

## C O N T E N T S

## [ f e a t u r e s ]

## SPECIAL REPORT: ART &amp; AESTHETICISM

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Ken Goldberg, Artist and Engineer. Professor of Industrial Engineering and Operations Research, Electrical Engineering and Computer Science.



Carole Hickman,  
Professor of Integrative  
Biology and Curator for  
the University of  
California, Berkeley  
Museum of Paleontology



# Ken Goldberg



Photo by Martin Sundberg

Ken Goldberg earned an undergraduate degree in Electrical Engineering at the University of Pennsylvania before going on to receive his PhD in the School of Computer Sciences at Carnegie Mellon University in 1990. He has been teaching at the University of California, Berkeley since 1995, where he aided in founding the Art, Technology, and Culture Colloquium. He has also acted as a visiting professor at MIT and the San Francisco Art Institute.

Additionally, Professor Goldberg is the recipient of the Young Investigator Award (1994) and the Presidential Faculty Fellowship (1995), awarded by the National Science Foundation. More recently, he received the Major Educational Innovation Award (2001) from the Institute of Electrical and Electronics Engineers and in 2000 the Joseph Engelberger Award (Robotics) from the Robot Industries Association. Goldberg's work as an artist has also been recognized and awarded at the Festival for Independent Visual Arts in Montreal and at the Interactive Media Festival in Los Angeles.

As both an engineer and an artist, Professor Ken Goldberg has created a link between the worlds of art and science. While the focus of Prof. Goldberg's work and study has been robotics and industrial automation, the application of these studies to the field of art has lead to the creation of a collection of unconventional and experimental projects. Such projects include *The Telegarden* and *Demonstrate*, which blend robotics and the internet as an interactive media.

**Berkeley Scientific Interview**

By: Liat Zavodivker, Deeshali Patel,  
Shail Gala, and Cynthia Hsu  
Biography by Jennifer Moitoza



**BSJ:** Which came first? Did you decide to be an artist first or an engineer?

**Ken Goldberg:** As a kid I was interested in art, in being a doctor, and in being an architect. My father and grandfather were engineers. I decided to study as an engineer because it was practical. In my family that is very important: earn a living first and then you can do your artwork. As I was working in engineering, I found that it gave me insights into how technology can be both subject and material for art.

**BSJ:** There is often a conflict between science and art. Artists are often criticized for being impractical while scientists are criticized for being not very expressive. Has your reputation as an artist ever hurt your reputation as an engineer or vice versa?

**Ken Goldberg:** In 1959 C. P. Snow wrote about the "Two Cultures" of Humanities and Sciences. I think it's still relevant. These cultures still have very different styles and personalities. Today with digital technology there are many people crossing over both between art and science or engineering. Some have said to me, "...be careful because art is not going to help your career as an engineer." So for the first few years I kept a low profile about my art at work. But increasingly I was encouraged. My colleagues especially here at Berkeley said, "...you should. It's a part of what you do and it is a valuable contribution."

**BSJ:** Can you think of any one incident when you have had to deal with a conflict between your interests?

**Ken Goldberg:** I was lucky because engineering became cool in the art world in the past decade. The art world is very conservative. The mainstream art world is mistrustful of technology. It's taken something like 40 years for video art to really become accepted and media art has moved much more rapidly but it is still considered a small sub-area or genre within contemporary art. Video art now has been in major museums and art shows. That has actually been very helpful because now I have a community.

**BSJ:** Was there a clear turning point when you decided to put the two areas together? And how do you think art and engineering are related to each other?

**Ken Goldberg:** Fundamentally, they are both very creative. I think artists don't always give engineers credit but engineers are solving

problems. They are trying to come up with new ideas, new theories, new methods, new proofs, new algorithms, new devices, and new applications. They are extremely creative. And they develop a sense of "taste" that I think is very analogous to the aesthetics of an artist.

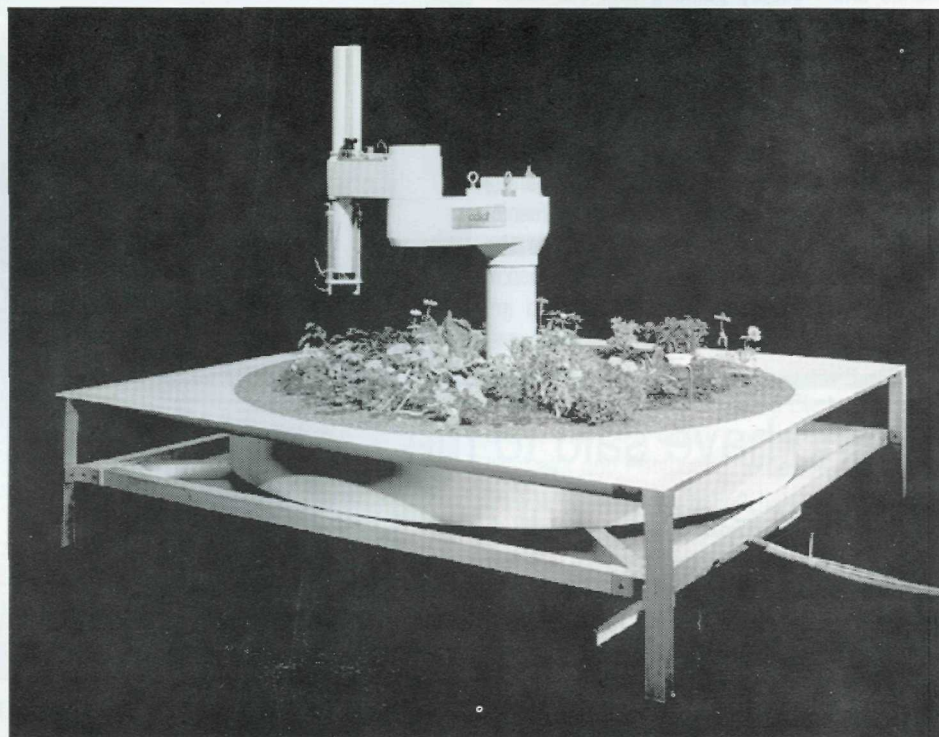
An example I often like to speak about is as follows: When an artist comes into a laboratory and sees a bunch of equations written down on the board and they see some journal paper, they look at it and they say, "wow, I don't understand any of this. It must be brilliant". And we know as engineers that there are a lot of things that get published that are not so brilliant. They may contain lots of equations but they are still not good engineering, not good research. On the other hand, the engineer walks into the art gallery and he sees a bunch of stuffed animals lying on the floor and his reaction is "wow, I don't understand any of this. This must be complete garbage." That asymmetry always surprised me that culture I think at large tends to give engineers and scientists the benefit of the doubt and not necessarily vice versa for the artists because a lot of artwork is misunderstood and misinterpreted.

With something that is so abstract, it requires just as much training and, if you will, scholarship to be a good artist as it does to be a good engineering. You have to know the history, you have to know all the theories that went before, you have to know what's hot, and what are the new things that are happening. For example, it

does no good at all to recreate exactly the same thing as what somebody else did and be ignorant of it. An artist makes this mistake sometimes and if engineers make it, it's the same problem. In both cases, you are constantly both learning what everybody else is doing and trying to intuitively figure out what's the new thing that I can do that no one else has thought of before, and that's perfectly applicable to both areas.

**BSJ:** In your experience, are art and science inter-dependent or perhaps one more dependent on the other? For example, if you had a project that had both an engineering purpose and artistic value, does one have to be more important than the other?

**Ken Goldberg:** The criteria I try to use; and I don't claim to succeed all the time, is that I want to make projects or artworks that are both technologically and artistically innovative. An artwork should present a new perspective, a new idea. One other side it should also work well. I don't want to put an artwork out there that's rickety and is going to be constantly breaking down. We spend a lot of time in my lab developing projects and making sure everything works. I work with the best engineers I can and do a lot of testing so that we can create something that we can really be proud of as engineers. And the other side of it is the aesthetics; the design and form of the system should also



A photo of the telegarden, the first ever interactive garden on the web. *Courtesy of Ken Goldberg*



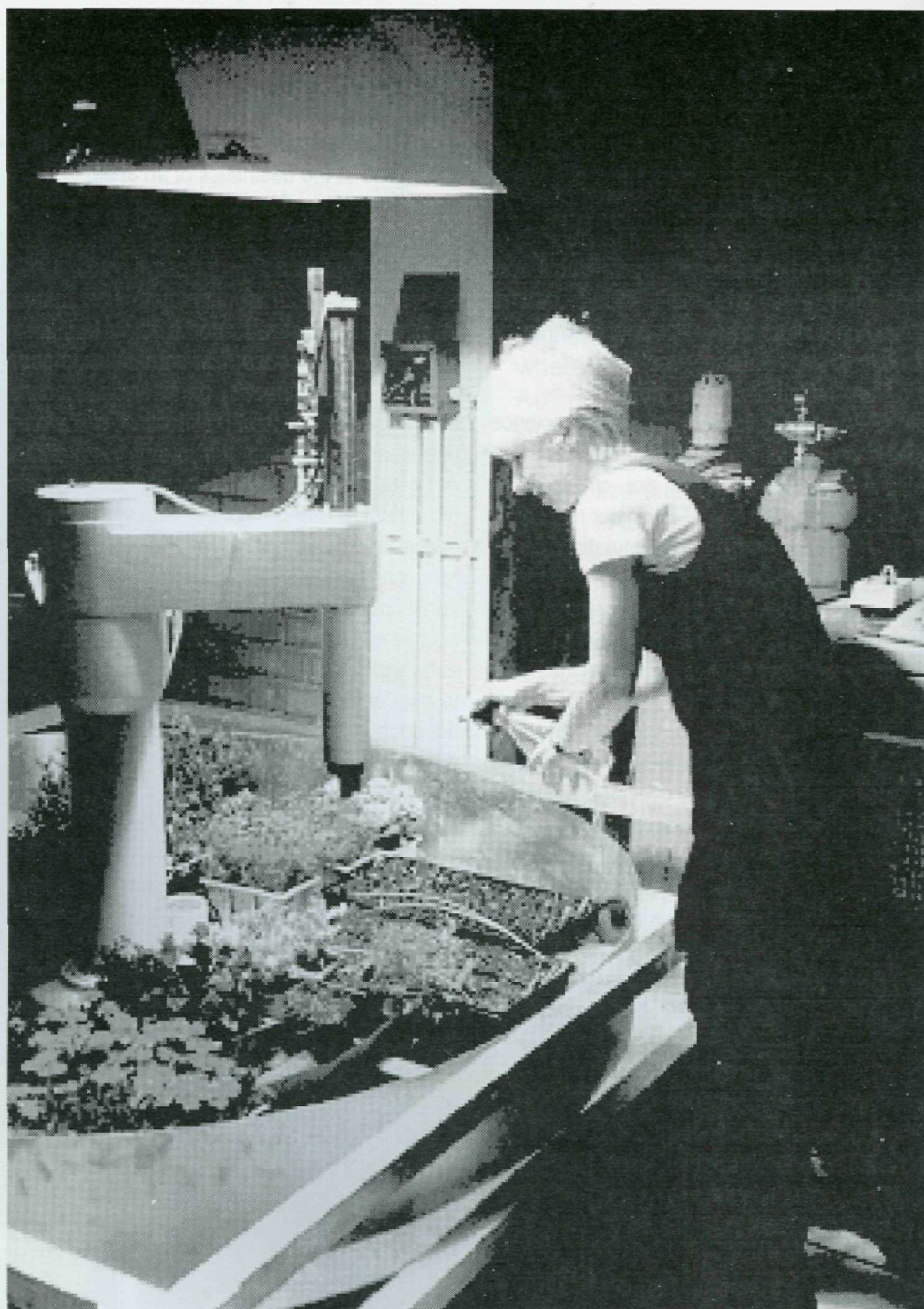
be elegant. I get a lot of outside designers involved and they work with us looking at the interfaces, graphics, fonts and the colors, so I really try to satisfy both of these two sets of criteria and it is demanding in that regard.

**BSJ:** In general, how would you define art?

**Ken Goldberg:** Art should be surprising. I know that according to many people art should be beautiful, pleasing, etc. To me that is just one view but contemporary art is really about surprise. As you know, surprise can be positive like a birthday party when you want it or it can be something negative like stubbing your toe. The idea is that it should be something you didn't expect but you see it, understand it and it teaches you something. I am more interested in the conceptual aspect than just beautiful pictures or sculptures.

**BSJ:** Can you please, briefly speak about your involvement with network robotics.

**Ken Goldberg:** That is an interesting case of art influencing engineering, where I sometimes question if we would've gotten involved in that research direction if it wasn't for my interest in artwork. That started when I was a grad student, doing pure research, just mathematical analysis of robots, geometry, and mechanics. And we were doing these experiments with robots in the lab. And so one night some friends and I started painting with this robot arm, just touching the arm to a brush, and I became very interested by this and just spent a lot of time, a lot of late nights in the lab with these industrial robot arms and sheets of paper, painting things. The paintings were never very good, there was always something missing; they always looked cold. Even though it wasn't like a laser printer, they had lots of brush strokes and dips and everything, but it wasn't very satisfying. So, I became interested in "watching the robot move". The next step was



An assistant watering the Telegarden as it grows.  
*Courtesy of Ken Goldberg*

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Some have said to me, "...be careful because art is not going to help your career as an engineer."

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to actually bring a robot out into a gallery, so we did that in two shows, and one of them we put months of preparation in getting the cable, the

power, and installing the thing, and everything else in the museum; it ended up being in the gallery for about four weeks. When the Net

came along, it hit me that suddenly you could create a robot on the net and you could essentially have an operation where people could come in from anywhere in the world, twenty-four hours a day, seven days a week, and you could leave it on out there for as long as you want it. That was the motivation, and then we started building the equipment, and got credit for the first robot on the internet in 1994, and then there was the Telegarden.

**BSJ:** Can you elaborate on Telegarden?

**Ken Goldberg:** The Telegarden was a garden



on the web, and we attached a big industrial robot arm to a planter we built around it. It was actually that exact same arm, so you see its size. Imagine about a nine-foot planter around the outside, and its sort of circular breadth. Then what we did was we attached to that a camera, right at the tip, and irrigation, so that it could water the garden where you moved it. It also had pneumatics so that it could reach down and dig a hole, suck up a seed, drop the seed in a hole, cover the hole, and water it, so you could actually plant seeds and water them, that was there, Telegarden over the internet. The thing that surprised us was you do this online; it's an artwork and it was meant to talk about the limitations, ultimately, of technology, but when you are somewhere sitting in the world, the last thing you want to do is garden; I mean, it's very useful for getting information but it's not really a substitute for the hands-on kind of experience. Bear in mind that was a critical but ironic or absurd application of technology but a lot of people missed that. They just saw it as "Oh, this is sort of cool," and spent a lot of time gardening.

One surprising thing for us was that some people were asking, "Was there a real garden?" And this is a very interesting question of, if you're on a computer, and you're interacting, it is actually very feasible to fake. One might take a real garden, take a bunch of pictures, throw them in an array, a database, and as you clicked, we would just give you the

images; how would you know? Some people started asking and that caught us completely off guard because we were building this robot, and working on the irrigation, and lots of piping, and all kinds of stuff, but then we really thought about it, and said, "You know what? It's true, it could be fake." But then, I started talking to Berkeley's distinguished Professor of Philosophy, Hubert Dreyfus. He pointed out that this a very old question. It's actually what Descartes asked, which leads to modern science, which is, "Well, how do I know that anything that I'm looking at through a microscope is real?" In fact, early microscopes had a lot of flaws; there were little hairs on the lens and they thought there was something there; there were weird color effects, phase shifts, and things; the early lenses were very bad. So there was a lot of inherent doubt, and that actually leads to the scientific method, which was all based on doubt: "Don't believe anything until you've verified it through different types of modalities, or the experiment has been repeated by others, et cetera," and that's been a much firmer footing for all of our modern technology. What I'm getting at there is that I think that through artwork, the effort of putting them together and getting them functional and operational and putting them out there, is that once people explore them and interact with them you'll learn from them yourself.

**BSJ:** Do you think that artificial intelligence can ever progress to a point where heuristically or

aesthetically it's as competent as the human mind?

**Ken Goldberg:** I really feel like an agnostic on that question; I don't know. I'm very interested in robots and the physical interactions. Do I think that robots will ever be as graceful and dexterous as humans? No. I think it's amazing how little we've been able to achieve in the last fifty years of robotics research, I mean, it gives you ultimately much more appreciation for the natural world. A cockroach is far more sophisticated than the best robot we know how to make right now, in terms of power consumption and responsiveness; there's no robot ever made that you couldn't step on in two seconds if you wanted to. In physicality, I think to recreate the body is going to be extremely hard. I mean, I think it's easy to make things that can fool some of the people, some of the time, but I think it's going to be a long way off; I think we are really far away. But that's not my real focus research area, actually; we really look at the physical, mechanical aspects.

**BSJ:** In terms of modern computer and engineering technology besides the internet, which you've mentioned that you've used a lot, how do other developments, for example computer-aided drafting or improvements in computer graphics change the way people look at art and computers, particularly art and engineering combined?

**Ken Goldberg:** Interestingly, if you look back, there was something happening even before the Internet emerged which was *Wired* magazine; it started around 1992. There was something in the air, when artists and designers started really looking seriously at computers. You may argue that it started even earlier, but it sort of hit a critical mass in the early nineties. You suddenly had a sense of the tools becoming easy enough to use; the cost was low enough that artists really could sit down and learn the tools, so it started becoming used in art schools; people were using Photoshop regularly, actually using computer tools like Illustrator and Photoshop, to design a painting, before we actually painted them, or design a sculpture. Then the Internet came out and it was this thing where everybody essentially had to be somewhat of a designer, had to have some skills of putting things together, to put websites together, and then, it also opened the doors. There's a barrier that still exists with artwork because people feel a little intimidated, if they're going into a gallery. Going to an art gallery can feel like work. But I think that with



A view of the campus from the Demonstrate camera, which allowed observers to zoom in at amazing magnitudes. *Courtesy Ken Goldberg and [Demonstrate.berkeley.edu](http://Demonstrate.berkeley.edu)*



the Internet, that barrier sort of drops, because you're surfing around and you go check out an artwork. It's right there; you can look at it. Right there you have a much bigger audience, and then a much bigger group of people who could get involved with it. I think that lead to a sort of tipping point where working with computers before was considered "not cool" from an art perspective. Then art suddenly became cool, and then every artist wanted to know what was going on with technology. How old were you in 1990?

**BSJ:** Seven.

**Ken Goldberg:** I was 29, now I'm over the hill! In 1990, there were no cell phones, and some people, very few people had email; it was just a whole different universe. Then there's the other thing you mentioned, graphics, computer graphics, and computers themselves have become so much more sophisticated. I was looking at some of the tools that are out there to do editing and home video and audio and mixing are so much more available and extensive and computers can definitely do incredible things, create graphics, videos, games, music, et cetera, and I think all those things are where technology has been a huge catalyst for art.

**BSJ:** From your ideas, art is more of a mainstream thing that everyone can do. Do you think that's a positive direction?

**Ken Goldberg:** Definitely, there was this poll they did, "What does the art museum most remind you of?" and the answer was church. I'm very much in favor of art being all around. You know, it comes back to the surprise factor; you have more chance of surprising someone if they don't know that they're walking into a museum, they instead just sort of stumble on it, and go, "What is that?" and so they learn something.

**BSJ:** Your recent project, *Demonstrate*, depicts a vision of art with stunning and sometimes disturbing realism; based on this, does art necessarily have to be beautiful, or can most technical aspects of science and engineering, like cameras, be considered an art form?

**Ken Goldberg:** It depends on the context. The images that were taken by the *Demonstrate* robotic web camera were not all beautiful by any means. At the same time, I think that this artwork is, as some artwork is, shocking, or it's quite disturbing; like photographs of dead bodies or of nuclear explosions. There's a question; I mean, conceptually the question is, "What is the idea? What is being exposed

here?" With *Demonstrate*, the range of images that were captured by the camera provided a cross section of what people were looking at. It was not beautiful, it's the concept of the whole project that is the message, if you will.

**BSJ:** What was the big picture of the

technology, and I think that's very understandable. I'm uncomfortable with this technology also (laughs), but I think that it's very important to get people to be aware of it.

**BSJ:** Was it surprising that people were being watched by cameras at the time or was it more



Photo by Martin Sundberg

*Demonstrate* project?

**Ken Goldberg:** The *Demonstrate* project aimed to raise questions, and get people thinking. I believe it's much better to know about technology than to remain blissfully unaware. Some people were uncomfortable with the

in the fact that people could control what they were watching on Sproul Plaza?

**Ken Goldberg:** Both. I think it was largely that people were surprised that cameras were that powerful and that they were able to zoom in at that kind of level of detail. A camera that's





Another breathtaking image of Berkeley's Ludwig Fountain and day to day activity.  
*Courtesy of Ken Goldberg and [demonstrate.berkeley.edu](http://demonstrate.berkeley.edu)*

ostensibly five stories up can zoom in fairly close, and that camera is only of intermediate sophistication; there are much more sophisticated ones being developed, and once you realize that, it is a discomforting idea. I hope people don't blame the messenger!

**BSJ:** Do you think that Demonstrate met its purpose while it lasted?

**Ken Goldberg:** Yes. We exposed the technology; over 4000 people registered online. I think that it got a lot of discussions going; from what I can gather informally from people I know there were a lot of discussions that went on about it, thinking about privacy. It's one thing to read this sort of article on privacy in the abstract, but I think it's another thing to bring the issues into your own backyard and say, "Hey, this is going to affect all of us."

**BSJ:** Why was the project shut down, and more importantly, do you have any regrets about the project being shut down?

**Ken Goldberg:** Demonstrate was always intended to have a finite duration. It was designed around the Free Speech Movement, and after the anniversary was over, it seemed like a natural time to take it down. It required, more than we expected it to, a lot of effort to notify as many people as we could about the camera, so we had these tables on out on

Sproul, we were putting up posters and flyers, and that took a lot of time. Also, monitoring of what was happening took a lot of energy too, so we couldn't sustain that forever. I talked about this with someone who said we spent four months developing it and it was only up for six weeks. I pointed out that in high-energy physics, they work for two or three years developing an experiment and it's over in a picosecond. If you measure it in terms of how many people saw the project, we know that at least four thousand, one-hundred people registered at the website, and something like twelve hundred pictures were taken, so the numbers were much higher than those you see at an art show.

**BSJ:** Now, this is a philosophical question: given all your experience using robots and seeing the mechanical interpretation, is there something about physical beauty which is beyond the scope of mathematical understanding, and what do you think it is?

**Ken Goldberg:** Mathematics is a very good way of expressing things in a rigorous and crisp, formal way, but there are so many things we can't express formally, for example, what makes something beautiful or novel. We can all recognize something and say, "Oh, that's new," but having a computer recognize something as new? That's not yet possible. Mathematics is beautiful formalism, but there

are many things that we don't know how to put into that framework, and I don't think we'll know within the perceivable future.

**BSJ:** Finally, what role, if any, do you envision artwork playing in future technological advances?

**Ken Goldberg:** Technology benefits art; I think that's very clear. Does art benefit technology? Yes, because both of them share an emphasis on creativity and innovation. I think that's why I think art and technology are very comfortable bedfellows here at Berkeley. The very innovative researchers in technology are by their nature creative, and they appreciate art. I think that in other places in the world, it's not always the case, and there's a big rift between the two, a lot of mistrust. Engineers are, I think, inspired by artwork, inspired by the way artists approach the world, and I think they'll end up being better engineers as a result of that. Some people say, "What are the practical benefits of going to the moon?" One could ask the same thing about artwork: "What are the practical benefits of artwork?" It's much more interesting to think about the environment that results from having artists and artwork around; how that encourages creativity and exploration for scientists, engineers, and all scholars.