



The Robot in the Garden

Telerobotics and Telepistemology in the
Age of the Internet *edited by Ken Goldberg*

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the Internet**

Edited by Ken Goldberg

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To the memory of M. G. and M. G.

Series Foreword

*Editorial Board: Roger F. Malina, Denise Penrose,
and Pam Grant Ryan*

We are living in a world in which the arts, sciences, and technology are becoming inextricably integrated strands in a new emerging cultural fabric. Our knowledge of ourselves expands with each discovery in molecular and neurobiology, psychology, and the other sciences of living organisms. Technologies not only provide us with new tools for communication and expression, but also provide a new social context for our daily existence. We now have tools and systems that allow us as a species to modify both our external environment and our internal genetic blueprint. The new sciences and technologies of artificial life and robotics offer possibilities for societies that are a synthesis of human and artificial beings. Yet these advances are being carried out within a context of increasing inequity in the quality of life and in the face of a human population that is placing unsustainable burdens on the biosphere.

The Leonardo series, a collaboration between the MIT Press and Leonardo/International Society for the Arts, Sciences, and Technology (ISAST), seeks to publish important texts by professional artists, researchers, and scholars involved in Leonardo/ISAST and its sister society, Association Leonardo. Our publications discuss and document the promise and problems of the emerging culture.

Our goal is to help make visible the work of artists and others who integrate the arts, sciences, and technology. We do this through print and electronic publications, prizes and awards, and public events.

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Acknowledgments

On August 15, 1994, my colleagues and I were beta testing a web page we'd linked to an old IBM robot arm and camera, allowing remote users to excavate for buried objects in a sandbox. An email arrived from a stranger named Don Patterson: "I don't believe that this is real. It would be easy, at least conceptually, to entirely fake this site." Patterson's comment came as a surprise, but he was absolutely correct: It would be "conceptually easy" to fake the site. Could anyone know the difference? This dilemma has a rich history: philosophers have studied skepticism for centuries. The word *telepistemology* does not exactly roll trippingly off the tongue, but it captures the subclass of epistemology that is the subject of this book.

I'd like to thank Bert Dreyfus, who encouraged this project from the beginning, for his many insights and intellectual generosity. Bert introduced me to Jeff Malpas, who edited my first prospectus for the book, and to Michael Idinopulos, who spent a year as a post-doc in the role of assistant editor. Michael's keen intelligence, rigor, and tact were essential to this project; it has been a true pleasure working with him.

I am fortunate to have a superb editor at MIT Press. Doug Sery trusted his instincts and shepherded this book through each stage with charm and confidence. He and Roger Malina, editor of the *Leonardo* series, were instrumental in selecting top-notch reviewers. I am honored to have worked with the contributors to this volume. Their professionalism, brilliant writing, and intellectual generosity set the highest standards.

The following friends and colleagues provided feedback and advice at the early stages of my thinking on this subject: Steve Antonson, John Canny, David Gibson, Adele Goldberg, Ann Goldberg, Eduardo Kac, Chine Lanz-

mann, Peter Lunenfeld, Lev Manovich, Michael Naimark, Eric Paulos, David Pescovitz, Debra Pughe, Sue Spaid, and Richard Wallace provided feedback and ideas at the early stages of my thinking on this subject.

Telepistemology is central to a series of net art projects I've developed in collaboration with some extraordinary artists and engineers: George Bekey, Erich Berger, Karl Bohringer, Florian Brody, John Canny, Billy Chen, Judith Donath, Bob Farzin, Lind Gee, Steven Gentner, Gil Gershoni, Sarah Hahn, Adam Jacobs, Gregory Kuhn, Woj Matusik, Rosemary Morris, Randall Packer, Mark Pauline, Eric Paulos, Joe Santarromana, Carl Sutter, Richard Wallace, and Jeff Wiegley.

I am also grateful for the advice I've received from Ruzena Bajcsy, George Bekey, Shawn Brixey, Brian Carlisle, Catharine Clark, John Craig, Elizabeth Daley, Erik Davis, Steve Dietz, Jim Gibson, Michael Grey, Kate Hayles, Selma Holo, David Hunt, Jon Ippolito, Reena Jana, Caroline Jones, Marc Lafia, Jean-Claude Latombe, Susan Miller, Leo Marx, Matt Mason, Howard Moraff, Christos Padadimitriou, Mark Pesce, Larry Rinder, David Ross, It-suko Sakane, Shankar Sastry, Julia Scher, Tom Sheridan, Leonard Shlain, Gerfried Stoker, Hal Varian, Paul Wright, Heidi Zuckerman-Jacobson, and my students and colleagues at UC Berkeley.

An attempt to explore beyond one's area of expertise risks being viewed as folly, trespass, or both. But as Philip Rieff said: "You only live once, if then." I thank my entire family for their love and encouragement, and my wife Tiffany Shlain, best friend and digital diva, who continues to teach me the value of proximity.

Contributors

Ken Goldberg is associate professor of industrial engineering and computer science and founder of the Art, Technology, and Culture Colloquium at UC Berkeley. In 1994, Goldberg led the team that developed the first robot on the Internet. His net art installations have been exhibited in the Interactive Media Festival, Ars Electronica Center, Walker Center, Kwangju Biennale, and in the 2000 Biennial at the Whitney Museum of American Art. Goldberg has taught at the SF Art Institute and was selected as one of 3 artist groups to represent the United States at the ICC Biennale '99 in Tokyo.

Goldberg received his Ph.D. in 1990 from the School of Computer Science at Carnegie Mellon University. His primary research area is geometric algorithms for feeding, sorting, and fixturing industrial parts. Goldberg serves on the Advisory Board of the IEEE Society of Robotics and Automation and has given invited lectures on telerobotic art at MIT Media Lab, CMU, Stanford, NYU, NY School of Visual Arts, IBM, Interval, and Xerox. Goldberg won the National Science Foundation Young Investigator Award in 1994, NSF Presidential Faculty Fellow in 1995, and the Joseph Engelberger Award in 2000.

Albert Borgmann has an M.A. in German literature from the University of Illinois (Urbana) and a Ph.D. in philosophy from the University of Munich (Germany). Since 1970 he has taught at the University of Montana. His special area is the philosophy of society and culture with particular emphasis on technology. Among his publications are *Technology and the Character of Contemporary Life* (University of Chicago Press, 1984), *Crossing the Postmodern Divide* (University of Chicago Press, 1992), and *Holding on to Reality: the*

Nature of Information at the Turn of the Millennium (University of Chicago Press, 1999).

Thomas J. Campanella is an urbanist, historian, and cultural critic. He writes on a wide variety of subjects related to cities, landscape, and the changing built environment. His work often bridges scholarship and journalism, and has appeared in *Salon*, *Wired*, *Harvard Design Magazine*, *Landscape Journal*, *Orion*, and other publications. Campanella holds graduate degrees from Cornell and MIT, where he recently completed a Ph.D. in the Department of Urban Studies and Planning. He is currently a Fulbright fellow in Hong Kong, where he is working on a book about the transformation of the Chinese landscape in the Deng Xiaoping era.

John Canny is a professor in the Computer Science Division at UC Berkeley. His MIT Ph.D. in 1987 was the ACM dissertation winner that year, and he became one of the first Packard Foundation Fellows in 1988. He has since worked in robotics, computational geometry and algebra, graphics, and HCI. He directs the 3DDI project (3D Direct Interaction), which is an MIT-University of California collaboration supported by BMDO and ONR. His goal for the next decade or so is to nurture a human-centered approach to computing.

Judith Donath is assistant professor of Media Arts and Sciences at the MIT Media Lab, where she is the director of the Sociable Media Group. Her research focuses on the social side of computing, synthesizing knowledge from fields such as graphic design, urban studies and cognitive science to create novel and intuitive mediated environments.

Donath is the creator of numerous projects that address the problem of design for social interaction, such as *Visual Who* (a visualization of activity and affiliations in a virtual community), *Portraits in Cyberspace* (a participatory art show), and *The Electric Postcard* (a popular web/email amalgamation). She received her doctoral and master's degrees in media arts and sciences from MIT, her bachelor's degree in history from Yale University, and has worked professionally as a designer and builder of educational software and experimental media.

Hubert Dreyfus is philosophy professor in the Graduate School at the University of California, Berkeley. He received his Ph.D. at Harvard University and has taught at Brandeis University and MIT. His publications include: *What Computers (Still) Can't Do*, third edition, MIT Press (translated into ten languages); *Being-in-the-World: A Commentary on Division I of Being and Time*; (with Paul Rabinow) *Michel Foucault: Beyond Structuralism and Hermeneutics*; (with Stuart Dreyfus) *Mind over Machine*; and last year (with Charles Spinosa and Fernando Flores) *Disclosing New Worlds: Entrepreneurship, Democratic Action, and the Cultivation of Solidarity*. As his publications suggest, Dreyfus thinks of himself as an applied philosopher reflecting on the bearing of the work of existential phenomenologists such as Martin Heidegger and Maurice Merleau-Ponty on current cultural developments such as the attempt to create artificial intelligence, and the effect of the Internet and various technologies that facilitate action at a distance on everyday human interactions. Dreyfus is currently working on a second edition of *Being-in-the-World*, which will expand his Heidegger Commentary to include Division II of *Being and Time*.

Alvin Goldman is regents' professor of philosophy and research scientist in cognitive science at the University of Arizona. His most recent book is *Knowledge in a Social World* (Oxford University Press, 1999), which develops an objectivist approach to social epistemology, covering science, law, democracy, information technology, and issues in the theory of speech and argumentation. His earlier book, *Epistemology and Cognition* (Harvard University Press, 1986), explored individual epistemology with special attention to the interface between epistemology and cognitive science. He is well known for his development of a causal theory of knowing and a reliabilist approach to knowledge and justification. In addition to epistemology, he has worked on the theory of action and on topics in the philosophy of mind, especially folk psychology and consciousness.

Goldman received his B.A. from Columbia College and his Ph.D. (1965) from Princeton University. He has spent most of his teaching career at the University of Michigan and the University of Arizona, with visiting appointments at the University of Pittsburgh and Yale University. He has been a fellow of the Guggenheim Foundation, the National Science Foundation, the Center for Advanced Study in the Behavioral Sciences, and the National Humanities Center. He served as president of the Pacific Division of the

American Philosophical Association and president of the Society for Philosophy and Psychology.

Oliver Grau is a new-media art historian. He teaches at Humboldt-University of Berlin and is doing research in the history and theory of virtual reality (financed by the Deutsche Forschungsgemeinschaft DFG) within an international network. He is author of *Die Sehnsucht im Bild zu sein: Zur Kunstgeschichte der Virtuellen Realität* (forthcoming 2000).

Involved in various exhibitions and festivals, he has published and lectured widely on the subhistory of media art in Europe, Asia and North and South America. Grau spent one year in Italy courtesy of the *Deutscher Akademischer Austauschdienst* (DAAD). He works and publishes primarily on the history of immersion, critical theory, body criticism, and the aesthetics of the sublime.

Marina Gržinić was born in Rijeka (Croatia), and has lived and worked in Ljubljana, Slovenia, since 1976. She holds a Ph.D. from the Faculty of Philosophy, Ljubljana, and works as researcher at the Institute of Philosophy at the ZRC SAZU (Scientific and Research Center of the Slovenian Academy of Science and Art) Ljubljana, and as a freelance critic and curator. Gržinic has written several books, including: *Ljubljana, Ljubljana* (with Ales Erjavec, 1991), *In Line for Virtual Bread: Time, Space, the Subject, and New Media in the Year 2000* (1996), *Fiction Reconstructed: New Media, Video, Art, Post-Socialism, and the Retro-Avant-Garde: Essays in Theory, Politics, and Aesthetics* (1997).

Together with Aina Smid, Gržinic has produced more than 30 video art projects, numerous installations, a CD-ROM (*Artintact 4*, ZKM, 1997), and a net.art site, *Axis of Life* (<http://lois.kud-fp.si/quantum.east/>). Gržinic and Smid have presented and exhibited their media works in more than 100 video festivals in Europe and throughout the world. They have received several major awards for their video productions, including: first prize at the Videonale Bonn in 1992, the *Deutscher Videokunst Preis* at ZKM Karlsruhe, first prize at the *1. Festival International de Video y Artes Electronicas*, Buenos Aires, 1996. They participated in the exhibitions *Europe, Europe: A Hundred Years of Avant-garde in Central and East Europe in Bonn*, 1994 and *I and the Other (Ik + De Ander)* at the Beurs van Berlage, Amsterdam 1994. They also

presented a selection of their video works at the Museum of Modern Art (MOMA) Video Viewpoints program, New York, in 1994.

Blake Hannaford received the B.S. degree in engineering and applied science from Yale University in 1977, and the M.S. and Ph.D. degrees in electrical engineering from the University of California, Berkeley, in 1982 and 1985, respectively. Before graduate study, he held engineering positions in digital hardware and software design, office automation, and medical image processing. At Berkeley he pursued thesis research in multiple target tracking in medical images and the control of time-optimal voluntary human movement. From 1986 to 1989 he worked on the remote control of robot manipulators in the Man-Machine Systems Group in the Automated Systems Section of the NASA Jet Propulsion Laboratory, Caltech. He supervised that group from 1988 to 1989.

Since September 1989, Hannaford has been at the University of Washington in Seattle, where he has been associate professor of electrical engineering since 1993. He was awarded the National Science Foundation's Presidential Young Investigator Award and the Early Career Achievement Award from the IEEE Engineering in Medicine and Biology Society. His currently active interests include haptic displays on the internet, surgical biomechanics, and biologically based design of robot manipulators. He is the founding editor of *Haptics-e*, *The Electronic Journal of Haptics Research* (www.haptics-e.org). His lab URL is <http://rcs.ee.washington.edu/BRL>.

Michael Idinopulos received a B.A. from the University of Chicago and a Ph.D. in philosophy from the University of California, Berkeley. In his doctoral dissertation, entitled *Perceptual Content*, he defended a robust view of perceptual content, advocating it as a solution to central problems in epistemology, the philosophy of mind, and cognitive science. He spent 1998–1999 at UC Berkeley's ALPHA Lab working on this book, co-developing a telerobotic web site, and studying telepistemological questions surrounding robotics and the Internet. He works in New York for McKinsey & Company, a management consulting firm.

Martin Jay is Sidney Hellman Ehrman Professor and chair of the history department at the University of California, Berkeley. He has taught Euro-

pean intellectual history there since 1971, when he got his doctorate from Harvard. Among his books are *The Dialectical Imagination* (Boston: Little, Brown, 1973, and Berkeley: University of California Press, 1996); *Marxism and Totality* (Berkeley: University of California Press, 1984); *Adorno* (Cambridge, Mass.: Harvard University Press, 1984); *Permanent Exiles* (New York: Columbia University Press, 1985); *Fin-de-Siecle Socialism* (New York: Routledge, 1989); *Force Fields* (New York: Routledge, 1993); *Downcast Eyes* (Berkeley: University of California, 1993); *Cultural Semantics* (Amherst: University of Massachusetts Press, 1998).

A fellow of the American Academy of Arts and Sciences and winner of Guggenheim, National Endowment of the Humanities, American Council of Learned Societies, and Rockefeller Foundation fellowships, he has been an associate of St. Antony's College, Oxford; Clare Hall, Cambridge, and the Stanford University Humanities Center. Since 1987, he has written a biannual column for *Salmagundi*. He is currently writing a book on the history of the concept of "experience" in Western thought.

Eduardo Kac is an artist and writer who investigates the philosophical and political dimensions of communications processes. Equally concerned with the aesthetic and the social aspects of verbal and nonverbal interaction, Kac examines linguistic systems, dialogic exchanges, and interspecies communication. His pieces, which often link virtual and physical spaces, propose alternative ways of understanding the role of communication processes in shaping consensual realities. Internationally known in the 1980s as a pioneer of Holopoetry and Telepresence Art, in the 1990s Kac created the new categories of Biotelematics (art in which a biological process is intrinsically connected to computer-based telecommunications work) and Transgenic Art (new art form based on the use of genetic engineering techniques to transfer synthetic genes to an organism or to transfer natural genetic material from one species into another, to create unique living beings).

Kac works with electronic and photonic media, including telepresence, holography, computers, video, robotics, and the Internet, as well as biological systems, such as animals, plants, bacteria, and organic tissue. 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 the journal *Leonardo*, published by MIT Press. In 1995 he received the Shearwater Foundation Holography Award for his body of work in the medium. In 1998 he received the Leonardo Award for Excellence. His anthology "New Media Poetry: Poetic Innovation and New Technologies" was published in 1996 as a special issue of the journal *Visible Language*, of which he was a guest editor. Writings by Kac on electronic art and literature as well as articles about his work have appeared in books, newspapers, magazines, and journals in more than twenty countries. Eduardo Kac is a Ph.D. research fellow at the Centre for Advanced Inquiry in Interactive Arts (CAiIA) at the University of Wales, Newport, United Kingdom. He is an assistant professor of art and technology at the School of the Art Institute of Chicago and has received numerous grants and awards for his work. The 88-page book *Teleporting An Unknown State*, published by Kibla, in Maribor, Slovenia (ISBN 961-6304-00-3) documents Kac's work in telepresence, telematics, and biology. Kac can be contacted at: ekac@artic.edu. His work can be seen at: <http://www.ekac.org>.

Machiko Kusahara is associate professor at Kobe University Graduate School of Science and Technology. She is the author of many writings in Japanese and in English including *Alife and Automata* (Art@Science, Springer 1997), *Signed by Artist* (Cyberart, Springer 1997), and *Flora and Fauna* (Fleshfactor, Springer 1997). She is also widely known as a curator and researcher in media art since 1985. After working in the field of computer graphics since 1983, in 1989 and 1992 she published seventeen laserdiscs of historical computer graphics animation. She was involved in founding of Tokyo's NTT InterCommunication Center, Tokyo Metropolitan Museum of Photography, and Digital Image. She curated exhibitions internationally and served as a jury member in major international competitions. She works and publishes primarily in the interdisciplinary area between art, culture, science, and technology with a background in art, computer science, and history of science. Currently her research focuses on the correlation between culture and digital technology such as network, artificial life, and digital entertainment. She is also a committee member of the Virtual Reality Society of Japan, Multimedia Contents Association, Japan Science, and Technology Corporation among others. Kusahara taught media art theory and practice in the Tokyo Institute of Technology Faculty of Art from 1994 to 1998.

Jeff Malpas is professor of philosophy and head of School at the University of Tasmania in Hobart, Australia. He is the author of *Donald Davidson and the Mirror of Meaning* (Cambridge, 1992), *Place and Experience* (Cambridge, 1999), and many scholarly articles. He is also the editor of a number of collections including (with Robert Solomon) *Death and Philosophy* (Routledge, 1998). In 1998–1999 he was a Humboldt Research Fellow at the University of Heidelberg.

Lev Manovich is an artist, a theorist, and a critic of new media. He has published more than forty articles, which have been translated into many languages and reprinted in eighteen countries. In his writings, Manovich places new media within the larger context of modern visual culture, relating it to the histories of art and cinema. Manovich was born in Moscow where he studied fine arts and architecture and participated in the underground art shows. Moving to New York in 1981, he began working in computer animation in 1984 at Digital Effects, one of the first commercial companies devoted to producing 3D animation for television and film. Manovich received an M.A. in experimental psychology from New York University (1988) and a Ph.D. in visual and cultural studies from the University of Rochester (1993). He is now an assistant professor in the Department of Visual Arts, University of California, San Diego, where he teaches studio and theory classes in new media. Currently he is working on a book entitled *The Language of New Media* for the MIT Press. His articles and projects are available at <http://jupiter.ucsd.edu/~manovich>.

Eric Paulos is a Ph.D. graduate student in the electrical engineering computer science department at the University of California, Berkeley. His research interests revolve around robotics and internet based personal telepresence, particularly the physical, aural, visual, and gestural interactions between humans and machines and various permutations of those interactions. Since developing *Mechanical Gaze* in 1995, he has been involved in the design of numerous web and internet based telepresence systems. Most notable are small human-sized helium filled tele-operated blimps (Space Browsers), the first internet accessible tele-laboratory (Legal Tender), and the first lethal control of internet connected machines. His current work focuses on Personal Roving Presence devices (PRoPs) designed to allow a remote user to explore and interact freely within a distant space. He is also