The Vitality of Digital Creation

Timothy Binkley

The Journal of Aesthetics and Art Criticism, Vol. 55, No. 2, Perspectives on the Arts and Technology. (Spring, 1997), pp. 107-116.

Stable URL:
http://links.jstor.org/sici?sici=0021-8529%28199721%2955%3A2%3C107%3ATVODC%3E2.0.CO%3B2-V

The Journal of Aesthetics and Art Criticism is currently published by The American Society for Aesthetics.

TIMOTHY BINKLEY

The Vitality of Digital Creation

I would rather be a cyborg than a goddess.
—Donna Harraway

I. NUMBERS INVIGORATE PICTURES

Since numbers and pictures are diametric opposites, digital images are at first glance improbable players in the drama of culture. An image is a visible *percept* concretely embodied in a physical object. A number is an invisible *concept* abstractly designated by formal symbols. The aesthetic principles that guide our appreciation of pictures have no relevance to plying digits, and the mathematical rules that govern reasoned formulae have no bearing on understanding art. "Paint by number" is a derisive appellation in the halls of high art, alluding to the idle parlor pastime that mindlessly fabricates vapid objects worthy of artistic ridicule. A "digital image" is trifling if not oxymoronic.

Despite this apparent contrariety, computers have rapidly infiltrated everyday communications where they routinely ingest, digest, and regurgitate vast amounts of digital imagery, along with many other types of information including text, sound, and numerical data. Computer-assisted pictures are filling the theater of civilization—sometimes surreptitiously—as they play growing roles in magazines, classrooms, cinemas, homes, banks, arcades, ... and even in art museums and artist's studios. Indeed, the impact on art is sufficiently developed to warrant a cover article in *ARTnews* announcing that "computers are transforming the way images are made, objects are studied, and visitors view pictures."[1] We read that "the digital revolution, in a rainbow of 16 million colors, has arrived."[2] In the short span of two decades, the look of computer art has evolved from austere to luscious and it is creating new roles for art as it also supplants some of the techniques employed in traditional art making. A computer can streamline and expedite tedious manual tasks to increase the artist's creative potential. But more important, it augurs novel scenarios for working, playing, and knowing that have yet to unfold.

For better and for worse, the changes being wrought by our increasing involvement with computers promise to be far-reaching. We are not simply creating a revolution in art, but are overhauling the foundations of culture. The consequences of digitizing our discourses encompass not only expanded creative phenomena, but also extended interconnections between art and the rest of culture as we interact more frequently and more fully with each other across geographic, political, and cultural boundaries. Europe and Japan have made significant strides toward networking their citizens with high-speed digital communication links, and a new government initiative in the United States seeks a national fiber optic "highway" that will open floodgates of data from around the world and further shrink the circle of the "global village."[3]

Visual data are paramount in shaping the interface as well as supplying the content for this network. Since the amount of information contained in images tends to be massive, computerized high-bandwidth[4] links make it possible to share them as never before. Moreover, pictures are superbly demonstrative and eminently computable, transcending the parochial limitations of natural languages. They are now likely to play increasingly larger roles in all types of communication since they are becoming much easier to make and to move.

Digital images are no more or less paradoxical than thinking machines. Computers can be enigmatic because they challenge some of the most fundamental tenets of Western civilization, from ontological presuppositions about what exists to epistemological presumptions about how to find out.[5] They also stage riddles

to the common sense forged by centuries of experience through the eyes of Western philosophy. An automobile that talks to you abrogates the mind/matter barrier but also engenders an unnerving feeling that your quotidian taxonomy is crumbling. Problems about understanding digital technology lurk in the long shadows cast by a still colossal Platonic dualism. Despite the forcefulness of a variety of recent philosophical attacks, everyday language still harbors dichotomous residues cleaving mind from matter, representation from reality, and emotion from cognition. As a result, we will continue speaking about computers in paradoxes until our language catches up with our creativity.

The fortitude of computers in resisting the daunting weight of so much history comes in large measure from the way they are able to amalgamate the affective power of illusionistic images with the ideational responsiveness of automated calculation. Machines that figure can play dual roles. Digital technology challenges dualism by spawning nimble avatars of holism conceived from a cross-pollination of science and art. We are constructing silicon bridges across time-honored mental abysses.

Despite its novelty, the digital revolution builds upon long-standing, if sometimes misunderstood, traditions in the arts. The background out of which digital images vigorously leap is insightfully described by David Freedberg in *The Power of Images.* He delineates numerous examples from different periods where images have been endowed with a variety of primitive powers, from healing the sick and saving the damned to arousing the lascivious. Quoting Nelson Goodman, he explains how "the domineering dichotomy between the cognitive and the emotive"[6] has prevented us from recognizing this power. Because of our predisposition toward the same dualism that computers challenge, we have failed to acknowledge universal human responses to images throughout history, in many different cultures, both inside and outside the context of art.

At the heart of Freedberg's argument is the realization that "representation is subsumed by presence."[7] This is explained in an interesting anecdote about how he became angry at the Madonna, and not simply at her likeness, upon being disappointed in a sculpture after a long and arduous hike to see it. He details at great length many other emotional responses to pictures that are predicated on seeing through a representation to make its subject present. This is why people pray to a statue or lust after a photograph. In each case, the spectator elides the physical representation to enter the spiritual presence. It is this ability to make the absent present that allows us vicariously to travel the world from an easy chair and have feelings about it through the voyeurism of magazines and television. From empathizing with the anguish of the starved, to being awed by the feats of a gymnast, our reactions tell of an experience that is more like having the subject of a representation before us than merely her transported likeness.

For Freedberg, the key to understanding the influence images exercise over us is their ability to re-present what they represent. The distinction between representation and reality does not always function as an impediment to being moved by a depicted person or event.[8] The artistic medium often barricades reality from representation only for the sake of preserving it. Sometimes an image encourages us to bask in the transcribed presence of its subject as traces of her existence are lodged in a medium that spirits her visage across space and time.

By thoroughly studying the history of human responses to images, Freedberg detected many factors that question a tidy separation of intellect and emotion and highlight the need "to acknowledge the role of sensation in knowledge."[9] But computers press this challenge to dualism much more deeply as they interpenetrate the image and the viewer to merge representation and reality in a new way.

Computers affect us, in part, because images do. But computers supersede our modern image-drenched culture of magazines and movies because we can influence them to act in response to us. Digital representations not only possess a power to move us borrowed from their analog predecessors, they also contain a *vitality* which enables them to engage us in unique and personal interactive experiences. If images make their subjects present to us, digital representations make us present to them. The computer opens up our image-saturated culture to a virtual universe composed of numbers that are oddly capable of reaching out to us. Our individual presences are delivered to the subjects of digital representations, and vice versa, as they engage

us in dialogue. Digital images transcend power to achieve vitality.

At the source of all this activity are two closely related transformations: the replacement of analog with digital media, accompanied by a shift from mechanical to computational models of technological problem-solving. Two main concepts characterize these changes: virtuality and interactivity.

II. THE VIRTUAL REALITY OF DIGITAL MEDIA

Throughout the ages, analog media have set the stage where artists petition posterity for a place in history. From the earliest cave paintings and stone carvings to the contemporary "mass media" epitomized by television, matter has been shaped into forms as a means of transporting messages across space and time. Digital media are relatively new players in the drama of culture, and their methods for managing information are fundamentally different. Analog media are primed for imprint, while digital ones are structured to symbolize. One is focused on concrete preservation and presentation, the other on abstract storage and manipulation. Although digital technologies can be excellent mimics of analog ones, their functionality is more diverse. In brief, analog media are prepared to *receive and preserve traces of events* while digital media are formatted to *store and process symbols of numbers.*

Both types of media can be used to represent reality, but they do it in quite different ways. What is a representation? In visual art contexts, the word conjures up images of pictures. The *Mona Lisa* represents someone sporting an enigmatic smile; *Guernica* represents a hideous massacre. In mathematics and science, however, representations tend to be abstractions that are more descriptive than depictive. At their most grand, they are theories; frequently they are diagrams; and at their humblest they are simply raw data.

These are two radically different ways to represent information about the world. A person's appearance is represented *in* a photograph that qualitatively depicts her visage, while height and weight are represented *by* numerical measurements that quantitatively capture more clinical traits. We can see her in the picture, but we can only infer her from the numbers. She may look gaunt, but her height and weight might lead us to conclude that she is fit instead. Appearances possess an incommensurable particularity that numbers lack, but the generality of mathematical structures makes them tools for inference and frameworks for theory.

An analog medium is usually primed into a smooth tabula rasa as preparation for it to receive an imprint of creative activity. The artistic gesture *maculates* a smooth continuum. The resulting echo is an analogue of the reality echoed: it tends to have curves where its source has curves and is straight where the original is. The reason for this similarity is that information is essentially *transcribed* from one physical material to another. A direct physical impression moves information from a subject to its analog representation. The camera is the apotheosis of analog representation, as it uses light to trace shapes of objects instantly onto film.[10] Similarly, analog music recordings on cassette transcribe fluctuations of sound waves through the air into fluctuations of electrons which are then transcribed again into varying magnetic fields on tape. Each analog medium is grounded in a particular material substrate where imprints are pressed to transcribe form from one substance to another.

Digital representations, on the other hand, take measurements rather than impressions of what they represent: their goal is *mensuration* rather than maculation. To achieve their transaesthetic epiphany, they *convert* information from material into numerical entities rather than transcribing it from one physical substance into another. For example, analog video transcribes light into electric current, while digital video converts light into pure numbers dissociated from any physical unit. An analog medium transfers shape to produce an analogue of one physical arrangement in another, analogous one. But digital media transform physical form into conceptual structure. A shape or color is converted into a number whose symbol is then inscribed on a ledger so that it can subsequently be ascertained by a machine or a person. The material out of which this ledger is constructed is incidental to the information stored, unlike the constitutive material defining an analog medium. Regnant technologies today use electrons circulating through silicon chips and iron oxide on magnetic disks, but optical disks are rapidly

overtaking their short-lived predecessors, and optical computers that use light instead of electricity to perform computations and store the results are under development. And based on the promising if surprising results of recent experiments, biochemistry may become the next medium for even faster computation.[11] All digital media are equally capable of producing identical results since their roles lie in abstract symbols and not in concrete materials. It is also relatively easy to move from one digital medium to another. For example, one can switch from magnetic to optical disks by connecting the appropriate disk drive to your computer. Compare this facility with the notorious difficulty in replicating the look of a painting on the printed page of a book.

Of course, one cannot store a number without using some kind of physical object. But the substance itself is of secondary importance in a digital medium since numbers are not inherently material entities. Symbols written on paper or on a computer disk are conventional marks established by a culture to stand for conceptual objects. A number is an abstraction that can be designated in a variety of different symbolic systems. A number symbol is sometimes called a *type,* while the various individual inscriptions of it are *tokens* of the type. The symbol type "II" was the Roman way to record the same number referred to by "10" in the binary system used by computers, which is called "2" in many contemporary languages. Each time someone writes a particular "2" in pencil, chalk, or ink, a new token is created which instances the same symbol type. The inscriptions written onto a digital medium as magnetic blips are tokens of number types, albeit tokens that are usually readable only by a machine. And all of these tokens ultimately refer to the same *concept,* the number two.

In contrast, the inscriptions made in analog media record physical traces of events that do not betoken concepts. This is true even when they must be played back by a machine to be seen or heard. For example, a video tape player simply transcribes a magnetic analogue of sounds and images to recreate something perceivable, and does not treat the recorded signals as having any symbolic function.

The fundamental purpose of an analog medium is to preserve and present specific perceptual displays. These two functions coalesce in the material substance of the medium. Even when storage and display activities are separated—as in the cinema, which dedicates film vaults and movie theaters to each respective function—they are tied together in a celluloid-based liaison neither can escape. You cannot play a videotape in a film projector, and vice versa. To get from film to video, you need a characteristically analog transcription: you need to videotape the film. In a digital medium, by contrast, the two functions of storing and displaying information are relatively independent. The fundamental purpose of a digital medium is to keep track of sometimes enormous collections of organized numbers. These numbers need to be exhibited somehow to have meaning, but since they are abstractions, they are not endemic to any particular medium of expression. This is why the contents of a digital medium are computable, while those of an analog medium are not. Computation is allowed to happen in the interstices digital media create between storage and display. A spark of vitality is ignited in these hidden recesses. The reason digital media are able to nurture this force is that they are designed to host busy minions rather than to bear enduring marks.

Digital media are both more temporary and more permanent than analog ones. A gessoed canvas and a piece of unexposed film are emptied of form as they are prepared to receive an imprint and hold it forever, as best they can resist the ravages of time. The analog medium is stripped of irregularity and sensitized to perturbation. A canvas can be overpainted or scraped, but it is not intended for repeated use, and once a piece of film is exposed, there is no turning back. But a digital medium is designed precisely to be used over and over again. Instead of being primed as a tabula rasa, it is preformatted with a rigid structure into which any stored information must be received. A digital medium is an imposing edifice where fresh digits are repeatedly entertained in assigned locations, much as theater seats receive different theatergoers for each performance. Digital information can be shuttled in and out of a computer with astonishing speed and accuracy. Yet despite this essentially changeable nature, digital media are paradoxically more, rather than less, resilient. Since they store tokens of numbers rather than

traces of events, digital images are more impervious to the vicissitudes that assail analog images. A few scribbles across the surface of a canvas will significantly mar its aesthetic qualities, but similar scrawls over a ledger of numbers will not generally affect its utility. Provided the numbers can still be discerned from their tokens, no information is lost. This is also why there is no "generation loss" in making copies of digital information. Every time a copy is made of an analog image, the succeeding copy depends for its fidelity upon the accuracy of transcription. Invariably, some details are lost with each generation, so that after repeated copying the original image has deteriorated. But copying information from a digital medium does not take place by transcription, by making imprints of imprints. To copy a digital file, the numbers are read and inscribed anew each time. So each copy, even if it is several generations away from the original, is still an "original" inscription of the information. This does not make digital media impervious to error, it just means that the possible errors are of a different type, namely errors of reading and writing rather than of transcribing. It turns out that processing tokens of numbers by computer can be done with considerably more accuracy than mechanically or manually replicating traces of events. This is not surprising since discerning a number from a symbol is much easier than matching the color of a swatch.[12] Creations in digital media really have no *original* against which copies can be compared. In this respect, they are quite different even from the traditional media of literature and music, which use extensive symbolic systems for expression. When writing a novel or a symphony by hand, one produces an original text or score, but this is not so when composing at the keyboard of a computer.

Recursive transcription lies at the core of analog culture. Most visual information that reaches us in analog media has passed through several layers of transcription. A picture in a book or magazine was transcribed first from an actual event onto a film negative, then onto a film positive, then transcribed again onto an etched printing plate, and finally imprinted onto the page we see. Video signals pass through similar cascades of copies to bring a performance from the studio to the home. Modern culture took up residence in this echoing theater of mimesis and filled it with the surfeit of images that produced the postmodern crescendo of simulacra.

This intrinsic transcriptive nature is perspicuously presented in some of Magritte's paintings. His familiar "Human Condition" images capture the elusive epiphany of analog media, where representation and reality become indistinguishable. But this magic is worked only in the recursive universe of transcription, where the medium of paint is tricked into making a picture of a picture look like the picture itself. Pictures of pictures are a familiar theme throughout the history of art, and they demonstrate the omnivorous appetite of mimetic media that enabled them to feed on themselves to produce a frenzy of procreation in the modern world. Although the promiscuous proliferation of transcribed visual information has become a wonderful channel for disseminating culture, it has a one-way valve at each analog aperture. Once frozen in a medium, the image is trapped and can only go deeper into mimesis. This is one reason why, although analog media are adept at transporting likenesses of their subjects, they cannot reverse the direction to bring viewers any closer. Digital media are able to do this because they do not transcribe, and hence do not recurse in the process of recording information. Information is immediately converted when it enters the digital universe. That conversion process can only be performed once: you can measure a table, but you cannot then measure the measurement. You might measure a measuring tape to check its accuracy, but this is no way to replicate the digital information it produces. Once converted from percepts into concepts, from material into numbers, information is freed from the infinite regress of transcription and may travel back and forth between the user and the used. Computer algorithms often use recursion, but it is mathematical rather than physical and serves a completely different purpose that is transactional rather than presentational. By abandoning physical recursion devoted to the service of impersonal dissemination, digital media become capable of carrying on individual dialogues with each one of us.

Digital media are adept at storing vast collections of numbers, and computers are adroit at manipulating them. But the arcane tokens of these thinking machines are incomplete by themselves. Since concepts are not appearances,

the curious digital image is unfulfilled without a transformation of numbers into percepts. To get *visual* information into the computer and onto a digital medium, we require a conversion from objects to numbers. To get it back out again, the converse conversion is needed. Even if our interest is primarily in numbers—say for pecuniary purposes—machine-readable tokens must be translated into human-readable ones before we can comprehend them. These conversion processes are usually carried out by specialized pieces of hardware called (oddly enough) *converters.* There are analog-to-digital converters for input, and digital-to-analog converters for output. They typically form the heart of an *interface,* which consists of a hardware/software system for automatically and swiftly moving information back and forth between people and computers (or sometimes between two different machines). The canonical output interface found in most graphics computers takes numbers stored in a specialized portion of memory called a *frame buffer,* and converts them into a video image on a monitor. But there are myriad other interfaces for changing numbers into pictures, from printers to cameras to looms. Some interfaces output numbers as pigment on paper, others as photographic film, still others as pen drawings. There are also a host of nonvisual interfaces that turn numbers into sounds or movements. In addition, a variety of converse interface apertures admit numbers abstracted from events. The most common input channels currently in use are the keyboard and the mouse. Scanners and digitizing tablets are also frequently found in graphics settings.

As a result of this dependence on interfaces, digital media augment rather than undermine their analog forbears. Although they posses much vigor, computers by themselves have no power. Their vivacious missives remain ever mute without interfaces to the comfortable analog media we sentient creatures know and understand.

Herein lies another conundrum centering on the identity of a digital image. Its defining essence is a numerical file; yet its specific appearance can vary depending upon the output method that converts these numbers into colors. So while an array of numbers fixes a digital image's identity, they do not fully delimit how it will appear. Many of its detailed aesthetic qualities are prescribed by the interface used to output it, and no single one has any priority in establishing the correct appearance. When any computer artist creates his works at a computer, he views the images on a cathode ray tube, the "computer screen" that currently functions as the canonical visual output. There they are displayed as colors of light emitted by glowing phosphor. But if he chooses to output these images as silk-screens, they become pigment-based works with a quite different appearance. Which one is *the* digital image? Both and neither. The numbers function as the foundation of a visual construct, but they do not completely dictate its appearance. There is no privileged output; all are equally derivative from and dependent upon the digital source. Of course, the artist may choose to present the images only as silk-screens, in which case the computer becomes a tool in the service of an analog medium. But increasingly, creators of digital art are transmitting files for interaction as well as display by users on their own computers and output devices over which the artist has no control.

The digital image has a virtual existence. It is intangible and invisible, yet we can perceive it through interface portals that change its kernel of numbers into visual presentations. We have heard a great deal about "virtual reality" in the popular press, which revels in describing the fantasy potential of immersive systems. These elaborate paraphernalia encase the user in a cocoon of goggles, gloves, earphones, and a bodysuit that propel her into a full somatic experience of virtual universes, complete with monstrous adversaries and teleported lovers.[13] Yet the virtuality of such experience emerges not from the expensive hardware haberdashery, but from the humble abode of nimble digits. Numbers are the original virtual reality. They are timeless abstractions which nevertheless have a profound impact on everyday life as they guide us in building houses and bridges, as well as in destroying them. Any time we work with a digitally represented universe inside a computer, we are having an experience of the virtual reality mensurated therein. Even when we peer into the small screen of a personal computer, the denizens we encounter there—from T-squares to ninja turtles—are all virtual creatures open to our entreaties.

There are two kinds of "reality" in virtuality.

One is called the *image space,* which tends to be lodged in the frame buffer; the other is called the *object space,* which is distributed less specifically throughout the computer's general purpose memory. The image space is usually an array of numbers organized as representatives of picture elements, or *pixels,* which are the individual colored dots of a digital image. Each pixel has a corresponding location in memory where its current color value is stored. The canonical interface converts that number into a color on a video monitor, which is usually specified in terms of its primary components: red, green, and blue.

In addition to the virtual images that reside in a computer's image space, it is also possible to conjure up virtual objects which are described by their virtual "physical" properties, such as height, weight, and color. They might also be specified in much more general ways by associating them with mathematical formulae or algorithmic instructions that tell the computer how to generate them. Fantastic as well as familiar geographies can be created algorithmically from general instructions rather than by specifying each component separately, as a landscape painter does. Plants can be grown in the computer on the basis of parameters set by the artist rather than meticulously painted leaf by leaf. And animals can be evolved from virtual genetic information rather than delineated through individual physical traits.[14] Once conjured up in the computer's object space, a virtual camera can be commanded to take pictures of these strange new universes and transmit them to the image space which is our portal for peering into virtual reality.

III. THE INTERACTIVITY OF COMPUTER SIMULATIONS

The virtual reality hovering among ciphers hosted by a digital medium is more ephemeral than the pictorial space canonized by Renaissance painting and automated by photography. But this digital soirée is also strangely more alive since numbers are able to capture the essence rather than the presence of what they represent. Their mensurated subjects are rendered more abstract (virtual) than their maculated counterparts in analog media, but they are also rendered more real (interactive) since they can become aware of your presence and respond to you. Because they exist as numbers, they can be continuously subjected to computation based on user input.

Once deposited for delectation in solidified swirls of pigment, the analogously depicted world is a static one. A photograph traps the trails left by a fleeting moment in time and imprisons them in formed matter. These precious objects subsequently follow their own temporal trajectories of potential glory, as well as certain disintegration and decay, despite assiduous care by august institutions. Whatever power the images of these analogized worlds have, it emanates from frozen apparitions. The transparent window of perspective, for all its lucidity, is nevertheless an impenetrable barrier to our entreaties. Though the physical objects that mediate pictorial space are not entirely impervious to intrusions (which are usually pernicious), their subjects are oblivious to our approach.

The openness of pictorial space, despite its insularity, is an arduous cultural achievement whose influence is ubiquitous today. Our discourse in the presence of pictures is often carried on as if we were perceiving the robust world they represent rather than a flimsy flat object. Our connection to reality through snapshots and television is familiar, conventional, and apparent: we see the face in the image and know the princess is sad. A concomitant belief in the veracity of photographs became a cornerstone of modern culture as the transcriptive dispersal of analog imprints permeated our everyday lives.

There is no transparent screen between numbers and pictures. The computerized connection between them is recondite and the numbers themselves remain reclusive. Yet digital universes are oddly more open to us than their analogously rendered forebears. A converse paradox characterizes the inscrutable interface which, despite its perceptual opacity, proffers an open portal inviting us to interact with creatures mysteriously lodged inside a small gray box. The computer can sense our presence and track our movements. Through a variety of input devices, measurements of our activities can be transmitted into a computer, lodged in a digital medium, cogitated mathematically to formulate a response, and the results output to us. We can engage a computer-mediated universe in a continuous dialogue. Out of this discourse, we can

generate convincing pictures that confuse and lie, as well as gripping games that thrill and edify.

Digital media are incomplete and useless without an interface to convert them to and from our perceivable world. But they are also unfulfilled without a computer to enliven them. They deliver us partners, and not merely pictures. Computers use formulas and numbers in order to simulate environments we can inhabit. In so doing, they do not display before us representations in the traditional sense, but invite us to enter the alternative realities of virtual universes.

The computer is not a medium. It transcends media since it uses material symbolically rather than analogically, making its digital representations vital and active. While feverishly manipulating tokens, its purpose is to invigorate abstractions, and not to sculpt substance.

The presence preserved in an analog medium is, by contrast, desiccated and passive. At best, it transports a trace of previous vitality by representing it in a material transcription. But the computed environment makes the representation and the viewer mutually present to each other. The characters residing in a virtual world can receive your missives and semaphores, and respond in like manner. In many ways, the experience feels more like having the subject before us than her mere representation. In discussing the power images can work on us, Freedberg suggests that "response is based on attempted reconstitution of the life of represented form."[15] This ancient vision that inspired mimetic supplication for centuries is brought much closer to realization in replete digital systems than transitory analog glimpses were ever able to achieve. The vitality of presence, and not merely its visage, is captured by computing machines. Virtual digital existence is not a generically reconstituted likeness or make-believe scenario, but a spontaneously created intercourse with an individual participant.[16]

Interactive virtual realities have already found many applications, both practical and pure. One of the earliest and most extensive uses was in flight simulation designed to give student pilots veridical training more safely and inexpensively than actual flight. As a consequence of their success, much of the funding that promoted the early development of interactive computer systems came from the military. But the technology has now become affordable enough to appear in information kiosks at art museums and shopping malls that help visitors navigate and learn. It has also become a standard resource in most design studios, and even shows up in fine art ateliers.

The computing assistant initially emulated traditional tools, in much the way cinema first copied the stage. These virtual tools quickly became popular, especially in commercial settings, because they are faster, cheaper, and more versatile than their manual predecessors. In the second half of the 1980s, the field of graphic design was revolutionized by computers as art directors discovered their cost effectiveness. The computer can instantly draw a straight line or a perfect circle, and just as easily undraw it and change it at the whim of a client. Since the information is virtual, it is infinitely malleable; and since it is computable, it is tirelessly responsive. The virtual environment is circumscribed by logical rather than physical limits. Indeed, one of the dangers of using computers is that they provide so much flexibility and forgiveness that it is easy to become engulfed in a mesmerizing odyssey of endless tinkering. The pitfalls of working in a virtual studio adumbrate whole new genres of artistic risk.

Because they perform in a virtual theater, computers have parted the curtain on a kind of pageantry unapproachable by analog media. Some of these spectacles are the special effects we frequently see in television commercials and in films such as *Terminator II* or Kurosawa's *Dreams.* But the most dramatic new player on the cultural stage is the interactive experience found in gallery installations and home computers as well as the Internet. Interactivity epitomizes the unique contribution computers are making to our culture. Some fine artists have begun presenting works that literally engage us by offering unique and personal encounters with a virtual universe. In 1986, Grahame Weinbren and Roberta Friedman created one of the first major interactive works, *The Erl King,* which allows the user to navigate through a cinematic world based loosely on the legend, but expanding out from it into psychoanalysis and pop music. Jeffrey Shaw created a very different kind of work in *The Legible City* (1989), which offers the participant a real bicycle to ride through virtual cities. His computerized metropolises are based on real cities, such as New York

and Amsterdam, but letters from a text, with their heights appropriately adjusted, réplace the buildings.[17]

The computer is now beginning to revolutionize the entertainment industry as sales of multimedia titles surpass box office receipts. Because the computer is not allied with any particular medium, it interfaces to all of them with a facility that gives us broad and rapid access to information for both fun and profit. Interactive computer games have achieved great popularity through their lively combination of fantasy and action. And digital versions of encyclopedias and other databases are superseding their printed counterparts because of the vastness of their contents and the swiftness of access to specific details.

The possibilities of interactive art have only begun to be explored. And the overall enhancement of our ability to visualize is having a profound impact on science as well as art. Whole new vistas of science and mathematics are opened up by looking through the portal of a computer into a virtual universe. The general holistic thrust of digital representation encompasses the barriers between art and science, which weaken as our art gets imbued with numbers and our science gets advanced by art.

Virtual reality is both more and less real than analog representations. But we are being challenged to rethink the reality/representation distinction. Our sense of reality is—paradoxically—a concept. It is an idea that has been formed by the history of our representations, and not vice versa. Ian Hacking sums it up this way:

> Reality is an anthropomorphic creation. Reality may be a human creation, but it is no toy; on the contrary it is the second of human creations. The first peculiarly human invention is representation. Once there is a practice of representing, a second-order concept follows in train. This is the concept of reality, a concept which has content only when there are first-order representations.[18]

So our sense of reality is determined in large measure by the scope of our representations. By comparison with traditional analog representations, digital representations are *virtual* since they are embodied in abstract numbers rather than in concrete objects.[19] But they are also comparatively *real,* since they can possess a responsiveness unavailable to analog pictures. Digital representation is forcing us to reconsider what is real and what is not.

For lack of a better word, we call computers machines, even as they harbor a vitality previously limited to living organisms. Thinking machines elicit strong emotions of both fear and excitement. Grandiose visions of a divine digital democracy carry high hopes and sweet dreams that undoubtedly will never be realized, or will be degraded and abused. And the moralistic homilies about a sinister big brother may shroud the makings of a different kind of culture. Amidst the emotions is an underlying reality which intimates fundamental changes in the way culture is practiced and preserved. No one can know yet precisely where the "digital revolution" will lead, but the better we understand its nature, the better we will be able to deal with it and to direct it toward fair and humane purposes. We are facing a daunting phalanx of practical and philosophical questions about access, privacy, copyright, and a host of other issues that are demanding our attention.

Since ancient times, things and ideas have been separated. Compare Praxatiles's *Aphrodite* with Euclid's *Elements.* One is an expressive and inspiring material object subject to the onslaughts of people and weather. This does not prevent it from conveying ideas as well as emotions. The other is an intellectual construct impervious to sticks and stones, but nevertheless dependent in some way upon objects to survive, and capable of arousing sublime feelings. Marble is chipped and worn, eaten by acid as it is pummeled by rain. Theorems are pristine as the day they were conceived, and they will remain that way forever. Yet they are both passive cultural products spawned by a human agency that deposited them in the annals of history. And now the distinction between them is not so clear as our creations become agents.

TIMOTHY BINKLEY
Graduate Computer Art Department
School of Visual Arts
209 East 23 Street
New York, New York 10010

INTERNET: BINKLEY@SVA.EDU

1. Mark Dery, "Art Goes High Tech," *ARTnews* 92 (February 1993): 74–83, p. 83. A recent issue of *Art Journal* was also dedicated to computers in art (49:3, Fall, 1990).

2. Ibid., p. 75.

3. Integrated Services Digital Network (or ISDN) was made available throughout France beginning in 1987 and is now widely used in other countries. ISDN is a system for rapid transmission of digital information over standard phone lines. Fiber optic networks with much greater capacity are now being implemented in many locations, particularly in Japan, and they are the main focus of the "Information Superhighway" currently being promoted in the United States by government and industry alike.

4. The "bandwidth" of a communication channel is simply a measure of the amount of information it can convey in a fixed amount of time. Standard telephone lines that use electrical signals have a relatively low bandwidth that is insufficient to transmit motion pictures, although it is perfectly adequate for voice communications. Optical fibers employ light rather than electricity to transport information, and as a result have a high bandwidth capable of transmitting several motion pictures simultaneously.

5. The debate over the limits of artificial intelligence epitomizes the often confusing efforts to make sense of "thinking machines." See John R. Searle, Paul M. Churchland, and Patricia Smith Churchland, "Artificial Intelligence: A Debate," *Scientific American* 262 (January 1990): 26–38. Some of the greatest fears and highest hopes are aroused by visions of a thoroughly computerized future. One of the most provocative scenarios is sketched by Hans Moravec in *Mind Children: The Future of Robot and Human Intelligence* (Harvard University Press, 1988). For a well-articulated alternative viewpoint, see John Searle, *The Rediscovery of the Mind* (MIT Press, 1992).

6. Nelson Goodman, quoted in David Freedberg, *The Power of Images: Studies in the History and Theory of Response* (University of Chicago Press, 1989), p. 25.

7. Freedberg, *The Power of Images,* p. 28.

8. Ibid., p. 438.

9. Ibid., p. 435.

10. See Roland Barthes, *Camera Lucida* (New York: Hill & Wang, 1981) and Susan Sontag, *On Photography* (New York: Dell, 1977), whose views I discuss at length in "Camera Fantasia: Computed Visions of Virtual Realities," *Millennium Film Journal* 20/21 (Fall/Winter, 1988/89): 6–43. Even if the artwork is an abstract painting, its analog medium still stores at least traces of the artist's gestures, analogues of which are inscribed onto the canvas.

11. See Leonard M. Adleman, "Molecular Computation of Solutions to Combinatorial Problems," *Science,* November 11, 1994, pp. 1021–1024.

12. I discuss these ideas further in "Transparent Technology: The Swan Song of Electronics," *Leonardo* 28 (1995): 427–432, and "The Quickening of Galatea: Virtual Creation Without Tools or Media," *Art Journal* 49 (1990): 233–240.

13. The movie *Lawnmower Man* presents a most fanciful (and unrealistic) vision of this kind of immersive virtual reality.

14. Some of the techniques used in algorithmic creation are described in Benoit Mandelbrot, *The Fractal Geometry of Nature* (New York: W. H. Freeman, 1977); Alvy Ray Smith, "Plants, Fractals, and Formal Languages," *Computer Graphics* 18 (July 1984): 1–10; and Stephen Todd and William Latham, *Evolutionary Art and Computers* (New York: Academic Press, 1992).

15. Freedberg, *The Power of Images,* p. 242.

16. Kendall Walton has given an innovative and provocative account of representation in *Mimesis as Make-Believe* (Cambridge: Harvard University Press, 1990). His extensive discussion touches on some aspects of make-believe that are present in interactive virtual realities, but does not accommodate many of the salient features of participation in computed universes.

17. For additional examples, see Cynthia Goodman, *Digital Visions: Computers and Art* (New York: Harry N. Abrams, 1987); Herbert W. Franke, *Computer Graphics, Computer Art* (New York: Springer Verlag, 1971); and William J. Mitchell, *The Reconfigured Eye: Visual Truth in the Post-Photographic Era* (MIT Press, 1992).

18. Ian Hacking, *Representing and Intervening: Introductory Topics in the Philosophy of Natural Science* (Cambridge: Cambridge University Press, 1983), p. 136.

19. Susanne Langer spoke of pictures as creating virtual worlds, but in digital universes even the images are virtual and what they depict manipulable. Computer creations are abstract, in opposition to the concreteness of paint. See Langer's *Problems of Art* (New York: Charles Scribner's Sons, 1957).