"VIDEOPLACE": A Report from the ARTIFICIAL REALITY Laboratory
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VIDEOPLACE: A Report from the ARTIFICIAL REALITY Laboratory

Myron W. Krueger

Abstract—The author argues that one of the computer's most unique features, its ability to respond in real-time, has yet to be fully exploited. For the past 16 years he has been creating an interactive computer medium in which the computer perceives a participant's actions and responds in real-time with visual and auditory displays. He describes his conceptual discovery process as well as work in progress.

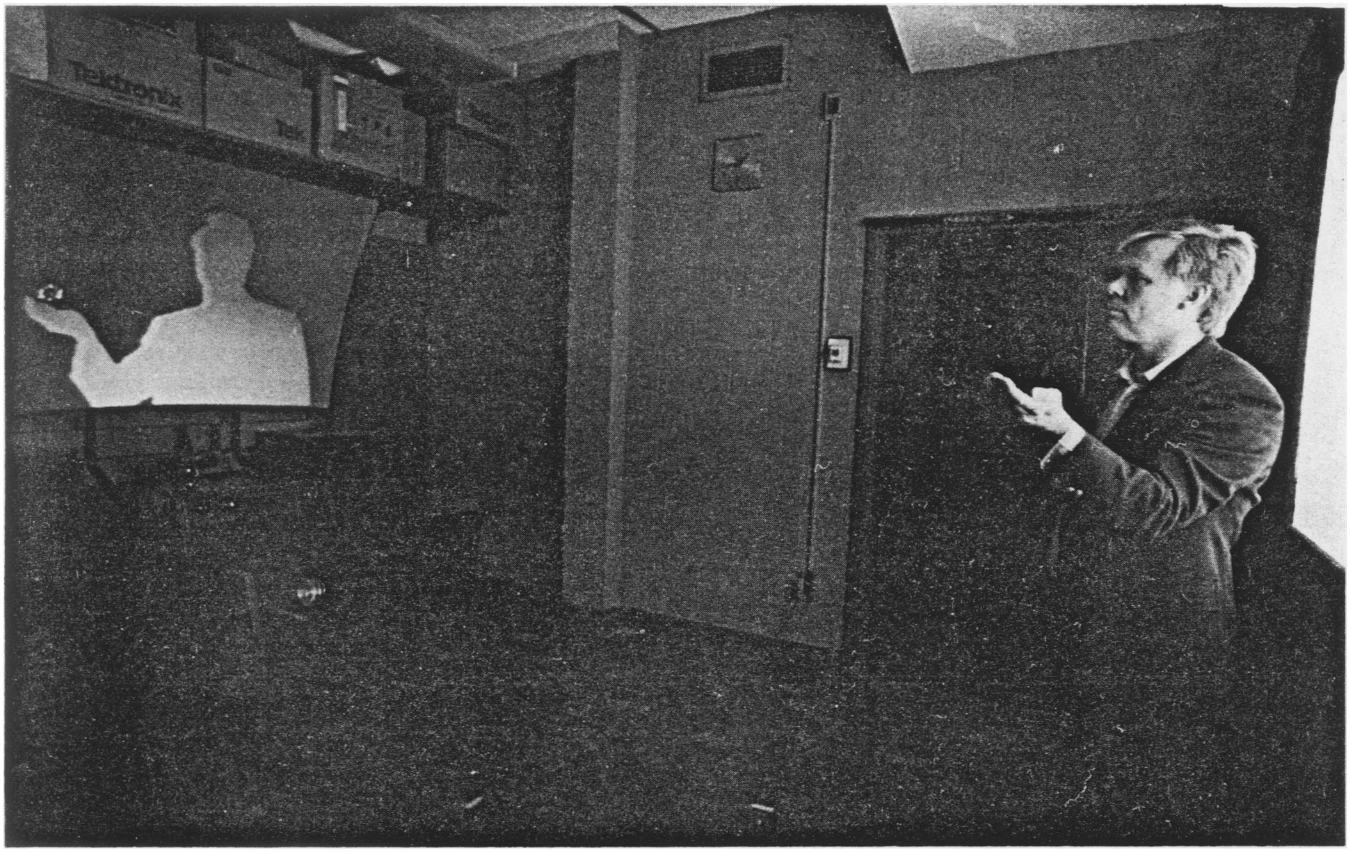

Fig. 1. *VIDEOPLACE*, an interactive medium, being developed in the ARTIFICIAL REALITY Laboratory. In *VIDEOPLACE*, two fundamental cultural forces—television, purveyor of passive experience, and the computer, symbol of forbidding technology—have been married to produce an expressive medium for communicating playfulness and inviting active participation.

I. INTRODUCTION

The term 'computer art' implies a novel artform based on the computer. However, most works of computer art fit into the existing tradition. They can be viewed hanging on walls, standing on pedestals or projected as film. They fail to exploit the computer's most unique feature: its ability to respond in real-time. It could be argued that computer art which ignores responsiveness is using the computer only for visual design automation, rather than as the basis for a new medium.

For the past 16 years I have been creating an interactive computer art form—the Responsive Environment. In this medium, the computer perceives a participant's actions and responds in real-time with visual and auditory displays.

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II. BACKGROUND

Searching for the Essential Computer

As a computer science student in the mid-sixties, my goal was a philosophical understanding of the computer. This task was more difficult then than it would be today, because computers were surrounded by elaborate institutional structures. The idea of personal computing was a science fiction fantasy.

At that time, the user would submit a deck of cards to a clerk who would take them into the inner sanctum containing the computer. The output, in the form of a computer printout, would be ready several hours later. Perception of the underlying computer was greatly distorted because the user was separated from the machine by the operating system.

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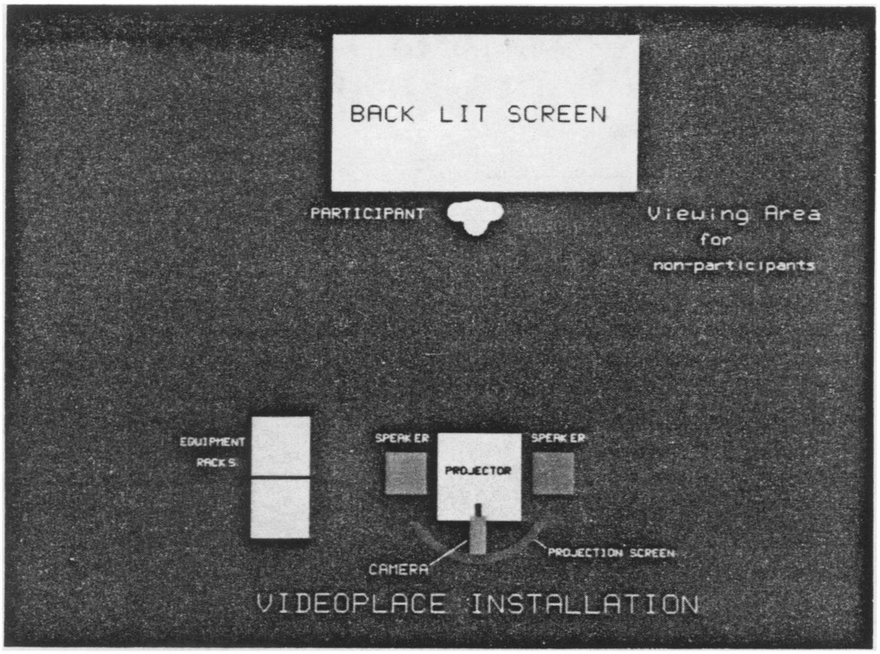


Fig. 2a. Diagram of the *VIDEOPLACE* environment. A participant stands in front of a back-lit screen and faces the projection screen. Speakers flank the projector. Equipment racks to the left of the projector contain the general- and special-purpose processors necessary to control the real-time interactions.

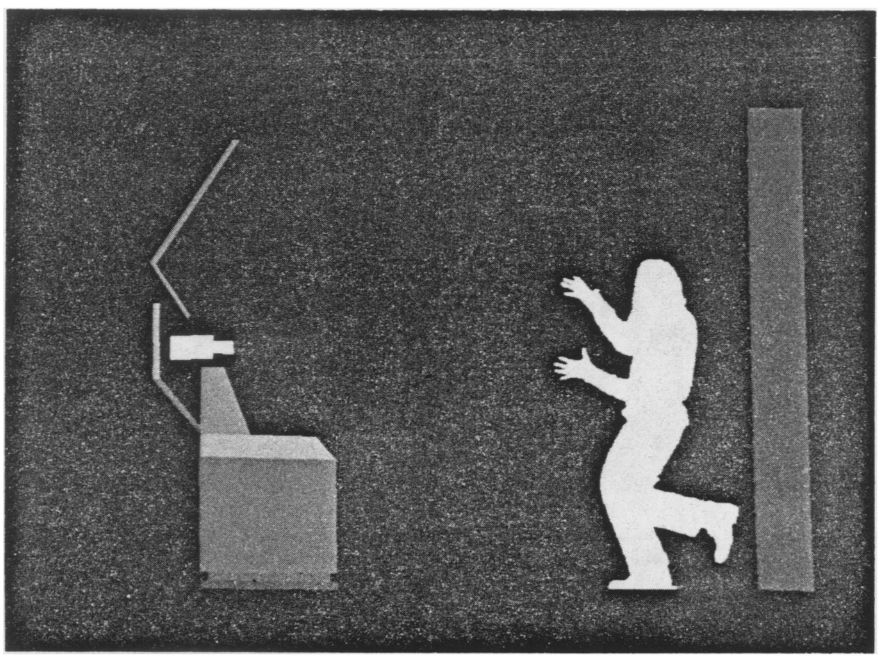


Fig. 2b. Side-view representation of the *VIDEOPLACE* environment. The participant stands in front of a back-lit screen. A camera positioned below the video projection screen, facing the participant, picks up the participant's image and sends it to the computer system.

To circumvent this problem, I vowed to use only those computers which I could operate on a one-on-one basis. This meant using the big machines in the middle of the night and gaining access to single-user laboratory machines.

The next step in demystifying the computer was to peel off the software layers that obscured the hardware. Programming in machine language, without an operating system, revealed the naked computer. I was astonished to discover that the popular conception of the computer as fundamentally mathematical was totally false. Logical maybe, mathematical never! The computer could perform trivial arithmetic and logic operations and make simple comparisons; but mainly it just moved things around.

In the sixties, the standard mode of programming was to input the program, followed by the data, and then to print out the results. Small laboratory computers offered a very different alternative. Input could come from any source that could be digitized. Output could be displayed as soon as it was computed. This was not a more complicated human–machine interface; it was a more basic one. The essence of the computer was its ability to respond in real-time.

GLOWFLOW

In 1969 I joined a group of artists, musicians and technologists who were working on a computerized environment called *GLOWFLOW*. We used the computer to control simple, but visually pleasing displays [1, 2]. There was a provision for the displays to respond to participants' behavior. However, due to the large number of people present, cause and effect were difficult to discern. In addition, the displays were slow to respond, and the sensing capability was very limited. Although the computer response was conceptually interesting, the artists in the group felt it was not important that participants be aware of how the environment responded. In fact, they favored an ambiguous relationship between cause and effect as they did not want the participants to be consumed by the interactive aspect of the environment. In their minds, there was a conflict between the quiet contemplation associated with traditional art and the idea of interaction. I did not share their ambivalence. My earlier conclusions about the nature of the computer convinced me that interaction was the *sine qua non* of computer art.

Computer Art

After this initial involvement, I became more aware of the art community's efforts in art and technology. Some of it was simply the 'laying on of hands' by artists to the creations of scientists or technologists. Much seemed simply inappropriate. Most artists lacked technical experience and found technical concepts alien to their definitions of art.

While my original expectation had been that I would use my technical skills to assist artists, I discovered that I had my own clear idea of what a computer artform should be. I saw that if my private vision was to be realized, I would have to become an artist. The insights that have guided my subsequent work are as follows:

(1) Computer art is fundamentally interactive. Other artistic uses of the computer are of interest, but they do not constitute a new artform based on the computer.

(2) The quality of the interactive relationships is paramount. Traditional ideas of visual or musical beauty are initially secondary. Response is the medium!

(3) If the responses are to be intelligent, it is imperative that the computer's grasp of the participant's behavior be as complete as possible.

(4) Real-time computer-generated graphics and synthesized sound offer the most powerful and composable responses.

(5) Visual responses should be projected on an environmental scale, and other sources of visual stimulation should be minimized.

(6) Participants should be able to understand how they personally elicit the responses. The experience is strongest when the interaction is between one individual and the computer.

(7) It is desirable to think in terms of inventing a tool for exploring the interactive medium, instead of creating a series of discrete objects, each of which is a 'piece'.

III. EARLY RESPONSIVE ENVIRONMENTS

After formulating these concepts, I began to develop the paradigm of a Responsive Environment. A Responsive Environment is an empty room in which a single participant's movements are perceived by a computer that in turn responds through visual and auditory displays. In 1970, I produced a Responsive Environment, called *METAPLAY*, which combined live video and computer graphic images and projected them in front of the viewer. Computer graphics drawn by an artist with a data tablet were superimposed on the participant's live image. Many interactions evolved in this framework, including one in which the participant appeared to draw on the screen by moving a finger through the air [3].

In 1971, I created *PSYCHIC SPACE* which employed a sensing grid on the floor of the gallery to detect the participant's movements. These movements were translated into graphically displayed action on a large video projection screen. *PSYCHIC SPACE* provided elaborately composed interactive relationships. In one, the participant's footsteps on the sensing floor controlled the movement of a graphic symbol within a projected graphic maze. If the participant attempted to cross a boundary illegally, the boundary could stretch elastically, the symbol could disintegrate, or the whole maze could move as if the participant's symbol were pushing it. There were approximately 40 different response modes that a participant could discover while moving through the maze. Each was designed to play with the idea of a maze and poke fun at the participant's compulsion to take it seriously [4].

After exhibiting *PSYCHIC SPACE*, I conceived an automated interactive medium and developed a detailed technical plan to implement it using a series of artistic concepts to guide the composition of interactions. However, the necessary technology did not exist. I have devoted the intervening years to developing the requisite perception, control, display and composition technology. Today, the system consists of two general-purpose computers and a number of highly specialized processors, including one that executes forty million instructions per second. During the course of this development, many problems in real-time perception and control had to be addressed.

IV. *VIDEOPLACE* AND THE ARTIFICIAL REALITY LABORATORY

The interactive medium that has evolved since *PSYCHIC SPACE* is called *VIDEOPLACE*. In *VIDEOPLACE*, two fundamental cultural forces—television, purveyor of passive experience, and the computer, symbol of forbidding technology—have been married to produce an expressive medium for communicating playfulness and inviting active participation.

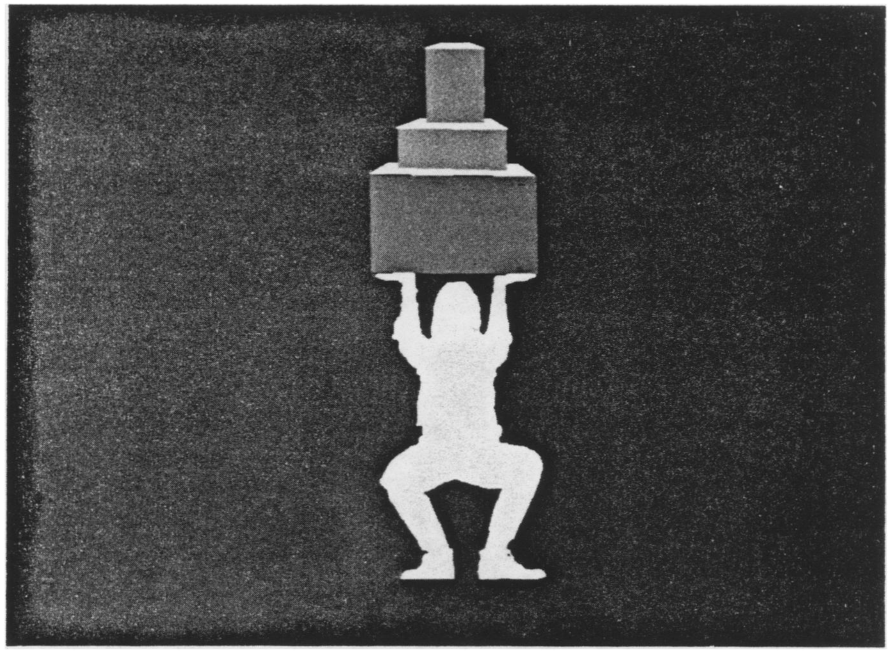


Fig. 3. A *VIDEOPLACE* graphic scene; interactive computer environment, 6-ft diagonal video projection screen display; 1985. The participant's image appears to lift a graphic object.

The *VIDEOPLACE* environment is dominated by a projection screen that faces the participant. A camera positioned below the screen picks up the participant's image and transmits it to the system (Figs. 1 and 2). The live image is combined with computer-generated graphics and the composite image is projected onto the screen. Specially built computers analyze the person's image and determine the effects of his or her actions on the objects in the projected graphic scene. Currently, the participant's colorized silhouette, rather than a fully detailed image, is displayed. The silhouette is used because it is an honest representation of what the computer perceives.

The potential created by this juxtaposition of live and computer images is significant. The thrust of computer graphics development from its inception has been the creation of realistic representations of three-dimensional objects and scenes. These scenes have become sufficiently lifelike that it seems natural to enter them. The *VIDEOPLACE* concept integrates a person's image with a graphic 'place'. The person's movements in an empty room are translated into actions in the graphic scene.

With a slight generalization of video keying, the participant's image can be placed in front of or behind graphic objects on the screen. It is also possible for the computer to analyze the relationship between the person's image and the objects. Since the existence and placement of graphic objects are completely

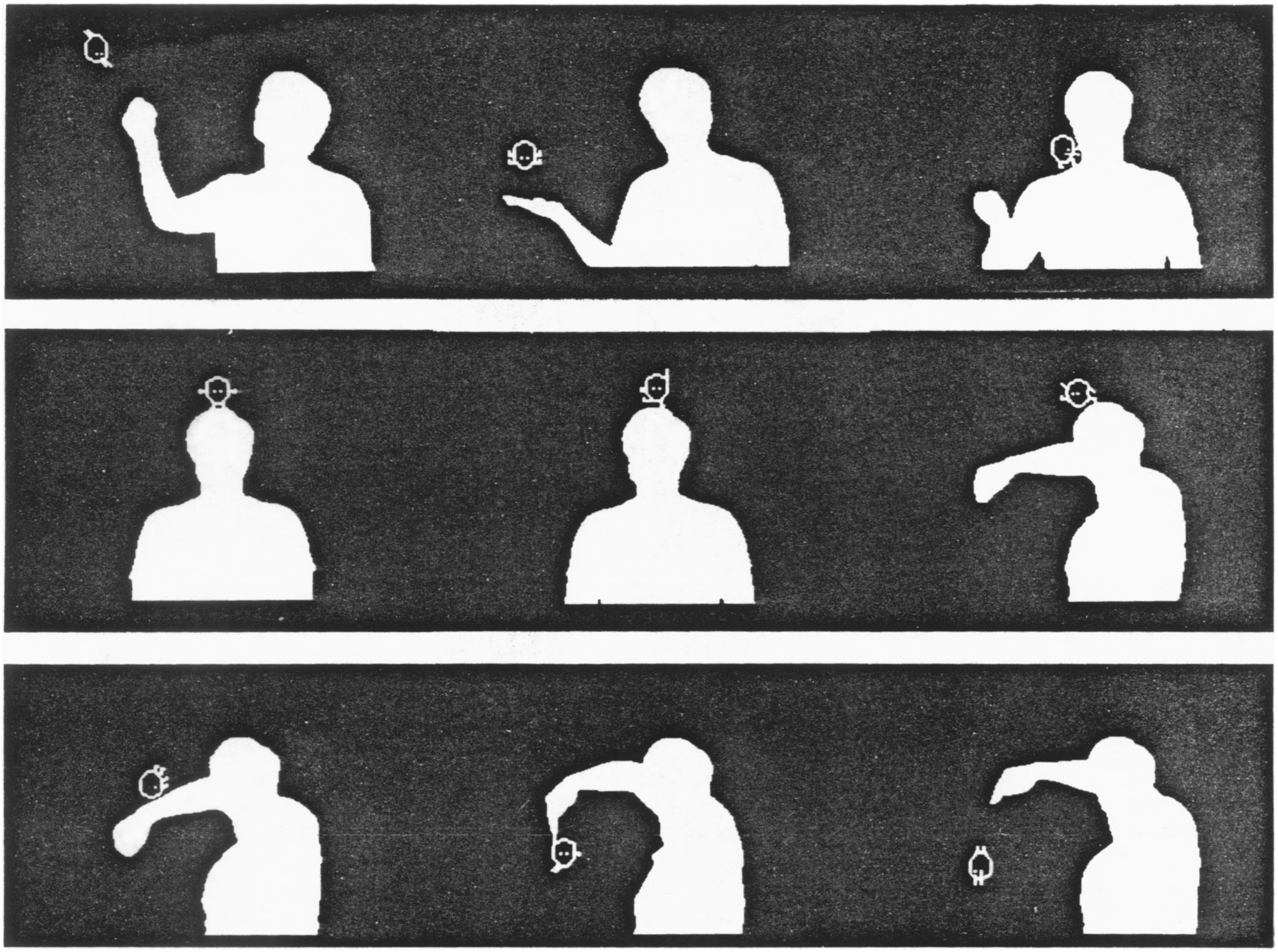


Fig. 4. A *CRITTER* interaction; interactive computer environment, 6-ft diagonal video projection screen display; 1985. CRITTER interacts with the participant. Beginning at the top left corner and reading across: CRITTER flies in, floats to a landing, climbs the participant's head, does a celebratory jig, leaps off, somersaults down, catches the participant's finger, dangles and dives off.

under the computer's control, the person's image can appear to make things happen in the graphic environment. The image can lift, push or throw graphic objects (Fig. 3).

The participant's image can also be manipulated by the computer. It can be colorized, shrunk, rotated, or moved anywhere on the screen. In addition, a sequence of frames with the participant in different poses can be stored and replayed. By these means, the person's image can defy gravity, swim graphic oceans or interact with graphic creatures. A second person, in another location, can also appear on the screen and share an experience [5].

VIDEOTOUCH

During the *METAPLAY* exhibit, I observed a set of phenomena that I termed VIDEOTOUCH. People feel that their images are extensions of their identities. What happens to their images happens to them. What touches their images, they feel. They immediately accept the reality of any image that includes their own. For example, a person alone on the screen with a graphic object will touch it, half expecting it to react. If two people in different places find their images together on the screen, they will interact [6].

Since 1974, an experimental version of the *VIDEOPLACE* system has been under development [7]. All of the features described above have been implemented, at least in prototype form. The computing power required is enormous, especially in light of the well-kept secret that, while computers can do arithmetic problems quickly, they are very slow at performing perceptual and intellectual tasks. Therefore, we compose with a subset of the medium while continuing to develop the system.

CRITTER

In one *VIDEOPLACE* interaction a graphic creature, called CRITTER, perceives the participant and engages his or her video image in whimsical interplay (Fig. 4). Synthesized sound communicates the personality of the creature.

Initially, CRITTER flits about the screen, just out of reach. If the participant makes a move towards it, CRITTER avoids contact. However, if the person is still, an emboldened CRITTER moves toward him or her. If the person moves away, CRITTER gives chase. If the participant remains still and slowly holds out his or her hand, CRITTER will land on it.

Having made contact, the creature climbs the image of the person's outline, adjusting to the local terrain as it climbs. If the person moves during the ascent, the creature clings until the participant slows down and then continues climbing until it reaches the top of the person's head.

Attaining this goal becomes a punctuation for the interaction. Each time it happens, CRITTER takes a different path in its ensuing behavior. The first time, CRITTER does a jig in celebration. Then, it analyzes what the person is doing. If the participant's hands are down, CRITTER paces nervously. If one of the hands is at shoulder level, CRITTER does a flying somersault and lands on that hand. If the hand is stretched out horizontally, CRITTER jumps to that hand, turns around and executes a back jackknife to the bottom of the screen. If an arm is extended to form a steep slope, CRITTER dives off the head and rolls down the arm. At the last moment, it catches the participant's finger and dangles. The person can dislodge CRITTER by a shake of the hand.

When CRITTER climbs to the top of the head for the last time, it jumps up and down—causing the person's image to disappear. (Many participants report an urge to look down at their bodies when their image disappears.)

CRITTER's behavior is conceived and controlled in terms of states. At any given moment, CRITTER is in a particular state in which it attends to certain aspects of the participant's behavior and is prepared to respond in specific ways. In each state, certain events are recognized as boundary conditions; these trigger the transition to a new state. An interaction is a series of such states and transitions which provide a complete experience. There are approximately 100 states that determine CRITTER's behavior. Only a temporary computer memory limitation prevents composing an additional thousand.

This piece provides a novel experience. At the immediate level, the participant has an engaging encounter with an artificial entity. As the experience progresses, it becomes apparent that an intelligence that toys with our expectations is behind the interaction.

Unexpected responses constitute a form of visual humor, reminiscent of Magritte's paintings or the sight gags of Vaudeville. A long interaction can establish a story line with a series of experiences that follows a coherent theme and can be thought of as similar to film or literature rather than sculpture or painting. A current goal is to create experiences so complex that they cannot be fully explored in a single session.

The *CRITTER* interaction currently takes place in a minimal version of *VIDEOPLACE*. The projected graphic scene will be augmented in the immediate future so that a three-dimensional context can be provided for the interactions [8]. We have also built hardware that shrinks the participant to CRITTER's size, increasing the potential for interesting interactions within the graphic scene.

The scene itself will be an active element in the mature medium. Instead of a realistic portrayal of a three-dimensional world, it will represent a fantastic landscape that has the ability to transform itself. Obviously, the relationship between the participant and the scene need not be limited to the laws of physics. *VIDEOPLACE* is an artificial reality in which the laws of cause and effect are composed by the artist [9].

INDIVIDUAL MEDLEY and FRACTAL

Two *VIDEOPLACE* experiences are less narrative in nature. In these, the participant's body is used to control the generation of patterns and sound. An elaborate digital synthesizer, run by a dedicated computer, creates the sound. The audio is conceived as an integral part of the interaction and is driven by the same knowledge of the participant's actions that determines the graphic display.

INDIVIDUAL MEDLEY is a family of related interactions. The digitized image of the participant's silhouette is used as both a component and a controlling element of the display. The eight most recent silhouettes are continuously stored. The individual's movements modulate the sound and determine the color of overlapping areas of the silhouettes. A variety of interactions is possible within this framework (see Color Plate No. 2). In one interaction, the system stores visual material while the person is in motion. When the participant pauses, this visual history is played back, with variations. When a participant leaves the environment, the final dynamic image created remains on the screen to pique the interest of the next participant. The newcomer, initially believing this to be a passive display, discovers its interactive nature only after becoming part of the piece.

In *FRACTAL*, complex, animated, geometric designs and sound are controlled by the movement and position of a participant's arms. The position of each arm and the rate and degree of arm motion produce a kaleidoscope of color and form with accompanying audio. The participant can learn to control color combinations as well as sound and visual patterns (Fig. 5). Each of these experiences is the physical exploration of an abstract space [10].

Interactive Experiments

A number of additional facets of the *VIDEOPLACE* medium are being explored. In one experiment a connection between three-dimensional graphic spaces and movements of the participant's head is defined. Moving the head to the right or left causes a corresponding change in the point of view. Elevating the head slightly moves the point of view forward. This control is very simple and quite easy to learn.

In a related interaction, a three-dimensional object is displayed. Movements of the head cause the view of the object to change appropriately. This relationship is identical to that produced by a hologram, except that the realistic set of viewing relationships created can be altered to flirt with the viewer's real-world expectations.

In another series of interactions, the participant is able to draw on the screen using the image of a finger. One hand controls the color. The other positions the 'brush'. The hands can also be used to bend curves into desired shapes (Fig. 6). In another experiment, the participant can type using the image of his or her fingers moving through space to select characters for display (Fig. 7). An additional series of experiments involves the use of the participant's body as a musical instrument.

Composing Interactions

All of the interactions in *VIDEOPLACE* are composed. Many eventualities must be considered and appropriate responses planned. Each particular interaction is tested with a number of participants. This process reveals flaws in the initial idea as well as unanticipated participant reactions and expectations which can be used to revise the interaction.

The system is presently being augmented to support a significantly greater repertoire of possible responses than currently exists. Initially, the structure of the interactions will be analogous to that of a musical composition or a novel: an introduction establishing a theme, a set of

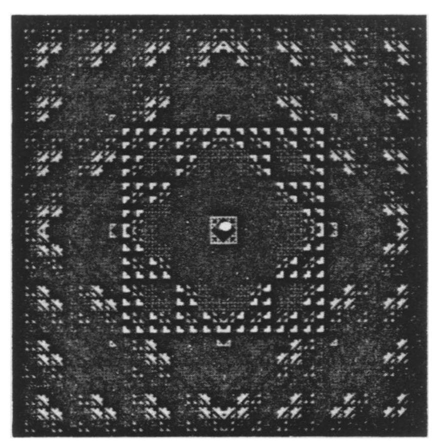


Fig. 5. An interactive *FRACTAL* pattern; interactive computer environment, 6-ft diagonal video projection screen display; 1985. This is one of thousands of patterns that can be generated by a participant's movements during a *FRACTAL* interaction.

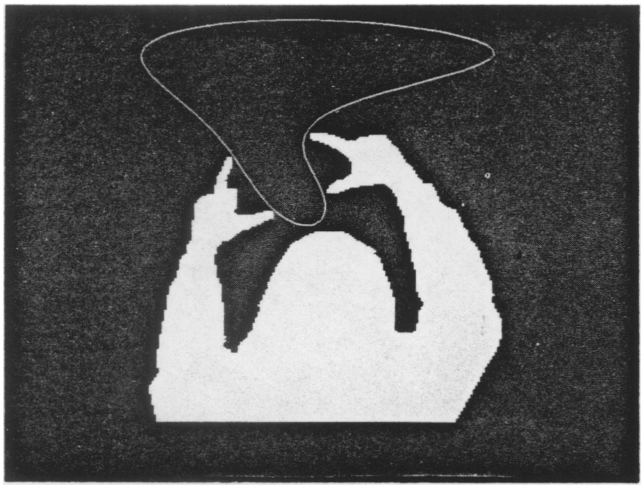


Fig. 6. An experiment in creating curved shapes; interactive computer environment, 6-ft diagonal video projection screen display; 1985. The image of the participant's hands is used to create and alter curved shapes.

Fig. 7. An experiment in 'typing'; interactive computer environment, 6-ft diagonal video projection screen display; 1985. The participant's image points to a letter causing it to appear as part of a 'typed' message on the screen.

variations on that theme, and a series of climactic events that resolves the tension.

Such interactions obviously imply a degree of intelligence on the part of the system, an almost-human awareness of events as they occur. While the system thus far acts only on encoded intelligence, the underlying strategy addresses a greater challenge. The entire system is implemented as a model of real-time intelligence. A Reflex System handles the immediate response to the participant's behavior and a Cognitive System monitors the experience, seeks to understand it in semantic terms and makes strategic decisions that will affect its future course. At the moment, the Reflex System is fully operational. The framework for the Cognitive System exists. It is used to translate our conceptual descriptions of the interactions into a form the Reflex System can act on in real-time.

The issue of having the Cognitive System monitor and modify the experience as it unfolds is now being addressed. The Cognitive System will engage the participant's attention, then attempt to maintain the participant's interest and create a unique experience tailored to individual behavior. It will ruminate upon its experiences when it is alone in an effort to improve its future performances. Unlike any existing artificial intelligence system, it will always be on. It will have a continuity of identity enabling it to accumulate experience. Ultimately, it will be capable of autonomously inventing new interactions.

V. CONCLUSION

Until the twentieth century, visual art was static, the audience was passive and artistic communication moved strictly from artist to viewer. With the advent of film and kinetic sculpture, the artist could deal with time, motion and narrative, and the viewer could vicariously experience dynamic events. An obvious next step is a medium that invites the audience to participate and actually influence events.

VIDEOPLACE is an experimental artform that explores this next step. To a large extent the technological demands of the medium have guided its development. *INDIVIDUAL MEDLEY* was the inevitable spinoff of hardware conceived in 1972 and originally developed in 1976 for the video perceptual system. *FRACTAL* had its beginnings in a loose wire. However, both of these families of interactions are almost digressions. The *CRITTER* interaction, with its potential for narrative development, comes closer to exploring the unique potential of the medium.

The interactive medium is a new artform of great promise [11, 12]. The *VIDEOPLACE* interactions redefine the human body's relationship to reality. We have expectations for how our physical actions will affect the world. *VIDEOPLACE* uses these expectations as a compositional element. By defining unusual relationships between cause and effect, this medium comments on our sense of reality.

Acknowledgements—Financial support for *VIDEOPLACE* provided by the U.S. National Endowment for the Arts, the Wisconsin Arts Board and the Connecticut Research Foundation is gratefully acknowledged.

REFERENCES AND NOTES

1. M. W. Krueger, "Responsive Environments", *Proceedings of AFIPS National Computer Conference* **46**, 423–433 (1977).
2. M. W. Krueger, *Artificial Reality* (Addison-Wesley: Reading, MA, 1983). This describes in detail the genesis of earlier Responsive Environments and the concepts behind *VIDEOPLACE*.
3. Krueger [1, 2].
4. Krueger [1, 2].
5. The Responsive Environment is inherently a telecommunications art form. *VIDEOPLACE* was originally proposed in 1974 as a satellite communication between various states as part of the U.S. Bicentennial. *PSYCHIC SPACE* and *METAPLAY* were also telecommunication environments as the graphics computer and the gallery were over a mile apart and were joined by a video communications link. For additional reading on telecommunication artforms see E. Gidney, "The Artist's Use of Telecommunications: A Review", *Leonardo* **16**, 311–315 (1983).
6. VIDEOTOUCH was the subject of a proposal to the National Endowment for the Arts (U.S.) in 1972 and of a *VIDEOPLACE* piece shown in the Milwaukee Art Museum in 1975.
7. Since 1974 an experimental version of the *VIDEOPLACE* system has been under development. The initial research was conducted at the University of Wisconsin. In 1978 I came to the University of Connecticut and founded the ARTIFICIAL REALITY Laboratory to continue the project.
8. We have recently acquired three workstations from Silicon Graphics Inc. which allow us to provide a three-dimensional context for the interactions.
9. Krueger [1, 2].
10. Fifteen pieces based on the themes of *CRITTER, INDIVIDUAL MEDLEY* and *FRACTAL* were exhibited at the Real Art Ways Gallery in the Hartford Arts Center in Hartford, Connecticut; at the 7th Invitational Symposium on Finite Elements in Storrs, Connecticut; and at the IEEE ASIS Conference in Philadelphia, Pennsylvania during 1984. When an individual entered the exhibit, the system detected his or her presence and selected an interaction. It sensed when the participant left the environment and chose an interaction from a different category when a new person arrived. A participant could learn to control the selection of interactions. A small, port-

able *FRACTAL* system has just been implemented with the intent of making *VIDEOPLACE* interactions easier to exhibit in the future.

11. S. Wilson, "Environment-Sensing Artworks and Interactive Events: Exploring Implications of Microcomputer Developments". *Leonardo* **16,** 288–292 (1983).
12. G. Shortess, "Neural Art: Works Based on Concepts of the Nervous System", *Leonardo* **16,** 306–309 (1983).

GLOSSARY

colorize—video technique for coloring grey-scale values in a video image.

data tablet—a device for putting two-dimensional information into the computer.

digitized—converted into its binary equivalent.

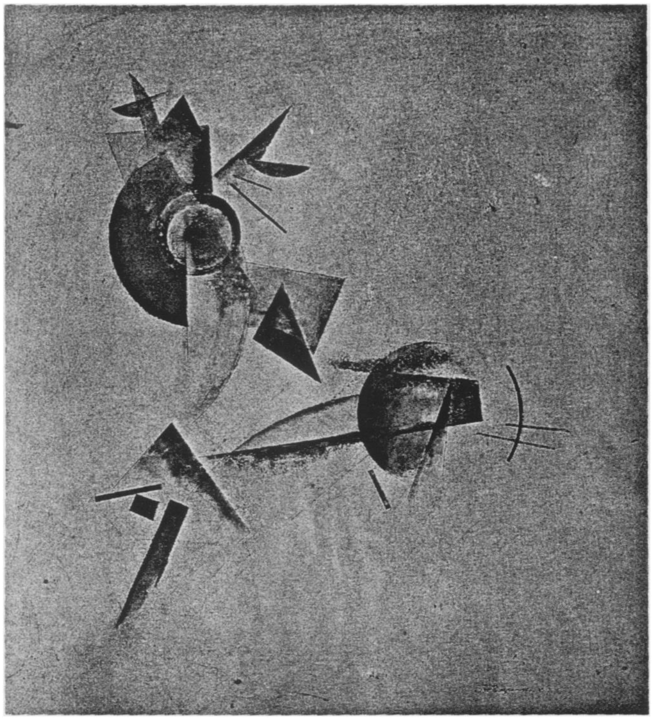
machine language—a language specific to the hardware of a particular computer.

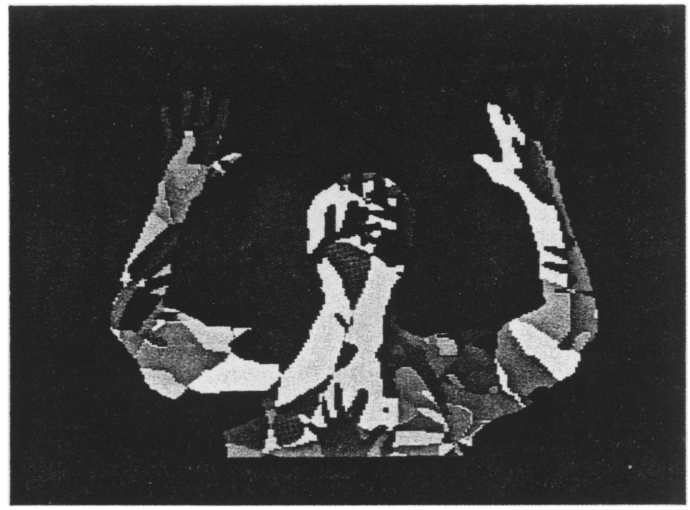
operating system—a program written by the manufacturer that controls the resources of a computer.

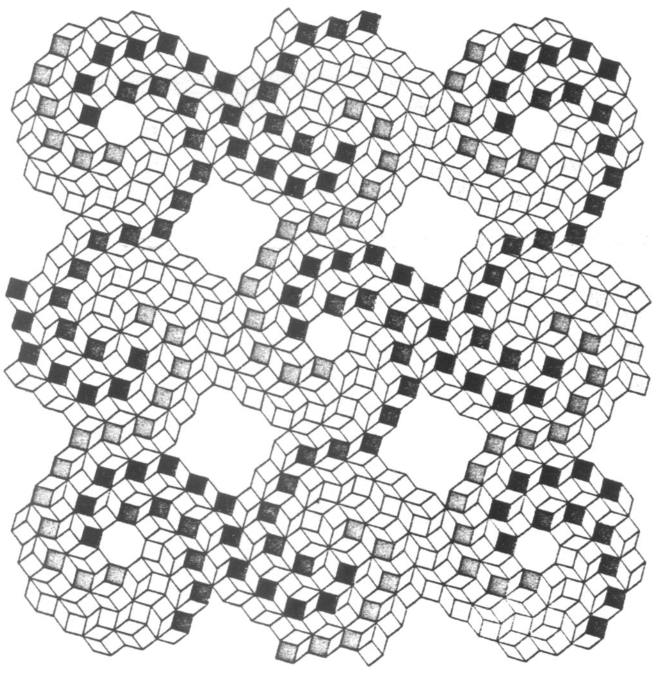
real-time system—a system that computes its results as fast as needed by a real-world system; in this paper, the term means that there is no perceptible delay between human action and computer response.

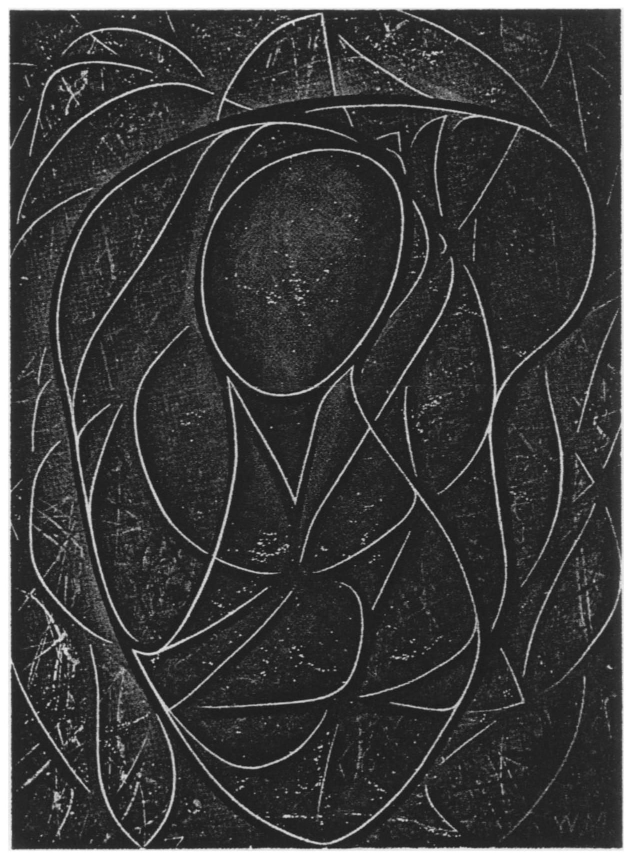
state—in an interaction, a situation with composed contingencies.

video keying—a technique used to insert part of one video image into another to form a composite image.









No. 1. Top left. Aleksandr Rodchenko. Untitled, gouache on paper, 21 × 29.5 cm, 1917. (Collection of John Milner. Reprinted by permission.)

No. 2. Top right. Myron W. Krueger. *JIGSAW*, an interaction from the *INDIVIDUAL MEDLEY* series; interactive computer environment, 6-ft diagonal video projection screen display; 1985.

No. 3. Bottom left. Tamás F. Farkas. Nine subsystems cooperate to form a complex system.

No. 4. Bottom right. Yakov Vinkovetsky. *Image in Space (Abstract Themes, Composition No. 29–80)*, acrylic and oil on canvas, 48 × 36 inches, 1980.