The DARPA Robotics Challenge

By Gill Pratt and Justin Manzo

Any news broadcast reveals that Mother Nature and human nature are not always on our side. Shifting demographics make society increasingly susceptible to both natural and man-made disasters. Densely populated coastal cities prone to flooding and bad weather invite heavy tolls from natural disasters. Man-made disasters come in many forms, such as chemical spills, weapons of mass destruction, release of radiation, and so on. Humanity must improve its defenses against such threats, i.e., we must prepare for the unexpected.

During the Fukushima disaster, many Japanese citizens, aware of the development of humanoid robotic platforms, asked, "Can't robots help us?" It turns out that they could not, at least not then. The Defense Advanced Research Projects Agency (DARPA) Robotics Challenge (DRC) aims to work up to robots that can help in the near future. The DRC is a program in human-scaled robotics for disaster response. DARPA's goal is to create robots that could interface with human environments, use human tools, and be commanded by humans without specialized training. We want robots that can adapt to assist in any disaster.

Why a Challenge?

DARPA issued a challenge to seek solutions to a series of problems by posing them to the community. How can we design a robot to respond to an unstructured set of tasks? How can we make it work in partnership with a human leader despite limited communications? How do we benchmark performance? What tools do we use? We don't know the answers, but we do know that no corporation, school, or individual is going to solve these problems alone.

We also chose the challenge model as it offers the best way of engaging the global community. If the prize structure is properly tuned and the solution is valuable enough, we'll reach not only major robotics contractors but also individual thinkers, hobbyists, and academics.

We felt a more diverse funding model was necessary compared with the previous model of the DARPA Grand and Urban Challenges as we did not have an existing technology base (i.e., automobiles) from which to start. We are providing development funds to some teams, chosen through proposal evaluation, with a number of down-select points based on performance. We are allowing other teams with independent funding to compete without submitting proposals. We will remove a barrier to entry for software developers by providing a robot and technical support to teams that perform best in a preliminary, simulation-based competition; simulations will run on an open-source tool that we are developing in parallel and hope will become a community-standard resource for producing and sharing new robots and testing environments. In total, more than 100 teams from around the world are registered: large contractors, small businesses, universities, government agencies, and groups of individuals.

Collaboration Brings Solutions

We believe that we can achieve unique knowledge transfer through a community-wide challenge. For example, as we develop the government-funded platform and simulation environment, we have a hotline to experts with a vested interest in the program's success. If we are having difficulties in developing a real-time simulation environment or scoping requirements for a walking controller, we can reach out to hundreds of participants. What elements are critical in rolling out these tools? The decision should rest with the engineers and scientists who will use them and who collectively possess the theory and applied experience to prescribe solutions.

By proposing a challenge that addresses manipulation, locomotion, perception, and communications, we force experts in each domain to pool their intellectual horsepower. We are seeing super-groups formed from institutions that might never have collaborated otherwise. Between teams, we see an increase in cross-talk using challenge-endorsed forums; such cooperation might not occur in a conventional, performer-based program. Nobody wants to give away the secret sauce, but in pointing each other to key resources, teams significantly raise the knowledge floor.

Digital Object Identifier 10.1109/MRA.2013.2255424
Date of publication: 6 June 2013

Benchmarks

When you aim to solve the issues we are taking on, there is no falling back on a single standard to benchmark a good robot. We are leveraging great work done at the National Institute of Standards and Technology on its E54.08.01 rescue robotics metrics but taking a step back with their oversight. Rather than scoring the functions that describe robot performance (e.g., visual acuity, dexterity, maneuverability), we look at holistic solutions that reflect a robot's ability to complete a mission. We feel that this is the only way to develop a robot that can operate in an arbitrary environment, rather than having a "hose grab" mode and a "ladder climb" mode. The successful robot will adapt to its surroundings and operate despite degraded communications.

In writing benchmarks, we routinely see the value in community involvement. For example, we cannot pick a scoring rubric out of thin air, so we solicit input from participants on how to score the events. In the Virtual Robotics Challenge, set for June 2013, we face the difficult task of measuring robotic performance in events based on time, speed, and bandwidth usage. To resolve how we determine a winner, we proposed a set of rules and teams helped to generate a set of scoring criteria that preserves the authenticity of the challenge. Experts in remotely operated robots, robotic manipulation, and locomotion weighed in with different perspectives to expose flaws in methodology and develop new means of assessment that will force teams to complete tasks efficiently. Thus, we anticipate the competition will drive innovation in the areas where we need to push community focus.

Conclusions

We expect to see great strides in a number of directions as a result of the DRC, including new crosslinkages in the robotics community. In the end, the community wins under any or all of three scenarios: we create algorithms necessary for multifunctional robotics, we develop one or more excellent robotics platforms, or we coalesce on an open-source simulation environment with a widespread user base that catalyzes the industry. With so many thought leaders engaged, we are confident that the resulting technologies will soon be able to help humans respond to whatever crisis the world dishes out.