

Telerobots

By Erico Guizzo

In this issue, Erico Guizzo (EG) interviews Ken Goldberg (KG), IEEE Fellow and engineering professor at the University of California, Berkeley, about telerobots, androids, and Heidegger.

EG: In the past year, six companies started selling telepresence robots [1]. I tested two of the robots myself, discussing at length their technical merits as well as their practical shortcomings. Telepresence robots didn't come out of nowhere; they stem from a convergence of different technologies, each with its own history. The advent of robotic telepresence also reflects a powerful trend where many of us are becoming ever more connected and available. What made these robots possible now? What's so appealing about roaming around as a machine in a remote place? And where is this technology taking us, literally and figuratively?

To explore these themes, I spoke with Ken Goldberg (Figure 1), IEEE Fellow and engineering professor at the University of California, Berkeley, and a member of *IEEE Spectrum's* editorial advisory board. When he's not developing geometric algorithms for automation or prototyping robot cameras to spot wild birds [2] or computer-controlled flexible needles that steer through soft tissues [3], he's delving into the interactions between technology, art, and media. If anyone can make a connection between robots and Heidegger, it's Ken.

EG: I recently asked Marvin Minsky what he thought of current



Figure 1. Ken Goldberg served as a RAS Vice President of Technical Activities from 2006 to 2009. He studied algorithmic automation, medical robotics, and networked telerobotics. He also cotaught a course at UC Berkeley on the philosophy of technology. (Photo courtesy of Kathrin Miller.)

telepresence robots. He complained that they don't have legs. And I've seen other people complaining that they don't have arms. What do you think of their design?

KG: Wheels are probably sufficient. When you add arms and hands you need more actuators, more sensors; it increases costs. But robotic parts and technologies are getting better and less expensive. Brian Carlisle [former CEO of Adept Technology] observed that we can buy a car, which includes a ton of metal and is filled with actuators and sensors, for under US\$10,000: we should be able to do the same for robots. Volume reduces cost. People want robots that clean the house (and change diapers) but that will take much more research. In the meantime, can robots enhance communication?

That's the idea behind the new generation of telepresence robots. They build on infrastructure such as fourth generation (4G) and wireless fidelity (WiFi), but how should they be designed? For instance, the Rovio [a home robot sold by WowWee] is about the size of a cat, so you can't have an eye-to-eye conversation with a human, unless you want to talk to your cat. Eye contact is important. So is the ability to point to things in the environment, which can be accomplished with a laser and a two-axis gimbal. There are many design issues in making telepresence a compelling experience.

EG: And why do we want to physically extend ourselves to distant places anyway? Telephone and Skype aren't enough?

KG: The idea of remote control, you click a button here and something happens over there, is a very powerful and satisfying experience. We love our TV and garage remotes. The history of robots is intertwined with the history of remote control. It goes back to Tesla's experiments with a radio-controlled boat, which he demonstrated in New York in 1898 [4]. After World War II, the first robots were master-slave telerobots used to handle radioactive substances. Today, telerobots are used for exploration, in space and underwater, and for bomb disposal. Telepresence is different because you're not manipulating an object or performing a repair; you're interacting with people. There are humans on both ends. The goal is to give the remote operator a sense that he or she is closer to the people on the other end. And hopefully vice versa.

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Figure 2. Eric Paulos with personal roving presence (PRoP) in 1998. (Photo courtesy of Eric Paulos.)

One of the benefits of telepresence robots is that they enhance your sense of agency in the remote environment. You are not just a passive conversationalist; you can take the initiative to move around and explore. That really matters. It allows for spontaneity and greater potential for discovery.

EG: In 2001, you edited a collection of essays titled, *The Robot in the Garden: Teleroobotics and Telepistemology in the Age of the Internet* [5]. One of the articles, by John Canny and Eric Paulos (Figure 2), describes a telepresence robot [6] (Figure 3) very similar to the

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commercial versions we're seeing today. Why did it take nearly ten years for these robots to become commercially viable?

KG: When people like John Canny and Eric Paulos were developing tele-robots and camera systems, the Internet and wireless networks weren't as

fast and reliable as they are today. Now networks have more bandwidth and better quality of service. That makes a huge difference. The other thing that has changed is that it's less expensive to build a robot today, because the components you need are getting better and cheaper. So companies like Vgo, Anybots, and Willow Garage are now commercializing these robots. When can they get the price down to a point where it's available to a large number of people? When that happens, things will get very interesting.

EG: Today we use cell phones, e-mail, instant messaging, Twitter, Facebook—and soon some of us may be using telepresence robots. We're staying connected in more ways and for longer periods of time. Where is this going?

KG: Last spring I taught a course with UC Berkeley philosopher Hubert Dreyfus on the philosophy of technology. Our aim was to give students, many of whom will be creators of technology, a broader historical and social perspective to understand technology. Our starting point was the 1954 essay by Heidegger, "The Question Concerning Technology" [7]. Let me say first that Heidegger is a problematic figure. He was deeply flawed personally. But we can't dismiss everything he wrote. He's one of the most influential philosophers of the 20th century.

In a nutshell, Heidegger asserts that technology is not specific tools or methods. "The essence of technology is nothing technological." Instead, technology is a mode of being, a philosophical attitude that we're immersed in. This is not something we have consciously adopted; it's all around us, we're engulfed in it. Heidegger calls this *Gestell* and argues that the essence of this technological mode of being is a drive to make the world increasingly available for use.

For example he considers the Rhine River. Rather than approaching the

river as primitives, who ponder how the gods created it, or as poets, who focus on its unique beauty, we approach the river as a resource available to generate power. We build coal and oil stockpiles, vast hedge funds, and comprehensive databases and cloud networks. We treat the world as a resource and want to make it more and more accessible for future use. The most popular technologies of our age are those characterized by flexibility and their ability to be reconfigured, such as polymers, genomics, stem cells, nanotechnology, the Internet . . . and robots.

Heidegger warned that this world-view can overwhelm us: we'll start applying this attitude to ourselves. We'll view ourselves as resources, and make ourselves increasingly available. This seems to be coming true with cellphones and laptops and Facebook



Figure 3. Anybot commercial telepresence robot (2010).

and Twitter: compared with ten years ago, we're developing an overwhelming personal sense of obligation to be constantly online, exposed, and available.

EG: I guess Heidegger would have hated telepresence robots . . .

KG: Exactly. Telepresence makes the world more available. As researchers, we're excited about it, but from Heidegger's perspective, it's another step along a dangerous trajectory. At the end of the essay, he says we're at a crossroads, we can continue toward a supreme danger, where we are engulfed and overwhelmed and transform ourselves into resources. But Heidegger also saw a bright side, a way out of this situation. As this trend continues, maybe we'll be jolted into realizing what we're doing and develop the capability to resist it, to set boundaries. In other words, maybe we have to hit bottom before we can stop the madness.

EG: Almost ten years ago, you led a telepresence research project called the *TeleActor* [8], using people as proxies for other people (Figure 4). Is the *Tele-Actor* a precursor to robotic telepresence?

KG: Our idea was to hire an outgoing person—a *Tele-Actor*—who could go to a place you're unable to go yourself. The *Tele-Actor* would wear a camera and microphone, and you'd see and hear as though you were there. The idea was to allow large groups of students or citizens to share remote experiences. For example, allowing a group of disadvantaged students to collaboratively steer a *Tele-Actor* through a working steelmill in Japan, visit a working microelectronics facility, or attend a dinner at the White House . . .

Dez Song and I were awarded an NSF grant to study collaborative tele-robotics. We could have used a robot, but we needed a highly agile, adaptable, and outgoing agent. We joked that



Figure 4. *Tele-Actor* Annamarie Ho. (Photo courtesy of Bart Nagel.)

rather than robots replacing people we'd have a person replace the robot. We did a lot of experiments, but the technology was not there yet. In 1999, we started with analog video, and we were constantly getting interference. Then we switched to an early version of WiFi, and network connections were slow and unreliable. On the client side, we prototyped using Java applets. It was primitive. I wished we had 4G networks back then.

EG: So when the operator spoke, the *Tele-Actor* repeated what was said?

KG: The key idea was that there would be more than one operator. Think of an actor taking directions from a group of remote directors. The *Tele-Actor* has to improvise. We investigated the interactions that would take place and see how they'd compare to normal situations. I think someone should repeat the experiment today.

EG: And in the future we can replace *Tele-Actors* with androids! We're already seeing some steps in that direction. What do you think of telepresence robots that look like

people, like the androids Hiroshi Ishiguro is creating [9]?

KG: Hiroshi's robots are not only very human but also very specific to individual humans. They are designed to act as surrogates in a very real way. This work has connections to psychology, mythology, and science fiction. It goes back to Galatea, the Golem, and later Pinocchio and Frankenstein and *Blade Runner*, and all the attempts to create something that's very lifelike. Hiroshi is pushing the limits and asking deep questions about how we view ourselves such as the Cartesian question: Are we automatons or not? [10] Androids and humanoids can help explore these questions. Maybe we'll discover things we want to avoid [11]. The only way we're going to find out is by experimenting.

References

- [1] IEEE Spectrum's telepresence special report [Online]. Available: <http://spectrum.ieee.org/static/telepresence>
- [2] CONE Project [Online]. Available: <http://www.c-o-n-e.org/>
- [3] Steering flexible needles through soft tissue [Online]. Available: <http://automation.berkeley.edu/projects/needlesteering/>
- [4] Available: <http://www.tfcbooks.com/special/missiles.htm>
- [5] Available: <http://goldberg.berkeley.edu/art/tele/>
- [6] Personal Roving Presence Project [Online]. Available: <http://www.prop.org/>
- [7] M. Heidegger, *The Question Concerning Technology Other Essays*. Harper Torchbooks, Jan. 19, 1982
- [8] *Tele-Actor* Project [Online]. Available: <http://teleactor.berkeley.edu/>
- [9] IEEE Spectrum articles on Hiroshi Ishiguro [Online]. Available: <http://spectrum.ieee.org/tag/hiroshi+ishiguro>
- [10] Descartes' meditations [Online]. Available: <http://www.wright.edu/cola/descartes/>
- [11] K. Goldberg, Ed. *The Robot in the Garden: Telerobotics and Telepistemology in the Age of the Internet*, Cambridge, MA: MIT Press, June 2000.

