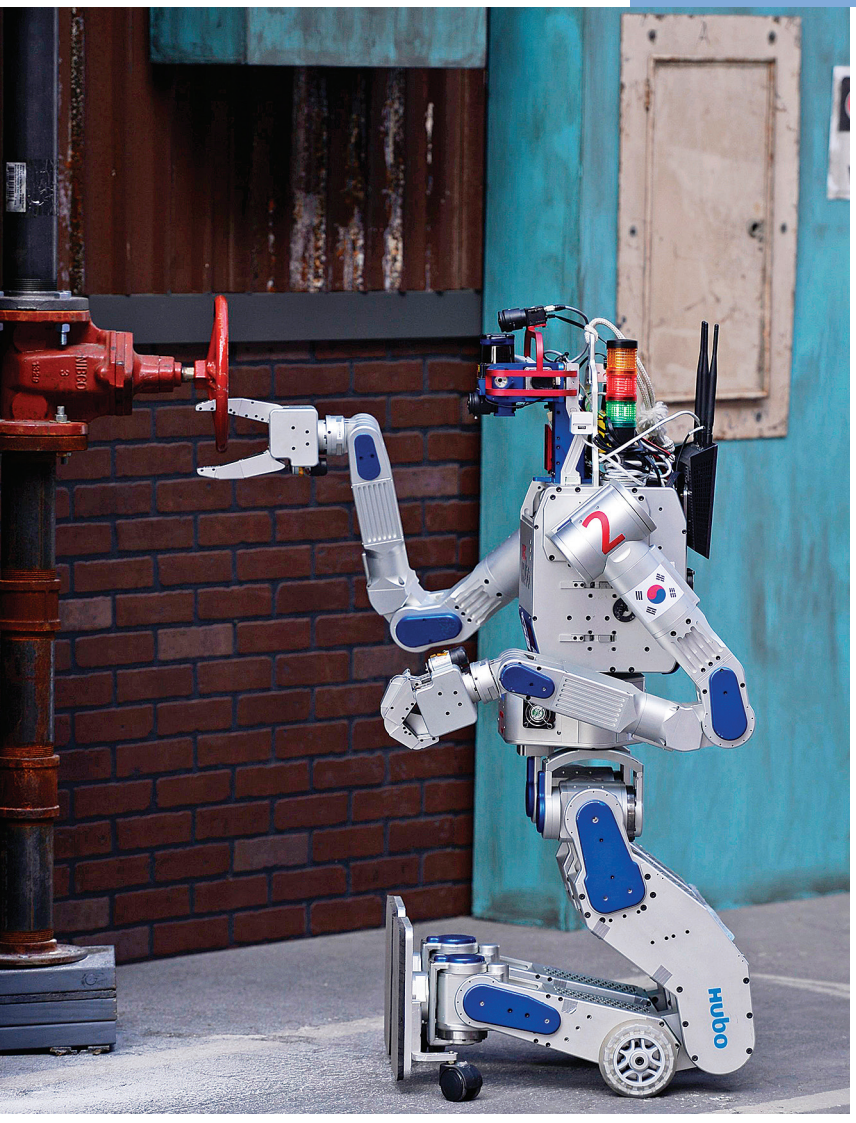


DARPA/AP PHOTO

44 MINUTES, 28 SECONDS: WINNING TIME FOR THE DARPA ROBOTICS CHALLENGE

THE HARD LESSONS OF DARPA'S ROBOTICS CHALLENGE

What we learned from pushing 23 humanoid robots to their limit

In what must be the biggest public display of robot adoration and empathy ever witnessed, thousands cheered as the team from the Korea Advanced Institute of Science and Technology (KAIST) won the DARPA Robotics Challenge (DRC) in Pomona, Calif., on 6 June. Its robot, an adaptable humanoid called DRC-Hubo, beat out 22 other bots from six countries in a two-day competition organized with the aim of advancing the field of disaster robotics. The team from KAIST, which is in Daejeon, South Korea, walked away from the competition with the US $2 million grand prize.

DRC-Hubo's ability to switch from walking bipedally to rolling on wheels gave it a distinct advantage. Many bipedal bots had spectacular and sometimes comical falls while trying to perform tasks such as opening a door or operating a drill. But DRC-Hubo's unique "transformer" design allowed it to perform tasks faster and, perhaps more important, to stay on its feet–and wheels.

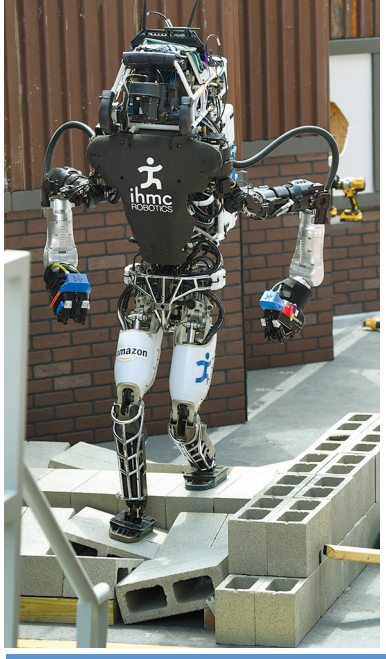
DRC-Hubo prevailed over the other robots because it finished the competition's eight tasks with time to spare: steering a utility vehicle through an obstacle course, getting out of the vehicle (which is more challenging than you might think), turning a handle and opening a door (simple for us, but hard for a robot), opening a rotating valve, using a battery-powered tool to cut a hole in a piece of drywall, inserting a plug into a wall socket, overcoming rough terrain »

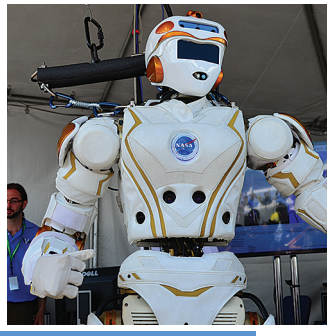
HUBO THE HERO: DRC-Hubo, run by the Korea Advanced Institute of Science and Technology, can skate on wheels when it kneels.

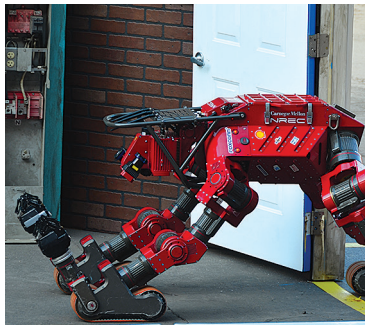
or clearing debris, and climbing a short flight of stairs.

Now that the DRC is over, what have we learned?

—ERICO GUIZZO & EVAN ACKERMAN







CHALLENGERS AND CHALLENGES: Team IHMC Robotics' humanoid [left] made it over some rubble. TRACLabs' humanoid fell getting out of a vehicle [top]. Teams were not allowed to see their robots directly [top right]. CHIMP [bottom right] was the only bot to pick itself up after a fall. The next challenge will center around sending a robot like Valkyrie [bottom] into space.

SOFTWARE IS A HARD PROBLEM

At an event like the DARPA Robotics Challenge Finals, it's easy to focus on the hardware because it's the part we can see. But something just as important was going on in the garages hundreds of meters away. That's where the operators ("robot drivers") received data from the robots' sensors, interpreted it, and told the machines what to do, because the drivers were not allowed to watch the robots directly during the competition.

One of DARPA's main goals with the challenge was to generate significant improvements in the ability of robots and their human operators to work in concert to perform difficult tasks, but we felt that the DRC tasks could have been—and perhaps should have been—even more challenging. For example, in the task requiring the robot to navigate over a pile of rubble, we wanted to see teams push a "go over rubble" button that would make the robot scan the terrain, compute a viable path, and then traverse the obstacles without any further assistance. Granted, autonomy is a difficult hurdle to scale, but it's key to the future of disaster-response robots because relatively untrained users will need to be able to interact with this hardware. And that means letting the robot (or more accurately, the software) deal with as many complex tasks as possible on its own.

RIGHT NOW, NOT WALKING IS A BIG ADVANTAGE

Of the top three robots in the DRC Finals, third place went to a robot that rolled on tracks, second place went to a walking biped, and first place went to a biped equipped with wheels that it could use instead of walking. During two days of watching robots fall over, we were most impressed by the ones that had the option to avoid walking.

"Bipedal walking [for robots] is not very stable yet," Jun-Ho Oh, a professor of mechanical engineering who led the KAIST team, told *IEEE Spectrum*. "One single thing goes wrong, [and] the result is catastrophic."

It's important to note that in a real disaster area, wheeled mobility may be close to useless. So despite how well the wheeled designs did at the DRC, it shouldn't minimize the future potential and value of bipedal walking. As roboticists from the Institute for Human & Machine Cognition, in Pensacola, Fla., pointed out during a postcompetition workshop, bipedal walking lets you move across areas where you only have a footstep-size safe place to move, and, unless you can fly, no other mobility design does that.

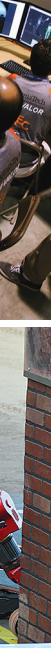
FALLING IS USUALLY OKAY...

From what we could tell, none of the teams expected their robots to survive falling as well as they did. To be honest, we were expecting shattered limbs and geysers of hydraulic fluid across the course. But with a few exceptions, the hardware stood up very well. Or rather, the hardware was stood up by a team of humans after it fell.

Take, for example, MIT's Atlas robot. It fell while getting out of the vehicle on the first day and broke its right arm. Still, after a quick tweak to the robot's software, it was able to perform the remaining tasks with only its left arm. An all-night repair session restored use of the damaged limb for the second day's tasks.

It was a bit disappointing that only one of the robots that fell over, Carnegie Mellon University's CHIMP, managed to get back up again on its own. In fact, CMU's CHIMP was the only robot that even attempted to right itself. Though it's understandable that the teams didn't want to overengineer their robots, falling happens—even to us humans—and we're much better at walking than robots are. If legged robots are ever

CLOCKWISE FROM LEFT: MARK RALSTON/AFP/GETTY IMAGES; EVAN ACKERMAN; CHIP SOMODEVILLA/GETTY IMAGES; EVAN ACKERMAN (2)



JOHN LAMB/GETTY IMAGES

going to be truly effective, falling and getting up is something that they're absolutely going to have to crack.

...EXCEPT WHEN IT'S CATASTROPHIC

There were a few unlucky robots that hit the ground hard and couldn't recover. The most disastrous fall of the competition was the tumble taken by TRACLabs' Atlas robot on day two, right after it exited the vehicle it had driven through an obstacle course. On impact, there was a 2-meter-long spray of hydraulic fluid, and the robot lay there "bleeding" in a puddle of green goo until it was hoisted up and hauled away.

ADAPTATION IS A HUGE CHALLENGE

You never know what a robot is going to encounter as it traverses the scene of a disaster. But as things stand now, even tiny changes in an area's layout, or small errors in programming or commands, can lead to catastrophic failures. This is why robots are not ready for real-world disasters and won't be for quite some time.

The robots that competed in the DRC finals are more versatile and adaptable than any we've seen before. However, it's worth noting that the teams were given the choice of having the robot clear a path through debris or maneuver over uneven terrain: No legged-robot team chose the debris clearing and no wheeled-robot team tried to tackle the terrain. Teams understandably took the easiest course open to them, but in a real disaster area, a robot would likely have to deal with both rough terrain and debris. That's one downside of a competition of this type: It fosters a focus on mastering specific skills as opposed to developing the most capable and versatile robot—and those two things aren't always the same.

WHAT'S NEXT

DARPA's goal with this competition was not to present a robotic platform that could immediately be deployed into disaster areas. DARPA is all about high-risk, high-reward, long-term technological pushes, and that's the context in which the DRC should be considered.

About 10 years ago, DARPA held a Grand Challenge and an Urban Challenge for autonomous vehicles. They were successful, with a handful of self-driving cars and trucks completing the courses. Today, we're just starting to see autonomous-vehicle technology reach the cusp of mainstream adoption. So when we have real disaster-response robots in 5 or 10 years, we can thank the DRC for starting it all.

It's not likely that we'll see another humanoid challenge of the same magnitude as the DRC for some time, but there are still things to look forward to: This year, NASA will hand over several of its Valkyrie humanoid robots to university teams in preparation for a robotics challenge intended to explore the possibility of sending humanoid robots into space and, eventually, to Mars.

COMPUTERIZED DIAGNOSTIC AIDS FAIL IN EARLY TEST

Tools for doctors get poor grades two years ahead of mandatory U.S. rollout

In just two years, computerized systems that help physicians choose diagnostic imaging tests will be mandatory for most elderly patients in the United States. But these decision-support systems fail two-thirds of the time, according to a new study published in June in *The Journal of the American Medical Association*. The study was the largest of its kind, involving more than 3,300 clinicians in eight different states and over 117,000 orders for advanced diagnostic imaging.

Use of advanced imaging such as X-ray computed tomography (CT) and magnetic resonance imaging (MRI) increased dramatically from 2000 to 2010, raising concerns about unnecessary costs and—in the case of CT—radiation exposure to patients. Making a decision about whether or not to order an imaging test is "really complex, and more and more physicians are expected to have command over an enormous volume of information," says Peter Hussey, a senior policy researcher at the Rand Corp. and the lead author of the study.

Computerized clinical decision-support (CDS) systems—software packages that help physicians choose diagnostic tests or next steps in treatment—are meant to help. The clinician enters information