Recasting Robotics Challenges as Experiments

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This month's column deals with how we can and should treat competitions and challenges as repeatable experiments.

The science is what you do [back at the lab but] throw away the night before the competition.

—Jim Firby, 1994
[from Balch and Yanco 2002, http://www.aaai.org/ojs/index.php/aimagazine/article/view/1603/1502]

Challenge and competition events in robotics provide an excellent vehicle for advancing the state of the art and evaluating new algorithms and techniques in the context of a common problem domain. As evidenced by RoboCup and the Defense Advanced Research Projects Agency (DARPA) Grand Challenge, there is no question on the impact that competitions have had on robotics research and development. Beyond forcing technology out of laboratory environments, competitions provide an opportunity for the research groups to benchmark approaches against each other to enhance understanding of relative advantages and shortcomings. More importantly, competitions have clear measures of success and require integrated implementation of complete robotic systems.

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However, this focus on clarity and integrated development can come at the cost of research, exploring specific aspects of robotics in depth as well as emerging topics. Robotics (and especially robot challenges) are inherently efforts in developing integrated systems, but research is often about examining the functionality of specific modules in isolation. We argue that a rethinking of the role of challenges in robotics is needed, where specialized research and integrated development can be pursued in tandem as a catalyst for innovation. Specifically, we propose recasting challenges as research experiments. Under this paradigm, participants use checked-in modular integrated systems, where the participants can plug and play their research modules in an interoperable manner. This will allow the participants to focus on generating the best possible method for the robotics community to build upon, without the burden of hacking together a one-off integrated system for fear of not showing well.

Expand Common Functionality and Avoid Picking Winners and Losers

We can already see the enablers of experiment-based challenges coming together in terms of modularity, interoperability, and open-source development. Several competition-based challenges have begun separating hardware and software development using controlled standard platforms, such as the Aldebaran NAO for the RoboCup Standard Platform League and LAGR robot for the DARPA LAGR program. More importantly, the challenges should not simply be a form of picking winners and losers in terms of demonstrating one group's technical prowess compared with others at a single point in time. Instead, the challenges should enable better algorithmic and systems development on a continual year-round basis across the robotics community. Implied is that challenges should demand open-source interoperable software that will benefit the work of other participants and community as a whole. As such, the incentive for challenge participants is to increase the impact of their work (and publication citation count) rather than winning the single event. RoboCup has had a long and fruitful tradition of requiring open-source releases of competition code but with significant overhead for making disparate codebases interoperate. Such codebases could be better interoperated with the large robotics community using middleware packages based on interprocess communication, such as Willow Garage's robot operating system (ROS). ROS has a demonstrated ability to enable modular

CORRECTION: The December 2010 "Competitions" column should have been titled "The ICRA Robot Challenge," and the authors should have been listed as Steve Balakirsky, Matei Ciocarlie, Craig McGray, Jason Gorman, and Mark Yim. We apologize for the error.

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interoperable robot software development over decentralized code repositories and a variety of robot platforms. As is already occurring at conferences such as AAAI and IEEE International Conference on Robotics and Automation (ICRA), challenges based on functionality over competition and on interoperability over fragmentation are already showing promise.

Competitions Inspire, Challenges Build

Competitions and experiment-based challenges have complementary roles to play. Competitions are about inspiring the community to go beyond the boundaries of what appears to be possible or feasible. In contrast, experiments are about codifying our knowledge that currently exists for future refinement of our methods and generation of new scientific questions. The original role of autonomous robotics competitions, such as the AAAI Robot Competition and RoboCup, was to inspire people to make capable robots a reality and convince the larger public of their benefit. Such events had lofty goals and were able to make visceral progress. The inaugural AAAI Robot Competition aimed to produce robots capable of navigation and exploration in unknown environments with clutter and people, which has not become commonplace in robotics. RoboCup is still on its path to field internationally competitive humanoid soccer players, with several significant humanoid platforms spawning from this effort. Due, in part, to the success of these competitions, robots have become a reality for society, playing a significant role in our homes, offices, hospitals, pitches, roads, battlefields, and other planets. As the robotics research and development ecosphere grows, the role of robotics has evolved from "Can we produce functioning robots?" to "How can we make better and more capable robots?" In this regard, our challenging problems must also continue to evolve to adequately serve the needs of the robotics community and users.

Common Evaluation Through Democratized Access to Advanced Robots

Assuming all researchers have access to common platforms, the thousands of papers annually published about robot computation should have solid comparative experimental results. Independent evaluation and reproducibility are the hallmarks of scientific research and essential for embodied research, as in robotics. Otherwise, our community is left with a best demo/video wins culture. However, providing universal access to state-of-the-art robotic platforms is a big resource challenge in terms of time, space, and finances. One recently developed option is the PR2 Remote Laboratory, created by Bosch Research and Brown University as part of Willow Garage's PR2 Beta Program. The Remote Laboratory was created to enable access to use and run experiments on PR2 mobile manipulation robots for a broader population of researchers and users. The Remote Laboratory allows the researchers to use a PR2 like most other Web services (via http://pr2-remotelab.com/), where user interfaces and robot controllers can be purely created for common browsers using HTML5 and JavaScript, without additional software installation.

This year, the Remote Laboratory has been made available to teams participating in the AAAI 2011 "Learning from Demonstration Challenge." This year the task centers on food preparation, where teams develop learning nodes that build on existing capabilities in ROS for table setting and preparation for a meal. Teams can create custom Web interfaces to allow many more users to demonstrate the task to the robot through the Internet.

Conclusions

We have argued for the recasting of robotics challenges as experiments rather than competitions. Experiment-based challenge could not only help better merge research with demonstrations but also provide a common ground for comparison of robotics algorithms. When combined with open-source interoperable software frameworks, the adoption of experiment-based challenges can move the community away from specialized one-off demonstrations toward a better collective understanding of the state of the art of autonomous robotics.

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