealing that addresses 'nonexclusive differences so the other is other without being thought of in merely negative or propositional terms such as that of the nonself'. In this she illuminates the prejudice lying beneath normalising standards and uniformity in modernism. This view is also characteristic of contemporary social science research.

In a recent issue of *Mondo 2000* Brenda Laurel, a theorist and practitioner in the electronic arts, discusses the following topics that relate to the issues addressed in this paper:

- mind/body problem and anti-feminist bias in hacker stereotypes;
- need to build virtual reality so people (nontechnologists) can shape it from inside the experience;
- difficulty of addressing multiculturalism and cultural diversity in multimedia;
- advocates 'infinite diversity in infinite combinations';
- advocates model of 'fusion' people such as Brian Hughes and Sandy Stone who combine knowledge from social science and humanities with computer sciences;
- departs from concept of global, non-unique culture characteristic of modernism. Advocating instead individual and cultural uniqueness as contributing to whole.

Metaphors of modernity intended to model reality are mechanical, divisive and orderly. Those of the postmodern are fragmented and combined serendipitously. Metaphors influenced by the new view of simultaneous unity and diversity (ie, *autopoesis*), are biological and associative. They often involve nets or webs that join in multiple harmonious dynamic patterns.

This latter view has potential for applied as well as conceptual usage. For example, in the applied discipline of education Ralph Abraham, a mathematician, suggests the simple model of the 'daisy world' of James E Lovelock and Lynn Margulis as a teaching tool. This model allows students to understand the earth as a self-regulating system. According to Abraham, it educates them 'to be better members of the board of directors of the planet' (Gleick 1987, 279).

A concern shared by many artists, designers, educators, literary theorists such as Helene Cixous, and philosophers such as Maurice Merleau-Ponty (1962), Mark Johnson (1987), and John A Schumacher (1989) is the importance of corporeal experience, the play of the senses beyond that of sight. Schumacher goes so far as to propose that the nature of all human inquiry is based on posture. The developmental psychologist

Howard Gardner's theory of multiple intelligence also reflects this view (Gardner 1983).

Graphics beyond sight: utilising sensual corporeal information

At the University of North Carolina, whole body movement in a virtual environment assists physicians in directing a gamma-ray beam to destroy cancerous tumours. At the Human Interface Technology Lab at the University of Washington, meteorologists fly through virtual weather systems, designers sit in virtual cars and walk through unbuilt office buildings. At Autodesk Inc in Sausalito, Randal Walser states that virtual reality is an artistic media for building imaginary worlds. At this site, able bodied participants play racquet ball with disabled partners and learn to experience the sensation of flight without a plane. In nearby schools children use the technology developed by Autodesk to create virtual worlds. At NASA's Ames Research Center near Mountain View one may fly through a virtual simulation of the Valley of Marinis on Mars (Stewart 1991).

William Gibson depicts disembodied intellects of expert programmers travelling through landscapes of visual information in his cyberpunk science fiction. Current work in scientific visualisation in combination with the hardware and software of communication networks provides the grounds for the existence of this space. Combining these technologies with developing virtual reality may present new ways of knowing beyond the modern biases of power and efficacy of alphanumeric symbols and text as validated vehicle of communication. Although tactile and kinaesthetic information has been introduced to virtual reality environments they currently continue the modern bias of the privilege of sight as a perceptual tool.

The importance of this bias is revealed if we consider the role of instruments such as the microscope, telescope, cameras and videos. Postmodern critics have directed our attention to the objectification of gaze, alienation and dehumanisation involved in the design and use of these instruments. Continuities of the modern into the late or postmodern are also characteristic of computer graphics and some virtual environments. The thinness of modern reality, the mind/body separation was strongly embedded in the origins of computer technology. The discomfort many artists have felt in moving from traditional media to electronic media related to the difficulty of communicating content that involves bodily response. Most electronic art involves bodily alienation; however, an exception that comes to mind is the early work using biofeedback instrumentation. The opportunity to involve bodily response is undoubtedly one of the reasons that virtual reality is so exciting to artists.

Jaron Lanier, creator of virtual realities, claims that experience of the best virtual reality simulations heightens experience of the ordinary world. It does so by increasing our awareness of what is missing from the technologically constructed virtual world. He stresses infinite subtlety of the physical world where there is always something new to see, and something unexpected to discover. This reminds us that our human adaptability and skills of self-creation evolve, fill in or make complete any conceptual structure intended to model reality.

Conclusions

Breakdowns and boundaries as well as cultural continuities occur in similar form across many disciplinary areas. High technology, especially computers, presents an interesting subject area for discovering both breakdowns and continuities in culture change from modern through the postmodern to the new paradigm of connectivity. Surprisingly, this latter area with its links to the premodern view of a harmonious connected magical view of the world traces its origins to the use of computer graphics in the description of complex patterns of natural phenomena. These patterns had previously been considered too irregular for study. The new paradigm accepts the simultaneous irregularity and regularity of these patterns. This new view allows scientists and technologists to focus on the alogical and associative as well as the logical, as artists have.

Similar assumptions mark the work of artists and theorists involved in reconstruction, art as social and spiritual connection and expression and the work of scientists and technologists involved in cognitive science and neural net research who

have come to value emotion as much as intellect for cognition (Levine & Leven 1992). Characteristics traditionally valued by artists, such as emotional expression, associative and alogical connections of information and reliance upon sensual perception, are coming to be valued in the world of technology. Combined with the concerns of reconstructionists and critics such as Cixous for life affirming connections between people, humans and nature, these views provide a possible new view that contrasts sharply with the emphasis on disembodied observation that has been characteristic of modern science. It is a sharp departure from the emphasis on objective surveillance and noninvolvement of modernism and from the relativistic fragmented view of the postmodern. For example, the modern view accepts the use of electronic technology to record and view human suffering with no physical, sensual or emotional involvement. It is this position that accepts the use of computer controlled video surveillance as integrated into smart missiles. This position also led to the development of virtual environments to simulate battle conditions. The postmodern perspective revealed the problematic nature of broadcast television and video embodying the modern perspective. Will new user/audiences join technologies of video, computer graphics and virtual reality to the new world view of connectivity to create widespread breakdown of the model of the world as objective manageable information?

References

Cixous, Helene, 1990, *Reading With Clarice Lispector*, trans Verena Andermatt Conley, University of Minnesota Press, Minneapolis.

Clifford, J, 1988, *The Predicament of Culture: Twentieth Century Ethnography, Literature and Art*, Harvard University Press, Cambridge MA.

Dede, C, 1988, 'The Role of Hypertext in Transforming Information into Knowledge' in *Proceedings of the National Educational Computing Conference '88*, ed WC Ryan, International Council on Computers for Education, Eugene, Oregon.

Derrida, J, 1987, *The Truth in Painting*, trans Geoffrey Bennington & Ian Macleod, Chicago University Press, Chicago.

——, 1989, *De l'esprit: Heidegger et la Question*, Galilee, Paris. (In English, *Of Spirit: Heidegger and the Question*, trans Geoffrey Bennington and Rachel Bowlby, University of Chicago Press, Chicago.)

Eco, Umberto, 1979, *The Role of the Reader*, Indiana University Press, Bloomington, Indiana.

Ellul, Jacques, 1964, *The Technological Society*, Random House, New York.

Flower, Linda, 1989, *Problem Solving Strategies for Writing*, 3rd ed, Harcourt Brace Jovanovich, San Diego CA.

Fairchild, K F, Poltrock, S E and Furnas, G W, 1987, 'SemNet: Three Dimensional Graphic Representations of Large Knowledge Bases', in *Cognitive Science and its Applications for Human-Computer Interaction*, ed R Guindon, Lawrence Erlbaum, Hillsdale NJ.

Gadamer, Hans-George, 1975, *Truth and Method*, trans & eds Garret Barden and John Cumming, Seabury Press, New York.

——, 1976, *Philosophical Hermeneutics*, trans David E Linge, University of California Press, Berkeley.

Gardner, Howard, 1983, *Frames of Mind: The Theory of Multiple Intelligences*, Basic Books, New York.

Gleick, James, 1987, *Chaos: Making a New Science*, Viking, New York.

Heidegger, Martin, 1977, *The Question Concerning Technology and Other Essays*, trans William Lovitt, Harper and Row, New York.

Holbein, Hans, cited by Robbie and Tony Fanning in *The Complete Book of Machine Embroidery*, Chilton Book Company, Radnor, Pennsylvania.

Ivins, W M, 1973, *On the Rationalism of Sight, with an Examination of Three Renaissance Texts on Perspective*, Da Capo Press, New York.

Jones, B J, 1989, 'Computer Imagery: Imitation and Representations of Reality', *Leonardo*, Supplemental Issue: Computer Art in Context.

——, 1990, 'Computer Graphics: Effects of Origins', *Leonardo*, Supplemental Issue: SIGGRAPH.

Johnson, M, 1987, *The Body in the Mind: The Bodily Bases of Meaning, Imagination and Reason*, University of Chicago Press, Chicago.

Krohn, Wolfgang, Gunter Kuppers & Helga Nowotny, 1990, *Self Organisation: Portrait of a Scientific Revolution*, Kluwer Academic Publishers, Boston.

Leonardo, 1990, 'Digital Image Digital Camera', Special Supplement.

Levine, David S and Leven, Samuel J, 1992, *Motivation, Emotion and Goal Direction in Neural Networks*, Lawrence Erlbaum Associates, Hillsdale, New Jersey.

Lichty, Tom, 1989, *Design Principles for Desktop Publishers*, Scott, Foresman Computer Books, Glenview Ill.

Lucas, R, 1986, *Evolving Aesthetic Criteria for Computer Generated Art*, masters thesis, Ohio State University.

Margolis, Howard, 1987, *Patterns, Thinking, and Cognition: A Theory of Judgment*, University of Chicago Press, Chicago.

Maturana, Humberto and Varela, Francisco J, 1987, *The Tree of Knowledge*, New Science Library, Boston.

Merleau-Ponty, M, 1962, *Phenomenology of Perception*, The Humanities Press, New Jersey.

Nelson, T, 1987, *Literary Machines*, edition 87, no 1, Project Xanadu, San Antonio Texas.

——, 1988, 'Managing Immense Storage', *Byte*, 13 (1).

Ong, Walter, 1971, *Rhetoric Romance, and Technology: Studies in the Interaction of Expression and Culture*, Cornell University Press, Ithaca.

——, 1958, *Ramus, Method and the Decay of Dialogue: From the Art of Discourse to the Art of Reason*, Harvard University Press, Cambridge.

Putnam, H, 1975, *Mind, Language, and Reality*, Cambridge University Press, Cambridge.

——,1980, 'Models and reality', *Journal of Symbolic Logic*, Vol 45.

Schumacher, John A, 1989, *Human Posture: The Nature of Inquiry*, State University of New York Press, Albany NY.

Stewart, Douglas, 1991, 'Through the looking glass into an artificial world-via computer', *Smithsonian*, Vol 21 No 10, January.

Turner, G, 1986, 'Electronic Characterisation' *American Cinematographer*, Vol 67 No7.

Winograd, T and Flores, F, 1986, *Understanding Computers and Cognition: A New Foundation for Design*, Ablex Publishing Corporation, Norwood NJ.

Weizenbaum, J, 1976, *Computer Power and Human Reason*, W H Freeman and Co, San Francisco.

Zeltzer, D, 1985, 'Towards an integrated view of 3-D computer character animation' in *Proceedings Graphic Interface '85*, Montreal Canada.

Beverly J Jones teaches in the School of Architecture and Allied Arts, University of Oregon, Eugene, Oregon. Her interests are technology and culture, aesthetics and research methods. Her e-mail address is beverlyjones@aaa.uoregon.edu