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ONE ON ONE

The Robot in the Cloud: A Conversation With Ken Goldberg

By **QUENTIN HARDY**

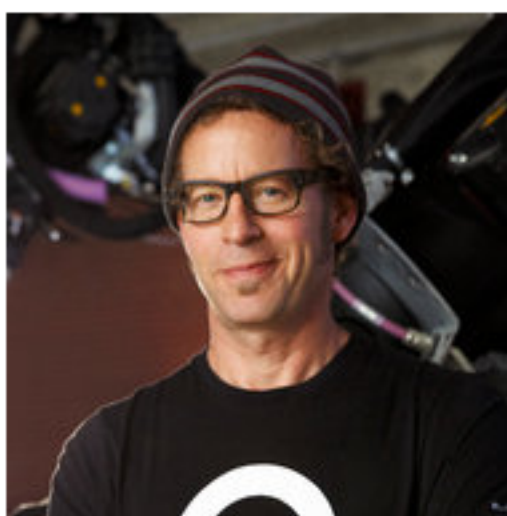
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Ken Goldberg has been thinking hard about robots for almost three decades.

His work ranges from over 170 peer-reviewed papers on things like robot algorithms and social information filtering to art projects about the interaction of people and machines. A professor at the University of California, Berkeley, he is establishing a research center to develop medical robots to assist in surgery. That is just the latest development in what he thinks will be one of the great technology breakthroughs of our age: the fusing of robotics and cloud computing. He talks about it in this edited and condensed conversation.



Ken Goldberg Eric Rorer

- Q.** What is cloud robotics?
- A.** Cloud robotics is a new way of thinking about robots. For a long time, we thought that robots were off by themselves, with

The cloud is different from my Internet “telegarden,” though. The cloud can have all the computation and memory stored remotely. That means all of the endpoints can be lightweight, and there is a huge collective benefit. These robots can address billions of behaviors and learn how to do important things quickly.

- Q.** What are some examples of this?
- A.** Google’s self-driving cars are cloud robots. Each can learn something about roads, or driving, or conditions, and it sends the information to the Google cloud, where it can be used to improve the performance of other cars.

Health care is also very promising: Right now radiation treatments involve putting a radioactive seed next to a tumor, using a catheter that has to push through other tissue and organs. The damage could be minimized if the catheter worked like a robot and had motion planning to avoid certain objects. Tedious medical work, like suturing a wound, might be done faster and better. Giving intravenous fluids to Ebola patients is difficult and risks contamination; some people are looking at ways a robot could sense where a vein is and insert the needle.

Another area is household maintenance, particularly with seniors. Robots could pick up clutter, which would help elderly people avoid falling and hurting themselves.

- Q.** Where are some of the most interesting developments?
- A.** In about a year Google bought eight robotics companies. No one knows what they are doing. For sure, it’s not connected with cars; I have students in both the robotics and the self-driving car teams, and they’re not allowed to talk with each other. They may be trying to build a core operating system for robots, but that’s just a guess. They have collected some of the best minds in the field.

Another thing is Microsoft’s [Kinect sensor](#), which can sense and model objects in three dimensions. It costs about \$100 and is getting cheaper. Very soon we’ll see 3-D sensors in every laptop, following your motions and modeling human faces. If lots of that information is shared in the cloud, it will be used to make robots more perceptive, able to deal with sensing and space better.

- Q.** What are the risks?
- A.** There are a lot. Obviously, if your household robot is hacked, you could have all of your personal data, like your house layout and where your valuables are, sent out around the world. Privacy is a worry there, too, particularly if you consider who may be selling the robots. War robots worry me, too. A drone attack in the U.S. would be terrifying.

- Q.** Isn’t that how war works elsewhere already?
- A.** Yes. But if it happened here, and people knew there were drones in the sky monitoring them, maybe able to take them out at any moment, everyone would feel vulnerable.

- Q.** What are some things you learned about robots early on, which are still true?
- A.** The telegarden had an insight I didn’t appreciate at the time, which was how social it was. There was a chat room and people interacting in the garden. More than 100,000 people visited. They could have planted seeds on top of each other, or over-watered someone’s plant, but mostly they didn’t. They watered for other people when those people went on vacation. Maybe that was because it was a garden.

More important was a philosophical question it raised. A student asked, “How do I know there is a garden there?” since that kind of thing can be easily spoofed. That’s when we got into the idea of tele-epistemology — how do we know that remote things, things done via robot, are true?

- Q.** And?
- A.** We don’t. It’s kind of like when the telescope was invented and people saw the moons of Jupiter, or the microscope showed microorganisms living on your hand. People began to wonder what else they didn’t see. The Internet garden reinvigorated that sense of doubt.

- Q.** Are you saying we can learn from robots, too?
- A.** For a robot, the world is uncertain and jagged. When it gets new information, it has to change what it thinks is true. You could say it’s good with doubt. Robots could teach us a lot about never finally believing your own perceptions.

- Q.** Can we program a robot to behave ethically?
- A.** I don’t think so. An ethical conflict is an exception. The idea that we can program a single answer is a mistake. There will still have to be human oversight. The hope is that realizing robots are prone to ethical failures will help us remember that we need to be careful, too.

- Q.** Are there things robots will never be able to do?
- A.** We’ll see them get more dexterity, but we won’t see them tell jokes, do research, or be creative.

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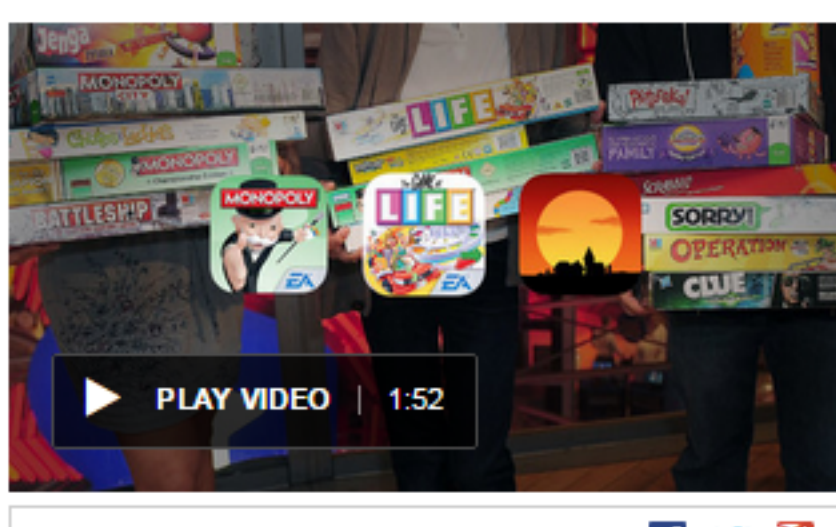
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