
Robotics Trends for 2012

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What's in store for robotics in 2012? Nearly a quarter of the year is already behind us, but we thought we'd spend some time looking at the months ahead and make some predictions about what's going to be big in robotics.

Or at least what we *think* is going to be big. Lacking divine powers (or a time machine) to peek into the future, we relied on our experience as longtime observers of the robotics landscape, covering the field here on Automaton and on [Hizook](#), another leading robotics blog. To make sure our forecasts aren't too far off, we asked a [group of roboticists](#) with different backgrounds for *their* predictions for 2012. This "panel of experts" provided invaluable insight, and after we tabulated everyone's suggestions we narrowed it all down to the final 12. It was not an easy task. So many great ideas. (*Thanks, panelists!*)

In making our selection, we tried to avoid the "perennial trends"—areas like environmental robotics, entertainment and [toy robots](#), and others that are always thriving with activity. We focused on *emerging* areas and we "followed the money," looking at where funding is going. For example, the [National Robotics Initiative](#), spearheaded by the U.S. National Science Foundation, will put a lot of resources into robots that can [collaborate with people](#). DARPA, for its part, has multiple programs that [involve manipulation](#) and [bionic devices](#). Europe's [Framework Programmes](#) is funding development of "cognitive systems and robots" that can assist people in everyday tasks. And in Asia, the decades-long funding of healthcare robots for older adults has intensified.

Again, we're not trying to present a comprehensive survey of the state of robotic research in 2012. We're hoping that the trends described here are helpful as a "heat map" that highlights promising areas and technologies in robotics and AI. We know that many readers will disagree with our choices. Some will feel outraged at our selections. Others will just want to learn more. In either case, we want to hear from you. Write us or leave a comment below. And as predictions go, only one thing looks certain: Robotics is going through an amazing time, and things should only get more exciting.

#1 CO-ROBOTS: ROBOTS AS CO-WORKERS AND CO-INHABITANTS

Robots typically fall somewhere on a spectrum between direct teleoperation and full autonomy. Unfortunately, teleoperation can be cumbersome, and full autonomy is often illusive. Somewhere in the middle lies a compelling trade-off, where humans and *co-robots* collaborate to perform practical tasks, such as [delivering medication to a person](#) (pictured below). Co-robots are at the heart of the \$70 million National Robotics Initiative (NRI) and they represent a definitive step toward robots migrating out of factories and academic labs and into our everyday lives. [According to the NRI](#), co-robots must be safe, relatively cheap, easy to use, available everywhere, and interact with humans to "leverage their relative strengths in the planning and performance of a task." "A lot of us are turning our attention in that direction," said a researcher from our panel of experts. (No wonder so many U.S. roboticists spent the latter portion of 2011 drafting proposals!) The program's scope is broad, but the key aspect of co-robots is clear: Co-robots must interact with humans. So expect to see a big jump in activity in human-robot interaction in all its myriad forms throughout 2012.



A study by Georgia Tech's [Human Factors and Aging Laboratory](#) used the PR2 robot to interact with older adults in the [Aware Home](#). Photo: Keith Bujak

#2 3D SENSING: THE KINECT REVOLUTION CONTINUES

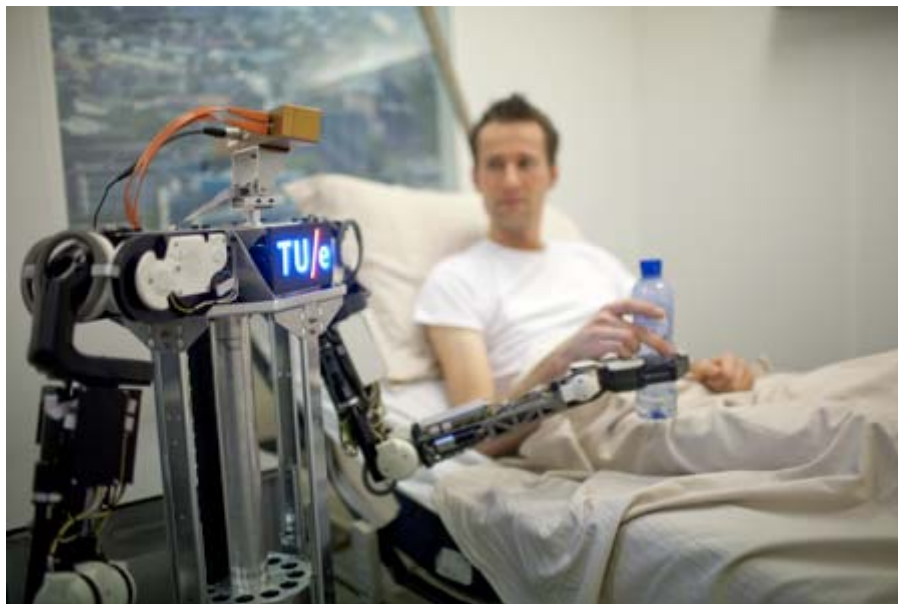
Last year, a curious adornment started appearing on [many robots' heads](#). It was Kinect, the now-popular Microsoft 3D sensor. Cheap and easy to use, Kinect made 3D mapping and motion sensing accessible, and the robotics community embraced it wholeheartedly (see [one example](#) in the photo, below). "People have been searching for a low cost alternative to laser rangefinders, and now we have one (for indoor use, at least)," one of our panelists told us, adding that she expects to see a "surge" in usage. Indeed, the [Kinect 2](#), which may appear sometime this year, will feature higher resolution and frame rate, allowing the device, if you believe the rumors, to [read lips](#). New types of cameras also promise to expand the possibilities of 3D sensing. So-called "[computational cameras](#)"—like the [Lytro](#), based on technology developed at Stanford—capture both intensity and angle of light and allow for refocusing already-snapped pictures and the creation of 3D images. This new wave of 3D sensors may not only give robots better "eyes," but they could also provide an effective way of "[3D scanning](#)" everyday objects, generating libraries that robots would access to finally understand this thing we call "the real world." "3D sensing is already hot," one of the panelists commented, "but with the Kinect and the next generation of similar cheap sensors, the sky is the limit."



Microsoft's Roborazzi robot features a Kinect for navigation and a camera for snapping pictures of people. Photo: Bill Crow/Microsoft

#3 CLOUD ROBOTICS: THE FORECAST CALLS FOR CLOUDS

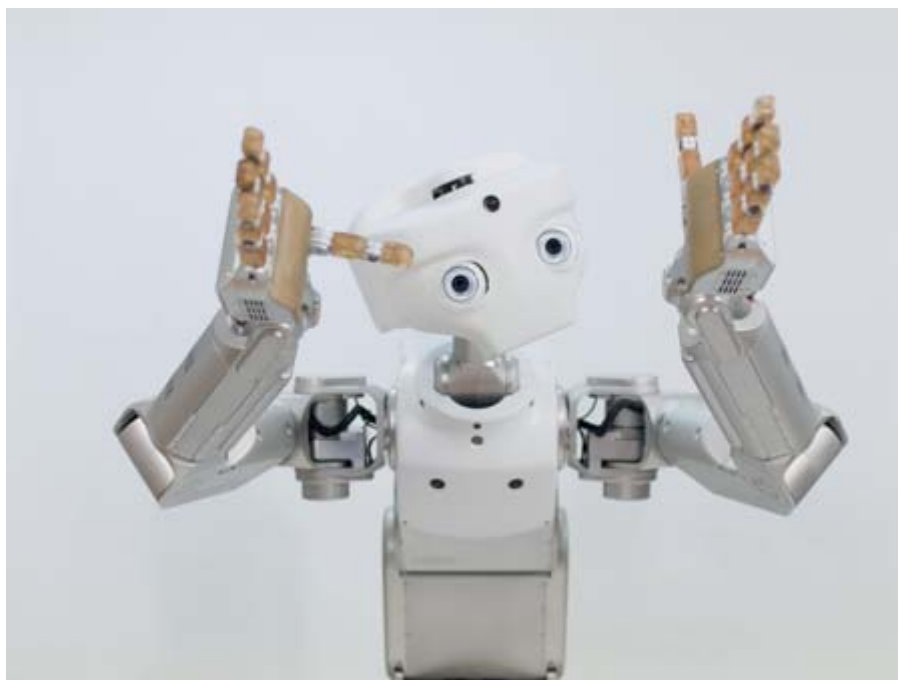
Several research groups are exploring the idea of robots that rely on cloud-computing infrastructure to access vast amounts of processing power and data. This approach, which some are calling "cloud robotics," would allow robots to offload compute-intensive tasks like image processing and voice recognition and even download new skills instantly. A lot of activity should be happening in this area this year. Or as one researcher put it to us, "the cloud will explode." In particular, Google has a small team creating robot-friendly cloud services that, if they become popular among roboticists, could be a tectonic shift in the field (imagine every robot using a "Google Maps for Robots" for navigation). In Europe, a major project is RoboEarth, whose goal is to develop a "World Wide Web for robots." a giant cloud-enabled database where robots can share information about objects, environments, and tasks (see photo of a test of the system, below). Many other projects are taking shape, and we expect that in 2012 "cloud robotics" will sound less like a buzzword and more like a serious research domain.



A robot connected to [RoboEarth](http://RoboEarth.org) serves a drink to a patient during a trial of the system. Photo: RoboEarth.org/TU Eindhoven

#4 COMPLIANT ACTUATION: ROBOTS WITH A SOFT TOUCH

When robots interact with humans, safety is a key concern. Conventional position-controlled arms like the ones that dominate factories just won't cut it. Making robots with a soft touch is key to a future where humans and robots can share spaces and collaborate closely. For this reason we expect to see numerous improvements to compliant actuation and tactile sensing technologies in 2012. Examples include better series elastic actuators (used by robots like the Meka M1 in the photo below) and [tactile skin](#). In addition, we expect researchers to think "outside the box"—developing new, clever types of compliant systems far removed from electromechanical motors. For example, in 2011 [we saw a number of soft-bodied robots](#) that, much like their meat-bag biological counterparts, are inherently squishy. These include iRobot's Hexapod JamBot, based on [particle jamming actuators](#), and OtherLab's Ant-Roach Pneubot, [an inflatable robot](#) made of fabric and pneumatic actuators. These and other projects point to a tantalizing future filled with compliant and soft-bodied robots that we expect to start taking shape in 2012.



The [Meka Robotics M1](#) compliant robot with custom series elastic actuators. Photo: Meka Robotics

#5 SMARTPHONE-BASED ROBOTS: THE NEW ROBOT BRAINS

Almost every robot these days need a combination of sensors, CPU, display, and network connectivity. Smartphones and tablets offer a combination of sensors, CPU, display, and network connectivity. Do you see where this is going? At one end of the spectrum, iRobot has demonstrated a [remote presence prototype robot](#) called [Ava](#), which uses a tablet to


control its mobile base. At the other end of the spectrum, two Seattle engineers quickly raised over US \$100,000 on fundraising website Kickstarter with the promise of developing a cute little smartphone-powered robot called Romo (pictured below). These are just two examples of a trend that we believe has earth-shattering potential for robotics. Mobile devices—based on Apple's iOS and Google's Android—are riding an extraordinary, unprecedented wave of innovation. We think (we hope) that robotics can take advantage of this same wave. The result would be many more robots moving out of the lab into the marketplace. "More and more smarts in cellphones, like [Apple's voice assistant] Siri, will impact robot toys and research this year," one of our panel members told us. Indeed, thanks to smartphones, robots will only get smarter.




Romotive, a Seattle start-up, created a tracked mobile robot powered by a smartphone. Photo: Romotive

#6 LOW-COST MANIPULATION: A ROBOT ARM YOU CAN AFFORD

With the ever-improving economics of computing and developments like the popularization of 3-D sensors, the overall cost of a robot is dropping precipitously. Except for one thing: Actuators seem to be holding up the show. This is most evident with grippers and high degree-of-freedom arms for manipulation. We're not talking about hobby servo solutions; we're talking about what many roboticists want. They want a powerful system for mobile manipulation: human-type form factor, compliant actuation, respectable payload (at least 5 kilograms). Oh, and did we mention cheap? Like all for less than \$5000. In other words, could a new robot arm do for manipulation what the Kinect is doing for 3D sensing? An ICRA 2011 paper by Stanford researchers on a low-cost compliant manipulator suggests it is possible (system pictured below). And indeed, there is a fair amount of funding in this direction—from NSF's NRI to DARPA's three manipulation-centric programs (ARM-H, ARM-S, and M3). As one researcher explained to us, all this funding should lead to "interesting new hand designs and autonomous manipulation systems."

A large, empty rectangular box with a thin black border, intended for a photograph of the Stanford low-cost manipulator arm.

 Stanford low-cost manipulator arm

Stanford researchers developed a low-cost compliant 7-DOF arm. Photo: Morgan Quigley

#7 SELF-DRIVING VEHICLES: COMING TO A STREET NEAR YOU

Okay, you probably won't see autonomous vehicles driving near you anytime soon, unless you live in Silicon Valley, where Google has been extensively testing its famous self-driving Toyota Prius (shown below during at demo at TED) and now also a fleet of autonomous golf carts. But one thing's for sure: Autonomous vehicles have proliferated in the past few years, with projects in the United States, Germany, France, Italy, the U.K., and China. Last year, Nevada became the first U.S. state to permit autonomous cars to be legally be driven on public roads (though some speculate that Europe might prove more friendly to this type of vehicle than the United States.) Either way, autonomous driving features are already showing up on regular mass-produced cars. Some models of the Prius now have a driving assist function that keeps the car centered on its lane, and another function can park the car all by itself. Though carmakers will insist these are *not* autonomous driving features, it's clear that cars are becoming more robotic. Furthermore, it's likely that autonomous vehicles will drive another trend as well: As one panelist explains, we should start to "map, and perhaps even instrument, our environment" to help autonomous cars and robots navigate. "This is a shift," he says. "The emphasis used to be solely on local algorithms and computation. Folks are starting to realize that this is not the low-hanging fruit." Driving, we'll soon be able to say, is so 20th century.



Google *demonstrates* its self-driving car at the TED 2011 conference. Photo: [Steve Jurvetson/Flickr](#)

#8 FACTORY ROBOT HELPERS: THE FUTURE OF MANUFACTURING

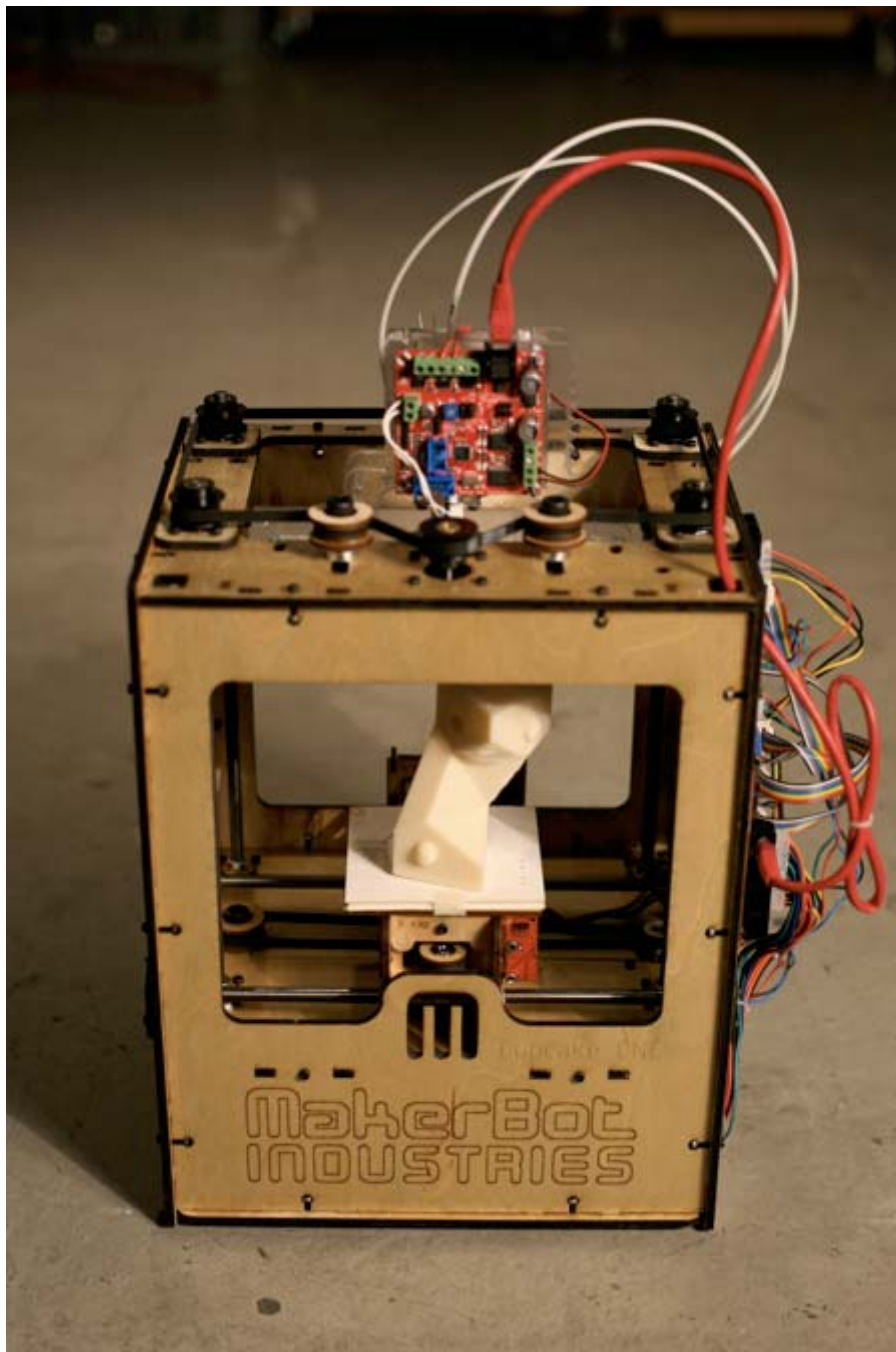
Last year, an announcement from electronics manufacturer giant Foxconn took the robotics community by surprise. The Taiwanese company said it was going to add 1 million robots to its assembly lines over the next three years. One million robots is a lot of robots—in fact, it's double the current industrial robot population. Many uncertainties remain about Foxconn's plans, including whether they can pull it off. What's clear, though, is that there's a huge need for flexible, capable, safe manufacturing robots—a new generation of industrial machines very different from the big, expensive manipulators in existence. And it looks like this new generation is beginning to arrive. Examples include [Kawada Industries' Nextage](#), [ABB's FRIDA](#) (pictured below), and [Yaskawa's Motoman SDA10D](#). But the factory robot everyone wants to see? It's the mysterious robot that [Rodney Brooks](#) is developing at his super-secretive startup Heartland Robotics. Is 2012 the year he'll unveil the machine? We hope so.



The ABB FRIDA concept is a 14-axis dual arm robot designed for working alongside human workers in manufacturing environments. Photo: ABB

#9 RAPID PROTOTYPING: A 3D PRINTER IN EVERY HOME

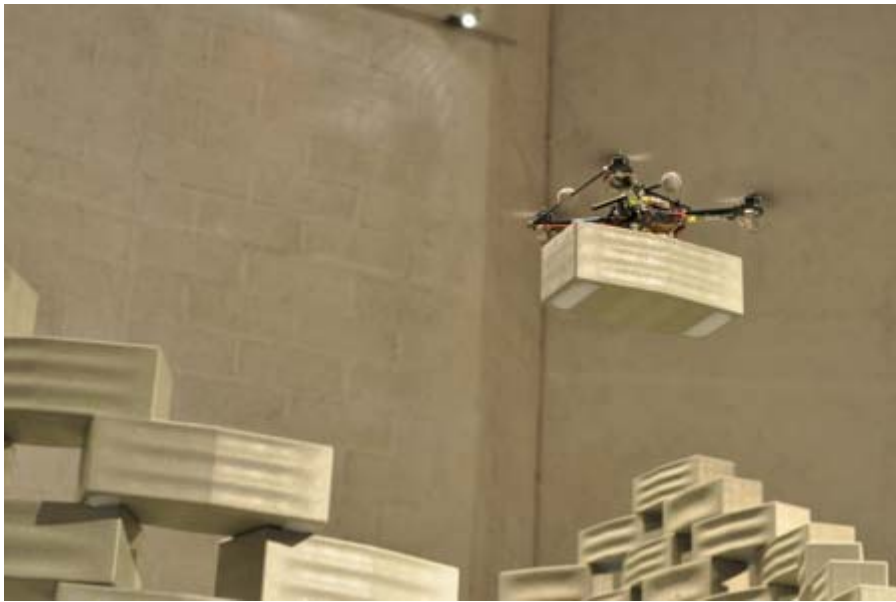
Rapid prototyping is incredibly useful; being able to quickly fabricate a part can save thousands of dollars, eliminate days of waiting, and allow you to figure out whether your neat design is indeed brilliant—or a flop. There is one rapid prototyping device (a robot in its own right) that will likely make a significant impact in 2012: MakerBot Industries' Thing-O-Matic 3D printer (pictured below). 3D printers are now a mainstay of academic and industrial robotics labs, but they're expensive (some cost over \$20,000). The Thing-O-Matic (and its ilk) make 3D printing available to the masses, retailing for as little as \$1000. Low-cost 3D printers could very well be the next big trend in home robots. MakerBot forecasted 10,000 units would be sold in 2011, but we're guessing they shattered their estimates: They were already ahead of schedule in *March* of 2011, and raised \$10 million in venture capital to expand their efforts. At the forefront of the DIY "maker movement," 3D printers like the MakerBot are fulfilling the "personal fabricator" scifi visions set forth in Neal Stephenson's "Diamond Age," allowing people to mockup, share, and refine digital products—using websites like Shapeways and Thingiverse—for home fabrication. Our bet is that 3D printing is going to keep moving in one direction: up.



One of the open-source 3D printers created by [MakerBot](#). Photo: [Bre Pettis/Flickr](#)

#10 UNMANNED AERIAL VEHICLES: CROWDED SKIES

Small UAVs, and in particular quadrotors, were *huge* in 2011. “They provide an entry path to UAVs for people who couldn’t have worked on them in the past,” one researcher told us. “I would expect interest in that to continue and grow.” Last year was just the beginning. In 2012, we expect to see additional UAV up-take by both professional and “citizen” researchers looking for inexpensive robot platforms (pictured in the photo below is a system used by ETH Zurich researchers). Consider DIY Drones, a popular website for UAV enthusiasts; it boasts more than 20,000 members who design, build, and *fly* their own autonomous UAVs. Buyers looking for already-assembled models have lots of options too. Walking through the mall during the holiday season, we saw literally a dozen stores selling UAVs, from Air Swimmers RC blimps (under \$40) to small smartphone-controlled helicopters (about \$100) to Parrot’s AR.Drone quadrotor (\$300). Brisk holiday sales created thousands of new UAV enthusiasts who, bolstered by ever-expanding open software and hardware resources, will work hand-in-hand with professional researchers to unveil some amazing flying machines in 2012.



A quadrotor helps assemble a tower as part of an art project by ETH Zurich roboticists and architects. Photo: Markus Waibel

#11 TELEPRESENCE ROBOTS: YOUR AVATAR IN THE REAL WORLD

Telepresence robots—mobile machines that act as your stand-in at a remote location—first became prominent in 2010, when Silicon Valley start-up Anybots introduced one of the first commercial offerings, an alien-looking robot called QB. In 2011, more robots hit the market, including the Vgo from Vgo Communications and the Jazz from French company Gostai (pictured below). “It’s an important technology with a strong business case, and will save both time and money for business travelers,” one researcher told us. Indeed, we think that 2012 will be a milestone for telepresence robots, and robotics in general: By the end of the year, hundreds of QBs, Vgos, Jazzes, and others will be roaming around offices—a place where robots were nonexistent—all over the world. It’s a first in robot history. And in 2012 a new entrant promises to make this market even more competitive: It’s likely that Suitable Technologies, a Willow Garage spin-off, will introduce its much-awaited remote presence system as well. So expect to see more telepresence robots near you—if you don’t become one yourself.



The Jazz telepresence robot by [Gostai](#). Photo: Gostai

#12 BIONICS: THE LINE BETWEEN HUMANS AND MACHINES GETS BLURIER

Cyborgs and other man-machine hybrids have long captured people's imagination. We're still far from the technology envisioned in science fiction shows like "The Six Million Dollar Man" and "Robocop," but researchers have made significant progress in the past two years. Areas like [robotic prostheses](#) and [brain-machine interfaces](#) seem to be building lots of momentum, and we expect to see some promising milestones in 2012. In particular, exoskeletons are literally [strutting out of the lab](#). This year, Ekso Bionics (formerly Berkeley Bionics) will begin [selling its robotic suit](#) first to rehab clinics in the United States and Europe, hoping to have a model ready for at-home physical therapy by the middle of 2012 (see photo of a "test pilot," below). At the same time, a DARPA-sponsored project by Johns Hopkins University and the University of Pittsburgh has been [testing a brain implant](#) that allows patients to control an advance robotic arm with their thoughts alone. Many other groups are also working on technologies that promise to blur the line between humans and machines; it won't happen overnight, but now the promise is not just science fiction anymore—it's real.



A “test pilot” tries the exoskeleton created by [Ekso Bionics](#). Photo: Ekso Bionics

A version of this article was originally published in the March 2012 issue of [IEEE Robotics & Automation Magazine](#).

The authors are thankful for the timely and thoughtful feedback from a number of researchers: Raffaello D’Andrea, Tiffany Chen, Matei Ciocarlie, Steve Cousins, Aaron Edsinger, Kaijen Hsiao, Charles C. Kemp, Masaaki Kumagai, Matt Mason, Hai Nguyen, Daniela Rus, Bruno Siciliano, Stefano Stramigioli, Gaurav Sukhatme, Russ Tedrake, Andrea Thomaz, and Holly Yanco.

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