RoCKIn Innovation Through Robot Competitions

By Pedro U. Lima, Daniele Nardi, Gerhard Kraetzschmar, Jakob Berghofer, Matteo Matteucci, and Graham Buchanan

Robot competitions are a great way to drive innovation and facilitate collaboration, but how do you ensure the outcomes have some meaningful influence on real-world applications and foster research progress? However great the technological developments, public perception and uptake will be a struggle unless outcomes are seen as relevant for people's lives; research peers will also want to assess the value of potential research outcomes before they get engaged in a competition.

At RoCKIn, a multiyear European Union–funded robotics project consisting of educational camps, field exercises, and two competition events, the key goals have been to develop test beds and benchmarks that are relevant to real-world applications and to ensure outcomes are transferable above and beyond the project. The benchmarks are designed to be reproducible and repeatable both outside the project and within it, enabling objective, quantitative assessment of performance over time and providing feedback for future developments. The test bed design is open source and includes specifications on the dimensions of composing areas and their interconnections, objects present in the test bed, ranges of environmental conditions, and parameters that can be varied in a given range for benchmarking purposes. By combining the popular competition models with scientific rigor, we hope to create transferable innovation that can have an impact on domestic and industrial robot applications.

A unique feature of RoCKIn is its inclusion of both vertical and horizontal benchmarks: grading performance in individual tasks as well as in certain functionalities across tasks, such as understanding speech. The latter can isolate the causes of success or failure within the robotic system and provide invaluable information on how different functionalities interact in the performance of tasks.

To elaborate further on the speech-understanding functionality example: this involves giving a series of recognizable commands that conform to a command–argument structure (e.g., a command–evoking verb such as "go" followed by an argument such as "to the bedroom"). The robot would have to first transcribe the user utterance and then recognize the action to perform. Its performance is evaluated on factors including the word error rate of transcription, the number and percentage of correctly recognized actions (i.e., command signature without arguments), the number and percentage of correctly recognized commands (i.e., command signatures plus arguments), and the time taken to complete the test.

To perform these evaluations, data, including the robot's sensor data, the final command produced by the natural language understanding analysis process, and intermediate information produced or used by the natural language understanding system are collected. Teams are provided with a set of semantic frames, including the allowed arguments for and set of verbs evoking each frame, as well as a specific lexicon for the environment (such as object and room names) in advance.

The potential competitors got their first taste of these benchmarks and the rationale behind them at RoCKIn Camp 2014 in January, which was held at the Auditorium Antonianum in Rome, Italy. Here, over the course of five days, 63 participants from 13 countries were able to experience an intense program of educational lectures from leading experts in field of robotics along with practical, hands-on experience with domestic service and industrial robots.

More information on the benchmarking criteria and on the challenge in general can be found on the Web site http://www.rockinrobotchallenge.eu/. Some of the benchmarks and tasks that will be used in the two streams are summarized here. RoCKIn@Work (Figures 1 and 2) looks for innovative robot applications in industry, and RoCKIn@Home focuses on domestic service robots.

RoCKIn@Work Tasks

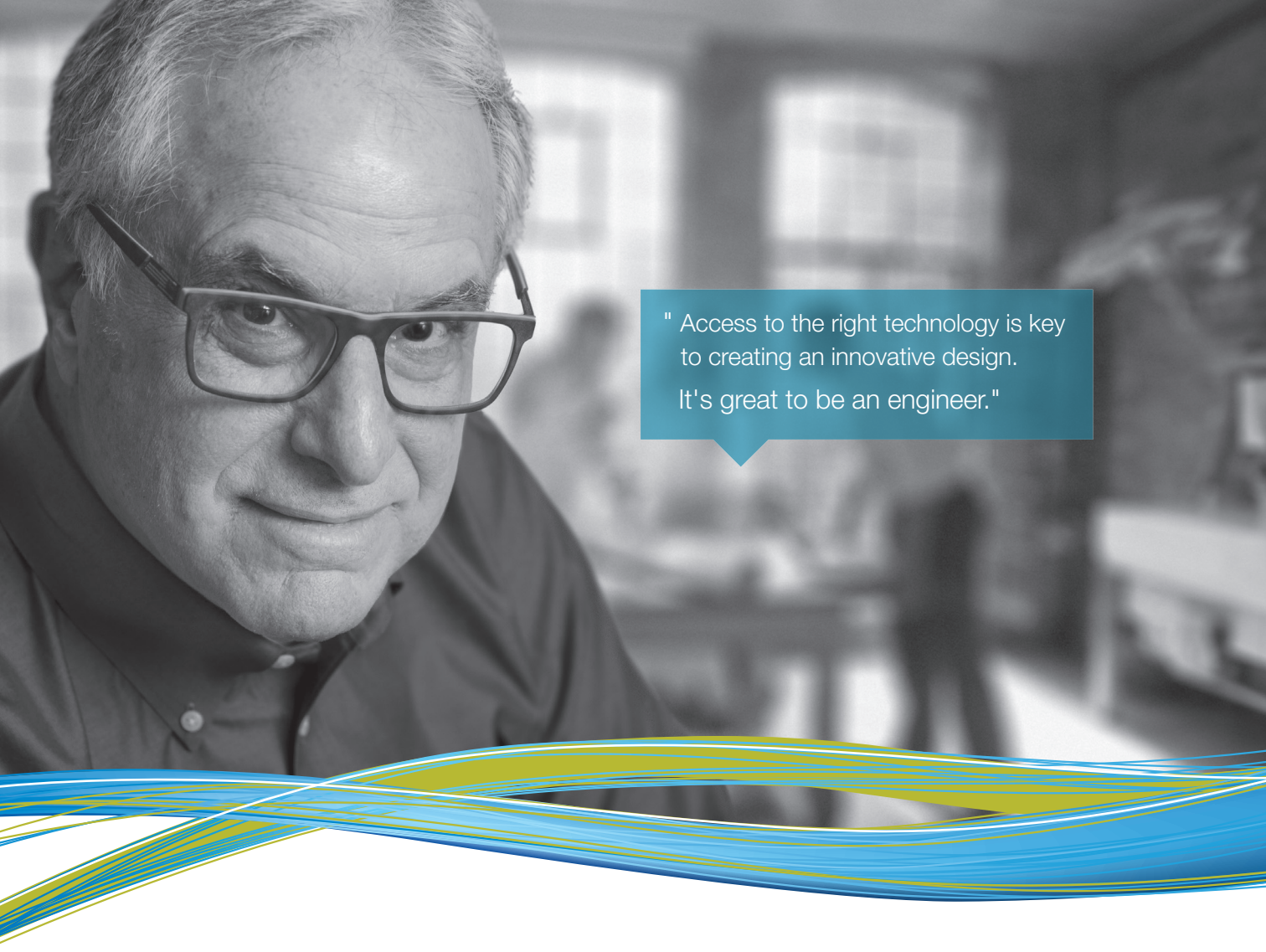
Assembly Aid Tray

The robots prepare an assembly aid tray and proceed with collecting the required bearings and bearing boxes and place them in the tray. The benchmarks for this task include accomplishment, complexity overcome (different levels of difficulty can be introduced), task scheduling efficiency, and navigation ability.

Plate Drilling

Retrieving the cover plates from a continuously moving conveyor belt, the robots must visually assess for defects

Digital Object Identifier 10.1109/MRA.2014.2314015
Date of publication: 10 June 2014



ENGINEERS START HERE.

Research. Design. Prototype.

From data sheets to development kits & tools to components, Newark element14 offers what you need for every stage of your design. **newark.com** | **800.463.9275**

Agilent Technologies

Featured Product:
33611A Trueform Waveform Generator
(29X7419)

Newark™ element14™

before placing the plates in the corresponding box. Faulty plates are taken to a drilling machine that must be activated by the robot. Accuracy, accomplishment, time, task scheduling efficiency, and manipulation ability are all benchmarked in this task.

Fill a Box

Working alongside humans, the robots must retrieve the desired parts and return with them. Raising the difficulty is that other robots will be moving around the arena, and so the assessment will be based not only on accomplishment and time but also on navigation safety and the interaction with other robots and the changing surroundings.

RoCKIn@Home Tasks

Catering for a Human's Comfort

In a task built around many smaller subtasks (Figures 3–5), the robots are required to provide support through opening the blinds, getting a glass of water, and finding reading glasses. The benchmarks will vary for every task, but the central themes are the time taken; speech understanding; and the quality of perception, navigation, and manipulation.

Figure 1. The RoCKIn@Work team gathers at RoCKIn Camp 2014.

Welcoming Visitors

The robots must respond to the doorbell and interact with people—recognizing who they are or why they are at the house. The criteria for this task include the time taken, communication skills, surveillance of unknown visitors, quality of perception, and the visitor handling behavior.

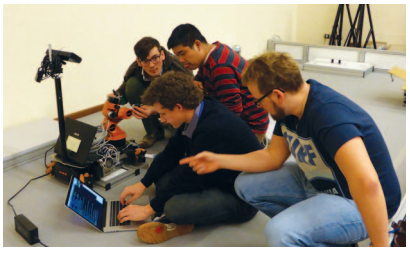


Figure 2. Participants set the KUKA youBot for action in the RoCKIn@Work arena at RoCKIn Camp 2014.

Instant Access to IEEE Publications

Enhance your IEEE print subscription with online access to the IEEE *Xplore*® digital library.

- Download papers the day they are published
- Discover related content in IEEE *Xplore*
- Significant savings over print with an online institutional subscription

"IEEE is the umbrella that allows us all to stay current with technology trends."

Dr. Mathukumalli Vidyasagar
Head, Bioengineering Dept.
University of Texas, Dallas

Start today to maximize your research potential.

Contact: onlinesupport@ieee.org
www.ieee.org/digitalsubscriptions

IEEE
Advancing Technology for Humanity

Getting to Know My Home

A changing environment will require the robots to adapt to their surroundings and learn where objects may have been moved, gaining intelligence of their settings and possibly querying humans about what changes may have occurred. The number and percentage of changes detected and the time spent mapping will be central to the assessment of this task.

These are just brief insights into what will be occurring at the competition events, the first of which is in Toulouse, France, 26–30 November 2014 (with local co-organization of LAAS/CNRS) and the second planned for Lisbon in November 2015. The benchmarking laid out aims to combine the academic rigor expected in a closed laboratory setting while targeting it toward real-life applications that will further improve public perception of autonomous assistants. We hope that RoCKIn sets a trend that will be replicated widely in the future. If you would like to get involved in the project, please visit our Web site (http://www.rockinrobotchallenge.eu/) for more details.

Figure 3. The PAL robotics REEM robot picks up household items in the RoCKIn@Home arena.

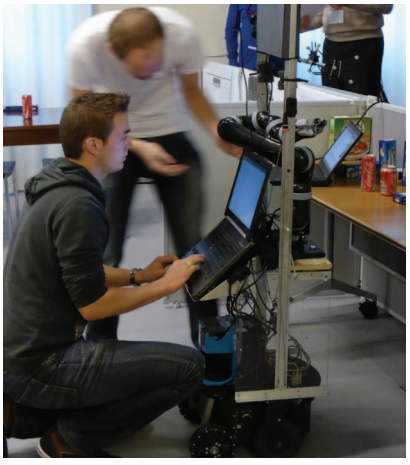


Figure 4. The RoCKIn@Home team Homer from University of Koblenz-Landau makes final adjustments before presenting its work at RoCKIn Camp 2014.

Figure 5. The SocRob@Home team from IST, University of Lisbon, maps the RoCKin@Home arena at RoCKIn Camp 2014.