Advancing Research at the RoboCup @Home Competition

By Fabrice Jumel

RoboCup (https://www.robocup.org/) is an annual international robotics competition, founded in 1996, that aims to promote robotics and artificial-intelligence research. The initial challenge was for a team of robots to play soccer: it was the first competition that used soccer games to promote research and education. The goal of RoboCup is as follows: "By the middle of the 21st century, a team of fully autonomous, humanoid, robot soccer players shall win a soccer game, complying with the official rules of the Fédération Internationale de Football Association, against the winner of the most recent World Cup."

During the ensuing tournaments, different soccer leagues were created (depending on the robots' size and type of locomotion). Later, it was determined that the competition should include additional robot aspects and involve junior teams. The current major leagues cover different challenges: soccer (RoboCupSoccer), rescue (RoboCupRescue), logistics and industrial (RoboCupIndustrial), and domestic (RoboCup@Home). RoboCup rules are reviewed annually by each technical league committee and discussed with participants and other researchers in the field. Road maps are discussed regularly and used as references for future rules.

RoboCup@Home (http://www.robocupathome.org/) is the largest international annual competition for autonomous service robots, with 24 to 36 teams competing. The league aims to develop robot-service technology, in particular, for future personal domestic applications. The focus is on human–robot interaction and cooperation, navigation and mapping in dynamic environments, computer vision and object manipulation, and adaptive behaviors. A set of benchmark tests is used to evaluate the robots' abilities and performance in realistic, nonstandard home-environment settings (Figure 1).

A complete rulebook is available at https://github.com/RoboCupAtHome. Important modifications were applied for 2019 to propose tasks that are more comprehensible to the audience and give newbie teams more opportunities to handle various scenarios. The competition is organized in two stages, each consisting of different specific tasks, and ends with the finals. Setup days give participants time to examine the arena as well as the furniture and objects associated with the tasks. Challenge details are kept secret prior to the competition, and minor changes may occur in the arena during the events to mirror situations that can occur in real life (a chair can move from one room to another but not to the sink).

Figure 1. Robots are expected to perform in realistic, nonstandard settings.

Each stage provides a set of tasks grouped in two thematic scenarios. The housekeeper scenario features tasks related to cleaning, organizing, and maintenance (Figure 2), and the party-host scenario focuses on providing general assistance to a group of guests. For example, tasks for the housekeeper in stage one are to clean up, store groceries, serve breakfast, and take out the garbage as well as act as a general-purpose service robot that can perform all of the previous tasks and more on demand. Party-host tasks include, for example, carrying luggage, saying farewell to guests, finding friends, acting as a receptionist, and serving drinks. During stage two, the scenarios provide greater variability and uncertainty. More complex manipulation tasks are required, for example, during the clean-the-table task (the Procter & Gamble challenge). Another thematic challenge is the restaurant task, which is similar to serving drinks in stage one but in a real restaurant without previous setup time.

During all the tasks, a new principle called *ex deus machina* has been

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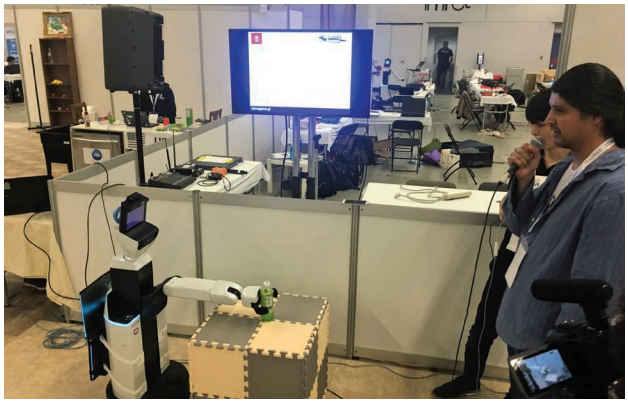

Figure 2. The housekeeper scenario features tasks related to cleaning, organizing, and maintenance.

Figure 3. Robots must demonstrate specific skills, such as decision making, navigation, and object manipulation.

proposed. In case a robot has difficulties completing a task, it needs to ask for help from humans. A robot has to succeed in the task to score. The score itself depends on the robot's degree of autonomy and performance. According to the task, different skills must be displayed, such as decision planning, people identification, person following, navigation, and manipulation of objects (Figure 3). Human–robot interaction, simple navigation, and perception skills are needed to score in each task. Teams must prepare at least two tasks in each stage. For example, during stage one, each team has six trials and needs to cover at least one task in each theme (housekeeper and party host) (Figure 4).

The qualification process provides two calls for participation during the year. Teams have to demonstrate that they are able to cover the tasks as defined in the rulebook. During Robocup@Home, poster sessions are organized for teams to present their work, research activities, and open source contributions. RoboCup ends with a general symposium, during

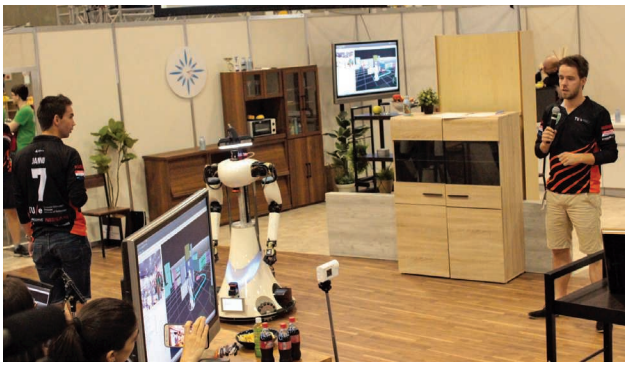

Figure 4. Each team has six trials and needs to cover at least one task in each theme.

Figure 5. Pepper, from SoftBank Robotics, is ready to tackle a social-platform task.

which researchers can present and publish scientific contributions. Robocup@Home, like the other leagues, places great importance on open source contributions. The teams' GitHub repositories provide valuable off-the-shelf solutions that are largely reused.

In terms of the robots more specifically, three subleagues are proposed: one open platform and two standard platforms (domestic and social). For the open platform, teams can compete with a personal robot (this can be a completely original one, a commercial solution, or an adaptation of a commercial solution). For standard platforms, teams are not allowed to modify the robots. Since 2018, the standard platforms use the human-service robot from Toyota (domestic platform) and Pepper from SoftBank Robotics [social platform (Figure 5)]. In all subleagues, the use of external computing devices and cloud solutions is permitted.

RoboCup 2019 (https://2019.robocup.org/) will be held in Sydney, Australia, in July; in 2020, it will be in Bordeaux, France. Many local competitions are also organized by RoboCup regional committees, including the annual RoboCup Open Germany, RoboCup Asia Pacific Competition, and Latin American and Brazilian Robotics Competition.