Speaking Of . . . Robotics

Two excerpts from talks given at a workshop on Cognitive Robotic Systems, held at Caltech from March 19 to 22.

Around the House

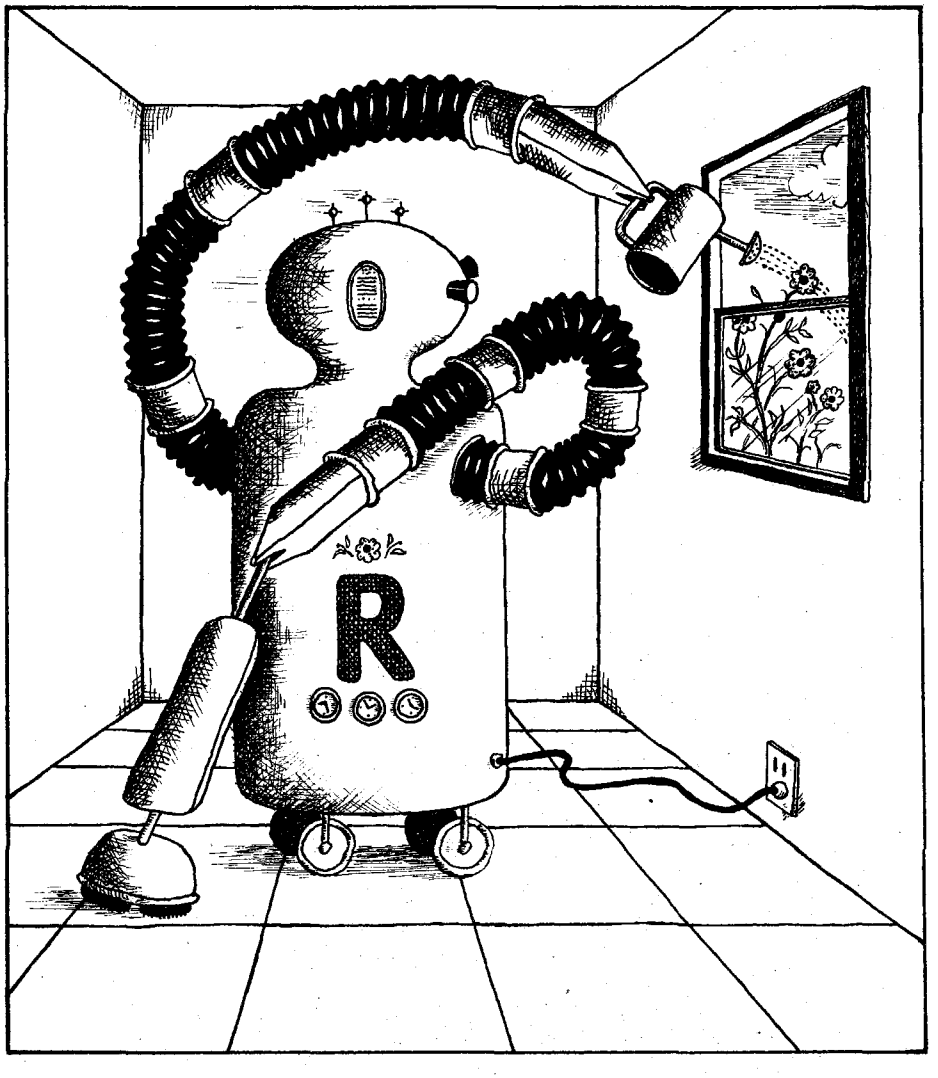
I have a pet area in robotics that I think is worth a lot of attention and that's the so-called household robot. In the next 25 years or so it can have a profound effect on the world. I've thought about it quite a bit, and there are two aspects I like. One is that it has a nice social aspect. If you have a real household robot that works, it doesn't really put anyone out of work, but yet a lot of people would want it because domestics are disappearing rapidly from the whole world. And at the same time (if we get over this recession) people's expectations are rising, and they would like not to do housework.

My own opinion is that a household robot that is useful and economical could be made almost immediately. And its first functions could be what I call surface care—working on the floor and maybe the yard. It can vacuum and wash floors, using standard gadgets it gets out of a special closet, and maybe it can clean up the yard the same way. To program it a housewife just puts a handle on it. Then she goes and vacuums a room, and when no one's around, it tries to do approximately the same thing, avoiding obstacles. When the housewife notices a dirty spot it's missing, she sticks the handle on and says, "No, you forgot this spot over here," and slowly gets it trained. In a while maybe it won't be just doing that, but it will be picking up—like, when it finds a towel or sock on the floor, it will know they should be taken to the laundry room.

There are some other nice things it can do too. It can patrol around the house at night when no one's home and watch for, say, water pipes breaking, or fires, or burglars coming in. For a long time I was in a quandary about what to have it do when it sees a burglar crawling in through a window. It could call the police, of course, but the guy *could* come in and steal something and get away anyway. And I think shooting the burglar has a lot of bad implications. What I finally decided is that it should crouch in a dark corner and bark ferociously.

I hope this will all happen fast, because when we get to the point of automating setting the table and washing the dishes, I want to watch, because that gets to be a little hard. Making beds actually isn't that hard. Rocking the cradle isn't hard either. Imagine someone said to you, "Look, we're going into mass production of this thing, and all it has to do is use its vacuuming attachment to vacuum, its floor-washing attachment to wash floors, and you can wire the house up with a coil, and it learns to navigate by being taken around, and it has access to a big computer downtown when it needs it" —and so on.

I think you could make such a machine for $25,000 if you were planning about a quarter of a million to start. And my own guess is that there's a market for about a million of them at $25,000, because $25,000 is less than a domestic costs, and in a big house one domestic is busy doing these chores, and there are at least a million big houses around. One can imagine the price getting down to maybe $10,000 in time, and at that point if it's a question of whether you get a second car or a household robot, my guess is a household robot will win fairly often. My guess is that over a 30-year span we'll have a market



of over a trillion dollars worth, and I think that's even conservative in some sense.

I think that 20 to 25 years from now there will be robots or autonomous machines doing things beyond our expectations. We ought to get past the idea of machines that move but don't think. I mean, everything that moves ought to have something in it that thinks. Trees don't have to think because they move very slowly, but even insects and worms do a little bit of thinking, and I think that all the machines we build will have in them some autonomous capability partly to control what they're doing and, perhaps more importantly, to worry about their own operation—to know that they need to oil a bearing or they're overheating or they need a replacement part and so on. And the beauty of that from my view is that if the rest of the world, the third world, is ever going to move fast, one of the things they could make use of is machinery. It's very hard for this to happen today, because when you send the machinery, they're not really able to take care of it and use it without growing up in the machine culture. But when you can have a machine, like a tractor, that can pretty much take care of itself, even if someone else drives it, that's a revolutionary thing for the rest of the world.

—Edward Fredkin, professor of computer science and director of Project MAC at MIT; Sherman Fairchild Distinguished Scholar at Caltech from September 1974 to May 1975.

Fourth Revolution

Throughout the history of Western civilization we've had a number of intellectual revolutions that have radically altered man's thinking about himself and the universe and his relationship to it, ranging from Aristotle to Leonardo da Vinci to Newton to Einstein, but I think that it is generally acknowledged that three of these revolutions have been most influential in determining man's image of himself and his role in the universe, and these are the Copernican revolution, the Darwinian revolution, and the Freudian revolution.

The Copernican, of course, shattered the old Ptolemaic model of the earth as the center of that around which all heavenly bodies revolved. Later on the Darwinian revolution, with its theory of natural selection, considerably restructured our thinking of the relationship of men-apes and our common ancestors. Finally the Freudian revolution forced us to abandon myths that we had earlier of the fully conscious rational mind, to admit to the subconscious dimensions of our own minds.

If one wanted to characterize each of these three revolutions along some common theme, one could say that they each in some sense served to diminish man's claim to his uniqueness—as a species compared with other biological species in the Darwinian case, and in other senses too, such as the conception of man endowed by God with strictly rational motivations, responsible for overseeing all other biological species from a vantage point at the center of the universe.

I think that we have, by this time, largely repudiated that concept, although I hear there are some people around who don't believe in Darwin, but nonetheless each of these revolutions in its own time met with considerable resistance and a great deal of controversy, especially by the establishment forces with a strong vested interest in whatever current rationalizations they had about the self-importance of human beings. These rationalizations were probably inspired by intuitively obvious observations that they made but which were ultimately based on false assumptions.

Each revolution was an unsettling one for the establishment and I guess for most of us in those days, until we sort of reknit the fabric of our claim to uniqueness and thus could reassert our collective pride again in being human beings. It required a restructuring of our thinking. At the time when it was not fashionable or respectable to advocate these revolutionary ideas, one took a great risk in doing so. You know the stories of the three people I mentioned; at least the first two took considerable risk in espousing these ideas, and I'd like now to take such a risk regarding a speculation on the fourth such major revolution.

I think it will be an equally profound and comparably important revolution in man's thinking about himself, sort of an assault on one of the last major non-trivial ways in which *Homo sapiens* claims to be unique; that is, our heretofore undisputed position as being conscious and self-aware organisms. I'd like to forecast that the usurper of this traditionally human prerogative will be an artifact of our own making, an intelligent robot of the not-too-distant future.

When I say that an intelligent computer in 50 to 100 years will be able to communicate with humans and to use a respectable subset of natural language, I think that I'm not too far off base. I think there will be a component of the software for these future computers that will be teleological in nature. They'll have their own autonomous internal objectives, depending on how they've been programmed. And they will, linguistically speaking, use the pronoun I, in quotes, properly. What I mean by that is that phonetically, phonologically, syntactically, semantically, and pragmatically they will use the pronoun "I" as a reference for themselves in a way that a human would under similar circumstances, and so it will be very hard to deny this attribute of self-awareness to such intelligent systems.

I'm really going out on a limb when I argue that this is both a necessary and sufficient condition for self-awareness because there may be some other aspects of it that we don't know about, but I suspect that this part of it—the proper use of the pronoun "I" in using English, in carrying out functions and tasks based on internal motivations—will come about, and that this demonstration will be philosophically and socially a very profound one.

—L. Stephen Coles, senior research mathematician, Artificial Intelligence Center, Stanford Research Institute.