5

Kinetics, Sound Installations, and Robots

5.1

Robotics and Kinetics

Introduction: Robots—Creatures of Art and Science

Robots are quintessential creatures of our time. Intelligent machines, once a oxymoron, are now becoming commonplace. Robots are as much at home in art, cinema, and literature as they are in science and technology. They are of increasing importance in mundane everyday worlds such as manufacturing and entertainment. Even more profoundly, robots raise intriguing cultural questions that seem to engage philosophers, artists, scientists, and technologists:

What is the limit of human abilities to create autonomous machines?
Where does the desire to create robots come from?
What is the nature of embodied intelligence?
Must robots be made to look anthropomorphic or zoomorphic?
How do our views of robots reflect on our views of humanity?
What practical and moral questions are raised by robots?
What are the dangers of creating autonomous machines?

This section reviews research undertaken by scientists, technologists, and artists to explore kinetics and robotics. Contemporary developments have begun to approach the successful creation of autonomous machines. Note that other chapters include other related scientific and artistic research, namely, artificial intelligence (7.6), artificial life (4.3), bionics (2.5), and telepresence (6.3).

Brief History and Definitions

The literature and history of the pre-industrial age is full of attempts in many cultures to create or describe moving and autonomous objects and lifelike automata. It is an age-old, worldwide dream. Here is a brief list:

- Egyptian priests created talking and moving statues that amazed worshippers.
- King-shu Tse of China (c. 500 B.C.) created magpies and horses that worked by internal springs.
- Hero of Alexandria, Ctesibius, and other engineers created elaborate automata, often activated by water. Hero wrote the *Treatise on Pneumatica.*
- Al-Jazari at Amid (c. 1206), a famous Muslim scientist, created the lifelike Peacock Fountain and wrote the *Book of the Knowledge of Mechanical Contrivances.*
- Albertus Magnus (1204–1272) created a life-sized automaton servant.
- Elijah of Chelm and Rabbi Low of Prague (1550–1580) wrote Golem stories.

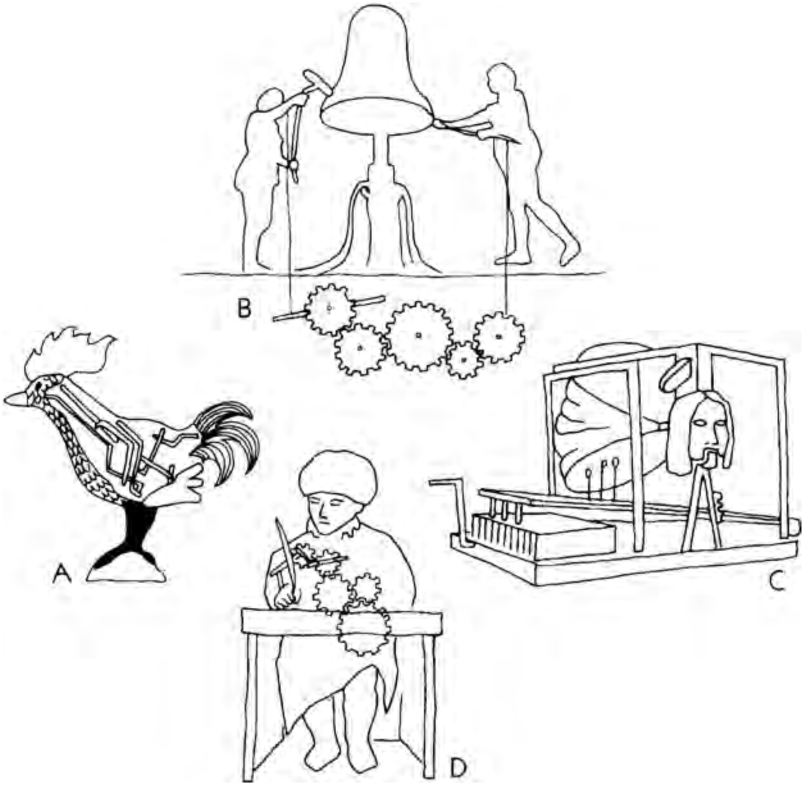

Fig. 5.1.1. European automata. A: Crowing cock atop Strassbourg cathedral; B: striking jacks atop Venice St. Mark's cathedral; C: Professor Faber's Euphonia talking head; D: Jaquet Droz's "Scribe," which duplicated human writing.

- Jacques de Vaucanson (1709–1782) created a duck that eats, drinks, splashes, and digests food and the Flute Player.
- Baron Wolfgang von Kempelen (1734–1804) created a talking machine and a sham chess player (with hidden midget).
- Pierre Jaquet-Droz (1721–1790) and Henri-Louis Jaquet-Droz (1752–1791) invented the Scribe, the Draughtsman, and the Lady Musician.

What is a robot? The term was originally coined by the Czech author Karel Capek in the 1917 short story "Opilec." It comes from the Czech *robota,* which means obligatory work or servitude. It also appears in Capek's play *R.U.R.* (Rossum's Universal Robots). In this play the robot is defined as an artificial humanoid machine created in great numbers for a source of cheap labor.

The term now has assumed a range of meanings. Some emphasize the humanoid (or animal) appearance, while others hold that robots do not need to resemble lifelike forms. For example, Webster's definition is: "an automatic device that performs functions normally ascribed to humans or a machine in the form of a human." Others stress the ability of the machine to do repetitive tasks or its sophistication in behavior, for example, dexterity or balance. Some hold autonomy or intelligent adaptability as critical components. For others, just the appearance, or humanlike or animallike movement is sufficient, for example, movie robots. Exploring the continua of appearance, function, and intelligence are some of the issues that intrigue scientific and artistic researchers.

The Robot Institute of America defines robots as "programmable, multifunctional manipulators designed to move material parts, tools, or specialized devices through variable programmed motions or for the performance of a variety of tasks." With this kind of definition, it becomes obvious that the distinction between the sophisticated machine and the robot is possibly fuzzy. The core elements seem to include: mechanisms that act on the physical world with something more than simple repetition. But even this core definition is eroding as researchers apply the term to software-only intelligences, for example, knowledge "robots" that act as information agents on the Internet.

Is It Art or Science?

Technological and artistic research probes both the "minds" and bodies of robots. What kind of sophisticated motion and manipulation can be created? How can robots deal "intelligently" with the physical and human world? What are the implications of the spread of robots into increasingly wide niches of culture? What can robots teach us about what it is to be human or animal? Some of the work produced by research labs could easily be considered as extensions of historical art traditions of kinetic sculpture or theater, and some of the works created by artists could function as research.

In the rush to focus on robots, it is easy to forget that our culture is dominated by many machines that are not robots. These, too, can use state-of-the-art technology and be culturally provocative. Some artists choose to explore the possibilities and implications of these nonrobot machines. Thus, this section includes chapters describing artists' work with kinetics and experimental sound.

An Overview of Scientific and Technological Research Agendas

Several trends have accelerated robot research and development in recent years. Intellectually, the fields of computer science, cognitive science, biology, and artificial life have seen the field of robotics—with its entities acting in the physical world—as a

Fig. 5.1.2. LEGO Mindstorms. Web advertisement for the Robot Discovery Set. LEGO and Mindstorms are trademarks of the LEGO Group. Copyright 1999 by the LEGO Group, used with permission, ⟨http://www.legomindstorms.com/⟩.

fertile environment to investigate concepts such as intelligence, agency, artificial evolution, communication, and the like. Technologically, the development of miniaturized, inexpensive microcomputers and electronic sensors and actuators have spurred research.

Practical applied worlds such as manufacturing, inventory management, space exploration, dangerous materials handling, medicine, disability assistance, and entertainment have sought to extend the microelectronic revolution into robot devices, seeking lower costs and extended capabilities. Applications are being developed in fields such as agriculture, building construction, domestic robotics, medical robotics, space robotics, traffic and highways and underwater robotics.

Around the world, many research institutes and labs have been formed. Researchers are actively pursuing a wide variety of inquiries. This section briefly reviews some of

Fig. 5.1.3. *Robodoc.* A robotic surgical assistant that can drill precise holes in bones ⟨http://www.robodoc.com/surgery.htm⟩.

the research agendas, with examples of some of the research pursued. Robot institutes in Japan, the United States, and Europe are pursuing a wide variety of theoretical and practical research topics. To provide an overview of research agendas, this list presents a composite of topics compiled from several advanced research centers and some samples of specific work:

Theoretical topics: adaptation and learning in biological and artificial systems, artificial life, artificial muscles, autonomous systems, biology, biorobotics, cognition, control, cooperation, evolution, graphic interfaces, humanoids, hybrid systems, intelligent decision systems, man-machine interfaces, manipulation, mechatronics, micro-robotics, mobile robots, nanorobotics, neural networks, object recognition, olfactory sensing, tele-operation, touch and vision guided manipulation, three-dimensional localization and planning, virtual reality, and vision.

Japan Robot Institute: ⟨http://www.gmd.de/People/Uwe.Zimmer/Lists/Robotics.in.Japan.html⟩

Fig. 5.1.4. No Hands across America Project (Carnegie Mellon University Robotics Institute). Road traffic visual analysis system is used to robotically steer a car ⟨http://www.ri.cmu.edu/projects/project178.html⟩.

The "scientific" agendas for robotic research claim scientific neutrality. Some artists, however, such as the ***Critical Art Ensemble*** take a perspective of "Contestational Robotics." They note the unstated biases in robotics research, which predominantly emphasize increasing the surveillance and police powers of established authorities (for example, robot police vehicles that can disperse protestors), and they seek to develop robots to serve as resistant forces, such as robot pamphleteers that can safely counter the police robots.

Examples of Conceptual Challenges and Approaches

Vision

Robot vision is another classical problem. Human and animal vision systems are tremendously sophisticated, filling in details that literally cannot be seen. For example, when humans look at a tabletop they think they see all of the legs even though the image of some

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Critical Art Ensemble and Robert Pell: ⟨http://www.critical-art.net/lectures/robot.htm⟩

legs are missing from the actual visual field. Carnegie Mellon researchers have a number of vision projects under way, such as: 3-D vision for navigation, SAPIENT (Situational awareness for driving in traffic); RACCOON (car following at night); NLIPS (lip-reading gesture—speech integration); and ARTISAN (object recognition for tele-robotic manipulation). MIT research includes: Wheelesley (a wheelchair navigation system) and Pebbles (a single-camera system for obstacle avoidance in rough, unstructured environments).

Sophisticated Motion

Researchers seek to understand the subtleties of human and animal motion. How do insects, birds, fish, animals, and humans move through and manipulate the world? How do they choreograph the ways that the senses and muscles work together? Early robot research helped accentuate the sophistication of everyday human and animal motion. For example, some early robot arms would obliterate eggs that they tried to pick up because the designers failed to understand the way feedback and control worked to help humans delicately adjust the way that force is applied. Researchers now are getting close to creating robots that can fly like insects, swim like fish, and conduct sophisticated human activities such as surgery:

Tim Smithers and Miles Pebody working at the Artificial Intelligence Laboratory at the Vrije Universiteit Brussel created *The Fish,* which was shaped like a fish and could move through water. Illustrating the crossovers between research and art, the Web description of this project notes that the research has terminated and that "now it is only exhibited as a piece of art."[1]

The Institute for Flexible Automation at the Technical University of Vienna has developed a robot that is capable of following objects with its camera "eyes." After being shown an object, it will follow it visually as the object is moved.

University of Southern California robotics research includes: AFV (autonomous flying vehicle) and cerebellar control of walking robots.

Humanlike walking is a major challenge. John Bares, a Carnegie Mellon researcher, notes that it is not easy to duplicate the sophisticated balance, sensor, and actuator accomplishments of our bodies:

Carnegie Mellon University: ⟨http://www.ri.cmu.edu/ri-home/research.html⟩
University of Southern California: ⟨http://www-robotics.usc.edu/nav.html#projects⟩
University of California at Berkeley: ⟨http://robotics.eecs.berkeley.edu/⟩

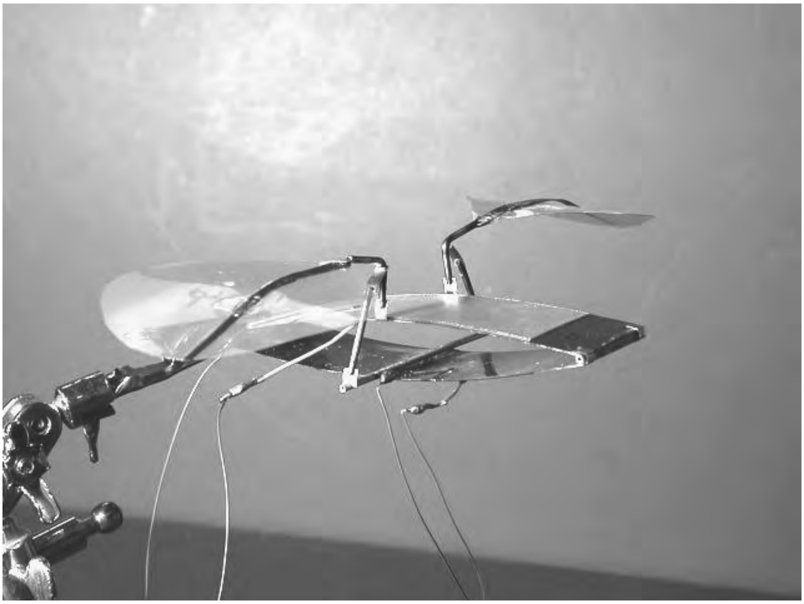

Fig. 5.1.5. Daniel Monopoli, DMI prototype. Research to create mesoscale flying robotic insects. Center for Intelligent Mechatronics at Vanderbilt University ⟨http://www.vuse.vanderbilt.edu/~meinfo/labs/cim/projects/flying.htm⟩.

It's very difficult to duplicate the human tendon-muscle-bone structure and power, . . . Humans walk dynamically, a process in which we must quickly plan foot repositioning—and then realign the body's center of gravity as we change feet and move forward. That's tough for robots, engineers have found . . . Control of legs and body to maintain an upright position is a worldwide challenge.[2]

But the difficulty just acts as a challenge to researchers. MIT's Leg Lab has developed a series of running and hopping robots. Isao Shimoyama at the University of Tokyo, and Atsui Takanishi and others at Tokyo's Waseda University, have also developed walking robots, including some that walk on stilts.

The University of Tokyo Robot Research Lab sponsors a project called the "remote-brained robots," which investigates the idea that sophisticated movement in the world will require massively parallel computing and that the brain can be separated from the physical robot:

A remote-brained robot does not bring its own brain within the body. It leaves the brain in the mother environment, by which we mean the environment in which the brain's software is developed, and talks with it by wireless links. . . . The brain software is developed in the mother environment, which is inherited over generations. It can benefit directly from the mother's "evolution," meaning that the software gains power easily when the mother is upgraded to a more powerful computer. . . . The remote-brained approach allows us to tie AI directly to the world, enabling the verification of high-level AI techniques which could previously only be used in simulation. . . .

There has been a missing link in research, between "AI, which couldn't survive if embodied in the real world" and "robots with feeble intelligence." Our approach, through building remote-brained robots, aims to open the way for engineering advances which will bridge the gap.[3]

Autonomy

Researchers have identified a series of conceptual challenges confronting the developers of practical robots. Autonomy is an issue underlying much contemporary research. How does one endow the robot with the ability to solve its own problems? Carnegie Mellon offers examples of research projects to address these issues, such as: an autonomous helicopter, cross-country navigation, an autonomous harvester, and neural net navigation.

Top-Down vs. Bottom-Up Subsumption Architectures

The last years have seen a debate grow about the most productive ways to conceptualize robot intelligence and deal with autonomy. Historically, robot intelligence projects stressed systems with massive integrated computing resources. In this view, sophisticated robots would need computing power for perception, planning, interpretation, and activation. Critics call this approach "Good Old-Fashioned Artificial Intelligence" (GOFAI). While the approach achieved some successes, it did not achieve its larger research goals.

Many contemporary researchers question the approach, believing instead that mastery of complex environments can be achieved by endowing robots with many small intelligences, for example, the ability of a robot leg to have a withdrawal reflex when it encounters an obstacle. Creating a framework in which these intelligences can learn from experience and intercommunicate can result in the emergence of sophisticated behaviors that look quite intelligent. Rodney Brooks at MIT is one of the most well-known proponents of this approach. His "insects" are famous for demonstrating quite adaptive behavior even though they start with a simple set of skills, sometimes called "subsumption." Brooks reasoned that GOFAI's attempt to create compehensive "maps" might work in labs, but what about the real world, with its vast spaces and unpredictable obstacles?

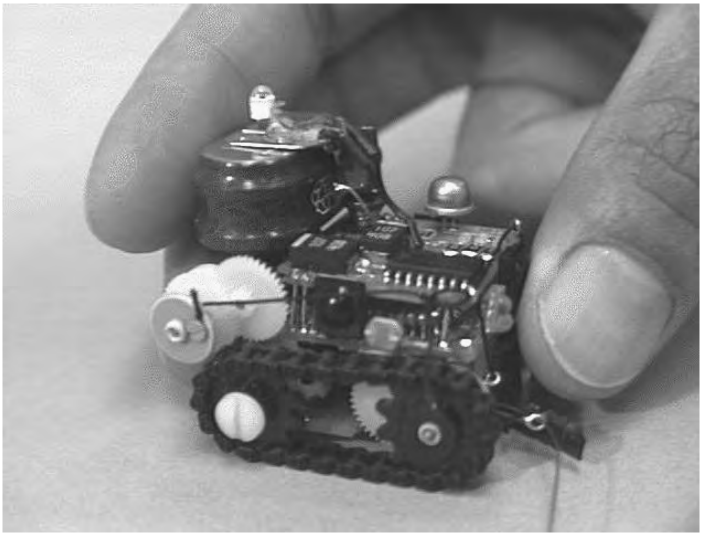

Fig. 5.1.6. Rodney Brooks. Ants project at MIT. Small robots demonstrate subsumption architecture by evolving complex behaviors from a simple repertoire ⟨http://www.ai.mit.edu/projects/ants/⟩.

This kind of approach is related to research on Artificial Life. The project description for the *Ants* micro-robotics project at MIT explains:

> The software on each robot is made up of many little programs, or behaviors. Each behavior monitors a few of the robot's sensors and outputs a motor command based on those sensor's readings. These commands are then sent to the motors based on a hierarchy; the outputs of more important behaviors override, or subsume, the outputs of less important ones.[4]

Brooks and Anita Flynn wrote a 1989 paper called "Fast, Cheap, and Out of Control: A Robot Invasion of the Solar System," in which they proposed using a swarm of microbots for space exploration. They claimed that the project would be shorter in development, less expensive, and more flexible than the traditional NASA approach of building highly sophisticated single robots. Other labs have similar projects under way in subsumption-oriented evolution of motion:

- USC robot researchers are working on the Rodney project, which explores the idea of "genetic walking," in which a robot develops walking skills through learning and evolving abilities.

- The University of Sussex, Centre for Computational Neuroscience and Robotics, created an eight-legged insect called Maggie. Equipped with whiskers, bumpers, and infrared sensors, it uses a bottom-up strategy to evolve walking abilities. The evolutionary process of its learning to walk took 3,500 generations of simulation on a Sun workstation.

Social Communication between Robots

The Interaction Lab at the University of Southern California, which is attempting to learn how to build robots that can interact successfully with humans and other synthetic creatures, studies interaction in a variety of scales and settings, including herds of physical robots, animal populations, and economies. They seek to develop methods for the "principled synthesis of group behavior and learning by imitation." Their multifaceted research program includes:

Multi-agent robotics: including dynamic task division, specialization, formations, learning behaviors and social rules, and distributed spatial representations. . . .

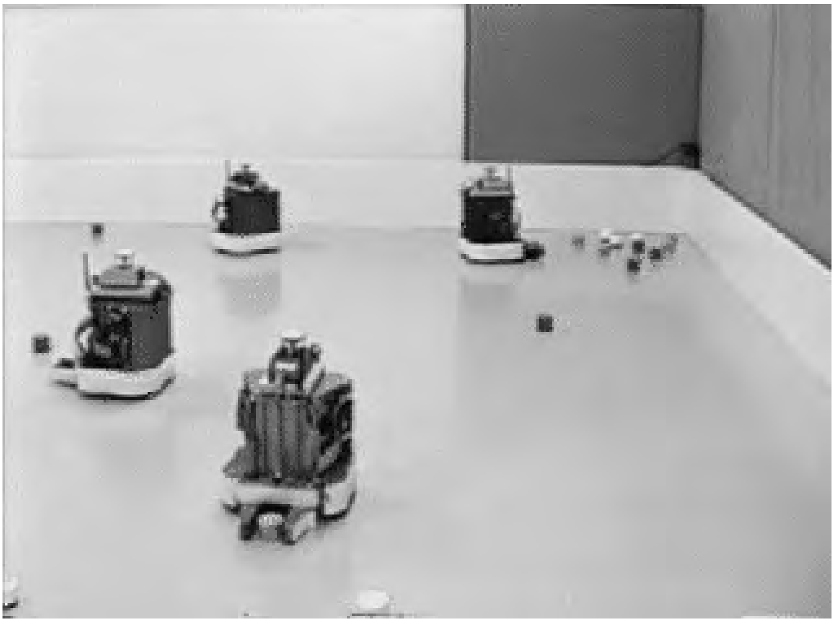

Fig. 5.1.7. Barry Brian Werger and USC Interaction Lab, study of social learning and behavior among communicating robots, ⟨http://www-robotics.usc.edu/~barry/SociallyMobile.html⟩.

Multi-modal representations: learning by imitation (perception, representation, motor control, and sensory-motor mapping). . . .

Multi-agent systems: methods for synthesizing and analyzing complex group behavior, including multi-agent/robot learning, dealing with nonstationary conditions, uncertainty, partial observability, and credit assignment; also cooperation and competition, and dominance hierarchies.[5]

Exploring bottom-up concepts of intelligence, the Artificial Intelligence Laboratory at the Vrije Universiteit Brussel is developing "language game robots," which communicate with each other by radio links. Researchers want to understand how complex intelligence can be built up and how language and cooperation might evolve. In one experimental "ecosystem" setup, robots competed for food (charging station access) and were allowed to negotiate and communicate in building up workable intelligence.

MIT's artificial intelligence lab sponsors a series of projects looking at social learning in microbots. "The Ants" project consists of a series of subprojects. In "Clustering Around Food," the robot ants send messages when they find food or when they see other robots with food. Building on simple behaviors, complex social foraging behaviors can emerge. The project description notes that the behaviors might be useful in projects like hazardous waste removal or planetary exploration. In "Tag," the robots enact a game like the children's game of tag, with one robot as "it," which tries to tag other robots and pass the "it" status. In "Manhunt," a complex game of team tag is played.

The Department of Cybernetics at the University of Reading supports a research project called "7 Dwarf Robots." These robots move about an enclosed space sensing the world via high-frequency sound waves and communicating with infrared signals. Endowed with intelligence primitives, they evolve complex behaviors, each exhibiting individual characteristics. Demonstrating the possibilities of social communication, the project description notes that "last year one robot (in Reading) programmed another robot (in upstate New York) with what it had itself learned, without human intervention." This lab has also produced insect walkers and the world's "first half-marathon robot."[6]

Humanoid Robots

Early robot research focused on animal and human models of intelligence and motion. Later, researchers abandoned these models, instead proposing that robot form ought to be free to assume whatever shape it needed to optimize its goals. Recently, however, researchers are again assessing whether there might be important reasons to build on organic models. This speculation arises from several considerations: appreciation of the "engineering" accomplishments of animal and human sensory-motor structures; analyses of intelligence that emphasized the importance of embodiment in shaping intelligence; and realization that many robot goals assume interactions with humans and physical environments, which are facilitated by human and animal forms for robots.

Rodney Brooks heads up the "Cog" project lab at MIT, which has undertaken many projects to explore humanoid robots. The project description explains its rationale:

If one takes seriously the arguments of Johnson and Lakoff, then the form of our bodies is critical to the representations that we develop and use for both our internal thought (whatever that might mean . . .) and our language. If we are to build a robot with humanlike intelligence, then it must have a humanlike body in order to be able to develop similar sorts of representations. . . . Since we can only build a very crude approximation to a human body, there is a danger that the essential aspects of the human body will be totally missed. . . .

A second reason for building a humanoid-form robot stands on firmer ground. An important aspect of being human is interaction with other humans. For a human-level intelligent robot to gain experience in interacting with humans it needs a large number of interactions. If the robot has humanoid form then it will be both easy and natural for humans to interact with it in a humanlike way.[7]

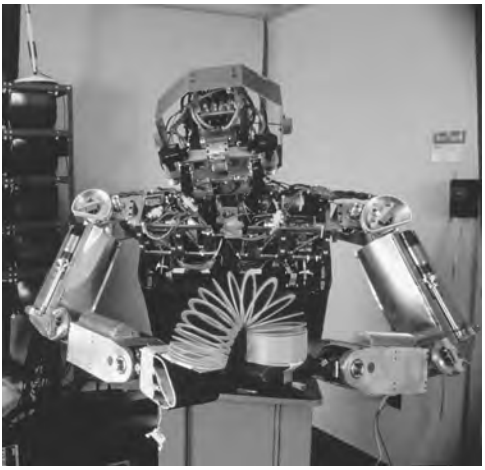

Fig. 5.1.8. Rodney Brooks. Cog project studies the importance of humanoid form in developing robotic intelligence, ⟨http://www.ai.mit.edu/people/brooks/⟩.

The description also responds to the question: Why not simulate the robot rather than build it? It claims that important understandings come from constructing robots to deal with the physical world that might be impossible to learn by simulation: "To do a worthwhile simulation you have to understand all the issues relevant to the simulation beforehand; but as far as human-level intelligence is concerned, that is exactly what we are trying to find out—the relevant issues."

The project will ultimately include many features of human life—motion, balance, vision, hearing, touch, vocalization, and the like. Brooks is famous for his robotic insects with their simple-behaviors subsumption architecture. In a *Popular Mechanics* interview, he indicated that Cog is based on similar principles: robots can build up complex behaviors based on simple ones (hearing, seeing, and moving for a humanoid robot), and experience in the world is useful for refining a robot's behavior. Cog can lean and turn its body and head but has no skin, arms, or fingers. It cannot walk or move. He explains the attempt to let it learn through experience:

> Cog must learn to relate what it sees in the camera to its own head motion, to know what motion is in the world and what is due to its own head . . . We're trying to find ways for Cog to learn about the world by itself—let it get its calibration from the world, just as humans do.[8]

Robots and Popular Culture

Robots have long been a feature of popular culture in literature and cinema, but for the public they have stayed in the realm of fantasy. In recent years, however, the increasing sophistication and decreasing cost of digital electronics has combined with the development of inexpensive sensors and actuators to bring robot construction within the grasp of nonengineers. Hobbyist robots have become available, and many more people are beginning to experiment. Public interest and literacy about robots has begun to accelerate. Sony's sophisticated $3000 dog robot sold out on its first day.

The difference in the public spread of computer knowledge and robot knowledge is instructive. In the 1960s, computers and robots were probably equally esoteric for nonspecialists. However, the advent of home microcomputers induced large numbers of people to educate themselves and experiment. Artists and teenagers became experts. This shadow world of nonofficial researchers fueled much of the innovation.

Curiously, robot experimentation did not experience the same surge in popularity. Although a full analysis of this divergence is outside the scope of this book, some reasons can be suggested. The practical business application of the desktop computer provided an economic motivation to push its development. The technical infrastructure for a plain computer—that is, CRTs such as a video monitor and keyboard—was already part of many people's experience. The problems of real-world action, for example, sensing and moving, were much more difficult than those for a device sitting in the limited domain of the desktop.

Now, the tide seems to be turning. Robots are becoming popular, like early microcomputers were. Children's toys such as Capsella and Robot Legos allow for easy sophisticated experimentation and construction. Popular events such as robot races and robot wars attract nonprofessional constructors and wide audiences. Hybrid art show/technical meetings such as Robotronika mix up traditional categories of who should be interested in this research. Artists and researchers fill the ranks of both presenters and audience. The Web makes robot news easily available; for example, NASA's "Cool Robot of the Week" offers a changing display of hobbyist and research robots.

Several events give examples of the expanding interest. The Robot Wars event is described in chapter 5.3. In the mobile robot competitions sponsored by the American Association of Artificial Intelligence (AAAI), competing robots are confronted with challenges they must solve. Both professionals and nonprofessionals are invited to participate. There were also challenges for the Fifth Annual Mobile Robot Competition. In the Call a Meeting challenge, a robot must schedule a meeting for two ficitional professors by shuffling between rooms to determine if they are occupied and then optimize the time while informing participants. In the Clean Up the Tennis Court challenge, a robot must collect a number of tennis balls and one powered Squiggle ball into a pen.[9]

Summary: Robot Hopes, Fears, and Realities

Wired magazine often presents a feature called "Reality Check," in which they ask a panel of experts when (if ever) various technological goals will be achieved. They convened a panel on the future of robotics to assess progress toward these goals: a self-driving taxi, a housecleaning robot, a self-replicating robot, and C-3PO (George Lucas's robot from *Star Wars*).[10]

Although not in total agreement, the panel suggested that achievement of most of these goals was still distant. The robot taxi would require sophisticated vision skills to differentiate the elements of urban clutter far beyond current capabilities, but limited autonomous vehicles might be available in areas of a city with specialized infrastructure.

NASA's Cool Robot: ⟨http://ranier.hq.nasa.gov/telerobotics_page/coolrobots.html⟩

Although work is proceeding on humanoid robots, the ease with which C-3PO moved in the world and interacted with humans is also still distant. Self-replicating robots could be achieved relatively soon if financial resources could be made available. Housecleaning robots were seen as similarly achievable, although they might take the form of swarms of small robots rather than the more common image of the robot maid.

Robots offer an interesting instance of research of importance simultaneously to science and art. They have mixed parentage: electrical and mechanical engineering, cybernetics, and artificial intelligence on one side and sculpture, cinema, automatons, and portraiture on the other. The urge to usurp God's ability to make something like a human is an ancient challenge and a taboo. The further development of the technology absolutely requires a multitude of perspectives from technical and artistic sources.

In a story written decades ago, the science fiction writer Isaac Asimov wrote his famous laws of robotics to govern the ethics of robot research, for example: (1) don't injure humanity; (2) obey human orders; and (3) protect itself. They seemed quite fanciful when first written, although now they seem highly practical and relevant. They are an interesting example of the arts anticipating research.[11]

Robots have not been the focus of much cultural theory except obliquely. Critical attention focuses on the poles of virtual disembodied existence and on organic bodies and the interrelationship between the two. Robots represent an interesting middle state—"embodied" in matter, not organic but controlled by an artificial mind. As research proceeds to investigate the links between intelligence, robotic embodiment, and the possibilities of alternatives to organic embodiment, robots may demand more theoretical analysis.

Notes

1. T. Smithers and M. Pebody, "Robotrinka Fish Description," ⟨http://robot.t0.or.at/exhib/⟩.

2. J. Bares, "Robot Research," ⟨http://popularmechanics.com/popmech/sci/9507STROAM.html⟩.

3. University of Tokyo Robot Research Lab, "Remote Brain Project," ⟨http://www.jsk.t.u-tokyo.ac.jp/⟩.

4. R. Brooks et al., "*Ants* Description," ⟨http://www.ai.mit.edu/people/brooks/⟩.

5. University of Southern California Interaction Lab, "Robot Communication," ⟨http://www-robotics.usc.edu/~agents/⟩.

6. Department of Cybernetics, the University of Reading, "7 Dwarf Robots," ⟨http://robot.t0.or.at/exhib/⟩.

7. R. Brooks et al., "Cog Project Description," ⟨http://www.ai.mit.edu/projects/cog/⟩.

8. R. Brooks, “Interview with Rodney Brooks,” ⟨http://popularmechanics.com/popmech/sci/9507STROAM.html⟩.

9. American Association of Artificial Intelligence, “Robot Challenge,” ⟨http://tommy.jsc.nasa.gov/~korten/competition96.html⟩.

10. *Wired*, “Reality Check—Robots,” ⟨http://www.wired.com/wired/4.03/reality.check.html⟩.

11. I. Asimov, “Robot Rules,” ⟨http://www.cc.gatech.edu/aimosaic/robot-lab/MRLHome.html⟩.

5.2

Conceptual Kinetics and Electronics

Artistic Research

In the last decades, artists have been active exploring robotics and machine-activated motion. Some of the art research shares similar agendas with the scientific/technological research, for example, exploring the limits of "intelligent" machines, the dexterity of machine motion, the relevance of artificial life and emergent behavior concepts, and the implications of telepresence and telerobotics.

Other artists, however, pursue divergent interests. For example, some artists create robotic/kinetic devices that reflect on the military/industrial origins of much contemporary research. Others create devices that demonically comment on issues of control and the relationship of machines to human activity. Still others abandon the utilitarian emphases of scientific research to explore the qualities of the devices' motion or appearance, such as beauty, mystery, intrigue, danger, or foreboding. Still, for others, the robots and machine environments are primarily used as dramatic settings to explore a panoply of personal or formal issues similar to those pursued by artists working in conventional media.

This artistic activity illustrates an important difference in the ways artists and researchers approach research. Even though scientists and technologists may give some heed to the context of their funding or research agendas, artists are much more likely to deeply explore the cultural context underlying the research activity. Similarly, robotics researchers usually emphasize the functional qualities of robot appearance or quality of motion or ignore them; artists can make these the focus of their work. Questioning what is taken for granted in other disciplines is often the heart of the artistic enterprise.

A more radical position would hold that robotic research is intrinsically art. In *Beyond Modern Sculpture* the art theorist Jack Burnham suggested that self-replication was at the core of art and that robotics was an inevitable continuation of that quest. These ideas are intriguing to some artists who work in the field. Building on Burnham's ideas, Bruce Cannon, whose works are described in a following section, wrote an essay called "Art in the Age of the Microcontroller," which considers the inherent aesthetics of electronics and robotics:

> [T]he automata of the last few centuries and the electronic robots emerging in the 1960s both represented for him the logical extension of this striving. He suggested that robots themselves were the ultimate extension of sculpture, and should be judged as such without any other esthetic criteria. That their striving [of artists toward self-replication] made them inherently art, regardless of their physical form.
>
> Despite the fact that he later recanted all this, it was and remains an amazing conceptual leap, one that I respect and admire. As an artist using computers, interested in artificial intelligence

and robotics, I strive toward the purity of this vision, but fail. I long to be able to strip away the superficial trappings in which I feel I must dress technological work in order for it to fit into the dialectic of the art world. I crave the unary pursuit of sentience and autonomy over the rote schematicization of the prevailing cultural fad.[1]

Kinetic Art Precursors

Contemporary artists working with robotics can trace their lineage to kinetic art. Kinetic art is art that moves, motivated by human touch, natural forces such as wind, or by motor. In the early part of the twentieth century, kinetic artists were crucial pioneers seeking to expand the arts to address contemporary culture. In that era, when the norms of the art world were firmly dominated by historical media such as painting and sculpture, making art that moved was radical. Also, in this era artists willing to work with electricity, motors, metal fabrication, and new materials were as much technological researchers as digital artists are today.

As will be explained in my book *Great Moments in Art and Science,* kinetic artists worked from a variety of perspectives. Some, like the Bauhaus artists, Futurists, and Constructivists, and artists such as László Moholy-Nagy, sought to create art that reflected on the new opportunities offered by industrial/technological "progress." Others such as the Dadaists, Surrealists, and artists such as Marcel Duchamp were more dubious about progress. Others such as Alexander Calder saw motion, change, and time as just more formal elements to be explored in composition.

In the 1960s and 1970s, artists continued the exploration of kinetics, refining old themes and expanding its concerns. Examples include Frank Malina, Nicolas Shoeffer, Otto Peine, Takis, Jean Tinguey, EAT (Experiments in Art and Technology), Lygia Clark, Helio Oiticica, Jesus Rafael Soto, Alejandro Otero, Pablo Neruda, Agam, Alexander Calder, and David Medalla. Interested readers should consult the histories of technological art listed in the bibliography.

Eduardo Kac's article "Foundations and Development of Robotic Art" identifies several artists from the 1960s and 1970s as especially significant precursors of contemporary robotic work. Nam June Paik and Shya Abe created *Robot K-456* in 1964. They rolled this "robot," which had a vaguely anthropomorphic/electronic look without very sophisticated behaviors, around the streets in attempts to create public events. In 1966, James Seawright created *Watcher* and *Searcher,* which were interactive kinetic sculptures. In 1970, Edward Ihnatowicz created *Senster,* which was a roboticlooking arm that sensed the presence of humans. In the 1970s, Norman White created the *Helpless Robot,* which asked humans to interact with it in order to make it function.

Contemporary kinetic artists update this work by incorporating more sophisticated technology and using the technology to explore cultural commentary or conceptual investigations. Also, note that the boundary between robotic and kinetic art is not clear because of the wide range of meanings the word *robot* has assumed. When does a sophisticated machine cross over to "robothood"? Conversely, many things called robots are not very sophisticated in their behavior. Humanoid appearance is not a requirement. Most likely, many of the artists who now think of their work as experiments in robotics would have considered it kinetic a few years back.

Kinetics and Light Sculpture

Milton Komisar

Milton Komisar's career spans decades. He was one of the first kinetic light artists to apply computers to control. His light sculptures are famous for their elegant movement of light and their progression in time created via computer program. Komisar describes his approach:

> Developing a system to work with Light in this particular way has led me to the idea of COMPOSITION IN TIME. This is traditionally a musical concept. There is no sound in my work. I do not want to create a multimedia art form. I believe it is possible to "mold" Light through time in such a way that a coherent composition is experienced by the viewer. The physical structure and the electronics are simply necessary tools to this end. I have been working with this goal in mind for the last twenty-three years.[2]

Gregory Barsamian

Gregory Barsamian creates kinetic sculptures that use stroboscopic technology to freeze and manipulate motion. The events combine the reality of constructed objects with the dreamlike quality of mediated vision. Barsamian has shown his work in several locales, including the ICC. He explains animation as a doorway to the unconscious:

> My technique adds the fourth dimension of time and allows the viewer to share the same physical space and time with an animated sequence. Animation is ideally suited to the realization of

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Milton Komisar: ⟨http://www.xlnt.com/neonart/mkomisar/mkomisar.html⟩
Gregory Barsamian: ⟨http://www.concentric.net/~Venial/⟩

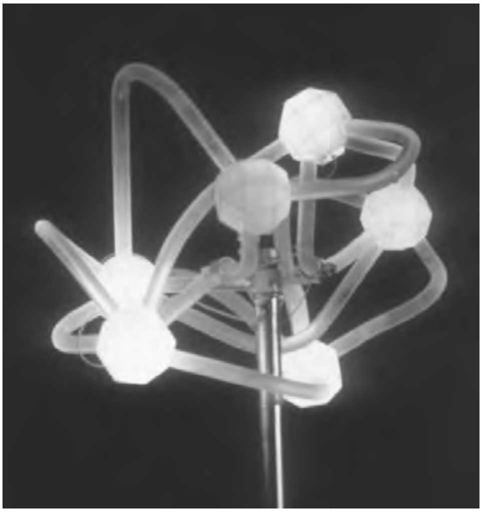

Fig. 5.2.1. Milton Komisar, *Sign of the Fish.* Modular units used in a computer-controlled light sculpture.

subconscious images and alternate realities. My passions lie in bringing these images to life in this most vivid form.[3]

Barsamian questions science's claim that it presents absolute vision. He questions the givens of perception and emphasizes the importance of the unconscious, noting that no one angle of view captures totality and that science is distrustful of the imagery of dreams:

In creating alternate realities, I confront the viewer physically in the language of the subconscious with a skepticism of our perceptions. The power of sharing the same space with these surreal three-dimensional images lies partially in witnessing your own act of interpretation. . . . It is the nature of that order that defines us as human beings. Order, however, is not what I offer you. Instead, I offer a three-dimensional window into an ontological bazaar where self-deception is an oxymoron.

In one installation called *Putti,* tiny cherubim fly around in circles, change direction, and transform back and forth with helicopters. The curator Janet L. Farber describes the event:

Putti is perhaps the clearest illustration of Barsamian's intentions. Hovering overhead, spinning figures of cherubs (putti) turn into helicopters and back again into winged babes. The nature of this transformation is purposefully ambiguous: Do the cupids become helicopters first or do the

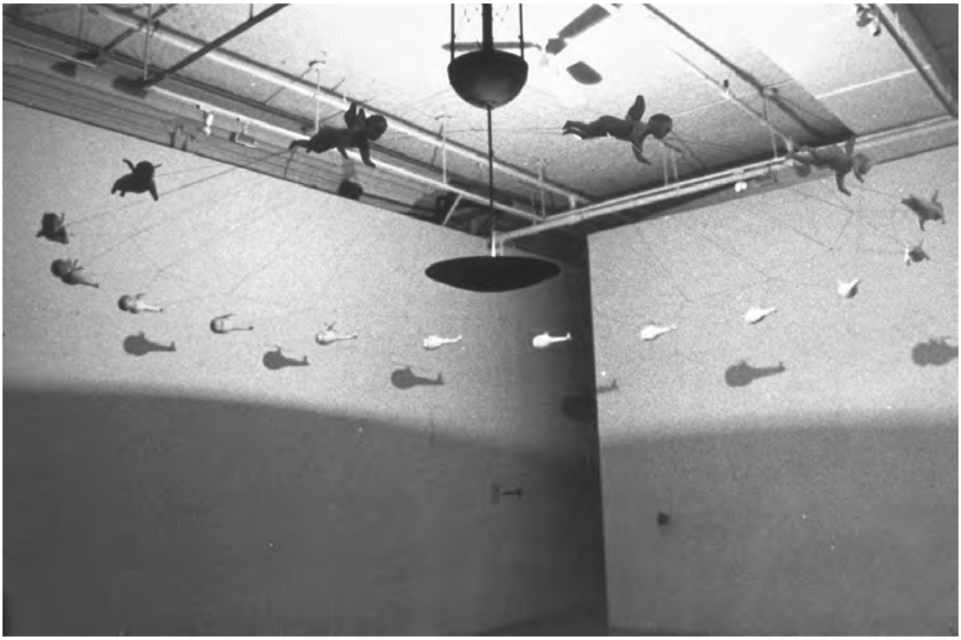

Fig. 5.2.2. Gregory Barsamian, *Putti.* A kinetic sculpture is illuminated by a stroboscopic light.

whirlybirds turn into ministering angels? . . . Yet, what does it say about human nature that the interpretation most frequently given of this transformation is negative? It conjures up the loss of innocence, the encroachment of police states, the buzz of Valkyrian war machines.[4]

Other Artists and Projects

James Seawright, director of visual arts at Princeton, has a long history of developing interactive kinetic sculptures, such as *Watcher,* which modify their behavioral and sound patterns based on changing light patterns produced by other sculptures or viewers. Recent work incorporates more sophisticated technologies, such as *Mirror I,* which focuses the sun's light in a complex way, arranging 225 mirrored blocks to precisely focus rays on an *X* on the sidewalk twelve feet away. ***Eric and Deborah Staller*** create kinetic and light public art, such as *Bubbleheads,* in which multiperson bicycles are driven by

James Seawright: ⟨http://www.tezcat.com/~divozenk/plaza/mirrori.html⟩

people, each wearing light sculptures. A yearly kinetic sculpture race called Da Vinci Days challenges artists, engineers, and others to design human-powered moving sculptures that must negotiate city streets, mud, the river, and a sand trap. ***Paul Friedlander*** creates stroboscopic kinetic light installations. Coordinating the movement of sound and light, ***Guy Marsden***'s sculptures confound traditional categories. Promoting the humanistic study of light, *Seth Riskin* creates dance and body movement events that incorporate light phenomena—for example, by including projectors or reflectors on his body. ***Jennifer Steinkamp*** sets up room-sized installations in which shadow, projection, and light movement "de-center" and "dematerialize" space and respond to visitor motion and proximity.

Conceptual Kinetics

What conceptual kinetic artists do is quite remarkable. They convert the mundanities of motors, gears and levers into philosophical and artistic discourse.

Bryan Rogers

Bryan Rogers was in the forefront of conceptual kinetics in the 1970s and 1980s. He appropriated state-of-the-art mechanical and electronic technology to create families of devices focused on particular concepts or cultural niches, for example, his "Timepieces," "Umbrella," and "Coffin" series. Illustrating this approach, his "Coffin" series featured multiple variations on the theme, for example, rotating coffins, self-propelled coffins, and coffins whose lids automatically opened to welcome the viewer. His constructions typically played with disjunction—finely crafted advanced engineering applied to the creation of unlikely objects, puns, and conceptual explorations.

Roger's approach is also evident in other works. His spearfishing piece is famous for the uproar it created. An aquarium was fitted with a rapid-action hydraulic harpoon that would periodically jut in and out. The event was picked up by the tabloid *National Enquirer* and caught the attention of the Society for the Prevention of Cruelty to Animals, even though the probability of harm to the fish was remote. In his multipart *Odyssetron* project, he undertook to create a seaworthy robot that could navigate itself

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Kinetic sculpture races: ⟨http://www.rdrop.com/users/batie/davinci97/kinetic.html⟩
Seth Riskin: ⟨http://web.mit.edu/mit-cavs/www/Seth.html⟩
Jennifer Steinkamp: ⟨http://jsteinkamp.com/html/art_statement.htm⟩
Bryan Rogers: ⟨http://www-art.cfa.cmu.edu/www-rogers/⟩

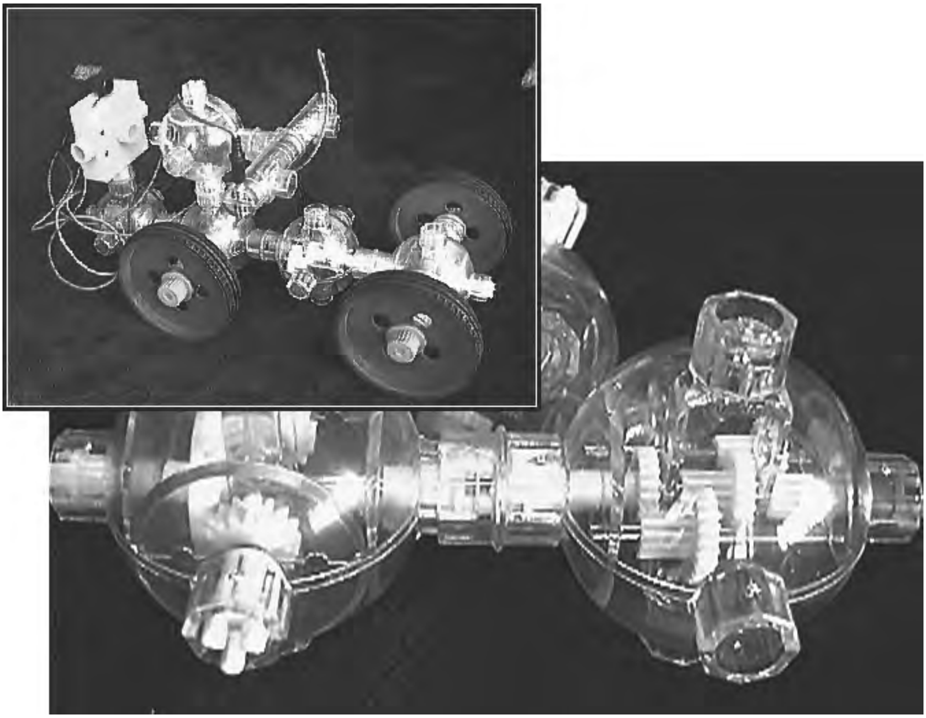

Fig. 5.2.3. Capsella mechanical experimenter kit, composed of modules such as motors, gears, and pulleys, to explore the principles of energy conversion and transfer. Photo: Stephen Wilson.

around the globe. Rogers holds degrees in both art and engineering and founded the Conceptual Design program at San Francisco State University. He developed the Studio for Creative Inquiry at Carnegie Mellon University.

Perry Hoberman

Perry Hoberman creates installations that expose the cultural underpinnings of technology. Typically, his works are simultaneously humorous and troubling. *Faraday's Garden* presented the viewer with a hodgepodge of consumer appliances such as radios and power tools and image-projecting machines. Ironically commenting on issues of control, the appliances automatically sprung into action, tripped by security foot pads, as viewers

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Perry Hoberman: ⟨http://www.hoberman.com/perry/⟩

Fig. 5.2.4. Perry Hoberman, *Faraday's Garden.* Household devices and image machines are activated by visitor's motion.

moved about the space (see also chapters 7.3 and 7.4). Here is the description of the installation from Hoberman's Web site:

The machines wait silently, ready to be activated at any moment by the footfalls of the public. When stepped upon, the switch matting triggers the various machines and appliances, creating a kind of force field of noise and activity around each viewer. As the number of participants increases, the general level of cacophony rises, creating a wildly complex symphony of machines, sounds, and projections. The machines and accessories (such as tapes, films, slides, and records) are collected from thrift stores, flea markets, and garage sales. Since they span the entire twentieth century, movement around the room also functions as a kind of time travel. All wires and switches are left exposed, creating an intense environment of electrical current.[5]

Alan Rath

Alan Rath creates sculptures built out of the paraphernalia of the electronic age. His sculptures incorporate electronics, video screens, speakers, microprocessors, voice chips, and robotic elements. He was one of the first artists to create tapeless digital video in which image sequences were drawn directly from chip memory. He has an electrical engineering degree from MIT and has worked as an artist since the 1980s.

His works have been described as playful, humorous, ironic, and beautiful. He typically makes the electronics and other constructive structures of his work visible to the viewer, and indeed works with the electronic infrastructure of connectors and components as aesthetic elements. Rath's view that the selection and construction of components is an important element of the art was expressed in an interview he gave on the "San Francisco Gate" Web site:

> Often there's not a single optimal solution, so things like the selection of an electronic part are open to interpretation. I'm picking components based on what they look like. To me, transformers can be attractive or ugly. The pieces are made in a certain meditative state. A lot of emotion goes into the building, and I hope they somehow contain that. You know, the Mars lander is a beautiful piece of sculpture. The people who built it identified with it, so it has a lot of soul. I want power from art at that level of commitment and mastery.[6]

Typically, the electronics are embedded in other artifacts of everyday culture as part of the cultural commentary. Dana Friis-Hansen, senior curator at the Houston Contemporary Arts Museum, wrote this introduction to Rath's "Bio-Mechanics" show:

> Alan Rath's "live machines" are eerily engaging—we are immediately drawn in by their uncanny, humanlike actions. On video screens, eyes move, mouths open, faces wince, tongues lick, hands gesture to spell out messages. Simple speaker cones seem to whisper, breathe, or pulse like a heartbeat. We cannot help but project human emotions—fear, curiosity, desire, pain, excitement, or the will to communicate—onto these otherwise confusing configurations of circuitry.[7]

Examples of the video and kinetic work include *Info Glut 3,* in which video screens display sign language as the sculpture speaks; *Message in a Bottle,* in which a small video screen enclosed in a bottle shows the image of a hand signing phrases by sign language; *Arecibo,* which uses hand signals to spell out the digital encoding of DNA being sent out in a radio beam's search for extraterrestrial life; *Ultra Wallflower,* in which several speakers hung on the wall in an arrangement suggesting plant life vibrate in isolated sociality; *Ouch,* in which the video image of the artist's face responds to being held in a vice; *Likker,* which has a tongue extended on a long metal rod; *ScannerII,* in which eyes glance to and fro as under surveillance. Rath has created a wealth of pieces that include enlarged video eyes and mouths that are simultaneously funny and ominous.

Later work includes robotics, such as *Robot Dance,* in which two kinetic structures vaguely representing hands play hand jive games together; *One Track Minds,* in which two small carts on a single track play approach-and-avoidance games with each other, and

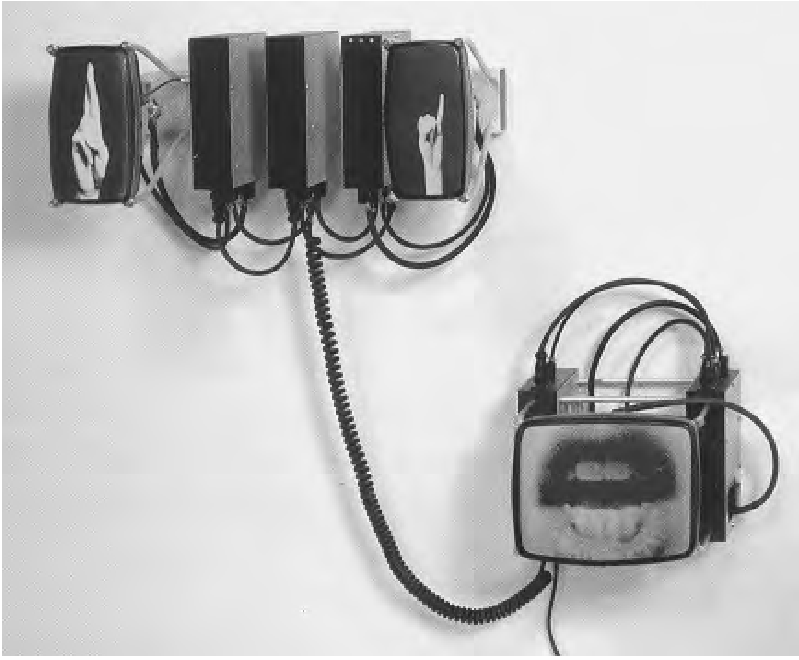

Fig. 5.2.5. Alan Rath, *Info Glut3.* A digital video sculpture speaks with sign language.

Five on the Wall, in which five constructions hanging on the wall engage in synchronized performance. He suggests that machine autonomy is a fascinating concept that he intends to pursue in further work: "Interesting is halfway between nothing and random."[8]

Rath indicates several motivations in his work. He is upset by our culture's ambivalent and shallow attitude toward technology. He notes that many of those whose decry technology fail to see its relationship to the everyday life they take for granted, such as shoes or glasses, and make unwarranted distinctions:

I don't know why people are so alienated from machinery. The next Freud will figure out why we perceive that stuff as external and different. I am amused by the idea that people might draw the line at machinery in a gallery. Somehow the technology and chemistry of paint is OK but other technologies are out of place. It's only that way because of the time we grew up in. Future generations won't see anything strange about it.

Similarly, many people—even those intimately involved with technology in their work—cut themselves off from appreciating the beauty of the technology. Rath believes that machines are an important part of the human exploratory and play potentials. He would like people to get more connected to that aspect of technology:

Our problem is not getting their experiential or toy possibilities [that is, the potential of the technology]. Play is one of the most significant human activities and machines help us play. Probably because our tax dollars are used to put robots on Mars, people don't like that to be called play. But it's obviously play. And then it becomes beautiful.

Bruce Cannon

Bruce Cannon creates conceptual kinetics and robotics that explore a variety of topics, such as life, death, time, social convention, personality, responsiveness, and relationships. His installations will often integrate surplus, ignored, and neglected cultural items with the latest in electronic and robotic technology. Several of the works incorporate electronic speech and proximity detection. Often the minimalist works are ironic and/or meditative. Here are excerpts from his artist's statement:

[Engineering aesthetics] function for me as grounding devices, reality checks on the often arrogant projects of both art and technology. They also invoke a reductive coding which I find interesting, and in fact have adopted as one of my principal techniques. While some of the pieces manage to exhibit lifelike behaviors despite their technical limitations, my general approach is to construct objects whose behaviors or characteristics are in some ways lifelike yet which embody little of the richness of being.

These machines' failure to transcend their artificiality is their most significant aspect. The pieces are not so much lifelike as referential to being, and what is missing is what resonates for me. I have come to think of this negative space as the place where the work happens, at its best a sort of electro-mechanical Haiku in which randomness and absence generate issues of sentience and presence which I would be unable to evoke directly.[9]

Doublespeak attempts to deconstruct social conventions of polite speech. It uses the subtleties of electronic sensors to accentuate a person's role in choosing what to hear, with a person's shadows triggering one facing sculpture to say what is expected of it while the other says what it's really thinking. *Contact II* comments on human relationships by reacting to a viewer's interposing in its space. It speaks phrases of love and admiration

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Bruce Cannon: ⟨http://www.siliconcrucible.com⟩

Fig. 5.2.6. Bruce Cannon, *Time Tree.* A robotic tree that moves at slow pace similar to that of plants. Courtesy of the artist and Gallery Paule Anglim.

until one gets too close, when it says, "I wish you were dead." In what appears to be a framed mirror, *Reflection* captures one digital portrait a day and scrolls through the time archive, showing an image of an accumulating life.

Tree Time (in collaboration with Paul Stout) is an installation that reanimates a lightning-struck tree transported from a forest. Robotic elements have been added so that the branches move at an almost imperceptible organiclike speed, its motion perceptible only over many days:

This machine is I think equal parts meditation on slowness and bastardization of nature. The obvious reference to Mary Shelley's Frankenstein in the lightning-struck tree, the garish reassembly, the electrification, the technological "improvement" upon the original organism, is intentional. Paul calls it eco-porn, which I think is nice . . . I associate both words with *Tree Time,* because of the pleasure and the pain, the beauty and the obscenity of the endeavor. In that sense, *Tree Time* is a morality story about limits.[10]

Cannon's paper "Anti-Speed" reflects on our culture's preoccupation with speed as a fear of mortality. *Tree Time* attempts to reflect that concern with time and its underlying meanings:

We're preoccupied with speed because we fear death. In other words, immortality is our goal, and since we can't have that we settle for the compression of time. The faster we can do things, the more things we can get done in the amount of time we do have. And this speeding up of the pace of life, the squeezing of more and more events into a given period of time, is the culture's desperate attempt to live longer.[11]

Paul DeMarinis

Paul DeMarinis's works straddle the world of art, music, invention, technological archaeology, and social commentary. DeMarinis carefully studies the history of technology and invention to discover its underexplored underbelly. He simultaneously celebrates its innovation and analyzes what has been sacrificed in its unfolding. He then develops elegant, unprecedented installations that communicate his investigations, mixed with personal and social references. DeMarinis's magic is that the accomplishment of these installations often require him to invent and extend technologies. Thus, his creative process is intimately intertwined with the very processes of invention, on which he comments:

My pieces deal, in part, with the way technologies mediate the relationship of people to their memories and to question the situation of technology in our lives, the mythos of technology. The fact that I use technology itself to delineate these themes means that I must develop alternate or sometimes "impossible" technologies. Without overly stressing the apparent impossibility of making a hologram of a record play the music in the record's groove, or making a clay pot recording of a voice, or making a bathtub make music, I must admit that many of the technologies in my pieces did not exist when I set out to make them. I have had to invent them. It is an important requisite of my art that the pieces actually work. I wouldn't be comfortable with a piece that created an illusion by conventional means. For me the real illusions are the ones that still mystify even when the technology is revealed and explained. Nor would I be satisfied if the works stopped there. There are many other cultural and personal themes woven into them.[12]

DeMarinis's brief descriptions of several of his installations illustrate this mixture of invention, humor, and analysis:

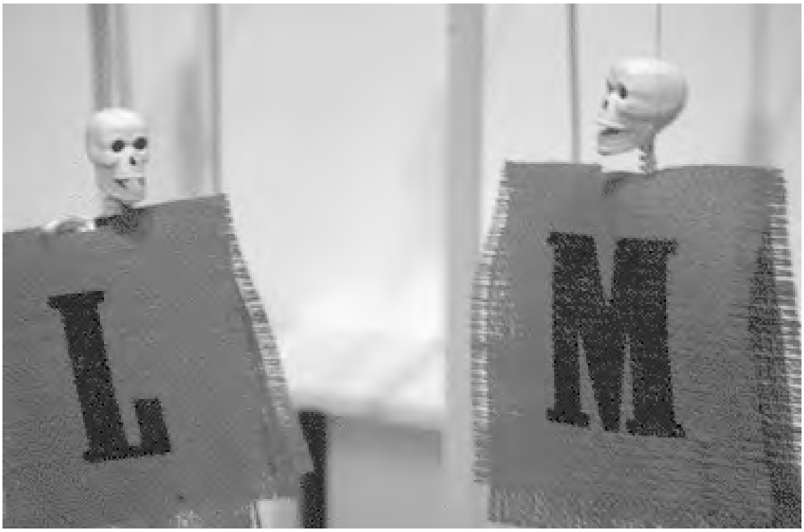

Fig. 5.2.7. Paul DeMarinis, *Messenger* (1998). Skeletons shake their letters to spell out a sent message.

- *RainDance/Musica Acuatica:* Twenty falling streams of water, modulated with audio signals, create music and sound when intercepted by visitors' umbrellas.
- *Living with Electricity:* Three domestic settings, each containing a throw rug, a lamp, a transduced rocking chair, and a sound-making device fitted with actuators. The three areas are interconnected via local area network so that rocking in one chair produces movement and sound in a different one.
- *Gray Matter:* Interactive electrified objects that produce sound and sensation when stroked with the hand.
- *Edison Effect:* Ancient phonograph records, wax cylinders, and holograms are scanned with lasers to produce music at once familiar and distant, like some faintly remembered melody running through the head.
- *Fireflies Alight on the Abacus of Al-Farabi:* A sixty-foot-long music wire with little dancing loops of monofilament is stretched in a dark room and illumined by an emerald laser beam. The loops dance on the harmonic nodes of the wire, producing flickering points of light and aeolian harplike sounds.

Each of his installations has a depth of historical reflection that is easily missed by the casual observer. *The Messenger,* presented in the Galerie Metronom in Barcelona, demonstrates this depth. Here is DeMarinis's short description:

The Messenger: E-mail messages received over the Internet are displayed letter by letter on three alphabetic telegraph receivers: a large array of 26 talking washbasins, each intoning a letter of the alphabet in Spanish; a chorus line of 26 dancing skeletons, and a series of 26 electrolytic jars with metal electrodes in the form of the letters *A* to *Z* that oscillate and bubble when electricity is passed through them.[13]

The installation seems a fascinating event to observe. Its historical referents make it even richer. It is based on a 1753 landmark telecommunications event in which an unnamed researcher with the initials C.M. sent messages via twenty-six charge-carrying lines that caused movement in distant static-electricity-detecting Leyden jars, thus indicating letters of the alphabet. DeMarinis sees this era's interest in electricity intimately tied to cultural developments in democracy. In the catalogue for *The Messenger* installation, DeMarinis shares some of his analysis of Francisco Salvá, a Catalan scientist's, experiments:

Electricity, though observed since ancient times, only became a subject of intense interest in certain enlightened circles during the first half of the 18th century. . . . In electrical demonstrations during the ancien regime, little distinction was made among the message being transmitted, the path of conduction, and the recipient. On one occassion in a demonstration before the king, organized by the Abbé Nolle, 180 guards were said to have been made to jump simultaneously [by shocks]. . . .

[In Salvá's experiments] 26 wires each carried a voltage corresponding to a letter. Salvá specifies a number of people, one for each wire. Upon receiving a sensible shock, each of these people, presumably servants, was to call out the name of the letter of the alphabet to which he corresponded. . . . Toward the final years of the 18th century, after Galvani's discovery of animal electricity, Salvá formulated a revised proposal for the telegraph using freshly severed frogs' legs as the indicators. Each leg, when stimulated by the spark, would dance and, in so doing, jerk a slip of paper on which the corresponding letter of the alphabet had been written. In the first decade of the new century, after Volta's invention of the electrochemical battery, Salvá proposed a scheme that proves politically correct to this day: electrical current flowing through the wires causes electrolytic decomposition of water, the resulting bubbles of hydrogen serving to indicate the letter selected.

Background materials for other installations provide other fascinating discourses on culture, technological history, and personal reflection. His description of his work *The Edison Effect* (reflecting on Thomas Edison's inventions and cultural context) shows a similar mining of technological history for its deeper meanings and its conversion of these ideas into visual poetry:

[I]t invokes a metaphorical allusion to the physical phenomenon known as the "Edison effect," wherein atoms from a glowing filament are deposited on the inner surface of light bulbs, causing them to darken. . . . the metaphorical image of the darkening of the light is an ancient one, recurring in the I-Ching, in Mazdaism, and in Shakespeare's oxymoronic "when night's candles have burnt out." Enantiodromic reversal at the atomic level can be used to symbolize opposing primal forces and may serve to mythicize otherwise commonplace occurrences. . . .

Eminent authorities, including French scientist Sainte Claire de Ville, upon reading announcements of the talking machine, pronounced it a fraud and a hoax perpetrated by a concealed ventriloquist. . . . Perhaps the very notion of compressing the vitality of human utterances, of squeezing the flights-of-fancy of musical invention into the unidimensional coffin of machine reproduction, was abhorrent on some primal level. Or, perhaps, there persisted the stubborn notion that sounds are inherently transitory and must always be synthesized or intoned anew . . .

A dream of early phonographers was to read with their eyes the wiggly line inscribed by the needle as a lasting trace upon the wax . . . Until very recently—the 1980s,—the memorative act of audition still consisted of dragging a diamond stylus, fingernail-like, across a vinyl blackboard. . . . [With the CD] the laser touches but fleetingly upon the groove, the impact of its photons abrading no material whatsoever. The rupture is complete. The emancipation of memory from touch has been fulfilled.[14]

DeMarinis claims that neither extreme of antitechnological Luddism nor unbridled technophilia are sufficient to reflect on the role of technology in culture. Art that attempts to make ideas physical is a fertile locus for considering the myths of technology:

Art is a response to belief and acts as a consolidating force within culture. It gives place, time, image, and sound to myths. But the myths of science are not content to be represented by picture, poems, and symphonies. The scientific revolution threw away the idea that things were connected by appearances and replaced it with the idea that things are connected by how they work. Thus the artist's role is to animate with the imagination the way things work.

I think of technology as having a dual-being. It is simultaneously a dream, or product of our dreams, and the medium in which our dreams are exchanged and elaborated. . . . To disentangle these two functions of technology is difficult. One could, of course, stand aside and take an antitechnological approach. I have chosen what is perhaps a more difficult path—to use technology itself to express and investigate this dilemma. I try to do this by standing technology on its head. Exploring alternative technologies, using physical principles that have not found any place in the dominant technology, re-connecting the dream and the mechanism. . . .

The promise of technology enabling us to be conscious masters of our experience, overlords of the material world, is long past. We have more the impression of being swallowed by our own doing. . . . There is no way out, but we are hopefully capable of an occasional lucid moment within our dream where we can savor and marvel at the whole process even as we are swept away by it, that being the nature of our experience.[15]

Other Artists and Projects

Comment on Popular Culture ***Sheldon Brown***'s outdoor installation *Video Wind Chimes* presented a video projector that looked like a streetlight but projects video from television stations that changes channels as it blows in the wind. ***Tammy Knipp***'s *Case Study* presented viewers with a simulation of dyslexic perception by asking them to vulnerably lay down under big video monitors that kinetically move toward them. ***Marque Cornblatt*** created kinetic and quasi-robotic devices that expressed the ambivalence of the cyber era. Using cyberpunk techniques of assemblage, he created installations that confuse and bemuse, such as self-propelled TV stands doing whirlies, and Icarus figures with windable wings. One critic described the works as being assembled out of the three *T*s—toys, trash, and technology. ***Joseph DeLappe*** created works such as *The Mouse Series* which customized computer mice as forms of social commentary, and *Masturbatory Interactant,* in which a bar-code scanner on a mechanical arm randomly selects self-erotic videos to be projected onto a plastic inflatable party doll. ***Jim Pallas***'s interactive scultpures usually comment on social processes, such as *The Senate Piece,* commissioned by U.S. Senator Carl Levin, in which kinetic objects respond to Senate processes—an inflatable senator comes to life during quorum calls and a dollar bill drops during Senate activities. ***Neil Grimmer*** created electronically controlled kinetic sculptures out of commercial items such as vibrators. The ***Art and Robotics Group*** of Canada created *SenseBus,* which allows everyday home objects to sense and communicate with each other without any central brain or traditional digital interfaces, and *SpaceProbe,* which was a collection of electro-art that incorporated unusual sensors and telemetry. ***Steve Gompf***'s *Televisors and Early Motion Picture Technologies* kinetically activates old wooden boxes and other found objects in an attempt to comment on the early days of television. ***Arthur Ganson***'s whimsical contraptions activate diverse materials and found objects to manifest "qualities least associated with machines."

Sheldon Brown: ⟨http://www.cra.ucsd.edu/~sheldon/⟩
Tammy Knipp: ⟨http://siggraph.org/artdesign/gallery/S97/art_knipp.html⟩
Marque Cornblatt: ⟨http//www.falsegods.com.transhuman.html⟩
Joseph DeLappe: ⟨http://digitalart.artsci.unr.edu/delappe.html⟩
Jim Pallas: ⟨http://www.ylem.org/artists/jpallas/JPALLAS1.HTM⟩
Art and Robotics Group: ⟨http://www.interaccess.org/arg/index.html⟩
Arthur Ganson: ⟨http://web.mit.edu/museum/exhibits/ganson.html⟩

Comment on Interaction ***Peter Dittmer*** created kinetic devices that explored language and communication. His systems typically engaged the viewer in a dialogue via onscreen text and spoken words. Things sometimes go wrong. The *Wet Nurse* kinetically acted on a glass of milk as part of its interactions. ***Mark Madel***'s interactive electronic sculptures, such as *Timesharing,* demand user interaction with the piece and each other, calling forth "blurred distinctions between interaction and relationship and between coercion and invitation." ***Laura Kikauka*** created kinetic works that question technophilia. A *Leonardo* article describes her *Hairbrain2000* harness, which creates a wearable viewing chamber in which sparks and relay clicks are activated by viewer motion. The artist group ***Sine::apsis*** experiments creates kinetic and robotic art events that attempt to introduce concepts from biology and artificial life into their installations in order to investigate complex behaviors and interactive structures. The ***Soda*** artist group's kinetic installations challenge the inertia of architectural spaces and the nature of autonomy—for example, with autonomously flexing panels and electrochromic mirrors with dissolving messages and *The Priest and the Dying Man* sculptural robots, which speak together about free will.

Extensions of Puppets ***Heri Dero*** creates shadow puppetlike kinetic assemblages by which he tries to capture the "machine as mystery, play, magic, and metaphor." In *Childhood/Hot and Cold Wars,* ***Ken Feingold*** built an installation reflecting on personal memories of the cultural history of the 1950s and 1960s by offering a grandfather clock full of rear-projected video images shaped by a globe of the earth that viewers could turn. In *Interior,* viewers touch a medical torso to control puppets speaking, seen outside of a window.

Linkage of Motion and Virtual Space In *Room for Walking,* ***Daniel Jolliffe*** offered a wagon with a video projection in its bed that reveals aspects of a virtual object as the viewers pulled it around. ***Doug Back***'s *Small Artist Pushing Technology* consisted of a monitor on wheels with an image of a small person pushing coordinates the same way that the viewer moves the monitor. ***Sigi Möslinger***'s *Sweetcart* revealed a digital landscape as a monitor is rolled about.

Peter Dittmer: ⟨http://www.foro-artistico.de/english/program/literat.htm⟩
Mark Madel: ⟨http://www.mggrd.com/mm⟩
Laura Kikauka: ⟨http://mitpress.mit.edu/e-journals/Leonardo/gallery/gallery291/kikauka.html⟩
Sine::apsis experiments: ⟨http://www.sine.org⟩
Soda: ⟨http://www.soda.co.uk/index.htm⟩
Heri Dero: ⟨http://www.ntticc.or.jp/permanent/heridono/introduction_e.html⟩
Ken Feingold: ⟨http://www.kenfeingold.com/⟩
Daniel Jolliffe: ⟨http://www.interaccess.org/touch/jolliffe.htm⟩
Doug Back: ⟨http://www.interlog.com/~steev/exhibition/networks/gallery/back.html⟩

Summary: More Than Robotics

Although not high technology, machines are a critical infrastructure for contemporary society. They are the brawn that ultimately translates intelligence to the world of stuff. Research attention is mostly focused on robots as the ultimate machines that incorporate intelligence and flexibility. But the lowly machine without robot aspirations is an important cultural icon. Indeed, some feel that the electricity that makes the technology go deserves more cultural analysis.

Since the beginning of this century, isolated artists have experimented with machine motion and electrical light. Usually they approached these technologies within the aesthetic traditions of seeking beauty of motion and illumination. Within the last decades, however, artists have explored the cultural implications of machines and light. The artists described in this chapter have been free to create mechanical installations that use the latest technologies but pursue cultural agendas unaddressed by mainstream industrial applications. In some ways they are the logical extension of the ancient art form of sculpture.

Notes

1. B. Cannon, "Art in the Age of the Microcontroller," ⟨http://www.jps.net/bcannon/⟩.

2. M. Komisar, "Statement," ⟨http://www.xlnt.com/neonart/mkomisar/mkomisar.html⟩.

3. G. Barsamian, "Description of Work," ⟨http://www.concentric.net/~Venial/⟩.

4. J. Farber, "Commentary on *Putti,*" ⟨http://www.concentric.net/~Venial/⟩.

5. P. Hoberman, "*Faraday's Garden* Description," ⟨http://www.portola.com/PEOPLE/PERRY/perry.html⟩.

6. "San Francisco Gate" Web site, "Interview with Alan Rath," ⟨http://sfgate.com/eguide/profile/⟩.

7. D. Friis-Hansen, "Curatorial Statement 'Bio-Mechanics' Show," ⟨http://www.camh.org/cam_exhandprograms/cam_onlineexh/cam_rath/rath-index.html⟩ [expired link].

8. "San Francisco Gate" Web site, "Interview with Alan Rath," ⟨http://sfgate.com/eguide/profile/⟩.

9. B. Cannon, "Artist Statement," ⟨http://www.jps.net/bcannon/⟩.

10. B. Cannon, "*Tree Time* Description," ⟨http://www.jps.net/bcannon/⟩.

11. B. Cannon, "Anti-Speed," ⟨http://www.jps.net/bcannon/⟩.

12. *ICC Journal,* "Interview with Paul DeMarinis," ⟨http://www.well.com/user/demarini/shiba.html⟩.

13. P. DeMarinis, "Description of *The Messenger,*" ⟨http://www.well.com/user/demarini/messenger.html⟩.

14. P. DeMarinis, "Description of *Edison Effect,*" ⟨http://www.well.com/user/demarini/edison.html⟩.

15. *ICC Journal,* "Interview with Paul DeMarinis," ⟨http://www.well.com/user/demarini/shiba.html⟩.

5.3

Kinetic Instruments, Sound Sculpture, and Industrial Music

Music has a long tradition of technological experimentation with devices to produce sound. Those that became accepted into the repertoire came to be called the standard instruments, such as pianos, trumpets, violins, and the like. Contemporary sound artists are attracted to the possibilities of using the tools and materials of industrial technological culture in sound making. They are interested in sound outside of music and speech. Sound artists were also among the first to explore electricity, recording technology, synthesis, sound editing, radio, and electronics. Contemporary artists have created a multitude of forms that integrate the visual and sonic arts.

They have worked in many ways. Some have pursued sensual novelty, trying to create sounds never heard before. Some develop alternative instruments. Some try to explore the sounds of the natural- and the human-built world. Others create kinetic sculptures and interactive installations that investigate critical themes in cultural analysis within the context of sound. Other chapters have described other science or technologically inspired investigations, such as the search for artificial intelligence and genetic music generating algorithms (4.3 and 7.6); acoustic ecology (2.4); auralization of information (7.7); and speech synthesis and computer manipulations of 3-D sound space (7.5).

Technological and electronic sound experimentation is a major chapter in the relationships among art, science, and technology. Sound artists and musicians have demonstrated many of the cross-disciplinary themes described in this book. Musicians and sound artists entered into the scientific discourse about sound and hearing early. They pioneered technological investigations of electronic sound and were among the earliest to work with personal computers.

Unfortunately, the consideration of sound-artist experimentation with technology is an enormous topic beyond the scope of this book. There are books, journals, and organizations specifically devoted to these inquiries. For example, some of those resources include: *Leonardo Electronic Music Journal, Electronic Music Journal,* and *SoundCulture.* This section attempts to provide only an brief sampling of the ways to consider the relationship of science and technology to sound art. It concentrates primarily on artists who work within the traditions of kinetic sculpture and installation.

A Brief Theoretical Overture

Some theorists consider sound grossly underexplored in analysis of the arts. Douglas Kahn and Gregory Whitehead edited a landmark book, *Wireless Imagination: Sound, Radio, and the Avant-Garde,* which collects theoretical analysis and historical documents. Some of the historical eras they consider include the age of the phonograph's invention, the Futurists' art of noise, Duchamp's gap music, the Dadaists' experiments with sound art, the Russian Constructivists, the Surrealists, and John Cage's experiments. Technology was simultaneously a provocation and a tool for this work, although Kahn and Whitehead shy away from technological determinism, searching instead for broader cultural themes.

They give voice to the view of many about the strange neglect of sound, given its unique kind of access to people's consciousness. They find the paucity of systematic theoretical attention a major lack:

> The human ear offers not just another hole in the body, but a hole in the head. Moreover, the absence of obstructive anatomical features such as earlids would seem to assure a direct and unmediated pathway for acoustic phenomena, with sonic vibrations heading straight into the central nervous system.[1]
>
> One would expect to find amid the accumulation of studies of modernism, postmodernism, the avant-garde, and postwar experimentalism a more faithful attendance to the cultural preoccupations of hearing—one of the two major senses, the "public" ones, as John Cage described them, for their ability to make contact from a distance.[2]

In part, they attribute the lack to the dominance of the "regime of the visual," a tendency in modern Western culture to focus on sight, a subject of much contemporary analysis. They claim that sounds cannot be objectified as easily as sights:

> Yet another problem exists in merely thinking about sound within a culture that so readily and pervasively privileges the eye over the ear. Visuality is so embedded that attempts at redress seem doomed to tautology. Many contemporary theories and philosophies, in fact, invoke aural, sonic, musical, and preguttural metaphors at the points where they are unable to speak, at the limits of language. How can we then rely on the same theories and philosophies to query the very sounds heard during such moments of matriculation? How, for instance, can listening be explained when the subject in recent theory has been situated, no matter how askew, in the web of the gaze, mirroring, reflection, the spectacle, and other ocular tropes? Visually disposed language, furthermore, favors thinking about sound as an object, but sound functions poorly in this regard: it dissipates, modulates, infiltrates other sounds, becomes absorbed and deflected by actual objects, and fills a space surrounding them.[3]

Other parts of this book will suggest that expanding the scientific, technological, and artistic attention given to other senses (touch, taste, and smell) will also open up new cultural issues.

The authors also note the privileging of "music" in Western thought about sound. Tendencies such as modernist autoreferentiality, the quest for nonobjectivity, the dynamics of musical rules, and music's mystical associations with the sublime are all mitigated against a culturally expansive approach to sound. Even the avant-garde traditions the book described—except possibly Surrealism—often framed their work as the expansion of music. As a result of its august tradition, Western music did not deal well with mass media, new technologies, and interactions with folk and non-Western traditions.

Only recently has a significant sound-arts movement of sound installation, audio, and radio experimental artists emerged. These artists have undertaken projects such as "the radicalization of sound/image relationships" and of "acoustics in architectural, environmental, or virtual space." Technological innovations and sound-art experimentation have always gone hand in hand. Kahn and Whitehead explain this relationship in part by teasing out the profound cultural implications of the new sound technologies.

For example, sound recording had a major effect on thought. It raised the spectre of technologizing the body and suggested access to previously unexplored regions, such as the afterlife and the unconscious. Radio similarly inspired the artistic imagination. It raised ideas of disembodiment—a sound could exist in two distant spaces at once. It referred to "the expanses of the ocean, to crowds, to other lands, and to the otherness of the unexplored globe."[4] Even more, it could shake up categories of thought, suggesting that the inflow of ideas in a nonlinear way from many sources at once. Innovations inspire artists and then they take it forward, both exploring its cultural meanings missed by technical practitioners and themselves inventing new technical extensions. It is a pattern often repeated.

Experiments in Sound Installation

Barry Schwartz

Barry Schwartz is engaged by the technological paraphernalia of industrial culture. He creates large sound installations with demonic machines, high voltage, mangled video monitors, chemical baths, and the like. The works convey a mixture of mesmerization and danger. Generally, he employs transducers to make sound and "probes the nexus and relationships among the electrical, mechanical, aural, visual, and theatrical systems." The "Robotronika" show description of Schwartz in the publicity for *Arcus Interruptus* provides some insight into his aesthetics and way of working:

> Schwartz's work incorporates metal, mechanics, computer-controlled hardware, chemically reactive agents, high-voltage electricity, and live video feeds. Reclaimed technological refuse, electrified

transit wires, telephone poles, an electrical tower removed from the landscape, and use of pre-existing structures are employed in the fabrication of his artwork. Past installations have featured electrically charged piano strings attached to high-voltage utility tower structures. During the installation and performance, Schwartz plays the strings, coaxing arcs of electricity to dance between his fingers. Creating an auto-electronic environment, Schwartz stands in fountains and waterfalls of nonconductive fluid, manipulating various mechanical devices.[5]

In describing one of Schwartz's "turntable" installations, one Web site calls Schwartz's work a "theater of shocks":

Equal parts death wish, weird science, and hot-wired art, Barry's theater of shocks and jolts gives brand new meaning to the word *turntable*—his version is a larger-than-life physical apparatus

Fig. 5.3.1. Barry Schwartz, *Turntable* installation. Industrial machinery is used in live performance.

which consists of a huge stainless steel disk mounted on a waist-high gimbal and amplified through STC via contact mics. Spinning this oversize metal plate like a large record, he utilizes an extended constructed "tone arm" that houses the stylus, a chunk of dry ice, which elicits low sobbing moans, squeals, and inhuman howls from the steel surface.[6]

In *Beam Gantry,* an installation performed as part of the European Media Arts Festival (EMAF), Schwartz constructed an "instrument" based on the structures used to suspend high-voltage wires all over the world. The work exploited both the iconic and functional qualities of the technologies. High-voltage piano wires drape down the sides with fluid pouring over them into a pool below. Video monitors, closed-circuit cameras, and concave dishes, suspended on cables, reflect sound and image from the event. Disembodied television sets sit sparking in the fluid. A performer sits on the structure generating sound, video, and mechanical interactions.[7]

In *I-Beam Music,* created in the 1995 Kampnagel (Internationale Kulturfabrik) in Hamburg, Germany, Schwartz collaborated with Nicolas Anatol Baginsky to create a large industrial-technology sound event with sophisticated sound analysis computer intelligence guiding its actions. The program describes the installation, which includes machines, computers, surveillance cameras, video projectors, water, high voltage, fire, and chemicals. A computer adds to the sound by recursively processing the sounds created by the mechanisms:

> During the performance, the six-string instrument undertakes an automatic journey through an environment twenty-five meters in length. Similar to the functional principle of a car wash, the string instrument travels through different situations and is being played there in very different ways: mechanical fingers pick the strings, chemicals create tones, extreme heat and cold tune the instrument.[8]

Gordon Monahan

Gordon Monahan experiments with a variety of technologies for producing new kinds of instruments. His *Large Hot Pipe Organ* makes use of large pipes and propane systems, tuned by experimentation with pipe lengths, shapes, and ignition systems.

Several performances play with the Doppler effect which changes the perception of a sound source's frequency depending on its movement. His catapult performance offered

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Gordon Monahan: ⟨http://www.tacheles.de/raven/artists/bastiaan/history.html⟩

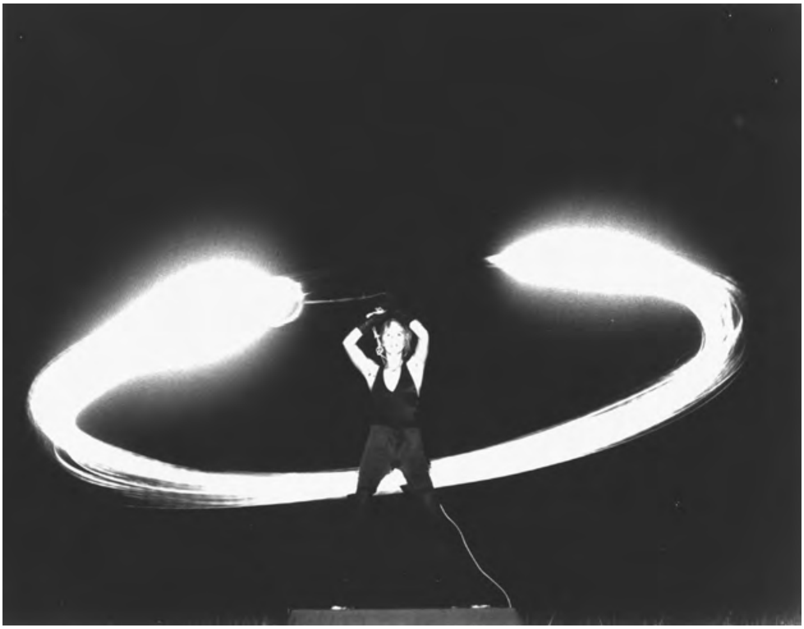

Fig. 5.3.2. Gordon Monahan, *Speaker Swinging* performance. The Doppler effect changes the frequencies of the sound.

strangely modified sound as speakers were thrust out of catapults. His *Speaker Swinging* performances typically involve performers swinging speakers above their heads with the effect sometimes augmented by electronic lighting. Monahan also creates Aeolean harps in which sound is generated by moving air or water.

Ed Osborn

Ed Osborn creates kinetic sculptures and public art installations that explore a variety of sound technologies. Usually the works function metaphorically, using the sound to stimulate viewers to think about concepts of interest.

Swarm used the electronic control of fans to create a semblance of biological flocking. The fans seemed to engage in leading and following behaviors, just as though they were many animals: "Alluding to themes of instability and physical force, technological acuity

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Ed Osborn: ⟨http://roving.net⟩

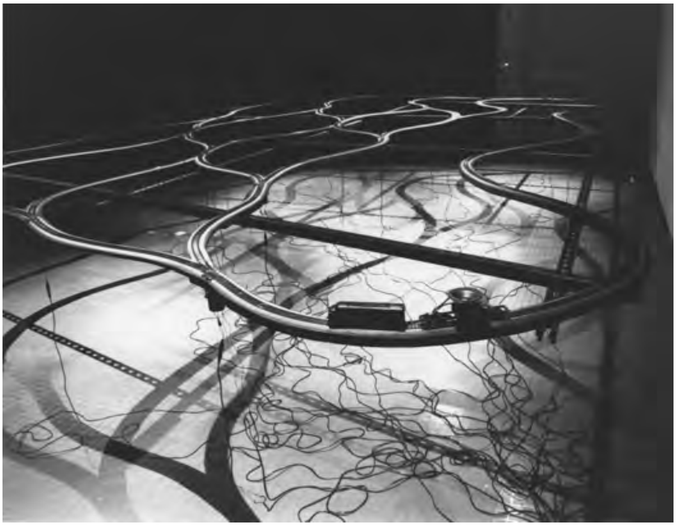

Fig. 5.3.3. Ed Osborn, *Parabolica.* An electric train with speaker attached creates a variety of moving sound events.

and hazard, and collective will, Swarm is an image of a living entity awakened and intoxicated by a sound of its own making."[9]

Skeletons investigates the coupling of audio and visual shadows and the physics of subaudible sound: "[T]hese works bring into hearing range the normally inaudible artifacts of physical movement, thus allowing a sonic depiction of a common but silent taxonomy of real motion in real space." In *Parabolica,* Osborn illustrates the tendency of artists to extend technologies in unexpected ways by extending the technology of model trains. He creates an installation in which the movement of the trains interacts with the sound sources they are "broadcasting," all relating to concepts of random distributions and chance:

> Each time the train goes around the track, the switches that determine what route the train will take get reset randomly so that it takes a different one through this matrix of paths. . . . So over time the train is describing with its motion the form of the bell curve. . . . As the train does this it broadcasts sounds of people talking about making decisions and plans, describing confidence and certainty, and sounds of highly stressed mechanical systems.[10]

Osborn also creates sound-based public art installations and conceptual works. The *Bus Shelter* project, at the University of Washington, creates sound representations of the flow of information systems in this university campus environment by "putting an ear to the ground"—reading the flow of fluids in surrounding plant life and the flow of Internet data: "Together, these two areas illustrate twin systems of sustenance and provide listeners with an aural image of very different kinds of living forces. The contrast also serves to highlight the relationships between and the demands placed upon these two support systems."[11] *Audio Recordings of Great Works of Art* is a ten year project in which he recorded the ambient museum sounds that could be heard while standing in front of specific famous works of art.

Nigel Helyer

Nigel Helyer is a sound sculptor who often works with public spaces. He uses sound to reawaken ideas that get submerged in everyday living and in the advance of technology, such as disembodiment. He believes that sound sculpture is potentially very powerful because sound "flows between everything," and tries to use technology to reclaim public space. The digital world is isolating people even further from important levels of experience. He describes his method of working:

> [M]y aim is to identify and scrutinize methods of defining, entering, and occupying public territories within urban space. Urban space in this context refuses the conventional representation of that homogenous continuum of spatial, economic, and ethical structures in which corporate and civic systems are ideologically interchangeable. Rather, urban space (be it the entire city or an individual built structure) is to be regarded as a vascular body rendered coherent by those flows of transactions, eddies of relationships, and the digestions of transmissions. . . .
>
> Electronic communications are to a great extent divorced from our quotidian "metabolic" life. The digital world is shielded from chaos; the talking clock will naturally speak while the city is burning down. We have attempted to establish a technological immune system, buffered from external influence, scanned for infection, backed-up, passworded and air-conditioned. It is a vascular system which cannot and does not share the chaos and flux which we "enjoy" on the street. This lack of biological frailty forms the basis of the sinister and dehumanising aspect of the digital process, but by some token we are fascinated by a network which lacks density but which operates at infinite speed. Our speech now exists beyond metabolism.[12]

Nigel Helyer: ⟨http://www.arts.monash.edu.au/visarts/globe/issue7/nhtxt.html⟩

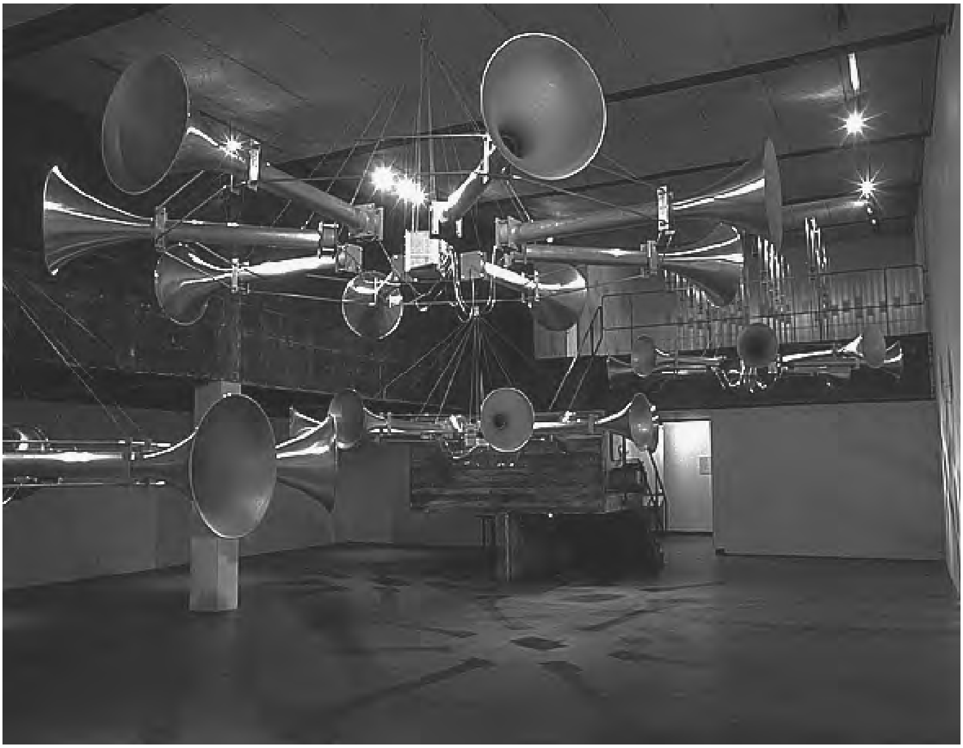

Fig. 5.3.4. Nigel Helyer, *Silent Forest.* A sound installation exploring the sounds of technology and war juxtaposed with sounds of Vietnam's forests.

One of his most known works, *Silent Forest,* explores the soundscape of the grand opera house in Hanoi as a locus where war, nature, and culture interact. He uses air raid sirens and digitally processed sounds of the Southeast Asian forest to create the event. The forest sounds of animals near extinction are rendered by old 78 rpm field recordings, themselves a reminder of technologies on the verge of extinction.

Physically the work consists of two multisource sound delivery systems—one modelled on early warning sirens, which act as an incongruous image to ironically link the technologies and soundscapes of Warfare with the technologies of Music culture. . . . This siren configuration acts as a physical and sonic leitmotiv, delivering the audio works which interrogate the politics of French colonialism (and subsequent North American neo-colonialism). The multiple, overlapping audiotexts juxtapose reconstructed fragments of Western art music which, by mimesis or concept, represent the "forest," with a series of "siren performances" to be finally overlaid by reconstructed fragments of traditional Vietnamese music. . . .

The arrow of time is resolute—the loss, silence, or absence evoked by such an inversion is manifold—in reality many of the animals and habitats preserved on these recordings no longer exist.[13]

Helyer explores the contradictions in broadcast and electronic sound reproduction. He uses the metaphors of silence and collaged sound to explore silences in larger cultural events. Technology serves multiple roles, supporting negative trends and allowing listeners to understand the trends:

The enigma of describing the tangible (phenomenal) through the organs of transmission is a central feature of the paradoxical logic that we accept on a daily basis (the telephone, radio, television, and telematics). My interest as an artist is to explore our habitual suspension of disbelief which these technologies demand, with research which parallels and inverts this enigma—to pursue the definition, locus, and function of silence and silencing is an exhumation of structure beneath the sedimentary layers of surface noise. . . .

At this juncture we have the opportunity to re-discover the original utopic possibilities of electricity, by re-immersing ourselves in the lost histories, the forgotten seminal points of an unformed discourse of transmission.

Trimpin

Trimpin creates sound installations that often use advanced technology to make sounds with conventional acoustical musical instruments. For example, he has devised methods for the machinelike activation of trombones, pianos, cymbals, and the like. He also does not restrict himself to conventional musical instruments; he created an installation to play composer Conlon Nancarrow's piano-roll composition via mallets striking one hundred hanging wooden shoes. Another installation called *Circumference* placed the audience in the middle of an array of plastic pitchers, galvanized pails, garbage can lids, circular-saw blades, dryer exhaust vents, along with more conventional percussion instruments. He has studied both music and mechanical engineering and was awarded a MacArthur "genius" award for his work, which was described by one newspaper account as "magical vision and technical ingenuity join forces in his work in ways that haunt, delight, and confound."

Trimpin: ⟨http://mitpress.mit.edu/e-journals/Leonardo/gallery/gallery291/trimpin.html⟩

Fig. 5.3.5. Trimpin, *Phffft.* An air-pulsated kinetic sound environment.

Trimpin also creates interactive works. A piece called *Phfft* activates two hundred acoustic tuned devices (reeds, flutes, pitched pipes, whistles, etc.) through viewer action. User motion and air currents activate a computer that activates the instruments. Trimpin is also interested in exploring the power of natural forces to activate sound. Some of his pieces use dripping water to activate drum heads. As part of SoundCulture96, he created an interactive fire organ for an Exploratorium exhibit on AIDS: "*FireOrgan* is a contemplative sanctuary of fire and sound, an extraordinary new instrument that uses fire, glass tubes, resonance, and thermodynamics to create an environment of deep, low tones activated by the presence of visitors and sometimes even fueled by their voices."[14]

Fig. 5.3.6. Bill Fontana, *Acoustical Visions of Venice.* Live sounds from twelve spots in the city are collected into one spot.

Bill Fontana

A pioneer of sound sculpture, Bill Fontana has created sound installations throughout the world that highlight aspects of the historical, cultural, architectural, and physical qualities of locations. He first started working with the simple technology of the field tape recorder and speakers. He then developed a series of innovative strategies for connecting the field situation with the viewer's space. The series of installations constitute a remarkable history of the use of technology to open new artistic possibilities. His paper "Resoundings" explains his approach and some of its history. He explains how recording became an intense compositional act:

I began my artistic career as a composer. What really began to interest me was not so much the music that I could write, but the states of mind I would experience when I felt musical enough

Bill Fontana: ⟨http://www.resoundings.org/⟩

to compose. In those moments, when I became musical, all the sounds around me also became musical.[15]

He describes experiences that were seminal in shaping his approach. In 1976, while he was recording a total eclipse of the sun in an Australian rain forest, he noted the radical changes in the forest as the eclipse proceeded:

During the minutes just before the moment of totality (having a duration of two minutes), the acoustic protocol between birds, determining who sang at the different times of day, became mixed up. All available species were singing at the same time during the minutes immediately proceeding totality, as the normal temporal clues given by light were obliterated by a rain forest suddenly filled with sparkling shadows. When totality suddenly brought total darkness, there was a deep silence.

This recording was seminal for my work because a total eclipse is always conceived of as being a visual experience, and such a compelling sonic result was indicative of how ignored the acoustic sensibility is in our normal experience of the world. From this moment on, my artistic mission consciously became the transformation and deconstruction of the visual with the aural.

Fontana's experience illustrates qualities often observed with high-tech artists. Scientistlike carefulness of observation and depth of analysis are integrated with a willingness to be amazed and a desire to communicate the experience. Fontana proceeds to explain how he came up with his trademark approach of linking the space of sound origins with the space of listening, overcoming the ephemeral qualities of sound:

One of the most useful methods has been to create installations that connect two separate physical environments through the medium of permanent listening. Microphones installed in one location transmit their resulting sound continuums to another location, where they can be permanently heard as a transparent overlay to visual space.

As these acoustic overlays create the illusion of permanence, they start to interact with the temporal aspects of the visual space. This will suspend the known identity of the site by animating it with evocations of past identities playing on the acoustic memory of the site, or by deconstructing the visual identity of the site by infusing it with a totally new acoustic identity that is strong enough to compete with its visual identity.

One project called *Perpetual Motion* illustrates the linking of technology, acoustical analysis, and cultural history that underlie the work. He proposes to create a sound sculpture of bells in Cologne's center that will be modified to pick up the resonant frequencies of the sounds that surround them—thus conceptually turning the bell inside out. Building on the natural tendencies of materials such as metal to resonate, he is attempting to fine tune the bells so they can "capture" sound instead of emanating it.

Other Artists and Projects

Unorthodox Instuments Previously associated with Survival Research Labs, ***Matt Heckert*** creates machines out of industrial materials, "big machinery" that create sound. Often he presents them as the "Automated Sound Orchestra." Samples include: *Rotary Violin,* a set of twelve piano strings on two revolving hoops, and *Big Boxer,* a motor-driven dome weighing about 240 pounds. *Weather Station* used 310 piezo speakers to create sounds based on outdoor light, temperature, and humidity. ***Peter Bosch and Simone Simons***'s *Krachtgever* (*Invigorator*) presents an installation built of many wooden packing crates that generate sounds via electonically controlled vibrators and strikers located inside. ***Ron Kuivila*** creates his own instruments and installations that use electronics to disassemble sound. For example, *Fast Feet, Slow Smoke* works with slow-motion sound, and *Comparing Habits* uses ultrasonics to convert even the subtlest of motions, such as the passage of air currents through a room into sound. *Radial Arcs* coordinated ninety-six stun guns, and *Spark Armonica* converted extreme spark sounds, which cannot be recorded or reproduced, into audible signals. ***Ken Butler***'s sculptural instruments represent bricolage of found objects, consumer culture, and kinetic activation. Converting sub-audible sounds into perceptible events, ***Nicolai Carsten***'s *Frozen Water* uses a bass speaker to activate ripples in a container of water facing it and overlays other frequencies to still the ripples with wave impedance. ***Shawn Decker***'s sound installations activate everyday objects such as *The Night Sounds,* in which motors strike piano strings attached to variously moving buckets, and *Wire Fields,* in which a gallery was strung with 32 piano wires activated by small motors that were affected by visitor motion, other strings' vibration, and sounds from a nearby garden. ***Nick Collins***'s installations often read user actions to activate events—for example, *Table de Seance,* in which movements of the Ouija board are converted to ethereal MIDI sounds from the surroundings,

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Matt Heckert: ⟨http://www.mattheckert.com/⟩
Peter Bosch and Simone Simons: ⟨http://prixars.orf.at/press/english/musikwin.htm⟩
Ron Kuivila: ⟨http://www.lovely.com/bios/kuivilla.html⟩
Spark Armonica: ⟨http://nttad.com/asci/archive/arttech/rkwork.html⟩
Nicolai Carsten: ⟨http://www.ntticc.or.jp/special/sound_art/carsten_e.html⟩
Shawn Decker: ⟨http://webspaces.artic.edu/~sdecke/⟩
Nick Collins: ⟨http://members.xoom.com/_XMCM/Nicollins/installations.html⟩

and *The Primrose Path,* in which walking on five paths activates five different sound effects used by the movie industry to represent walking.

Site-Specific and Architectural Installations ***Dan Senn*** builds sound-history-referencing installations that use technologies such as peizo transducers to activate spaces. His pendulum-based pieces range in size from eighteen inches to hundreds of square feet. One project called *Catacomb Memories,* suggesting a burial space, explored evocations of subaudio sound via unusual transducers. ***Robin Minard*** creates sound installations that integrate ambient sounds and attempt to heighten audience awareness of their surroundings. He often uses emerging technologies in their construction. *Neptun* completely surrounded a space with loudspeaker ribbon. *Still/Life* mounted piezo speakers on the floors and walls to create "plantlike" installations. ***Bill and Mary Buchen*** create "sonic architecture," in which architectural components are sonically activated. ***Minoru Sato***'s *Finding of a State of Light: Distribution of Luminous Intensity and Its Fluctuation* focuses on the lighting conditions in the gallery by making audible sounds produced by energy equivalent to them.

Other Technology-Exploring Sound Installation Artists Not Presented Elsewhere in the Book Gregory Whitehead, Kathy Kennedy, Christof Migone, Hank Bull, Tetsuo Kogawa, Dan Lander, Julia Loklev, Helen Thorington, Jean François Denis, Paul Panhysen, Terry Fox, Mineko Grimmer, Maryanne Amacher, Heri Dono, Ellen Fullman, Alvin Lucier, and *Martine Riches.*

Experimental Instruments—Bart Hopkins

Although not quite kinetic sound installations, the creation of experimental instruments offers a related example of technological experimentation. Many of the installations previously described could be conceived of as instrument construction. Some of this activity concentrates on extending state-of-the-art electronics and computers to generate new kinds of sounds. Some has little interest in this "high" technology; rather, the sound artists build instruments out of natural and man-made materials that have not been previously used for these purposes.

It would be a mistake, however, to dismiss this work as unrelated to science and technology just because it doesn't use electronics. Some of it exemplifies the key qualities

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Dan Senn: ⟨http://www.nwrain.net/~newsense/⟩
Robin Minard: ⟨http://www.mhsg.ac.at/iem/bem/minard1.htm⟩
Bill and Mary Buchen: ⟨http://www.users.interport.net/~sonarc/maintext.html⟩
Minoru Sato: ⟨http://www.ntticc.or.jp/special/sound_art/ms_e.html⟩
Bart Hopkins: ⟨http://windworld.com/emi⟩

of observation and experimentation that inform high-tech artists. Similar to scientists, these instrument-making artists are paying attention to their world—noting materials, physical principles, and relationships missed by others. Like high-technology developers, they are willing to take risks and experiment to achieve their visions. The instrument makers provide a vigorous example of ways artists can be connected to the processes of research.

Bart Hopkins, an instrument maker who works with flame organs among other forms, has been editor of the journal *Experimental Musical Instruments,* which serves a worldwide forum for this activity. Excerpts of an article he wrote on "pyrophones" illustrates the sciencelike attitude of many in this community. He is amazed, enthused, and curious about his topic. He is eager to share his discoveries and to learn more from other researchers. He is interested in natural phenomena but also motivated by aesthetic aims. The article explains the processes of this art/science—reviewing practical and theoretical research, analyzing of the physics, speculating on experimental actions, and attempting manipulations. For example, the article presents a detailed analysis of how flame tones come about.[16]

Hopkins edited a book called *Gravikords, Whirlies, and Pyrophones: Experimental Musical Instruments,* which compiled some of this experimental work. A sample of the contents give a feel for the range of activity—the nature of experimentation and the variety of technologies investigated:

Michel Moglia—Fire Organ
Richard Waters—The Waterphone
Godfried-Willem Raes—Pneumaphones
Don Buchla—Thunder and Lightning
Leon Theremin—The Theremin
Oliver DiCicco—Möbius Instruments
Sarah Hopkins—Whirly Instruments
Wendy Mae Chambers—The Car Horn Organ
Brian Ransom—Ceramic Instruments

Summary: Research as Art

Kinetic sound installation has been an active area of integration of research and art. Many of the sound artists have had to undertake their own research to realize their goals. In doing so they demonstrate the poetry that can come from investigation of new technologies.

Notes

1. D. Kahn and G. Whitehead, *Wireless Imagination* (Cambridge, Mass.: MIT Press, 1992), p. ii.

2. Ibid., p. 1.

3. Ibid., p. 4.

4. Ibid., p. 21.

5. "Robotronika" show, "Description of *Arcus Interruptus,*" ⟨http://robot.t0.or.at/exhib/schwartz.htm⟩.

6. "Recombinant" show, "Description of Turntable Installation," ⟨http://shell4.ba.best.com/~asphodel/recombinant/artists/schwartz.html⟩.

7. European Media Arts Festival, "Description of *Beam Gantry,*" ⟨http://www.emaf.de/1994/hochsp_e.html⟩.

8. 1995 Kampnagel Web site, "Description of *I-Beam Music,*" ⟨http://www.foro-artistico.de/english/program/I-BM/INDEX.HTM⟩.

9. E. Osborn, "Project Descriptions," ⟨http://www.sirius.com/~edosborn/artworks.html⟩.

10. *Switch,* "Interview with Ed Osborn," ⟨http://switch.sjsu.edu/switch/sound/articles/interview_ed/Ed.html⟩.

11. E. Osborn, "*Bus Shelter* Description," ⟨http://www.sirius.com/~edosborn/artworks.html⟩.

12. N. Helyer, "Artist Statement," ⟨http://www-personal.usyd.edu.au/~nhelyer/⟩.

13. N. Helyer, "*Silent Forest* Description," ⟨http://www-personal.usyd.edu.au/~nhelyer/⟩.

14. Exploratorium, "Trimpin AIDS project," ⟨http://www.exploratorium.edu/AIDS/trimpin.state.html⟩.

15. B. Fontana, "Resoundings," ⟨http://www.resoundings.org/Pages/Resoundings⟩.

16. B. Hopkins, "Pyrophone," ⟨http://windworld.com/emi/pyrophone.htm⟩.

5.4

Robots

Artists have explored robotics from a variety of perspectives, including: theater and dance; autonomy; extreme performance, destruction and mayhem; social metaphor; extending robot motion and interfaces; and robot architecture. (Artistic experimentation with tele-operated robots is considered in chapter 6.3.) The art world's growing interest is manifested by show/conferences such as "Robotronika," in Vienna, and Japan's ICC show "Evolving with Robots," which explores the idea that robots are no longer passive slaves but rather intelligent sensing communicating entitites.

Robotic Theater and Robotic Dance

Barry Brian Werger—Ullanta Robot Theatre

The Ullanta performance group creates scripted dramatic presentations that include robots as performers. The robots incorporate autonomous behavior so that each performance is slightly different, being altered by the robots' view of each other and their environment. At the "Robotronika" show, Ullanta presented a play called *The Self-Made Man and the Moon.*

Margo K. Apostolos

Margo Apostolos is a dancer and professor of dance who has been interested for a long time in the aesthetics of robot motion. She has choreographed dance works, worked with industrial designers, and collaborated with researchers on a variety of projects. In her paper "Robot Choreography: Moving in a New Direction," she describes this interest:

> Just as in dance the human body moves through space efficiently and artistically, just as a dancer performs in seemingly effortless movement, so may a robot. The graceful movement of the human form can provide a standard for the study of an aesthetic dimension of robotic movement.[1]

Her article analyzes historic definitions of dance and the philosophical questions in applying the term to robotic motions. She notes that choreographers such as Alvin Nikolais have been interested in "dehumanized" dance, which offers interesting conceptual crossovers. While robots are not as graceful as humans, there are many opportunities

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"Robotronika": ⟨http://robot.t0.or.at/exhib/⟩
ICC, "Evolving with Robots": ⟨http://www.ntticc.or.jp/special/robot/index_e.html⟩
Ullanta Robot Theatre: ⟨http://www-robotics.usc.edu/%7Ebarry/ullanta/⟩
Margo K. Apostolos: ⟨http://www2.hmc.edu/~alves/auscult.html⟩

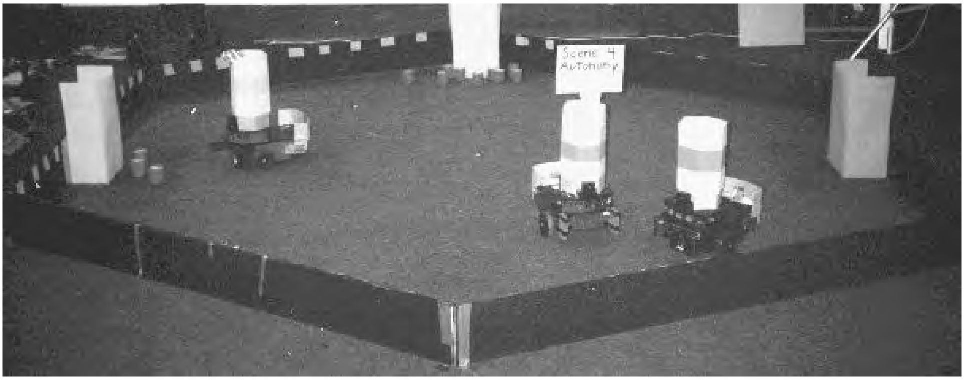

Fig. 5.4.1. Barry Brian Werger, *Ullanta Performance Robotics.* Robot theater in which robot actors enact plays.

for programming smooth motion that are typically not exploited. She also considers the unique motion capabilities of robots, such as 360-degree wrist motion, that can be explored. She shows how compositions can build on the rhythms of robotic motion and sound. In one later performance, a composer created a work called *Auscultations,* which amplified and modified the sounds of robotic joints and motions as the sounds for the dance. Apostolos's later research work involves working with NASA on space telerobotics and with the Annenberg Center for Communications on facial expressions and human-computer interactions.

Finally, she suggests that robotic dance is a unique area of inquiry in which scientists and artists can learn from each other. The description of her talk, entitled "Sensual Science: From Dance Performance to Space Telerobotics," explains this view:

> Sensual Science is presented as a way of looking at the world which employs creative thinking and artistic expression. Scientific discovery and artistic creation progress in various ways, and integration of the two processes may result in exciting new discoveries. Robot choreography will serve as an exemplary case of a blend in an artistic—scientific integration.[2]

Other Artists and Projects

In *Robot Puppet,* presented at the "Robotronika" show, ***Wolfgang Hilbert*** attempted to update the historical form of puppetry. Pulling on cords allowed the viewer to control a computer-activated virtual robot as a metaphor for the hope humans have of controlling their technology. Periodically, however, the robot acted self-sufficiently and exited from the interaction. Swedish choreographer ***Asa Unander-Scharin*** collaborated with mathematician and systems developer ***Magnus Lundin*** to create *Orfeus Kagan,* a dance for an industrial robot that attempted to mimic human motion. The U.K. performance group *VOID* produced *2 Minutes of Bliss,* in which performers shared a labyrinthine space with moving robots that carried video cameras and projectors so that the images were mergers of humans and robots. ***Paul Granjon and Zlab*** build robots that they use in performance, including *Toutou,* a singing and swinging dog; *Robot Tamagotchi,* a fluffy robot that needs care; and *Robot Head,* a radio-controlled speaking robot head controlled by the user's eye motions.

Autonomy

One of the major cultural issues of robotics focuses on autonomy because it is often identified as a distinguishing characteristic of being human. Is it possible to create autonomous machines? How does robotic autonomy reflect on human autonomy? Artists working with artificial-life concepts, such as Ken Rinaldo and Yves Klein, also explore the autonomy of robots (see chapter 4.3).

Simon Penny

Simon Penny creates installations and robotics that explore a variety of issues in technoculture. As described in the chapter on artificial life (4.3) and considered below, his *Petit Mal* installation is a landmark attempt to create robots with genuine autonomy.

Prior to this work, Penny created a variety of kinetic installations that highlighted aspects of cultural life, such as the culture of surveillance and the ramifications of the "datasphere" (the flow of information through culture in electromagnetic and other forms, see chapter 7.7).

His paper "Embodied Cultural Agents: At the intersection of Art, Robotics, and Cognitive Science," presented at the AAAI Socially Intelligent Agents Symposium at MIT in 1997, explains part of his agenda with *Petit Mal* and his thoughts about some of the unique features of art research:

Wolfgang Hilbert, "Robotronika": ⟨http://robot.t0.or.at/exhib/⟩
Asa Unander-Scharin: ⟨http://www.speech.kth.se/unander.scharin⟩
VOID: ⟨http://www.voidp.demon.co.uk/exeter.htm⟩
Zlab: ⟨http://www.zprod.org/zLabPrez.html⟩
Simon Penny: ⟨http://www-art.cfa.cmu.edu/www-penny/index.html⟩

Fig. 5.4.2. Simon Penny, *Pride of Our Young Nation.* A robot cannon locates visitors and thrusts its barrel at them.

Central concerns are an holistic approach to the hardware/software duality, the construction of a seemingly sentient and social machine from minimal components, the generation of an agent interface utilising purely kinesthetic or somatosensory modes which "speak the language of the body" and bypasses textual, verbal, or iconic signs. General goals are exploration of the "aesthetics of behavior," of the cultural dimensions of autonomous agents and of emergent sociality amongst agents, virtual and embodied. The research emerges from artistic practice and is therefore concerned with subtle and evocative modes of communication rather than pragmatic goal-based functions. A notion of an ongoing conversation between system and user is desired over a (Pavlovian) stimulus and response model.[3]

Penny suggests that artists bring unique perspectives to technological research that can advance inquiry. For example, with *Petit Mal,* the minimal funding of the project, his interest as an artist in its performative aspects, his sensitivity to cultural representation and audience projection, and his idiosyncratic goals, which differed from conventional research agendas, all resulted in robots that opened up new areas of inquiry for researchers:

My goal has been to focus on the social and cultural aspects of the question "how much can be left out" by concentrating on the dynamics of projection and representation (I mean this latter in a visual and critical theory sense). The tool for this exploration was *Petit Mal,* an autonomous Robotic Artwork. *Petit Mal* constitutes an Embodied Cultural Agent. . . .

I would like to emphasize here that I am an artist and *Petit Mal* was conceived as an artwork constructed according to an artistic methodology. That means: I approached the project holistically, I made most of it: from metal fabrication to circuit board prototyping to pseudo code with my own hands. My formal training is in art, I am an amateur in fields of robotic engineering, artificial intelligence, and cognitive science. My knowledge is unsystematic, it has been acquired on the basis of need and interest. However, my outsider status has allowed me an external and interdisciplinary perspective on research in these fields. . . . The formulation "autonomous robotic artwork" marks out a territory quite novel with respect to traditional artistic endeavors as there is no canon of autonomous interactive esthetics. . . . I am particularly interested in interaction which takes place in the space of the body, in which kinesthetic intelligences, rather than "literary-imagistic" intelligences, play a major part.

Artistic goals and technological research interplayed in the development of the project. Penny believes that systematic unpredictability and "nonoptimization" are artistically fertile and scientifically provocative:

I wanted to avoid anthropomorphism, zoomorphism, or biomorphism. . . . I wanted to present the viewer with a phenomenon which was clearly sentient, while also being itself, a machine, not masquerading as a dog or a president.

The heart of the mechanical structure of the robot is a double pendulum, an inherently unpredictable mechanism. Emblematically, this mechanism stands for the generative principal that the machine, as a whole, is unpredictable, and a little "out of control." This is the logic behind the choice of name for the robot. In neurological terminology, a *Petit Mal* is an epileptic condition, a short lapse of consciousness. The humour of this notion originates in the way in which it is contrary to the conventional idea of "control" in robotics. . . .

My approach has been that the limitations and quirks of the mechanical structure and the sensors are not problems to be overcome, but generators of variety, possibly even of "personality." I believe that a significant amount of the "information" of which the behavior of the robot is constructed is inherent in the hardware, not in the code. . . . In this sense then, my device is "anti-optimised" in order to induce the maximum of personality. Nor is it a simple task to build a machine which malfunctions reliably, which teeters on the threshold between functioning and nonfunctioning. This is as exacting an engineering task as building a machine whose efficiency is maximised.

Penny proposes that the art world's concern with cultural narratives can be a useful set of ideas for robot and autonomous-agent research:

People immediately ascribe vastly complex motivations and understandings to the *Petit Mal.* . . . This observation emphasises the culturally situated nature of the interaction. The vast amount of what is construed to be the "knowledge of the robot" is in fact located in the cultural environment, is projected upon the robot by the viewer, and is in no way contained in the robot.

Such observations, I believe, have deep ramifications for the building of agents. I believe it is a fallacy to assume that the characteristics of an agent are in the code and are limited to what is explicitly described in the code. In fact, the opposite is much closer to the truth. Agents, like any other cultural product, inhere meaning only to the extent that they are understood by, or represent to, the viewer or user.

The project following *Petit Mal, Caucus,* attempts to explore robot social behavior. Penny investigates the use of linguistic communication to build up an artificial society of machines.

Nicolas Anatol Baginsky

Nicolas Baginsky makes robots that use chaos theory and sophisticated intelligence to interact with viewers. Building on techniques from neural net research, Baginsky creates robots that create complex image or sound events.

One installation, called the *Elizabeth Gardner Project,* used analysis of images taken by its video eyes to control its reactions. The *Narcissism Enterprise* installation did more complex analysis of its visual field. Using neural nets, it analyzed the current viewers' image and built composites with other previous viewers' images through patterns it extracted on the fly:

The system decides which images it will return to the visitors as their desired optical and acoustic mirror images. It reflects selected aspects of the optical and acoustic appearance back on the visitor. It does this in a sensuous and playful way. . . .

This subsystem finds, extracts, and recombines facial features (eyes, noses, mouths) from the incoming video images. . . . Thus, composite images are created that unite in a new face the

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Nicolas Anatol Baginsky: ⟨http://www.provi.de/~nab/n_roblst.htm⟩

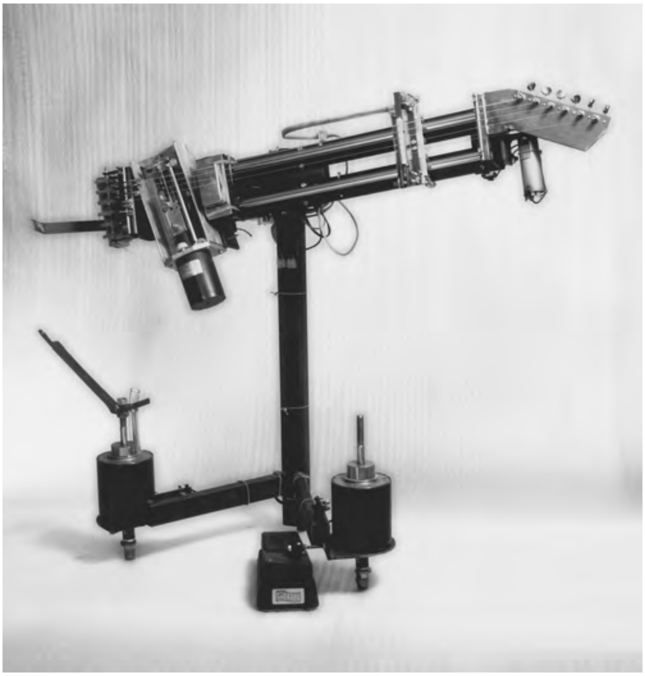

Fig. 5.4.3. Nicolas Anatol Baginsky, *Aglaopheme.* Robots learn by listening to their own and other robots' performances.

significant features of all those, for instance, with dark hair and a moustache. The classification of such "significant features" is not predetermined but are created by the system itself based on the perceived data.[4]

At the "Robotronika" show, Baginsky presented his "Aglaopheme" robot from the "Muses of the Other World" series. These robots use neural nets to learn to perform music. They listen to their own performances and that of other devices near them and try to extract rules. The system can invent "melodies" and improvise. It also develops pure "inhumane music." Human teachers can also interact with it to influence its learning:

The three sirens, "the Muses of the Other World," are partly robots, partly music instrument, and teach themselves to make music. In the assigned programs no knowledge of harmony and oscillation teachings is implemented. Instead, neural networks—coincidentally initialized—learn organizing and unsupervised melody improvisation and Instrumental Virtuosity.[5]

Extreme Performance, Destruction, Mayhem, and Control

For some artists, the military and industrial roots of robotics and machinery research are not neutral. They create artworks that use these technologies to reflect on these antecedents and history. For others, the machines offer opportunities for intense interactions that can offset the passivity of contemporary mediated culture.

Survival Research Labs

Survival Research Labs has a long history of creating events in which machines, teleoperated devices, and robots engage in extravaganzas of destruction and other kinds of extreme behaviors. It was founded by Mark Pauline in 1978, and since then has engaged hundreds of artists, engineers, and others in producing shows seen around the world. Elements have included everything from rocket motors and flame throwers to dead animal carcasses, the latest miniaturized electronics, and Internet control. The performances span the full range of what is called robotics. Many of the devices are radio-controlled by a human crew, while others are programmed for autonomous activities. Often there is an aura of danger for the SRL artists and the audience.

Typically, performances feature weird machines moving toward and away from each other, clobbering or shooting projectiles at each other, spewing flames, and making strange noises. One important goal is converting the technology from its original military or scientific purposes:

> Since its inception, SRL has operated as an organization of creative technicians dedicated to redirecting the techniques, tools, and tenets of industry, science, and the military away from their typical manifestations in practicality, product, or warfare.
>
> We build machines of a fairly large size—they are very extreme. . . . [T]hey are constructed by a basic plan which is the basic cry of physicists everywhere: you want to release the most energy in the shortest period of time.[6]

SRL's performances try to create a nonverbal narrative, a series of connected events that create settings for the machines and their activities. It is an art of spectacle that provides a "counter-narrative" to military research:

Survival Research Labs: ⟨www.srl.org⟩

Fig. 5.4.4. Mark Pauline and Survival Research Labs, *The Unexpected Destruction of Elaborately Engineered Artifacts.* Robots made from industrial waste engage in extreme behavior. SRL Video.

At SRL the lines [between art and technology] are very blurred. The kind of skills and ideas that go into the machines at SRL and the way that technology is portrayed is similar to the way that technology is portrayed in the schemes of the military. The similarities between SRL and the military's use of technology is that we're both trying to extract the most extreme performances out of the devices that we are dealing with, and trying to make a deep impression on people. In our case, we are trying to get an audience to sit still for an hour while trying to present a narrative production with machines as the actors. . . .

The reason you want to have a narrative sense to it is because the ultimate goal of the show is to make it look like it is a real world, like a habitat for these devices—that they belong here and this is what the machines do here. The aesthetics pretty much revolve around that.

SRL demonstrates the uneasy balance of fascination with technology and caution or aversion about its demonic potentialities. In most interviews, SRL tries to avoid specificity about its goals. Rather, they confront audiences with the disequilibrating experience of machines pushed in strange ways and leave the details to the audience and interpreters. Some see the shows as maniacal boys' infatuation with weapons; others see it as a preview of new kinds of mechanical beauty and ritual that may fill a world dominated by synthetic devices:

I think that the relationship that most people have with technology is very formal. In fact, most people have no relationship with technology except through their work: to make money at their jobs. At SRL, we try to take these kinds of things, and use those kinds of clichés and the way they are usually analyzed. We take them, pick them apart, and re-combine them into the images and ideas that we present at the shows. I think for some people it calls into question—reminds or even haunts them—of the things that connect with their day-to-day relationship with technology. . . . I'm accused of having all sorts of political stripes, from neo-Nazi to far left.

The shows are often banned by regulatory agencies. SRL considers it a political act to try to mount shows on its scale, which don't kowtow to safe, acceptable standards and take risks:

I mean, there's so much lame performance art that rich people are into. If the artist wants to get out of the ghetto, they have to be more traditional. My approach is more the opposite—I try to be more out of control. . . .

Even though it's difficult for us to get shows, we always eventually do them. The fact that people seek to interfere with us is only a measure of how threatening it is—which is a measure of how important it is. That's just the way it goes: it comes with the territory. I could obviously organize myself so that I didn't pose a threat. I would be able to get shows left and right and probably be rich and living in a nice house. But to me, that's not my role.

Pauline believes that artists must become much more proactive in working with technology. They need to avoid becoming infatuated with it for its own sake but still try to push it in ways beyond its normal uses. Only in this way can an artist provoke an audience to new understandings:

The fact of the matter is that if artists don't become conversant with technology then they will just be left out of the culture more than they are now. . . . I think that a lot of people who start getting into technology just to get into it for its own sake. You have to be very careful of that. But on the other hand, you can do stuff with technology that you can't do in any other way—and that's the only reason to use it. It's the whole thing that this society respects.

SRL sees technology as a primal force in human culture. Its performances attempt to put audiences in touch with those forces:

> There is this book where Nietzsche basically expounded the idea that technology was the will to power—where we basically will ourselves to be our own gods. We remake ourselves as god, and that's part of technology. You can use it to create forces on a level that can't be explained within the historical realm of the power of individuals like atomic weapons and rockets—things that could not have been imagined as being the domain of humans. Basically, its about the harnessing of natural forces and re-doing them in a more useful image. I think that's what we do at SRL: that's part of the extreme angle that the machines are developed with.

Some see SRL's activities as illustrative of possible human-machine co-evolution. Manuel De Landa's book *War in the Age of Intelligent Machines* posits the idea, based on research on nonlinear systems, that military machines can be seen as a symbiosis between humans and machines. *Wired* magazine organized a trialouge between De Landa, Pauline, and Mark Dery as an interesting way to explore this idea. De Landa offers his view of SRL work:

> What Mark does is push things far from equilibrium, to that point of unpredictability. From the videos I've seen of his performances, I gather that a lot of the experience has to do with the fact that you don't know when these machines are going to attack the audience; the question in everybody's mind is, "Hey, are these guys really in control?"[7]

Pauline describes the way his normal sense of his body fades into the background when he is working on one of the teleoperated machines. De Landa suggests that this connection is an example of the kind of machine-human symbiosis about which he writes. Pauline suggests that it is essential that humans entertain this kind of connection for future survival:

> [T]hat, to me, is the mark of a true machine consciousness—when a mechanical system gets to a point where there's a disjunction between you and what's going on because what's going on is just too complicated or too intense. Systems are getting so complicated that they're out of control in a rational sense.
>
> The role model for the future of human interaction with machines, if we want to avoid our own destruction and regain control, is to start thinking of our interaction with technology in terms of the intuitive, the irrational.

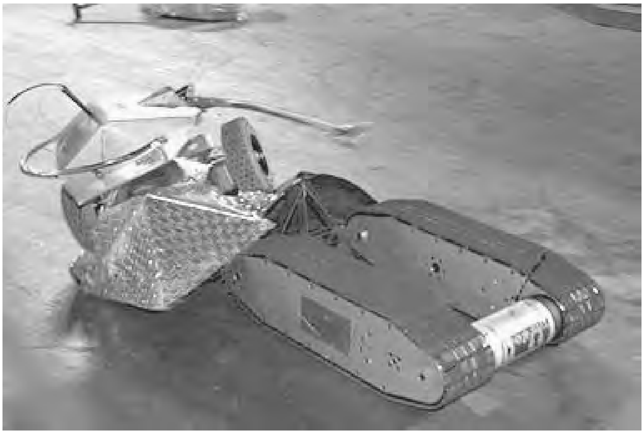

Fig. 5.4.5. *Robot Wars.* Two contestants joust for surpremacy.

"Robot Wars"—Mark Thorpe

Mark Thorpe, whose career included performance art and model building for Industrial Light and Magic (ILM), Lucasfilm's special effects house, organized a new kind of media event called Robot Wars. In these competitions, engineers and artists create robotic devices that do gladiator battle against each other. Elegance, strength, and cleverness are combined to create very strange entities, called sculptures by some and mechanical monsters by others. The "Robot Wars" Web site describes the events:

> Robot Wars is a mechanical sporting event that features radio-controlled robots (and autonomous robots) in a contest of destruction and survival. As a unique blend of sport, theater, art, and engineering, this event draws contestants from all over the U.S. . . . some from overseas. Robots are limited by weight, not size. Heavyweights weigh up to 170 lbs. . . . 300 lbs. for legged robots. A specially designed arena with mechanical hazards, custom lighting, and techno music all add to the drama and excitement of this new sport.[8]

Thorpe traces his development of Robot Wars to his interest in "dangerous toys" and his other experiences in special effects, sculpture, and performance. He attempts to cultivate its wide appeal across particular social groups. Some observers criticize the emphasis on

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Robot Wars: ⟨http://www.robotwars.com⟩

violence. They see Robot Wars as a glorification of destruction in a society already obsessed with violence. Thorpe believes it is a positive antidote to normal violence because of its emphasis on clean competition and its linkage of battle to creativity and innovation.

RW is so popular because of it's unique mix of art, technology, sport, and theater in a way that explores and celebrates basic life issues of survival and destruction without compromising human values—a rare combo in this age of dehumanization and political correctness. . . . RW is necessarily and wonderfully violent. But it is violent in a healthy way. . . . The main thing is that in Robot Wars no one is hurting anyone or being hurt, including animals.[9]

Eric Hobijn

Eric Hobijn produces computer-controlled events that often feature flamethrowers and other body-threatening arrangements. *Delusions of Self-Immolation* was a twelve-meter-long machine that audience members could subject themselves to. A European Media Arts Festival documentation describes *The Dante Organ* flamethrower performance:

Hobijn plays with the observer's secret wishes and hidden desires for spectacular images, his desire for kicks. Different than other media, however, where violence and danger is concealed from the viewer behind the television screen, a form of technology called Hot Hardware has been used here which, via an immediate intensity, removes any sense of distance.[10]

Seemen

Seemen is a loosely organized group of "postindustrial folk artists," engineers, and others who explore the potential of contemporary technology to create events that generate intense interaction for the audience. They see that many media and art forms create a passivity and remoteness from experience that can be counteracted. Dangerous machines and violence are often part of their agenda, but so is intense love. The actions of the robots "poetically symbolize man's struggles and triumphs."

An interview with Kal Spelletich explored some of the ideas underlying Seemen activities. The interviewer asked whether Spelletich sees it as part of the industrial dangerous art movement, such as SRL. He sees technology-mediated intensity as a possible antidote to cultural sloth:

Erik Hobijn: ⟨http://www.v2.nl/Organisatie/V2Text/PresentsE.html#Hobijn⟩
Seemen: ⟨http://www.seemen.org⟩

Fig. 5.4.6. Seemen. Robots built from industrial waste engage in acts of violence and love. Photography © Nicole Rosenthal.

The more people stay at home sitting in front of computers, playing video games and watching movies on video (staying passive audience members) instead of going out and getting real experiences (escapist vs. reality), the more they will be drawn to events that allow them to witness and experience their own mortality and humanity. We will always want to experience live things, To experience something live, not Memorex, Where something may not work as expected, where the outcome is different each time. People want real-life adventures. The more deprived you get the sicker you become. Thrill sports are booming because of this. . . .

I attempt both to give people a cathartic release and to challenge their preconceptions of what art and art content can be. The key is to keep the aesthetic image connected to a narrative or concept. Feasting, celebrating, bingeing, drug abuse, alcoholism, violence, sex, the human condition breaking down and pulling itself back up are all real-life things that can shape and change lives, like Carnival.[11]

The interviewer asked whether using military technology enables an audience to understand war better. It then asked if there wasn't a danger that using violent technology—for example, flamethrowers—just makes audiences more insensitive:

Fire needs context though, just like any other medium, be it paint, plaster, or film. No medium is the be-all end-all that instantly transforms into art. I have used fire as a landscape cleanser, metaphor for male ejaculate, as a river of fire to follow or cross, a waterfall of fire, as a salute to the day, as bad breath from Rush Limbaugh, trees armed with flamethrowers, underwater sea monsters spitting fire from watery depths, flaming robots fucking, fighting, and lovemaking, a bride carrying her own torch. . . . There is nothing wrong with being enraptured by fire. This was the original TV. You can stare at it for hours. It is as beautiful as a landscape with deer, a waterfall, flowers, and trees. But it is as retinal a trap as thick lush gobs of paint.

Seemen is active in the *Burning Man* "techno-pagan" festivals realized in the Nevada desert. They create technological installations that combine cyberpunk, industrial, and techno-experimental elements. Artists working with extreme technology span a wide range, from those focusing on violence to other kinds of intensity. Seemen straddles an interesting area where violence becomes life affirming. The publicity for an event called *Violent Machines Perform Acts of Love* challenges the audience to use machines as tools for engaging a variety of experiences:

Operate machines and robots performing sex acts, caring gestures, violent outbursts, dysfunctional behavior, superhuman effort, effusions of valor, loving strokes, visceral performances, fits of neurosis, fey gesticulations, nearfelt conduct, poetic eruptions, enigmatic follies, glutinous greed, resolving negative feelings, confrontation and resolution, outbursts of sincerity, proclamations of death, emanations of survival and feats of agility, all reckoning your most intimate interactions.

Other Artists and Projects

Christian Ristow, Chip Flynne, and Kimric Smythe (The People Hater Group) create carnival midway robots such as the *Drunken Master,* which has meathook teeth that "can mangle just about anything," and the *Randy Weaver* robot, a lifelike, gun-toting replica of the survivalist. The "orgies of mechanical destruction" are a "reaction to the wired society where we experience more and more of the world through TV screens and computer monitors. . . . Disneyland meets Faces of Death." Other groups exploring the potentials of kinetically activated military and industrial debris include the European groups ***Mutoid Waste Company*** and ***Spiral Tribe.***

The People Hater Group: ⟨http://www.discovery.com/area/technology/robotics/rob1.1.1.html⟩
Mutoid Waste Company: ⟨http://www.third-eye.org.uk/dc11/mutoid.htm⟩
Spiral Tribe: ⟨http://www.nwnet.co.uk/hulmecc/n-23/spiral.htm⟩

Fig. 5.4.7. Louis-Philippe Demers and Bill Vorn, *Court of Miracles.* A machine that moves by limping metaphorically suggests one part of the human condition.

Social Metaphors

Some artists attempt to exploit robots' dual status as artificial machine and vaguely anthropomorphic stand-in to comment on human society.

Louis-Philippe Demers and Bill Vorn

Louis-Philippe Demers and Bill Vorn create rich dramatic installations inhabited by robotic devices that can interact with humans. Their *Scavengers* installation attempts to enable visitors to directly experience a kind of machine life, society, and ecosystem. Here are extracts of the description from the Ars Electronica Web pages:

The installations are deployed in dark hazy spaces, in unusual architectural sites where the viewer is invited to consider an invented habitat created solely for the robot-organisms. . . . The robotic genders are designed on the basis of their behaviors in the habitat, and there are metaphors of natural societies: parasites, scavengers, overpopulation, flocks, etc. The machines are reduced to

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Louis-Philippe Demers and Bill Vorn: ⟨http://www.billvorn.com⟩

their most nominal expression to implement their intended behaviors. A simple hammer machine becomes a rhythmic element at the same time and a parasite when installed judiciously on another robot-organism. . . .

Rituals, hierarchy, chaos, aggregation, the collective versus the individual are among the potential behaviors addressed by the installations. . . . The installations also convey a displacement of sensations, perceptions and expectations: duality, ambiguity, and contradiction are part of the sculptures. The aesthetics of the societies are continuously in conflict when they are not animated. . . . As they move and react, the initial perception is destroyed. What was first seen as the external inert perception, the known experience of the objects, is continuously transformed.[12]

Their *Court of Miracles,* presented at ISEA 97, illustrates their approach of presenting machine worlds that are not "clean," like conventional industrial robots. Here are excerpts from their Web page:

A Cour des Miracles (The Court of Miracles) is an interactive robotic installation . . . spaces that are Surrealistic immersive sites where viewers become both explorers and intruders.

By creating this universe of faked realities loaded with "pain" and "groan," the aim of this work is to induce empathy of the viewer towards these "characters," which are solely articulated metallic structures. . . . Six of these characters have been created to populate the installation: the Begging Machine, the Convulsive Machine, the Crawling Machine, the Harassing Machine, the Heretic Machine, the Limping Machine.[13]

A commentary on the installation by Norie Neumark for ABC National Radio gives some of the flavor of the work, which vibrates between a sixteenth-century tableau and an advanced cyber future scenario:

Although I'm not really a robot lover, there was something about these metallic skeletal pieces, caught in cages, chained to walls, freakishly dismembered, screaming and writhing their agony that engaged me despite my prejudice. The work played at an edge of human-machine that, thanks especially to the sounds—whispering, howling, groanlike—and to the pained distortions of the movements, evoked a disturbing border state that much of the cyborg-mania misses. These miraculous/horrific, simple and strange machine freaks expressed and evoked an alienation from the smooth high-tech control-desire of the computer world as well as suggesting the impossibility of escape.[14]

Other installations include *The Frenchman Lake, Escape Velocity,* and *The Trial.* In a paper entitled "Real Artificial Life as an Immersive Media," Demers and Vorn suggest

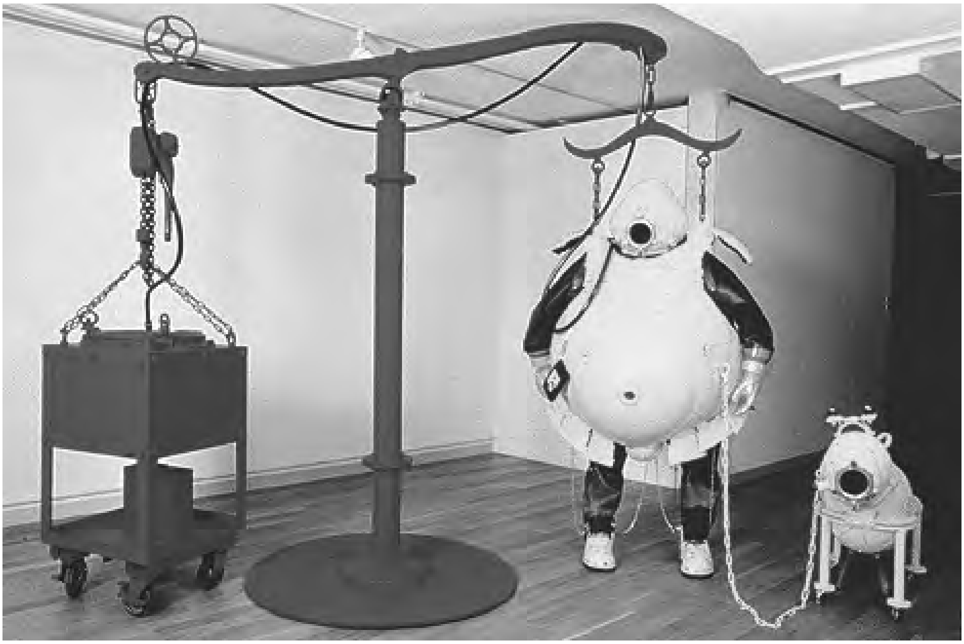

Fig. 5.4.8. Kenji Yanobe, *Yellow Suit.* Survival gear for unknown catastrophes.

that much interactive art is extremely limited in what it does—concentrating attention in a crippled way. Many installations are focused on direct reactive control waiting for commands rather than organically unfolding and evolving in genuine interactivity.[15]

Kenji Yanobe

Kenji Yanobe builds very elaborate robotic devices on the scale of small cars. He also builds robotic "suits" that resemble divers' suits. Many of the devices are large enough for a human to sit inside and operate. These robots play with the ambiguousness of humans' relationships to technology, referencing comic books, animation, and science fiction. Are the humans trapped or augmented? Often, works such as *Survival System Train,* containing cars for food production and water and air purification, seem to suggest preparation for some disaster. Marque Cornblatt's review of a 1997 Yanobe show presents some perspective on the work:

> Yanobe's work, made from industrial salvage, is designed to serve as the artist's personal survival gear as well as tools for conquest and protection in the event of nuclear accident or other disaster.

Looking at this assortment of personal survival suits and protective vehicles made me keenly aware of the isolation caused by our technologically aggressive culture. This armor of radiation-proof lead and glass seems to suggest that in spite of the wonders of science and technology, we are still essentially alone in the world, perhaps even more so, except maybe for the dog.

Yanobe claims that attitudes toward technology in Japan are much more positive than in the West, noting, for example, that Manga comic-book robots are usually portrayed as cute and friendly:

Yanobe . . . believes that in the West, historically we were often guinea pigs for technology and industrial development. The inevitable disasters, nuclear accidents, and environmental damage have fueled a distrust of technology and the big business behind it. In Japan, Yanobe states, technology is often seen as a benevolent force helping the nation develop and expand. . . . The cultural view is a level of intimacy and comfort with technology.[16]

He believes that the Japanese engagement with robotics and futuristic scenarios is a unique cultural strength and wants to build on that in his art. But Yanobe's optimism is mixed with wariness. Technology can run amok. He was concerned with nuclear accidents and the possibilities of widespread disaster:

My generation doesn't know about the war, . . . We were just comfortable in life. I don't know real crime, real war. That's why I want to know what is reality. Even in Japan, I can't understand reality, what is atomic disaster. One day, I plan to go to Chernobyl. I would like to try to see what happens in the world.[17]

He also worries about *otaku* (a Japanese word meaning "obsession"). He sees a shadow side to the fascination with technology and science fiction—an inability to distinguish fantasy and reality. He hopes to create works that straddle both worlds: "My generation is one that went into fantasy and fell in love with characters and stuff like that and animation. I'm from the *otaku* generation, I can see the danger and confusion between fantasy and reality."

Norman White

Norman White was one of the pioneers in electronics- and telecommunications-based art. His robotic installations typically offer social metaphors for relationships between humans. His aesthetics emphasize the importance of behavior in addition to appearance,

Fig. 5.4.9. Norman White, *Helpless Robot.* A robot tries to get help from passersby.

and his exploration of non-art settings. In *Helpless Robot,* a robot tried to engage passing humans to help it get more comfortable. It asked viewers to think about beggars, hustlers, and others who ask passersby for help. As people helped, it became more demanding. Another work reflects on sexual relationships:

Them Fuckin' Robots (1988). Fellow artist Laura Kikauka and I each built an electro-mechanical sex machine (hers, female; mine, male). . . . We then brought these two machines together for a public performance. The male machine, the first and last anthropomorphic robot I've ever built, responds to the magnetic fields generated by the female organ, thereby increasing its rate of breathing and moving its limbs, simultaneously charging a capacitor to strobing "orgasm." The

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Norman White: ⟨http://www.bmts.com/~normill/artpage.html⟩

female machine, on the other hand, is a diverse assemblage including a boiling kettle, a squirting oil pump, a twitching sewing machine treadle, and huge solenoid on a fur-covered board—all hanging from an old bedspring and energized by an electronic power sequencer.

Other Artists and Projects

Jim Whiting's *Unnatural Bodies* explores the metaphoric world of struggling humanity played out with robots. ***Ars Electronica***'s description of *Unnatural Bodies* portrays maimed robot-machines, "cruel-aggressive, electronically controlled figure-ensembles, sensible robots, and desolate machines, who are moving at a horrible scenario. It is populated with legless creatures in cages who can't run away, degenerated twitching, snapping rumps. At the end the danse macabre compresses, heightens, spastically, poundingly, crookedly creeping or hanging, garishly into that cry."[18] ***Mathew Sanderson*** creates robotlike sculptures that reflect on beauty and struggles. He describes his sculptures as "fossils" of a process of transformation from the human state: "The crawling female figure is supposed to look vulnerable and possibly wounded, but yet still full of strength and courage, fighting her way forward towards shelter." ***Ken Feingold***'s *OU* presents a robot half body similar to arcade fortune-telling robots that solicit money and offer to "answer" questions about the future. ***Frank Garvey***'s *Omnicircus* provides an array of robots—beggars, hookers, junkies, thieves, and musicians—surrealistically commenting on the social world. ***The Institute for Applied Autonomy*** is a group of artists who develop "Contestational Robotics" and "Robotic Objectors," which attempt to "invert the traditional relationship between robots and authoritarian power structure" by developing low-cost robots that can be used by "culturally resistant forces" such as *Little Brother,* which gives out pamphlets, and *GraffitiWriter,* which can mark public spaces. ***Adrianne Wortzel*** creates "robotic pageants," such as *Sayonara Diorama* and *Nomad Is an Island,* which combine elements of installation art, theater, and Internet art. In *Globe Theatre* robots moved through the audience taking notes. The events are often broadcast over the Internet via CUSeeMe videoconferencing systems. She received an NSF grant to work in collaboration with engineering professors to explore the control of robotics over the Internet.

Jim Whiting: ⟨http://www.aec.at/fest/fest91e/whitin.html⟩
Mathew Sanderson: ⟨http://www.newwave.co.uk/lou2/description.html⟩
Ken Feingold: ⟨http://www.kenfeingold.com/⟩
Frank Garvey: ⟨http://www.omnicircus.com/⟩
The Institute for Applied Autonomy: ⟨http://www.appliedautonomy.com⟩
Adrianne Wortzel: ⟨http://artnetweb.com/wortzel/⟩

Fig. 5.4.10. Chico MacMurtie, *Amorphic Robot Works.* Panorama of a robot-musician performance installation. Photo: Brian Kane ⟨www.briankane.net⟩.

Extending Robot Motion and Interfaces

Chico MacMurtie

Chico MacMurtie and the Amorphous Robotics Works creates award-winning robotic acrobats and musicians. His installations include operas, dances, and musical forms, often orchestrated by computer MIDI control. His robots perform a great variety of sophisticated motion, pushing the boundaries of how robots can move and methods of linking controllers to the robots. Appreciation of movement and sound is a critical organizing principle for the work. MacMurtie, the director, and tour director Mark Ruch, describe their motivations:

The work is an ongoing endeavor to uncover the primacy of movement and sound. Each machine is inspired or influenced, both, by modern society, and what I physically experience and sense. The whole of this input informs my ideas and work. [MacMurtie]

. . . [A]s there is a beauty and elegance in movement itself, there is equally potent an experience in watching a machine (human or organic in form), struggling to stand, attempting to throw a rock, or playing a drum. These primal activities, when executed by machines, evoke a deep and sometimes emotional reaction. It is the universality of emotional experience which intrigues us, and it is the contrapuntal use of machinery as artistic medium and organic movement as form which, perhaps ironically, combine to provoke these emotional reactions most readily. [Ruch][19]

Work such as *Tumbling Man* and *Walking Trees* concentrated on experiments with motion and alternative forms of control. *Tumbling Man* was a person-shaped robot

Amorphous Robotics Works: ⟨http://cronos.net/~bk/amorphic/info.html⟩

controlled by sensors that were placed on two people's bodies and caused the robot to try to mimic their motions:

Different parts of each participant are, however, connected to the limbs of the robot. Therefore, for instance, it is possible for the arms of one participant to control the arms of the robot, while the legs of the robot are controlled by the legs of the other participant. In order to make the robot carry out the intended movements, the two participants must collaborate. As the work proceeds, the connections can be changed so that the participants must discover the new roles of the interaction. This work is an example of kinetic robotic sculpture which involves interactivity between both participants and the robot.[20]

In the 1998 show "Robotronika," in Vienna, Amorphous Robotics Works and MacMurtie presented *Telescoping Totem-pole,* which explored the merging of robotics with organic forms shaped from malleable rubber inflatables. The "totem pole" attempted to model internal body processes and "represent the human condition":

In various stages, images of viscera unfold from the fabric, heads and premature forms emerge, rising to a promontory position over the elevating form. The symbolic representation of the viscera, heads, and forms being birthed from an organic mass is a reflection of our own internal cycle. Like all things that grow, a recollection of the impulse to arise, and subsequently subside, is generated by an internal clock.[21]

Austin Robot Group

For many years the Austin (Texas) Robot Group, composed of engineers, artists, and hobbyists, have pursued a wide variety of robotic experiments, what they call "cultural robotics." Projects have included robot musicians, robot blimps, cross-country navigators, and humanoid robots: "[T]he Robot Group is busy creating a rattletrap hybrid of weird science and Outsider Art. . . . the thirty-member organization synergizes the artists' desire to make art that reflects the Information Society around them, and the engineers' urge to give vent to their creative impulses."[22]

Austin Robot Group associates David Santos and James Perez create robot blimps. These small devices can be tele-operated or move under autonomous control. Santos's and Perez's projects include experiments such as blimp acrobatics and blimp eye-view

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Austin Robot Group: ⟨http://www.polycosmos.org/robotgrp/rghome.htm⟩

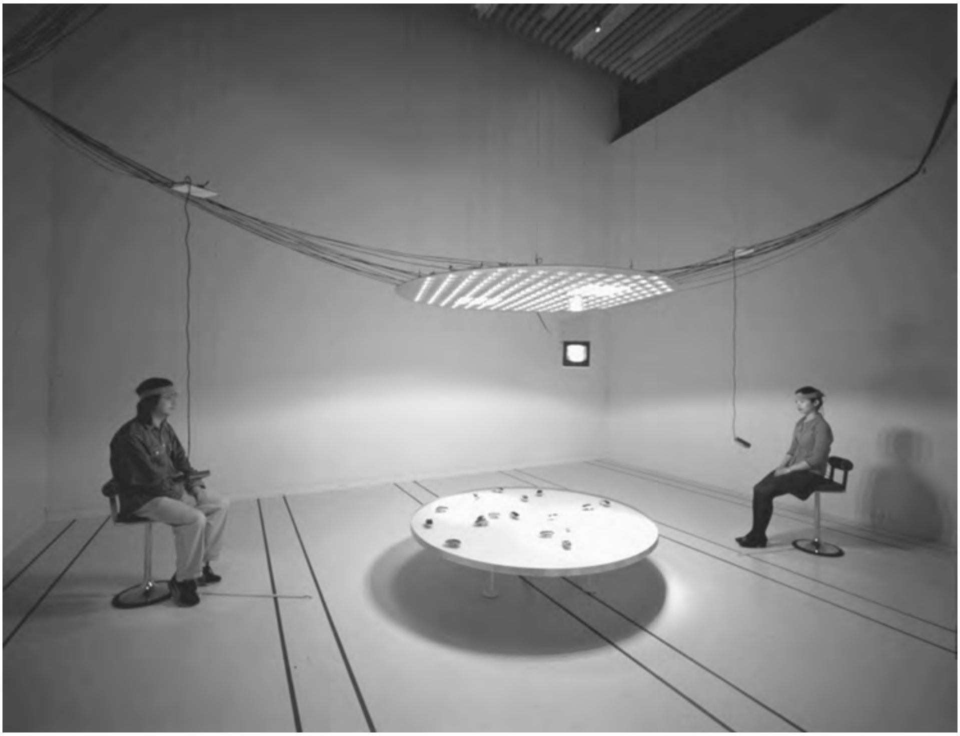

Fig. 5.4.11. Ulrike Gabriel and Otherspace, *Terrain_02.* Brain waves of two persons control the movement of solar-powered robots. Work in the collection of the NTT InterCommunication Center, Tokyo.

projects via wireless cameras. One of their projects was selected as the public art to be installed in the Austin, Texas, airport.[23]

Ulrike Gabriel

Ulrike Gabriel created a series of installations called "Terrain," in which viewers' brain waves affected the motion of a colony of small solar-powered robots. In *Terrain_01,* a single viewer controlled the environment. The installation consists of small mobile robots that have the rudimentary intelligence to pursue light and avoid each other. The viewer's brain wave affects the lights, illuminating the vehicles. These simple behaviors and brain-wave influence result in complex events. A 1993 Ars Electronica description explains:

In *Terrain_01,* a colony of autonomous beings moves within a circular world. On account of system-immanent nonlinear interactions, a complex structural formation develops with the continuous adaptation process of the individuals to the external environmental influences. The "living" movement pattern of the permanently active living beings lures the observer away to fantastic psychological interpretations of their behaviour.[24]

Gabriel worked with Bob O'Kane in creation of "Terrain." O'Kane was a technical specialist who had helped many of the artists at the Institute for New Media realize their works. An interview with O'Kane, connected to the display of "Terrain" in Japan, reveals cultural differences in the ways Western and Japanese viewers responded to the work:

In the West, people sit down and want to be in control of the installation. With the Asian ideas of meditation and relaxation, . . . the willingness to be removed from a situation seems much stronger here. It is generally easier for users here in Tokyo to make the system work, rather than in Frankfurt. There, people were really bothered by the idea that they are responsible for making it move. The viewers stand around the user, looking at him, expecting him to "hurry up and relax!" At the Ars Electronica, someone would sit down and it just wouldn't work. They would close their eyes, so they remove themselves from the situation. They relax, the robots start moving, they open their eyes to watch them, and then the lights would go off again, because they started to think about it, and the brain sensors picked up that activity. This would happen several times, because they wanted to be in control. The ultimate goal is to be able to watch the robots while they move, to "bear it with open eyes," as Gabriel describes it, to be rewarded, to observe a function of what you're doing.[25]

The next version, *Terrain_02,* used the comparison of two viewers' brain waves to orchestrate the control.[26]

Martin Spanjaard

Martin Spanjaard creates robotic talking balls named *Adelbrecht.* These unassuming balls periodically start rolling themselves about, knocking into things, and occasionally talking about life. They sense position, bumps, ambient sound level, touch, and low batteries. The ball also computes two emotional states—mood and lust. Various actions affect these states, for example, petting heightens lust but getting stuck decreases lust and increases anger. *Adelbrecht* was shown in the European Media Arts Festival and SIGGRAPH art shows. Spanjaard describes his interest in the human-machine boundary:

To describe this ball named *Adelbrecht* in the shortest possible terms: it's an anthropomorphised protozoa robot in the form of a ball forty cm in diameter. It, or let's say "he," talks about his life: rolling, bumping, people touching him, and so on, about the things happening in the life

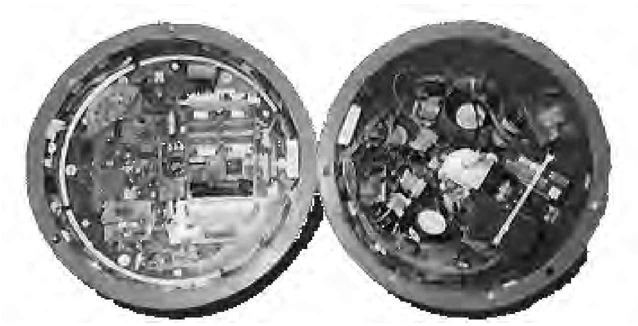

Fig. 5.4.12. Martin Spanjaard, *Adelbrecht.* The inside of a robot ball that rolls about, sensing position, touch, and sound, and talks about life.

of a ball. He confronts us with the boundaries between Being and Machine, with the transition from It to Him. Because I have written his behaviour, I function as example and source of inspiration. He is therefore also a self-portrait. Finally, he is an actor, trying to interest us enough to follow him for a spell. . . . An outer loop program uses all this (plus a diversity of sensorial information) to generate speech and behaviour: understandable, meaningful, but not predictable.[27]

In future versions, Spannjaard proposes to explore more complex computing based on fuzzy logic and a kind of "dreaming" in which the ball would contemplate its record of interactions stored from the time it was "awake" and moving.

Stephen Wilson

I created an installation called *Demon Seed,* which explored human tendencies to project evil onto technologies not fully understood. Four small moving robot arms organized themselves into a "robot dance troupe." Audience members could use a squeeze interface to influence the troupe. The Web site documentation explains:

Four computer-controlled robots "danced" in front of digitized images of demons from various world cultures. The computer choreographed the movements of the robot dance troupe. The choreography created synchronized motions that were simultaneously graceful and frightening.

Stephen Wilson: ⟨http://userwww.sfsu.edu/~swilson/art/demon/demon.html⟩

Fig. 5.4.13. Stephen Wilson, *Demon Seed.* A robot dance troupe is influenced by viewers' actions with a squeeze rod.

Each robot was costumed with objects appropriate to the culture of the images it danced in front of. One of the robots periodically could be controlled by audience members via two velvet-covered squeeze rods. Sometimes the squeezer would be invited to speak into a microphone. The robot they were controlling would then move and speak with computer-transformed versions of their voice. The installation probed the human tendency to project our fears and demons into objects we don't understand and can't control. It also explored touch and body motion as new visceral channels with which we will be able to communicate with computers and robots.

Robot Architecture

Many decades ago Nicholas Negroponte developed the idea of flexible robotic architecture. He asked why our architectural structures should have fixed forms when evolving computer and robotic technology created the opportunity to make buildings that could be dynamically adapted to different functions, persons, and contexts. He founded the Architecture Machine Group at MIT, which eventually evolved into the Media Lab. His early work called *Seek* created a computer-mediated environment for gerbils in

Fig. 5.4.14. Ted Krueger, *Responsive Rods.* Studies for robotic architecture.

which a robotic arm dynamically tried to arrange wooden blocks in a pattern based on the natural runs of the gerbils. Contemporary researchers continue this kind of inquiry.

Ted Krueger

Ted Krueger updates the ideas of flexible architecture to include ideas about new materials, artificial life, and sophisticated computer-mediated interactive intelligence. His paper "Like a Second Skin," presented at ISEA95, suggests that our present architectural models are unnecessarily timid:

Is this only a metaphoric operation? We make architecture out of the most inert and durable materials available: stone, glass, steel, reinforced concrete, or wood. We're unsure about plastics. To speak of a body, especially in the vicinity of epidermis, is to recall almost the opposite quality on every count—infirm, perishable, mutable, and frequently anti-inert. . . .

In this paper, I argue for the possibility of an intelligent and interactive architecture conceived of as a metadermis referencing recent work in the fields of mobile robotics, intelligent structures and skins, and interactive materials. These developments can serve as both a source of technical information and as a methodology by which architecture may develop qualities which are currently considered to be available only within the organic realm.[28]

He notes that much can be learned and adapted from other technologies. For example, fiber optics allow for the sensing of almost all aspects of life, such as position, orientation, rotation, pressure, strain, velocity, acceleration, and vibration. The shrinking of computers means that everything can be intelligently interactive—the idea of inertness may disappear. He suggests that current thought about "intelligent buildings" is primitive in its pursuit of optimization and efficiency. Organic life uses other methods to achieve robustness: "There is no necessary link between optimization and intelligence. It is possible that they are antagonistic. By inspection, one finds that many systems occurring in nature are not optimized but are rather a collection of apparently redundant and residual processes."

Later papers, "Autonomous Architecture," presented at the CAIIA conference Consciousness Reframed: Art and Consciousness in the Post-Biological Era, and "Symbiotic Architecture," presented at ISEA97, suggest that autonomy is a critical component for intelligent architecture. Enrichment of the variety of sensor inputs is useful for developing these kinds of autonomous agents. He extensively builds on the ideas of Rodney Brooks:

The availability of a wide range of sensing technologies suggests that the kind of awareness developed by architectural entities may be foreign to human experience. . . . The deepest levels of integration will arise from situations in which the representational systems are derived from the experiential.

The robot may, in fact, communicate with itself via the environment. The results of an activity are given by changes to the robot's context and may be directly perceived and made use of by other sensors. This is more efficient than passing the projected consequences of the action to a centralized comprehensive model and then verifying the model relative to the actual context.[29]

"Meterotic Architecture," presented at Consciousness Reframed II, argues that new "smart biomaterials" will enable artists and architects to embed distributed intelligence in the same materials that are used for construction.

Summary: Kinetics and Robots—Hybrids of Art and Science

Mechanics and electronics have allowed artists to create sculptures and installations that play in time. One could think of them as machine theater. Kinetic and sound artists augmented technology to create fantastic objects and spaces that were sensually interesting, comments on the scientific/technological nature of the world, and often explored other personal or cultural themes. In later years, much of the kinetics energy is focused on robotics.

Fascinating robotics research is progressing in scientific research institutes and artists' studios. The robot heritage stretches back to both sculpture and machines. Researchers seek to develop both the "bodies" and "minds" of these entities, and attempt to enhance the sophistication of the robots' abilities to move, sense, interact with humans, understand, plan, and act. Some work on models derived from animals and humans; others seek to create totally new kinds of behavior. Both seek to push the limits of human ingenuity and wonder about the implications of what they create. The artists' robots sometimes explore concepts of characterization and social metaphor.

Eduardo Kac and Marcel.li Antunez Roca, both artists who work with robotics and technological extensions of the body, drafted a statement after their participation in a robot art show called "Metamachines." They attempted to clarify what they saw as the unique qualities of robot art (autonomy and sophisticated intelligence) and to assert the need for changing art and cultural perspectives:

> Expanding the narrow definition of robots in science, engineering, and industry, art robots make room for social criticism, personal concerns, and the free play of imagination and fantasy. Robots are objects that work in time and space. Their open and diverse spatio-temporal structures are capable of specific responses to differing stimuli. Some of the visual forms that robotic art can take include autonomous real-space agents, biomorphic automata, electronic prosthetics integrated with living organisms, and telerobots (including webots).
>
> Robots are not only objects to be perceived by the public—as is the case with all other art forms—but are themselves capable of perceiving the public, responding according to the possibilities of their sensors. Robots display behavior. Robotic behavior can be mimetic, synthetic, or a combination of both. Simulating physical and temporal aspects of our existence, robots are capable of inventing new behaviors.
>
> One of the crucial concerns of robotic art is the nature of a robot's behavior: Is it autonomous, semi-autonomous, responsive, interactive, adaptive, organic, adaptable, telepresential, or otherwise? The behavior of other agents with which robots may interact is also key to robotic art. The interplay that occurs between all involved in a given piece (robots, humans, etc.) defines the

specific qualities of that piece. . . . Robots belong to a new category of objects and situations disruptive to the traditional taxonomy of art.[30]

Notes

1. M. Apostolos, "Robot Choreography," *Leonardo* 23(1990): 1.

2. M. Apostolos, "Sensual Science," ⟨http://www-leland.stanford.edu/class/ee380⟩.

3. S. Penny, "Embodied Cultural Agents," ⟨http://www-art.cfa.cmu.edu/www-penny/index.html⟩.

4. N. Baginsky, "Description of the *Narcissism* Project," ⟨http://www.provi.de/~nab/nab_int3.htm⟩.

5. N. Baginsky, "Description of Aglaopheme," ⟨http://robot.t0.or.at/exhib/baginsky.htm⟩.

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8. M. Thorpe, "Description of Robot Wars," ⟨http://www.robotwars.com/rwi/⟩.

9. Ibid.

10. European Media Arts Festival, "Description of Hobijn Performance," ⟨http://www.emaf.de/english/perform.htm⟩.

11. K. Spelletich, "Interview for a Book Called *Transitions,*" ⟨http://www.laughingsquid.com/seemen/⟩.

12. Ars Electronica, "*Scavengers* Description," ⟨http://193.170.192.5/prix/1996/E96auszI-scavengers.html⟩.

13. B. Vorn, "*Court of Miracles* Description," ⟨http://www.comm.uqam.ca/~vorn/chaos.html⟩.

14. N. Neumark, "Commentary on *Court of Miracles,*" ⟨http://www.comm.uqam.ca/~vorn/CdM/CdMcritique1F.html⟩.

15. Paper presented at the Convergence: Fifth Biennial Symposium for Arts and Technology, in 1995. (Also available at ⟨http://www.comm.uqam.ca/~vorn/chaos.html⟩.)

16. M. Cornblatt, "Review of Yanobe Show," ⟨http://www.sfbg.com/AandE/31/25/Art/index.html⟩.

17. Yanobe, "Interview," ⟨http://www.giantrobot.com/issue8/kenji/index.html⟩.

18. Ars Electronica, "Description of *Unnatural Bodies,*" ⟨http://www.aec.at/fest/fest91e/whitin.html⟩.

19. C. MacMurtie and M. Ruch, "Artist Statements," ⟨http://cronos.net/~bk/amorphic/info.html⟩.

20. C. MacMurtie, "*Tumbling Man* Description," ⟨http://cronos.net/~bk/amorphic/⟩.

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