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"I'm Here to Make You Feel Better"

Robots can already perform surgery and track your meds. Now, new models aim to provide therapy and support.

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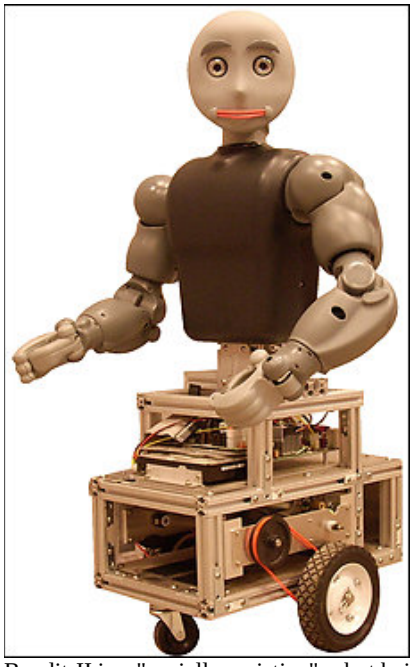

Bandit-II is a "socially assistive" robot being developed at the University of Southern California. (University Of Southern California)

Before consumers send their Roombas for repair, they sometimes etch their names on the machines in the hopes of getting their own robots back. Somehow, they grow attached to the squat, disk-shaped sweepers and worry that a new robot will have a different personality.

"People are grateful that the Roomba improves their lives, so they reciprocate by giving it attention like they would a pet," says Ja-Young Sung, a doctoral student at Georgia Tech who surveyed 379 Roomba owners in 2007 on their attitudes toward the robotic device. Sung found that many owners who gave their Roombas names also painted them, dressed them in costumes or turned them on to entertain friends.

That willingness to interact with an object that, if not inanimate, is hardly human presents both a challenge and an opportunity for creators of new devices that go far beyond housekeeping to imitate the actions of people and even provide therapy. Difficult as it is to design a robot that can assemble a Toyota or handle toxic waste, researchers are working on making machines that can coach, motivate and monitor people with cognitive and physical disabilities -- machines that are "socially assistive."

That term was coined by Maja J. Mataric, director of the Center for Robotics and Embedded Systems at the University of Southern California, and her research group to describe machines that could, for example, tirelessly encourage a stroke patient to do rehabilitation exercises; move alongside someone with dementia, giving directions to help navigate the hallways of an assisted living facility; or provide a catalyst to teach children with autism how to interact with humans.

Service robots aren't new; rehabilitation machines used primarily to push or pull stroke patients' limbs have been around for a decade. But such devices are expensive and not particularly good company, Mataric says.

Only recently have roboticists been able to go further, delving into the complex realm of human-robot interactions, as much a study of human psychology as of engineering. For a human to relate to a robot, the machine must be capable of expressing a personality, discerning the user's emotions and intentions, displaying feelings such as empathy, or following social conventions.

"A socially ignorant robot always takes a direct path, stops if something is in its way and interrupts at any point to do its task," explains Kerstin Dautenhahn, a research professor in the School of Computer Science at the University of Hertfordshire in the United Kingdom. "But a socially interactive robot modifies its path to avoid getting too close to a human, waits until the right time to talk and fetches items without being asked."

Research on such machines is in its earliest stages. "There are a handful of researchers working on socially assistive robotics versus thousands working on robot navigation, particularly for military applications," Mataric says.

Still, whether they're chunky vacuum cleaners or upright machines that can, after a fashion, walk, talk and respond, robotic creations seem to fascinate their human companions, and that, increasingly, is helping them ambulate toward new roles as medical caregivers. "Robots will never replace human interaction, but they can augment it," says Martha E. Pollack, dean and professor at the University of Michigan's School of Information.

"We can write algorithms to allow the robot to sense what a person is doing so it can respond immediately, appropriately and safely," Mataric says. "That wasn't possible 10 years ago."

Sensors attached to a person's wrist, elbow or clothing, for example, can allow a robot to detect the human's movements and respond. A heat sensor can instruct the machine to turn or move toward a warm body, enabling it to participate in a game of chase or create the appearance that a person has its full attention. "Artificial audition" technology has improved so that a robot can now track one conversation when several people in a room are talking. And eventually some machines might even provide a hug. To make that happen, François Michaud, a professor of electrical and computer engineering at the University of Sherbrooke in Quebec, is building a prototype with an element inside its motor that responds to feedback from the environment.

And if you're not in a hugging mood?

"The robot could sense how you're responding," Michaud says. "If it felt pushback, it would abandon the hug."

Side by Side

Building a robot that can "see" has been one of the stiffest challenges. "A robot that is much shorter than you are will have a hard time tracking and processing your facial expressions," Mataric says. As an alternative, her research team is creating machines that interpret other physiological data, such as skin temperature, heart rate and galvanic skin response, which is a measure of electrical resistance that corresponds to heightened emotions.

The better a robot can "perceive" and respond to human signals, the more likely a person will be to take its direction. In that vein, it's important that responses not be static. "People may be open to direct encouragement when they're fresh and require more empathy when they're tired," says Reid Simmons, a research professor in robotics and computer science at Carnegie Mellon University in Pittsburgh. "So the robot may need to change its speech and expression, just as a good therapist would."

It also helps if the machine's "personality" matches the user's. Working with stroke patients, Mataric has found that those who are extroverted prefer outgoing robots who stand close and speak fast with high-pitched voices and exhort them with such phrases as "You can do more than that, I know it" and "Concentrate on your

exercise." Introverts respond well to gentle nudging: "I know it's hard, but it's for your own good" and "Very nice; keep up the good work."

Although most children seem to have an easy time working with robots, adult users are more demanding. Still, the majority eventually embrace having a robotic companion and may even start playing games with it, hiding from it or trying to trick it into thinking they've already completed their exercises.

A robot must also be able to follow certain social conventions, such as getting on an elevator without mowing down other passengers. "Parents teach their children to wait until other people get off an elevator before stepping in," Simmons says. "But that's not the true rule, because if you wait until everyone gets off, you'll stand there forever. The real question is, which people are intending to get off?"

Those are particular challenges for robots designed to accompany cognitively impaired individuals. Walking side by side with someone is much harder for a robot than following or leading, according to Simmons. "The robot has to keep pace, not bump into the person, and know how to give directions based on the side of the person it's on," he says. "When you're walking with someone and talking, you give nonverbal cues to change direction, such as gesturing or moving slightly ahead."

Not Too Human

Beyond determining what socially assistive robots can do, researchers must consider how the machines should look. A phenomenon called the "uncanny valley," a phrase coined in 1970 by Japanese roboticist Masahiro Mori, suggests that the more humanlike the robot, the more humans will relate to it, but only up to a point, at which that good rapport suddenly drops off (the valley). "Machines that are almost, but not quite, like a person are worse than those that are either completely humanlike or a bit further away," Simmons says.

That's particularly true of robots designed to work with children with autism, who want something decidedly machinelike. Kaspar, for example, a diminutive robot being tested with children with autism in the United Kingdom, has a minimally expressive face and wires sticking out of its neck and wrists to make it clear to the kids that they're playing with a robot. "We tested another robot that looked like a doll with eyelashes and color on its lips, and the children didn't like that one as much at first," says Dautenhahn, who headed the team that created Kaspar.

Certainly no one would mistake CosmoBot, a 16-inch-tall robot designed by AnthroTronix, an engineering company in Silver Spring, for a person. And that seems to suit Libby, a 6-year-old with autism, just fine. Before being introduced to CosmoBot, Libby couldn't imitate even the most basic actions. But after several weeks of playing with the robot, she was mirroring its motions as it led her through a Simon-says game of raising her arms, patting her head and clapping.

"Her mother and the professionals who saw this were in tears," says Carole Samango-Sprouse, director of the Neurodevelopmental Diagnostic Center for Young Children at George Washington University. "It was incredibly encouraging that the robot, through repetition and predictable behavior, was successful in getting her to perform the motions she had seen adults doing for years."

Robots can also teach children with special needs how to play with one another. If a child is touching the robot inappropriately (slapping, say, instead of stroking), the robot may back away or emit a warning beep to encourage the child to change his behavior.

Dautenhahn has noticed that children with austism who play with Kaspar may also spontaneously begin interacting with their teachers. "One withdrawn boy who never played with other children or his teacher became

very interested in Kaspar's eyes," she says. "He pointed to Kaspar's eyes, then to his own, and then, smiling, to his teacher's eyes. This was an invitation to share, and the boy and his teacher played together."

Children with physical disabilities also respond well to robots. In three schools in Austria, PlayROB gives children with cerebral palsy and other severe disabilities the chance to play independently. Controlling the robot with a joystick, buttons, their mouths or even just head movements, the children can direct it to build Lego structures and do additional activities that let them experience the creative expression, spatial recognition and accomplishment that other children get from playing.

What's Next

The technology is ready, but researchers say they need to learn from clinicians which robotic features are needed to treat a disorder. And there remains a gap in funding: money for the research to prove that socially assistive robotics is ready to move out of laboratories and into schools and homes in a wide variety of capacities.

"Right now, funding is available to create robots to support the elderly and the very young, but what happens to people in the middle?" Dautenhahn asks. "Older children who are autistic or in wheelchairs grow up to be adults with those disabilities. I'm waiting for others to identify those needs so we can analyze how robots can help."

A longer version of this article appeared in Proto, a magazine of the Massachusetts General Hospital, available at http://www.protomag.com. Comments: health@washpost.com.