"Ornitorrinco" and "Rara Avis": Telepresence Art on the Internet
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# *Ornitorrinco* and *Rara Avis*

## Telepresence Art on the Internet

*Eduardo Kac (with a technical appendix by Ed Bennett)*

THIS PAPER IS A DISCUSSION OF AESTHETIC IMPLICATIONS AND PRACTICAL implementations of the author's telepresence art. *Ornitorrinco in Eden* and *Rara Avis,* two recent examples of worldwide networked telepresence installations presented publicly over the Internet, are discussed in the paper. A framework is presented to introduce theoretical and cultural aspects of this work. It is proposed that the use of electronic media in art to physically act on remote spaces constitutes a new aesthetic element, compared to the more traditional representational use of such media. It is also proposed that a new aesthetic is emerging out of artistic experimentation with operation of telerobots, co-existence in virtual and real spaces, synchronicity of actions, real-time remote control, man-animal-plant-robot interfaces, and collaboration through networks. In a technical appendix, Ed Bennett describes the design and implementation of the hardware and software used in *Ornitorrinco in Eden* and *Rara Avis.*
This is followed by a glossary defining the main technical terminology of telepresence systems.

Two of the many new technologies that have opened up new areas of artistic experimentation are telepresence and virtual reality. Scientific telepresence research has focused on telerobotics and teleoperation. The development of commercial virtual reality technologies has enabled a new level of interaction between humans and computers, allowing individuals to experience a completely synthetic environment from immersive or second-person perspectives. When used in radical ways, as a conceptual gesture that critiques aspects of the mediascape and contemporary life, hybrids of these and other technologies have helped electronic artists chart new directions for art [1].

Current scientific research clearly points to a future in which telepresence and virtual reality will become more integrated than they are now [2]. This integration will enable actions that will take place inside an immersive virtual environment to affect a physical reality and vice versa. The same can be said about the use of these technologies in art. However, today an objective distinction can still be made between the two [3]. In this sense, I will refer from now on in this essay to the word *telepresence* in relation to telerobotics; i.e., remote control of a nonautonomous robot in a distant physical space. I understand *virtual reality* as related to the creation and experience of purely digital worlds.

The distinction between telepresence and virtual reality can be further clarified by comparing the processes of these two technologies. Virtual reality relies on the power of illusion to give the observer a sense of actually being in a synthetic world. VR makes perceptually real what in fact only has virtual (i.e., digital) existence. By contrast, telepresence transports an individual from one physical space to another, often via a telecommunications link. Telecommunications and robotics can bring together the transmission and reception of motion control signals with audiovisual, haptic, and force feedback. Telepresence virtualizes what in actuality has physical, tangible existence.

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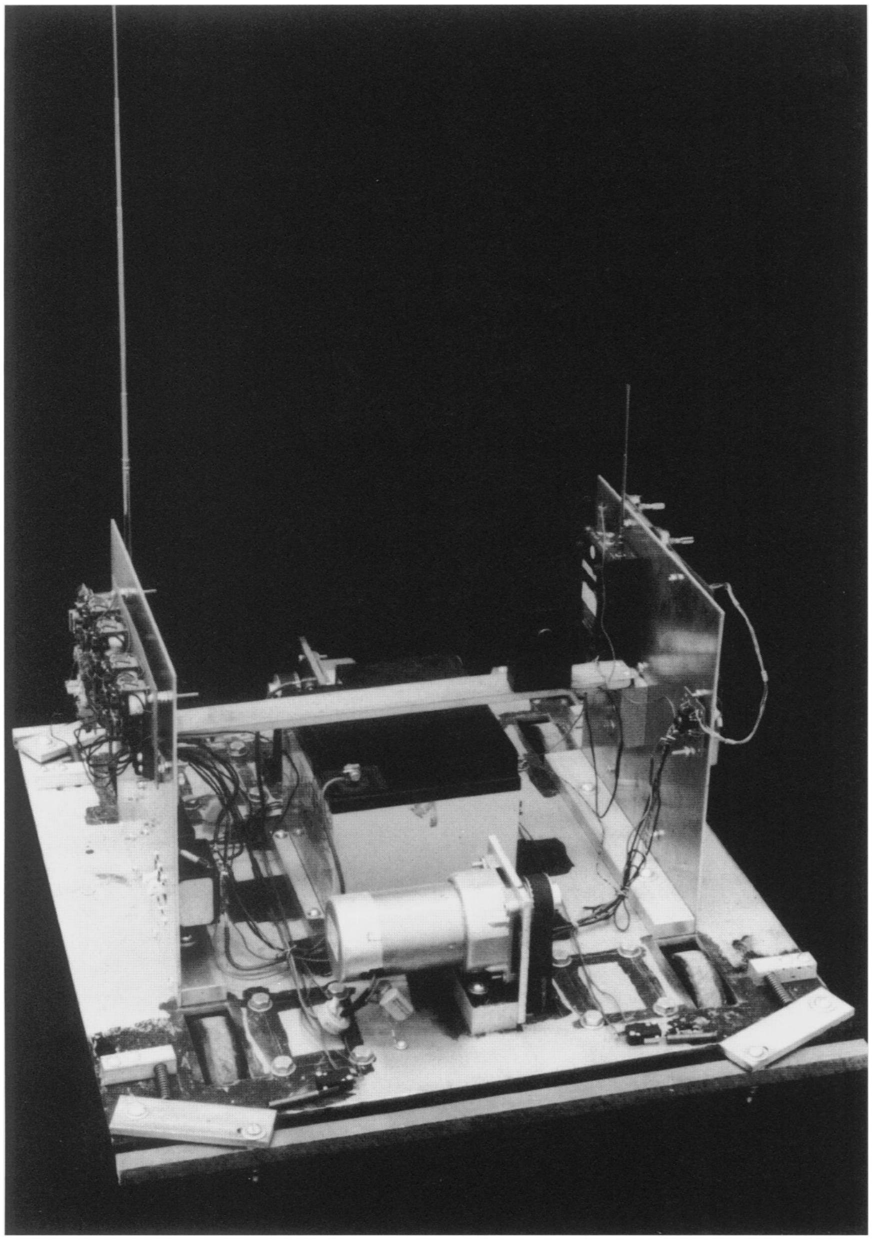

Fig. 1. The telerobot *Ornitorrinco*, by Eduardo Kac and Ed Bennett. *Ornitorrinco* was originally designed and built in 1989 as a fully mobile, wireless telerobot to be operated by one or more participant(s) from a distant geographic location. While *Ornitorrinco* always stayed in Chicago, it has been teleoperated from Rio de Janeiro, Brazil (1990); a remote site in Chicago several miles away (1992); Graz, Austria (1993); and both Seattle and Lexington simultaneously (1994)—always in telepresence art events. *Ornitorrinco*'s height is 18 inches, plus extendible antennae. (Photo: David Yox)

In fact, from this point of view, it would almost seem that virtual reality and telepresence technologies are opposite in nature. However, I propose that the rise of these two technologies indicates that the new domain of human experience and action now encompasses electronic space and physical space with the same intensity. Digital or synthetic worlds may become equivalent to tangible realities, since both telepresence and virtual reality technologies can project human action beyond its ordinary, immediate grasp.

The *Ornitorrinco* series of installations (*Ornitorrinco* means 'platypus' in Portuguese) is an ongoing collaboration between hardware designer Ed Bennett and myself. This collaboration, a long-term, ever-changing telepresence art project, started in 1989 [4] following initial conceptions and sketches I realized in the preceding two years. Through *Ornitorrinco* (Fig. 1) I propose to unite three areas of aesthetic investigation that so far have been explored as separate artistic realms: robotics [5], telecommunications [6], and interactivity [7]. I will now discuss some conceptual implications of our networked telepresence installation *Ornitorrinco in Eden.* A discussion of my networked telepresence installation *Rara Avis* will follow.

## Interaction, Telepresence, and Net Life

The introduction of televirtual technologies in society at large is remapping our domain of action and interaction in all public spheres. Today, as in the past, new information technologies redefine the human experience. It happened with the mechanical press, photography, telegraphy, the telephone, the phonograph, cinema, radio, television, the personal computer, and the Internet. New information technologies generate new situations as well as new ways of understanding familiar scenarios. They have the power to modify the social arena through the introduction of new forms of intercourse and negotiation of meaning. Today our systems of symbolic exchange are beginning to incorporate new multimedia elements introduced by the merger of telecommunications, real-time computing, and worldwide networking. It is clear that phone calls and email messages will never be the same when full-motion video (30 frames per second) takes over pervasive wide-bandwidth digital lines. Conversations will become multimedia, and telepresential experiences (incorporating tactile feedback, for example) will become ordinary. Technology will continue to migrate towards the body, reconfiguring, expanding, and transporting it to remote sites [8].

At the end of the twentieth century new art forms use technology to suggest a new concept of human potential, one that expands the reach of human presence in real time beyond spatiotemporal barriers. Through events, systems, and ephemeral installations this new art operates in the realms of mediascape and net life [9] and interfaces the human body to computers and other electronic devices. The dominant presence of the object in the visual arts [10] makes room for the immaterial experience of telepresence [11]. While a few decades ago we spoke about the process of dematerialization of the art object [12], it is time now to acknowledge that immaterial art is already practiced in the present.

Many artists working today with the tools of their time merge technologies of the visible and the invisible, configuring synthetic and telepresential environments in which physical boundaries are partially removed in favor of virtual and remote navigation. A new aesthetic is emerging as a result of the synergy of new nonformal elements, such as coexistence in virtual and real spaces, telerobotic navigation, synchronicity of actions, real-time remote control, body-sharing of telerobots, and collaboration through networks. The telepresence installation *Ornitorrinco in Eden* integrated all these elements simultaneously.

## *Ornitorrinco in Eden*

*Ornitorrinco* is the name of both an ongoing series of telepresence art installations and the telerobot used to realize them. This noun was chosen early on as the telerobot's name because of the unique nature of the platypus, which is popularly thought of as a hybrid of bird and mammal. The objective was to imply kinship between the organic (animal) and the inorganic (telerobot).

*Ornitorrinco* events have always involved at least two locations geographically remote from each other. One or more members of the public, the participant, navigates through an installation at a remote location by pressing keys on a telephone keypad and receiving visual feedback in the form of still or moving images on a computer or video monitor. Each new installation is always built to the scale of the telerobot and not to a human scale.

The networked telepresence installation *Ornitorrinco in Eden* was experienced publicly worldwide over the Internet on 23 October 1994, for approximately five hours (after more than one year of private experiments). This piece bridged the placeless space of the Internet with physical spaces in Seattle, Washington; Chicago, Illinois; and Lexington, Kentucky (Fig. 2). The piece consisted of these three nodes of active participation and multiple nodes of observation worldwide. Anonymous viewers from several American cities and many countries (including Finland, Canada, Germany, and Ireland), who received information about the event via listserv groups and word-of-mouth, came online (Fig. 3) and were able to see the remote installation in Chicago from the point of view of *Ornitorrinco* (which was guided by anonymous participants in Lexington and Seattle).

The mobile and wireless telerobot *Ornitorrinco* in Chicago was controlled in real time by participants in Lexington and Seattle. The remote participants shared the body of *Ornitorrinco* simultaneously. Via the Internet, they saw the remote installation through *Ornitorrinco*'s eye. The participants controlled the telerobot simultaneously via a regular telephone link (three-way conference call) in real time.

The space of the installation was divided into three sectors, which were all interconnected. The predominant visual theme was the obsolescence of media once perceived as innovative and the presence of these media in our technological landscape. Obsolete records, magnetic tapes, circuit boards, and other elements were used primarily for their external shape, texture, and scale, rather than function. This worked as a direct comment on the disposable environment we live in, made of products that become obsolete faster than users manage to understand and master their functionality. Theatrical lights were also used to enhance the visual experience and to control the projection of shadows in specific areas of the installation. Small objects were placed in strategic points in the space, including plastic globes that were actually pushed around by the telerobot, a self-propelled circular object which hung from the ceiling and moved in unpredictable ways, a little stationary robot with

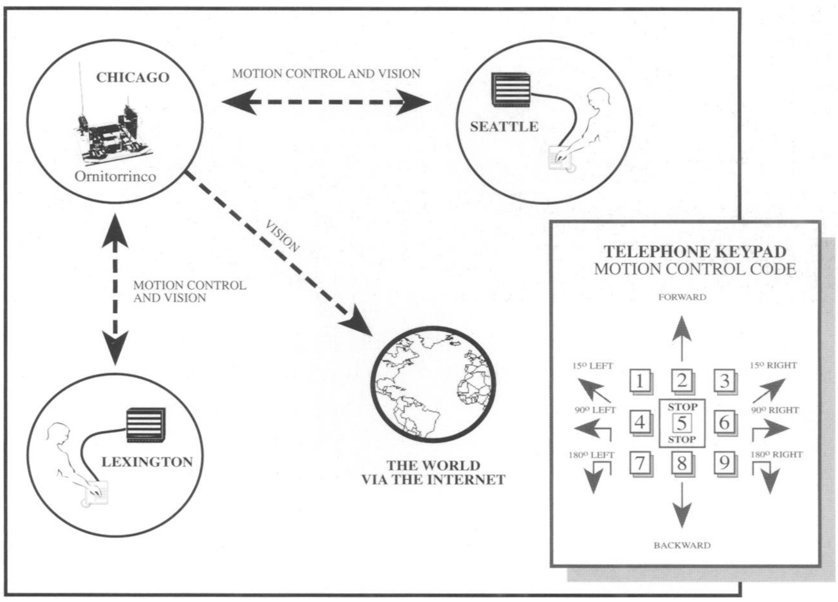


Fig. 2. This diagram shows the telerobot *Ornitorrinco* in Chicago being controlled simultaneously, in real time, by participants in Seattle and Lexington during *Ornitorrinco in Eden*, a networked telepresence installation by E. Kac and E. Bennett (1994). Participants pressed keys on the telephone to control the telerobot in real time and saw the remote space on the computer monitor from *Ornitorrinco*'s point of view, as digital video transmitted by the telerobot via the Internet (for simplicity, the computer itself is not shown). This digital video feed was simultaneously seen by many other Internet users. The inset shows how the standard telephone keypad was transformed into an intuitive Cartesian grid to enable easy remote navigation. (Illustration: Eduardo Kac with Roberto Marques)


Fig. 3. Screen image showing two viewers from Germany (left) and Finland (right) looking at the installation space in Chicago from the point of view of the telerobot *Ornitorrinco* (center), as it was simultaneously controlled by participants in Seattle and Lexington.

glowing eyes which upon close scrutiny revealed itself as a swiveling fan, and a mirror that enabled participants to see themselves as the telerobot *Ornitorrinco.* Objects like these provided the viewer with surprise encounters along the path of their exploration of the space and helped convey the atmosphere suggested by this teleparadise of obsolescence.

One of the main issues raised by this piece is the cultural need for a more direct sense of shared space and mutual presence in remote, networked environments, virtual or otherwise. As Geert Lovink pointed out in our panel at Ars Electronica in 1995, as hundreds of people log on to Web sites today, for example, they remain completely unaware of each other's presence in the same server [13]. As a result, technologies that are marketed as promoters of social interaction remain developed and practiced as information-dissemination technologies, as preservers of the same social isolation that characterizes television. The mutual awareness of participants sharing the body of *Ornitorrinco* already reveals the social (and political) significance of such experience. Unable to fully control the body in their own terms, they must cooperate for any navigation to be realized.

## Telepresence: Telecommunications As a Space for Action

In the new interactive and participatory context generated by this networked telepresence installation over the Internet, communicative encounters took place not through verbal or oral exchange but through the rhythms that resulted from the participants' engagement in a shared mediated experience. Viewers and participants were invited to experience together, in the same body, an invented remote space from a perspective other than their own, temporarily lifting the ground of identity, geographic location, and physical presence. As the piece was experienced through the Internet, anybody in the world with Internet access could see it, dissolving gallery walls and making the work accessible to larger audiences. With *Ornitorrinco*, we transform electronic space from a representation medium into an actuation medium.

By merging telerobotics, remote participation, geographically dispersed spaces, and the traditional telephone system as well as cellular telephony, real-time motion control, and videoconferencing through the Internet, this networked telepresence installation produced a new form of interactive art—one that does not conform to unidirectional structures that form the mediascape. In the next century mass media's monological discourse (one-to-many) will renew its system and its reach through pseudo-interactive gadgets, trying to absorb and domesticate the multilogue (many-to-many) genuinely practiced on the Internet. It is also clear that more and more people will live, interact, and work between the worlds inside and outside the computer. The expansion of communications and telepresence technologies will prompt new forms of interface between humans, plants, animals, and robots [14]. The *Ornitorrinco* project has pursued this strategy while at the same time insisting on undermining current trends toward stabilization of standards and other regulatory practices. The aesthetic of hybridization explored by *Ornitorrinco* calls for alternatives to the hegemonic configuration of the mediascape.

With new low-earth-orbit satellites, wearable computers, portable satellite dishes, virtual retinal displays, wristphones, holographic video, and a whole plethora of new technological inventions, new media will continue to proliferate, but by no means can this be seen as an assurance of a qualitative leap in interpersonal communications. *Ornitorrinco in Eden* creates a context in which anonymous participants perceive that it is only through their shared experience and nonhierarchical collaboration that little by little, or almost frame by frame, a new reality is constructed. In this new reality, spatiotemporal distances become irrelevant, virtual and real spaces become equivalent, and linguistic barriers may be temporarily removed in favor of a common empowering experience.

## *Rara Avis*

In the pursuit of new aesthetic possibilities, two strategies I have embraced are the hybridization of technologies and the exploration of hidden aspects of the new mediascape. In this sense, I use telecommunications media to implode their unidirectional logic and to create, in the domain of the real, a new kind of experience that gives precedence to democratic and dialogic experiences.

*Rara Avis*, an interactive networked telepresence installation that has subtle autobiographical elements, is the piece I created for the exhibition "Out of Bounds: New Work by Eight Southeast Artists," with technical direction by Ed Bennett. This exhibition was realized between 28 June and 24 August 1996, at Nexus Contemporary Art Center in Atlanta, Georgia, as part as the Olympic Arts Festival [15].

In *Rara Avis*, the participant saw a very large aviary as soon as he or she walked into the room. In front of this aviary the participant saw a virtual reality headset. Inside the aviary the viewer noticed a strong contrast between the 30 flying birds (zebra finches, which were very small and mostly gray) and the large tropical macaw, which was perched and immobile (Fig. 4). This macaw, like any other, has a long saber-shaped tail, a curved powerful bill, and brilliant plumage. Upon observing the behavior of the birds, the viewer noticed that the macaw—the most commanding bird in the aviary—appeared motionless. Only its head moved. This tropical bird was in fact a telerobot. Since the macaw's eyes were on the front of the head, as is the case with an owl, the telerobot was called a *Macowl* (Fig. 5).

The viewer was invited to put on the headset. While wearing the headset, the viewer was transported into the aviary. The viewer now perceived the aviary from the point of view of the Macowl and was able to observe himself or herself in this situation from the point of view of the macaw. The tropical bird's eyes are two CCD cameras. When the viewer, now a participant, moved his or her head to left and right, the head of the telerobotic Macowl moved accordingly, enabling the participant to see the whole space of the aviary from the Macowl's point of view. The real space was immediately transformed into a virtual space. The installation was permanently connected to the Internet. Through the Net, remote participants observed the gallery space from the point of view of the telerobotic Macowl (Fig 6). Through the Internet remote participants also used their microphones to trigger the vocal apparatus of the telerobotic macaw heard in the gallery. The body of the telerobotic Macowl was shared in real time by local participants and Internet participants worldwide. Sounds in the space, usually a combination of human and bird voices, traveled back to remote participants on the Internet.

By enabling the local participant to be both vicariously inside and physically outside the cage, this installation created a metaphor that revealed how new communications technology enables the effacement of boundaries at the same time that it reaffirms them. The installation also addressed issues of identity and alterity, projecting the viewer inside the body of a rare bird that not only was the only one of its kind in the aviary but was also distinctly different from the other birds (in scale, color, and behavior). The piece can be seen as a critique of the problematic notion of exoticism, a concept that reveals more about relativity of contexts and the limited awareness of the observer than about the cultural status of the object of observation. This image of "the different," "the other," embodied by the telerobotic Macowl, was dramatized by the fact that the participant temporarily adopted the point of view of the rare bird. Despite its glorious beauty, the telerobotic macaw could not fly. A new metaphor emerged in this context; viewers might have decided, once they were back into their own bodies outside the cage, that flying is ultimately not a great advantage after all, if all birds, big and small, rare or otherwise, remain immured together and have nowhere to go.

This piece created a self-organizing system of mutual dependence, in which local participants, animals, a telerobot, and remote participants interacted without direct guidance, control, or external intervention. As the piece combined

Fig. 4. The telerobotic Macowl with 10 zebra finches, one of which is flying away from the perch (left). *(Photo: Anna Yu)*

physical and nonphysical entities, it merged immediate perceptual phenomena with a heightened awareness of what affects us but is visually absent, physically remote. Local and online participants experienced the space in complex, different ways. The local ecology of the aviary was affected by Internet ecology and vice versa.

By the phrase "Internet ecology" I mean to clarify that the Internet is a shared resource, and that its global behavior changes dramatically depending on many unpredictable, uncontrollable factors, including the density of nodes in a particular geographic region, bandwidth availability and allocation, nature of the connection, modem and direct-connection speeds, processing power of individual personal computers and servers, choice of connectivity software, and user traffic at a particular time. In this sense, it is important to stress that networking is not broadcasting. To be on the Internet is not similar to transmitting a program over the air (despite emerging technological tours de force, such as satellite-enabled downloading of Web pages and broadcasting television on the Net). Networking is a complex system in which one's actions directly affects everybody else (whether one is aware of it or not), and I do not mean from a content-only standpoint; under certain circumstances, for example, one participant's slow modem could cause a whole videoconference to bog down.

While many members of the general public expect the Internet to function in the stable and efficient manner of the broadcasting industry, and are often disapointed to find out that that is not the case, it is precisely the current status of the Net as an unrregulated, global open space that I find to be fascinating from a cultural, philosophical, and political point of view. Unlike broadcasting space, which is controlled by a few who own the right to transmit and decide what is seen and heard by everybody, the Internet today defines a new kind of telematic space that has not been codified in art history books. This space can accommodate pictorial representation (as when an image is displayed), but this new space is not, in itself, the purveyor of a single picture-making style (as in the representational space of Cubism, for example). This new worldwide digital space, which is on its way to incorporate real time as wide-bandwidth digital networks become available, calls for a major transformation in the way we approach human endeavors—particularly art, since verbal, visual, and acoustic signs form the core of the network. Telepresence art makes it clear that action at a distance must be incorporated into the repertoire of elements explored by artists via networks (digital, analog, or a hybrid of both). As much as these new aesthetic elements expand the multimedia horizon of contemporary art, we must not embrace the technophilic or the technophobic extremes. Both positions are dangerous in that they fail to address the deeper, more complex social implications of new technologies—either by blindly embracing them or by fearfully refusing to accept their impact in our lives.

In *Rara Avis*, these social implications are also a crucial point. The topology of *Rara Avis* (Fig. 7) was carefully designed to expose the social gap implied in technological development. As the video feed, from the point of view of the Macowl (as seen by a local participant), went out from the Atlanta space into the Internet, one eye was digitized in grayscale (with the freeware CU-SeeMe) while the other was digitized in color (with the commercial product Enhanced CU-SeeMe). While anyone with Internet access could download the freeware and participate in the interactive component of the work, full participation in color was only accessible to those who had already purchased the commercial version of the freeware. The gray images were subsequently and automatically uploaded to the *Rara Avis* Web site (Fig. 8), where they became even more accessible—since more people today have access to (and feel comfortable with) the Web than to videoconferencing on the Internet [16]. The color feed was rerouted to the MBone, the multicasting zone of the Net, which only a much smaller group of individuals can access at present. Those lacking access to more powerful media saw the space in Atlanta in grayscale, at speeds that depended on the software, hardware, and connectivity available to them. Those with access to newer technology were able to experience the space differently, in color and at frame rates that reflected the processing power and bandwidth available to them [17]. In its geographic dispersal, *Rara Avis* was intentionally never exactly the same to remote or local participants.

The merger of local ecology with the cybersphere was perceived in varying ways by viewers and participants worldwide, depending on the kind of access they had. This clearly suggested that the mediascape—the highly technological environment in which we live—modulates and defines our perception of reality. Which makes us realize the inequalities promoted by technology, and, more importantly, that reality is negotiation, and that it is never the same for everybody.

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**9.** In my telematic interactive installation *Teleporting an Unknown State* (1994-96) the concept of net life, or life that depends on network activity for its survival, was realized. A single seed was planted on a bed of earth on 22 July 1996. Internet participants worldwide were invited to point their cameras to the sky and transmit photons to the installation space. Light from the sky of many countries around the world came together in the space to help the growth and development of a single life form. Evocative of the sun, a circular lens broke through the darkness and projected onto the fertile soil the light transmitted live via the Internet. Photosynthesis depended on remote collective action from anonymous participants. Collaborative action and responsibility through the network were essential for the survival of this organism. Birth (germination), growth, and death on the Internet formed a horizon of possibilities that unfolded as participants dynamically contributed to this work. The piece was shown in "The Bridge," the 1996 SIGGRAPH Art Show at the Contemporary Arts Center in New Orleans, from 22 July to 9 August 1996. See C. Gigliotti, ed., *SIGGRAPH '96 Visual Proceedings* (New York: ACM, 1996). On the Web, see http://www.uky.edu/FineArts/Art/kac/teleporting.html.

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**15.** "Out of Bounds: New Work by Eight Southeast Artists" was curated by Annette Carlozzi and Julia Fenton. *Rara Avis* credits: Eduardo Kac, conceptual design and direction; Ed Bennett, technical direction; Bob Connell, exhibit design; Joe Peragine, space design; Charles Bynaker, network systems programming; Michelle Lindsay, coordination and research assistance. The author would like to thank Simone Osthoff, Rodrigo Toledo, Nelson Pataro, Steve Waldeck, and Jane Peters for their support of *Rara Avis. Rara Avis* sponsors: Apple Computer, Inc.; VictorMaxx Technologies, Inc.; Home Depot; University of Kentucky; Atlanta Committee for the Olympic Games. See K. Maschke, ed., *Out of Bounds: New Work by Eight Southeast Artists* (Atlanta: Nexus Contemporary Art Center, 1996). On the Web, see http://www.uky.edu/FineArts/Art/kac/raraavis.html.

**16.** This, of course, is bound to change very soon, since videoconferencing on the Web itself has already been developed in its preliminary state.

**17.** The expression of social and technological inequality represented through access to higher or lower color depth and frame rate was suggested by science-fiction writer Neal Stephenson in his novel *Snow Crash* (New York: Bantam, 1993). On page 41, for example, he describes "the avatars of Nipponese businessmen, exquisitely rendered by their fancy equipment" and "black-and-white people—persons who are accessing the Metaverse through cheap public terminals, and who are rendered in jerky, grainy black and white."

# TECHNICAL APPENDIX

*Ed Bennett*

*Ornitorrinco* is the name of both an ongoing telepresence art project and the telerobot used to realize the project (see Fig. 1). *Ornitorrinco* events always involve at least two locations geographically remote from each other. In Place A, a member of the public navigates through a specially designed environment at a remote location (Place B) by pressing keys on a telephone keypad and receiving visual feedback on a video or computer monitor. The telerobot *Ornitorrinco* is a self-propelled mobile platform upon which experiments in teleoperation, remote control, and sensing can be mounted.

The intent of *Ornitorrinco*'s design is for the remote participants in Place A to have sole control over the robot's actions. If, however, a movement results in collision with an immovable object, stalling could damage the traction motors. Upon contact, spring-loaded bumper bars on the front and back ends of the platform trip switches, detecting whether the contact is made on the left, center, or right side of the platform. When contact is detected, say on the left, the left motor direction line is toggled momentarily, reversing that motor while it runs. Both motors are then shut off until the next command is received. This gives the telerobot the appearance of bouncing off of obstacles. We have named this action "decolliding." If the participant in Place A is receiving images often, the effect of the decollision process should be apparent and not disorienting.

*Ornitorrinco* consists of several interconnected systems. The telerobot is made from aluminum plate; it is 2 feet square and 18 inches high (plus extendible antennae). It is powered by a 12-volt lead-acid battery feeding two 3-amp traction motors and on-board electronics. Electronic systems include a black-and-white CCD video camera, microphone, radios, and motion control circuits. The wireless telerobot is connected to its base station (the transcoder) by two radio links, one for sound and video, and one for motion control. It travels at a fixed speed of 45 feet per minute and steers by rotating the left and right pairs of wheels in opposite directions in the fashion of some heavy construction equipment, enabling turns to be made while standing in place.

The first *Ornitorrinco* remote links were accomplished using a single standard telephone line for sound, image, and motion control. The telephone keypad was chosen as the input half of the user interface (instead of a joystick, for example) to make a direct reference to the telephone network and make any tone-dial telephone in the world one-half of an *Ornitorrinco* telepresence station. The other half was a videophone. We used a pair of LE-4 Still Image Transceivers with the one in Place B being interfaced into the transcoder. When the participant in Place A pressed a key on the telephone keypad, the touch-tone signal sent to Place B via telephone was received by the transcoder and then transmitted to the telerobot via radio, decoded in the telerobot, and the command executed. Keys 2 and 8 represent forward and backwards, respectively; keys 1, 4, and 7 are left turns; and keys 3, 6, and 9 are right turns. Key 3 turns right 15 degrees, key 9 turns 180 degrees, and so on. Key 5 causes the telerobot to stop if it is moving and simultaneously signals the transcoder to send an image from the telerobot's camera back to Place A, a process requiring about 6 seconds. When the telephone line was not sending motion commands or receiving a video image, the line carried environmental sounds from the telerobot's microphone from Place B to a loudspeaker in Place A. The telerobot's on-board motion control electronics are hard-wired logic with an instruction look-up table in EPROM.

As the *Ornitorrinco* project evolves, Eduardo and I are developing networked telepresence. Our first experiments in networked telepresence were in preparation for *Ornitorrinco in Eden.* We altered the control and communication topology to permit something closer to a live video feed to be car-

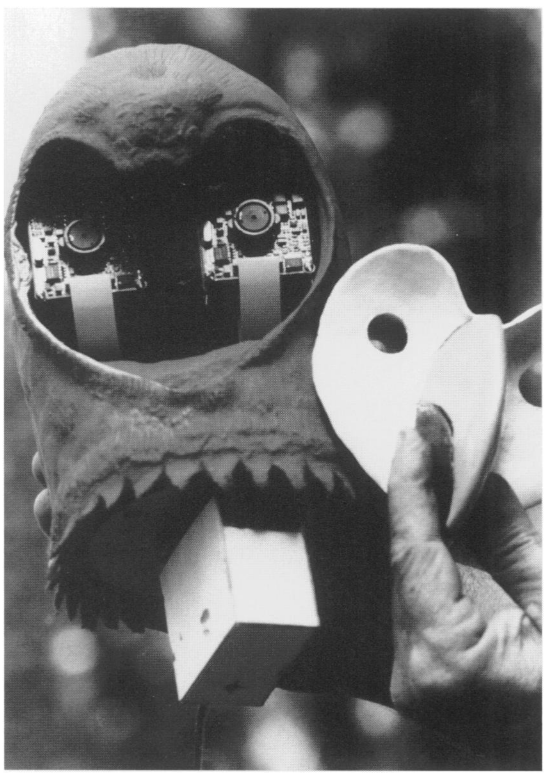


Fig. 5. The head of the telerobotic Macowl is made of two miniature CCD video cameras and a servomotor. The servomotor, which moves the telerobot's head, is controlled by a computer receiving directional information from the virtual reality headset. (Photo: Eric Lesser)

Fig. 6. As the local participant in Atlanta put on the virtual reality headset, she saw the aviary from the point of view of the Macowl (foreground). What she saw was immediately transmitted to the Internet (background frames). The two frames included in this illustration were captured from a live Internet feed and show birds in flight. Internet participants affected the space in Atlanta by taking control of the vocal apparatus of the Macowl. (Photo: Rod LaFleur)

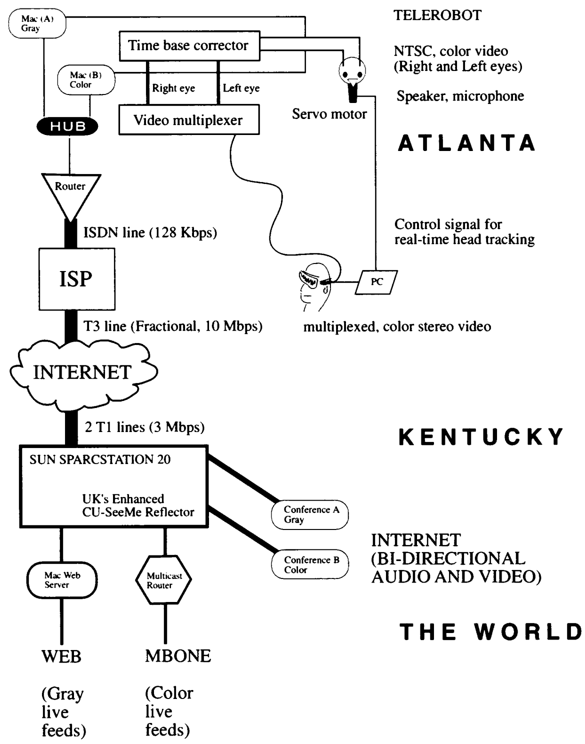
ried to multiple Place A's and to achieve simultaneous multipoint control of the telerobot's motion. This was accomplished by sending the video feed from the transcoder into an Internet-connected computer running CU-SeeMe, rather than the videophone, and using a conference call between Chicago (Place B), and Lexington and Seattle (Place A's), for motion control. In this case, key 5 was used only to stop the telerobot, since video images were coming live via the Internet. This hybridization of POTS (**p**lain **o**ld **t**elephone **s**ervice) and Internet obviously points to our next technological step in the continuation of the project, which is to realize all control and feedback through computer networks. In the case of *Ornitorrinco in Eden*, anyone on the Internet could see what was happening (see Fig. 2). Lexington and Seattle shared control of the body of the telerobot in that three-way conference call (see Fig. 3). We are currently working with technologies, including the Web, that enable many people worldwide to simultaneously control and receive feedback from a freely mobile telerobot through the Internet.

Telepresence art can take many forms. In the case of the ongoing *Ornitorrinco* project, the participants controlling the telerobot are always geographically remote from the telerobot. *Rara Avis*, which was shown at Nexus Contemporary Art Center in Atlanta, used a different spatial model defining the relationship between the telerobot—i.e, the Macowl (see Fig. 4)—and a local, rather than remote, participant who controlled the motion of the telerobot.

*Rara Avis* integrated personal telepresence (point-to-point) and networked participation. The participant in the gallery wore a CyberMaxx virtual reality headset (see Fig. 6) containing two color LCD video displays. Video signals going to the left and right eyes were distinct, providing a stereo (3D) image. The video signals originated in the Macowl's "eyes," two miniature color CCD cameras ("body cams") designed for police work or other covert surveillance. Dimensions of a single camera were 1.375 x 1.375 x 0.75 inches with a 0.0625-inch diameter lens aperture and 78 degree field of view. A specially fabricated mount provided the multi-axis adjustability and approximately 2.5-inch (65-millimeter) pupil-to-pupil spacing needed to duplicate human stereo vision. The camera assembly was siliconed to the inside of the Macowl's head, which was mounted on the shaft of a large model airplane servo, which in turn fit into a pocket on the top of the Macowl's neck (see Fig. 5). The servo had 90 degrees of movement in the horizontal plane (yaw). Servo position was controlled by a custom-built interface card running in a 386 computer. Custom software for the 386, based in part on sample code in the CyberMaxx developer's kit, interpreted the yaw position information from the headset's built-in tracker. The participant, therefore, controlled the direction the Macowl was looking by moving his or her head from left to right. Video signals going from the cameras to the headset were genlocked and multiplexed so that the headset accepted them.

Camera video also fed a monitor recessed into the gallery wall so that more than one person in the space could see the Macowl's current point of view. Those viewing the monitor did not see in stereo but rather saw the image from only one "eye." Other video connections included those to two PowerMacintosh computers, each running a CU-SeeMe client providing global accessibility to, and interactivity with, the environment. One PowerMac sent grayscale (black-and-white) digital

Fig. 7. Topology of the *Rara Avis* networked telepresence installation, by Eduardo Kac. This diagram shows a participant in Atlanta wearing a virtual reality headset. The participant's head motions were tracked by a computer, which controlled a servomotor in the head of the telerobotic Macowl. What the Macowl saw was transmitted to the Internet. The video images coming from the left and right eyes of the telerobot were digitized in black-and-white (grayscale) and color by two different PowerMacintosh computers and sent to a reflector in Kentucky running on a SPARC station. This reflector hosted the interactive component of *Rara Avis*, available to anybody with Internet access anywhere in the world. The grayscale video images were automatically and sequentially uploaded to the *Rara Avis* Web site. The color feed was rerouted to the MBone on scheduled cybercasts.




video to the Internet. Sound from remote CU-SeeMe conferees also entered the gallery through this computer. The sound was amplified and sent to a loudspeaker, giving the Macowl a "voice." The other PowerMac, running Enhanced CU-SeeMe, sent color video to the Internet. Both computers were connected to an omnidirectional microphone in the aviary. This microphone provided remote participants with sounds of the environment in Atlanta.

The two PowerMacs were connected via Ethernet into an ISDN router. *Rara Avis*'s dedicated ISDN line was configured for 128 kilobit-per-second (kbps) transfers. The line was active 24 hours, seven days a week sending the color and grayscale feeds to the *Rara Avis* CU-SeeMe reflector running on a Sun SPARC station at the University of Kentucky in Lexington. It was from this SPARC station that the connection to the MBone was made. When participants on the Internet viewed the inside of the aviary in Atlanta, their connection was to Lexington. The *Rara Avis* Web site was served by a Macintosh computer (networked to the SPARC station), which got a fresh CU-SeeMe image every 5 seconds (see Fig. 7). In order to accommodate those remote participants who had slow modems at home (less than 28.8 kbps), the automatic reload rate of the captured CU-SeeMe image placed in the Web site was set at once per minute. However, by pressing the Reload button on one's browser, the remote participant could get a fresh image more often than at 1-minute intervals. On a high-speed line, reloading retrieved a fresh image right away (see Fig. 8).

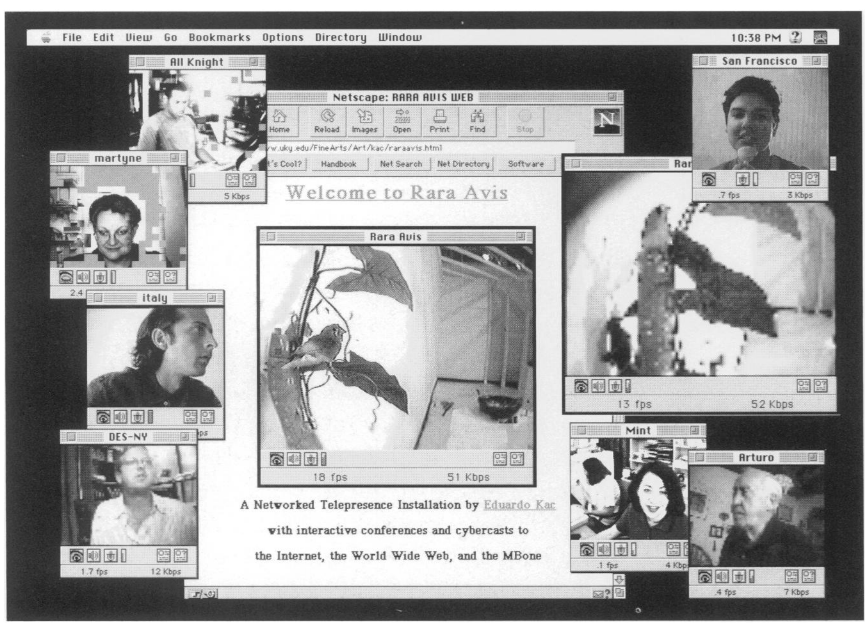



Fig. 8. Screen image showing the *Rara Avis* Web site with a current grayscale still video image (center) and a live color video feed (middle, right) from the point of view of the Macowl in Atlanta. Surrounding both large windows we see remote participants who logged on using grayscale as well as color videoconferencing software.

# Glossary

*Eduardo Kac with Ed Bennett*

**analog**—a method of storing, representing, or transmitting information using continuous variations of a physical quantity that represents (via analogy) the original; for example, the continuously changing voltage on a standard telephone line representing the speaker's voice; by contrast, digital storage, representation, or transmission relies on breaking down that continuity into discrete numeric units (see **digital**).

**bandwidth**—in broadcasting, it is the frequency range between upper and lower limiting frequencies (measured in cycles per second, or hertz); in networking, the amount of data that can be carried by a channel (measured in bits per second).

**browser**—software for navigating the Internet; the most popular current browser is Netscape.

**CCD camera**—a miniature video camera that uses solid-state image sensors (**c**harge-**c**oupled **d**evices).

**client**—software that enables the user to access a remote server; running the proper client software, the user can, for example, upload and download information to and from a server.

**CU-SeeMe**—videoconferencing software developed by Cornell University in 1992 and available both for Macintosh and PC platforms.

**digital**—a method of storing, representing, or transmitting information; digital information is always represented as ones and zeros; computers today are digital.

**EPROM**—**e**rasable **p**rogrammable **r**ead-**o**nly **m**emory; a kind of memory chip.

**Ethernet**—local area network protocol and wiring system that enables fast transmission of data; currently, Ethernet has, on average, a transmission rate of 10 mbps.

**feed**—transmission of a signal (e.g., a video signal) from one point to another.

**force feedback**—the kind of feedback received by the remote operator of a device when this device enables him or her to feel the actual physical resistance of tangible objects; for example, if the remote operator is wearing a robotic glove and he or she pushes the remote device—say, a robotic hand—against a wall, the operator would feel the resistance of the wall.

**fps**—frames per second; the frame rate of standard television is 30 fps.

**freeware**—software made available free of charge, usually downloadable from the Internert.

**genlocking**—synchronizing two video sources, allowing part or all of their signals to be displayed together; this is accomplished with a **gen**erator **lock**ing device.

**haptic feedback**—same as tactile feedback; the kind of feedback received by a remote operator of a device when this device enables him or her to feel the actual physical texture and shape of tangible objects; for example, if the remote operator is wearing a robotic glove and he or she uses the remote device—say, a robotic hand—and rubs it against sandpaper, the operator would feel the flat sandpaper texture.

**hard-wired logic**—control circuit that uses logic chips rather than a microprocessor.

**head tracking**—the ability to track head motions of the user of a particular device, such as a virtual reality headset, usually to feed the resulting position information to another device, such as a computer or a telerobot.

**ISDN**—**i**ntegrated **s**ervices **d**igital **n**etwork; international digital telecommunication standard that enables transmission and reception of digital information (voice, data, video, fax, control signals); the usual bandwidth of ISDN is 128 kbps (by comparison, the current standard modem speed is 28.8 kbps).

**kbps**—**k**ilo**b**its **p**er **s**econd (1024 bits per second); a bit (binary digit) is the smallest unit of digital data (one or zero).

**MBone**—**m**ulticast back**bone**; a network that has existed within the Internet since 1992 and which is made of routers that forward information (usually audio and video) efficiently to other networks in such a way (i.e., multicasting) that streams of information only travel once through any given wire on the network.

**mbps**—**m**ega**b**its **p**er **s**econd (approximately one million bits per second); more precisely, 1024 kbps (see **kbps**).

**mediascape**—term coined by analogy with the word "landscape"; the term suggests that we are surrounded no longer by a natural environment, but by media; it implies that our experience of reality is mediated by mass media and telecommunications systems; it may also imply that our reality has become this new communications environment; while landscape refers both to an expanse of scenery and its visual representation, the mediascape refers exclusively to the mediated environment we inhabit, and not to any form of pictorial depiction.

**multiplexing**—in video, a process that integrates two or more video signals into one channel.

**network topology**—the spatial configurations and the connectivity systems of a network.

**personal telepresence**—in the *Ornitorrinco* project, where it originated, the term is used by analogy with the personal computer, i.e., an accessible telepresence system used by an individual on the desktop, usually to connect from one point to another (although multipoint personal telepresence connections can also be made).

**real time**—immediate transmission and reception of a signal as it is produced by a device, without delays; live television is a common example of real-time transmissions.

**reflector**—software developed by Cornell University to retransmit incoming audio and video information to participants of a videoconference.

**router—a** device that routes data from source to destination; routers are the fundamental building block of the Internet; over long distances, Internet data automatically passes through many routers.

**server**—software that enables remote users, running client software, to download and upload information to and from a computer.

**servo**—short for servomotor; a type of electric motor that has internal feedback; a servo receives a control input signal and automatically positions a physical load.

**SPARC station**—SPARC stands for **s**calar **p**rocessor **arc**hitecture; SPARC stations are fast and powerful workstations developed by Sun Microsystems.

**teleoperation**—an action executed at a distance under remote control.

**telerobotics**—the field dedicated to the study and development of mostly nonautonomous robots designed to be remotely manipulated.

**transceiver**—a device capable of both transmitting and receiving information.

**transcoder**—a device developed by Ed Bennett to interface *Ornitorrinco* to the telephone line, receiving video and audio and transmitting motion control wirelessly.

**videoconferencing**—bidirectional, or multidirectional, simultaneous transmission and reception of video (and usually audio, too) for interpersonal communication.

**wide-bandwidth digital lines**—at the current pace of technological development, it seems that the new digital lines going into homes via cable modems in the United States have bandwidth of 10 mbps; at the same time, much wider bandwidth systems are already available in business settings (40 mbps T3 lines or 100 mbps Ethernet lines, for example), and gigabit speeds are imminent.

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**Eduardo Kac** is an artist and writer who works with electronic and photonic media. His work has been exhibited widely in the United States, Europe, and South America. Kac's works belong to the permanent collections of the Museum of Modern Art in New York, the Museum of Holography in Chicago, and the Museum of Modern Art in Rio de Janeiro, Brazil, among others. He is a member of the editorial board of *Leonardo* and a guest editor of the journal *Visible Language*.

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