RoCKIn@Home
Benchmarking Domestic Robots Through Competitions

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***Abstract*— The RoCKIn EU project introduces two competitions (RoCKIn@Work and RoCKIn@Home) motivated and based on research challenges originating in RoboCup (@Work and @Home). RoCKIn extends these challenges to networked robot systems and by increasing the emphasis on cognitive aspects. This short paper provides a brief overview on both the general concepts of RoCKIn and the current developments concerning the RoCKIn@Home competition and challenge.**

I. INTRODUCTION

In the last 20 years, robot competitions (e.g., RoboCup, DARPA Grand Challenge, AAAI Robot Competition, IEEE ICRA Robot Challenges, ELROB, to name but a few) have emerged as a powerful means to push the state of the art in robotics research and development (R&D).

RoCKIn stands for "Robot Competitions Kick Innovation in Cognitive Systems and Robotics" and it is a Coordination Action funded by the European Commission under its 7^{th} Framework Program, aiming at fostering research progress through robot competitions, including building up a community of participants composed of experienced and new teams, developing benchmarking methods and tools to be used during competition events, as well as specifying, designing and building test beds for benchmarking. Its goal is to speed up the progress towards smarter robots by building upon the principles of fostering research through scientific competitions, like RoboCup.

RoCKIn objectives will be realized by (see Figure 1)

1) specifying, designing and building open domain test beds for competitions that target the two challenges;
2) developing benchmarking methods through competitions that focus on particular subsystems but also on the integrated system, and are used in the testbeds;
3) organizing two annual robot competition events (in 2014 and 2015) based on the selected challenges and test beds;
4) organizing camps open to student participants, so as to help new teams get involved in the competitions;
5) dissemination activities targeting stakeholders in industry and academia, as well as regular citizens.

RoCKIn objectives will be pursued through two challenges, which have been selected due to their high relevance and impact on Europe's societal and industrial needs: domestic service robots and innovative robot applications in industry. The two RoCKIn challenges were originated in RoboCup and thus named RoCKIn@Work and RoCKIn@Home. Specifically, RoCKIn is aiming at introducing in the @Work and @Home framework a research infrastructure supporting the development of cognitive and networked robot systems (i.e., systems composed of static sensors networked with mobile robots, sensors and actuators). Moreover, RoCKIn plans to build benchmarking methods and tools to be validated through the competitions and, provide the basis for new frameworks for performance evaluation of dependable robots. In this paper, though most of the concepts will be general for RoCKIn, we will refer to the @Home challenge.

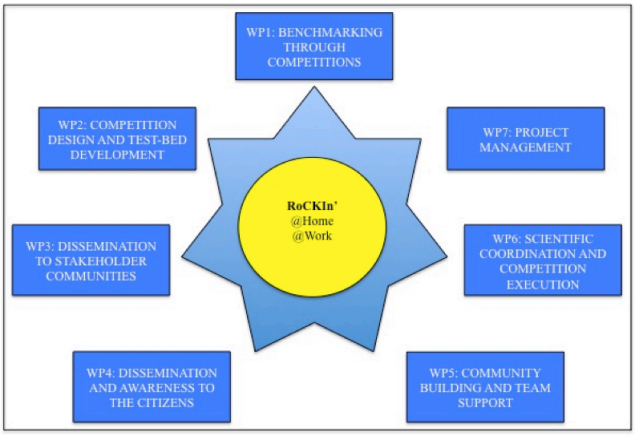

Fig. 1. The relations between the different RoCKIn activities.

II. BENCHMARKING THROUGH COMPETITIONS

In recent years, the need for a more systematic evaluation of the performance of robotic systems has been outlined. This need has produced a number of initiatives, including the creation of benchmarks, the development of standard experimental testbeds, and the developments of scientific competition and challenges. However, a significant progress is needed to reach the level of *scientific experiment*, as in other scientific areas [1], [2].

The evaluation of performance of robotic systems requires handling systematically the variability in tasks, environments, environment conditions/scenarios (e.g., light intensity, with or without the presence of humans) and robots usually present in robotics experiments. Experiments must be replicable, meaning that all specifications for the tasks, scenarios, robots must be clear and well-defined. This way, experiments can be reproducible during the same competition, or in

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different competitions and laboratories worldwide, where the test beds were replicated. The resulting test beds, designed and built so as to represent the different scenarios by suitably changing the environment conditions and features, will enable running the set of specified tasks several times under controlled (but realistic) conditions, providing means for objective comparison and statistically significant evaluation of robot performance. Methods to benchmark experiments (e.g., an algorithm to calculate the error between the desired path and the path followed by a robot in a navigation experiment) must be developed, and software tools to calculate them online, in real-time, must be developed to be part of the test bed structure (e.g., a test bed computer periodically queries a robot evolving in the test bed for its latest location estimate) and mandatory to be included in the robots themselves (e.g., the code that answers the test bed queries and provides the robot location as estimated by a localization algorithm running on-board).

Several issues of interest can be tackled using replicable test beds as benchmarking support: assessing the ability of a single robot to perform a variety of tasks in the same well-specified scenario, or to perform the same task in a variety of environment conditions and features; comparing the performance of different robots (or of a networked robot system - NRS) in the same task and fixed scenario; or generalizing to the most difficult case of comparing the performance of different robots (or NRS) in different scenarios [3].

Robot competitions designed to be used as scientific benchmarks must take these issues into account. In RoCKIn, we are specifying testbeds for the @Work and @Home challenges that will be used in the RoCKIn camps and competition events. Our aim is to realize an infrastructure that will last after the project lifetime, so as to enable the continuation of benchmarking tests by several research groups worldwide on the two application areas, as well as to provide a methodology to design and build new scenarios and tasks. The test beds will include changeable scenarios features and conditions, methods and tools to compute benchmarks, designed to serve pre-established sets of tasks. We are considering to benchmark separately the performance of the networked robot system *functionalities* (e.g., self-localization, person tracking, grasping an object) and the performance of the NRS while executing the full *task* integrating those functionalities. By doing so, we can test the solutions used for each of the composing functionalities, and how well they performs across a variability of scenarios and tasks, instead of assessing only the overall performance in the task, as in most competitions.

III. RoCKIn@Home

As previously mentioned, RoCKIn aims at two main contributions in the framework of the @Home and @Work competitions:

- the introduction of networked robot systems (i.e. systems composed of networked robots, sensors and actuators, which may be mobile or remain at a fixed location);
- a new methodology and tools for benchmarking the performance.

At this stage of the project we are designing the competition and here we sketch the main underlying ideas.

RoCKIn@Home currently envisages a user story that concerns an elderly person, named"Granny Annie", who lives in an apartment together with some pets. Granny Annie is suffering from typical problems of aging people: She has some mobility constraints. She tires fast. She needs to have some physical exercise, though. She needs to take her medicine regularly. She must drink enough. She must obey her diet. She needs to observe her blood pressure and blood sugar regularly. She needs to take care of her pets. She wants to have a social life, and welcome friends in her apartment occasionally, but regularly. Sometimes she has days not feeling so well and needs to stay in bed. She still enjoys intellectual challenges and reads books, solves puzzles, and socializes well. For all these activities, RoCKIn@Home is looking into ways to support Granny Annie in mastering her life.

Based on this overarching story, we are developing scenarios where networked robot systems cooperate to perform tasks that include handling the home pets, bringing objects to Granny Annie and a welcoming a visitor, in addition to other devices in the environment that can provide additional perception and actuation capabilities to the networked robot system. In order to accomplish such tasks, the NRS requires functionalities such as searching a pet, filling a pet food containers, navigating a mobile robot around an apartment, understanding human gestures, performing human-aware navigation (e.g., keeping a safe distance to the human), manipulating object and dialoguing with humans. A test bed reconfigurable to set the scenarios for all the above tasks is being specified, including the corresponding benchmarking methods and tools.

Our approach to benchmarking will be realized by providing specific benchmarks for each of the functionalities that have been outlined above. This may lead to the creation of specific benchmarks as well as to the adoption of benchmarks that are already available to the scientific community. In this way, we can outline the best solutions for a given system functionality and analyze the impact of the performance of each system functionality on the overall system performance. Moreover, by measuring the performance of individual functionalities, we can assess the performance of systems that provide only some of the functionalities that are required to accomplish the overall task. Finally the overall system performance will be built by considering both the performance on individual functionalities and the overall performance.

IV. CONCLUSIONS

Scientific robot competitions are an ideal instrument to provide benchmarking methods and tools for scientific robot experiments. RoCKIn is an European funded project that is working towards the development of these ideas while preparing test beds and competition events to test them.

Simultaneously, RoCKIn is building up a community of old and new researchers interested in robot competitions and disseminating robotics research through competitions to academic and industrial stakeholders and citizens in general.

ACKNOWLEDGMENT

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