ROBOTS IN THE HOUSE!
Willow Garage - Open Source Robotics
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Eons before there were Roombas and Lego Mindstorms, we humans imagined electromechanical helpers who would make our existence easier. In our dreams, robots would move about, sense and manipulate their environment, do our chores, and cater to our wishes. We envisioned empathetic machines we could trust with our homes, our children, or even our planet.

The 60s and 70s ushered in the era of industrial robots that took over some human drudgery. And, more recently, robots have emerged that autonomously explore new terrain, help law enforcement disable explosives, or even perform microsurgery. While positively invaluable to humanity, these robots seem somehow freakishly apart from humans (or at least less personal than R2D2). They inspire imagination but also fuel trepidation.

Robots are now coming to the forefront of popular conversation.[1] Confronted with the technology to create what we once just imagined, the media, technologists, and social scientists are discussing the practical, psychological, and ethical consequences of machines with intelligence.[2] This is an opportunity for industrial designers, interaction designers, and human factors experts to apply their disciplines to help society interpret a new product category that will change the way we live.

Robotics has lingered where software was before personal computers or even early work stations entered the industry. If a company or scientist wants to create a personal robotic application today, they start by developing the robot itself. In 2007, a team of researchers and engineers formed a company, called Willow Garage, to address the need to build a robot from scratch so that developers can focus on making robots do useful things. Using open-source collaboration, researchers both inside Willow Garage and from the broader robotics community are working together to eliminate obstacles that have held the industry back. Today, their efforts have led to the development of ROS (Robot Operating System) and PR2 (Personal Robot 2). PR2 is demonstrating that a general purpose robot can work, opening doors (literally) for innovation, collaboration, and a new industry to bring the technology home.[3]

PR2 has been designed as an open development platform for robotic applications. It has similar size and proportions to a human, and is optimized for situations found in everyday environments, such as opening standard doors. The robot integrates arms, mobility, sensors, computation, and batteries into one system, and works together with an open source software platform. Now in a late-stage prototype phase, the robot has been designed from the ground up to be robust, capable, fully integrated, and extensible.[4]

The technical challenges in creating an autonomous robot are substantial. For example, how can the developers ensure the robot, which weighs hundreds of pounds, doesn't collide with people or furniture, and if it does, how can they be sure the encounter is harmless? How can multiple individual robotic specialties, like grasping and vision, be combined in a single multipurpose robot to allow many applications? While the challenges are significant, the collaboration and open-source model mean they are being addressed simultaneously for the benefit of many.[5] The effort is unique because it:

- Enables developers to focus on the applications not the platform. The goal is to replace the difficult and costly process of building a robot from scratch and free researchers to focus on unsolved problems rather than building the hardware and implementing software that has been done before.

- Adopts product development process from industry, including a user-centered approach, phased design, iterative prototyping, reviews and refinement, schedule-driven deliverables, commercial materials and manufacturing, and a cohesive, experienced team. (Often traditional research has had to depend on a kludged together one-off model developed sequentially by a series of grad students and only appropriate for one researcher's needs.)
- Provides a forum for collaboration. The company actively engages research labs and companies as partners, collaborators, customers and advisors in the development. Detailed information about the hardware design, software and development process is regularly shared with the community on a public Web site.
- Provides an open source platform that is extensible. The development philosophy favors a modular design using standard components and protocols to facilitate adaptation and extension. The modular hardware interfaces are available on line; the software platform is open source.
- Avoids the limitations associated with research grants or academic theses. Willow Garage is funded like a foundation by private sources committed to the product and process, with no obvious payoff in sight.

A personal robot is a robot used by a person as a productivity tool. As robots move from factory automation to personal productivity applications, they pose what could be their biggest challenge: the need for design that inspires adoption, not trepidation. Of course, a healthy dose of concern is necessary for ensuring that people don't immediately run up to hug the personal robots that could be misused or mistakenly cause harm. This balanced expectation management is a research area that has been inspired by the ongoing efforts of designing the PR2. In human-robot interaction research, Willow Garage is currently delving deeper into the behavioral consequences of setting expectations with personal robots as being more or less capable of interacting with people.

A rich mix of design and social science research continually informs the development of Willow Garage's personal robots. Drawing from the human-robot interaction research,[6] the team has been able to make more informed design decisions about, for example, why and how to *decrease* the human-like appearance of PR2, the reasoning behind why PR2 has a wider rather than taller head. Similarly, Willow Garage is now drawing from lessons already established in animation to enable more predictable (and, hopefully, safer) interactions between people and robots. In collaborations with animators from the film industry, the team is working toward creating more "human-readable" robot behaviors, meaning that anyone watching the robot could make a reasonable guess at what it is doing. If a person knew that PR2 was about to plug itself into an outlet, that person would also be likely to know that it's not safe to stand between the robot and the outlet. Also, if someone could understand that PR2 needed help in achieving a task, then the person could help the robot perform a task more efficiently or was otherwise impossible to do alone.

While robots may do some functions fully autonomously, introducing people into the mix of possible interactants opens up the design space to include challenges in human-robot interaction. A person walking down a busy sidewalk may seem to be an autonomous being, despite the fact that this person could not walk down that busy sidewalk without the implicit communication and cooperation that occurs between the many people on the sidewalk to avoid collisions. The fact that a person knocks on a door to be allowed into a building does not make him less of an autonomous being. By relying upon communication and collaborative interaction with people (or others) in a personal robot's environment, Willow Garage sees the enormous interaction design space between people and robots may be even more fruitful than trying to build robots that try to accomplish tasks entirely on their own. As such, the team is conducting research in-house on how to build better user interfaces for controlling robots as well as for enabling more interactive behaviors between people and robots as social actors,[7] including

people-dodging in busy walkways and allowing for reasonable degrees of personal space between people and robots.[8]

As robots move into the realm of our personal space, designers will face the usual demands of a new, complex product but also the more emotive side of these mechanical heroes. Will the solutions that emerge bond us to these devices? Evoke fear? Or just be removed and impersonal like our washing machines and rice cookers? We can't wait to see how the IDSA community responds to the challenge.

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[1] Markoff, John, "Ay Robot! Scientists Worry Machines May Outsmart Man," *The New York Times*, July 26, 2009, p. 1.
[2] Ganapati, Priya, "Robo-Ethicists Want to Revamp Asimov's 3 Laws," *Wired*, July 22, 2009.
3 Saenz, Aaron, "Willow Garage: The Personal Robot Will Be Open Source," *Singularity Hub*, (http://singularityhub.com/2009/06/22/willow-garage-the-personal-robot-will-be-open-source/), June 22, 2009.
[4] Willow Garage, (http://www.willowgarage.com).
[5] Markoff, John, "Opening Doors on the Way to a Personal Robot," *The New York Times*, June 8, 2009.
[6] Carl F. DiSalvo, Francine Gemperle, Jodi Forlizzi, and Sara Kiesler, "All Robots Are Not Created Equal: The Design and Perception of Humanoid Robot Heads," *Design of Interactive Systems*, 2002, pp. 321-326.
[7] Reeves, Byron and Nass, Clifford, *The Media Equation: How People Treat Computers, Television, and New Media Like Real People and Places*, New York, NY: Cambridge University Press, 1996.
[8] Takayama, Leila and Pantofaru, Caroline, "Influences of Proxemic Behaviors in Human-Robot Interaction," *Intelligent Robotics and Systems (IROS)*, 2009.