TOWARDS THE ROBOT BUTLER: THE HUMABOT CHALLENGE

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The HUMABOT Challenge has been the official robot competition for the 2014 IEEE-RAS International Conference on Humanoid Robots (HUMANOIDS'2014), which was held during this conference in Madrid (Spain, November 18-20th). In fact, after a long time running this Humanoids Conference around the world, this is the first time that a competition is organized jointly with this event. In the following, some clues will be given concerning the logistic problems and the main aspects to succeed with this new competition.

The original idea of this competition was due to Prof. Carlos Balaguer, General Chair of HUMANOIDS'2014. It is noticeable at this respect that Prof. Balaguer was the Coordinator of the Robotics Spanish Network (years 2006-09) and, during this period, a national humanoids competition (CEABOT) was consolidated thanks to his impulse. In the CEABOT competition there is the rule that the winner is in charge of organizing the next edition. It should be mentioned that University Jaume I (UJI) has been participating since 2007 and has won four years consecutively (2007-2010). In addition, UJI has been co-organizer of the competition since 2010. So, due to this long time experience, Prof. Balaguer chose UJI as the organizer of the first HUMABOT Challenge edition.

A year before the Challenge, and during the very preliminary stage, we were envisioning a competition including three different dimensions, depending on the humanoid platform size selected: mini, middle-size or large. The mini platform was the easiest for us since CEABOT is based on it, and we had a long experience in this [Garcia08] [Jardon08]. However, the capabilities of these platforms (eg Robonova) are much lower than those of the next middle-size segment (eg NAO and DARwIn-Op), where in addition we have a previous experience [Garcia11] and where, at international level, there are well-established competitions (i.e. RoboCup). Moreover, the segment of large humanoids relied exclusively on a platform and a sponsoring company. Thus, after becoming aware of the restrictions of all kinds (economic, international impact, etc.) it was decided to drastically simplify the competition, focusing exclusively on middle-size humanoid platforms, around 50 cm high, making it possible the use of popular platforms like NAO and DARwIn-Op. Our aim was to design a competition with an affordable entry-level, suitable for graduate students who are interested in pursuing a PhD in robotics. In our experience, using real robots in teaching has been accompanied by an increase in the enrollment rates [Alemany12]. We tried not to overlap with existing

competitions like RoboCup@Home, though both share some common principles, e.g. the robot must perform manipulation tasks in a domestic environment [Stuckler12]. We aimed to define three realistic problems, which could be easily stated in a single sentence, yet provided a significant challenge with the available resources.

The logistic issues. In parallel to design scenarios and rules for the competition and, a year before the challenge, an international committee to assist in spreading the event worldwide was selected. This committee consisted of: Pedro Lima (IST, Portugal); Luca Iocchi (Università di Roma "La Sapienza", Italy); Sven Behnke (Rheinische Friedrich-Wilhelms-Universität Bonn, Germany); Peter Stone (Univ. of Texas, USA); Eiichi Yoshida (CNRS-AIST JRL, Japan); Alan FT Winfield (UWE Bristol, UK), and Pedro J Sanz (UJI, Spain) as Competition Chair. Likewise, a local committee to design and implement all the logistical details of this competition was created, consisting of: Enric Cervera (UJI, Spain); Juan C. García (UJI, Spain); Guillem Alenyà (IRI-CSIC-UPC, Spain); Francisco Blanes (UPV, Spain); Fernando Gómez (UHU, Spain); Sam Pfeiffer (PAL Robotics, Spain). Moreover, and from the very beginning, the official website of the event was available, and it has been a key point to disseminate and exchange all the necessary information to guarantee the success of this initiative, updating in a suitable manner the different recommendations and guidelines to follow by potential competitors. A simulation model of the competition was published in advance at the website, for the potential participants to check their skills in a simulated environment. It is worth to mention that through this website became available, not only a complete simulation model representing the scenario, but also the online connection to a NAO platform in the real kitchen scenario, where after mandatory identification the teams could carried out their algorithms, thus obtaining valuable feedback.

How to attract the teams? One of the most critical points in the organization of a new humanoid's competition is the capability for offering something different able to attract the potential teams. To this respect, this Challenge is taking advantage of the strong impact associated with a well-known International Conference like HUMANOIDS. Moreover, and unlike many other competitions in this segment, not everything is focused on a single platform. In fact, they were proposed as examples two of them (ie NAO and DARwIn-Op), but even admitted other possibilities, always fitting certain size specifications. Finally, other major attractors were the existence of funding to cover costs of mobility, equipment and, last but not least, the existence of three prizes for the potential winners of this challenge (i.e. 1000 € - 1st place, 700 € - 2nd place, 300€ - 3rd place).

In order to participate, the teams were required to fill a short form in the official website and submit an up-to five pages original qualification document with some information about the team, the robot to use, team's related research interest and a summary of past relevant work and scientific publications. In addition to this document, the team had to submit a link to a video that demonstrated the current status of the robotics research of the team. Videos of simulation contributions were also accepted, only in case that real robots are unavailable. If the candidates already had a robot platform, the video should show the current state of their robot performance. Based on the aforementioned information, the local committee was able to select the best teams to participate in the competition. In addition, this preliminary process included the selection of those teams, which would be granted (up to 2000€ depending of the origin of the team location) with a travel support for the students.

The competition was oriented to real robots, but a simulation setup was prepared too, for research groups who could not afford a real platform. They would thus have the opportunity to test their algorithms, while in the final competition, a standard platform would be available for them. Onboard computation was not enforced, but the robot should operate in a fully autonomous way, without human intervention.

The setup, albeit at the robot scale, was realistic and addressed to challenging problems involving manipulation, grasping, and object recognition under casual lighting conditions. In the envisioned concept concerning the HUMABOT Challenge scenario, the robot is an integral part of the house and helps its occupants to live there better. The robot is located in a kitchen corner (Fig. 1), consisting of a kitchen module and a table. The kitchen module consists of two lower cupboards, a working surface in the middle, and a higher shelf with a microwave oven.
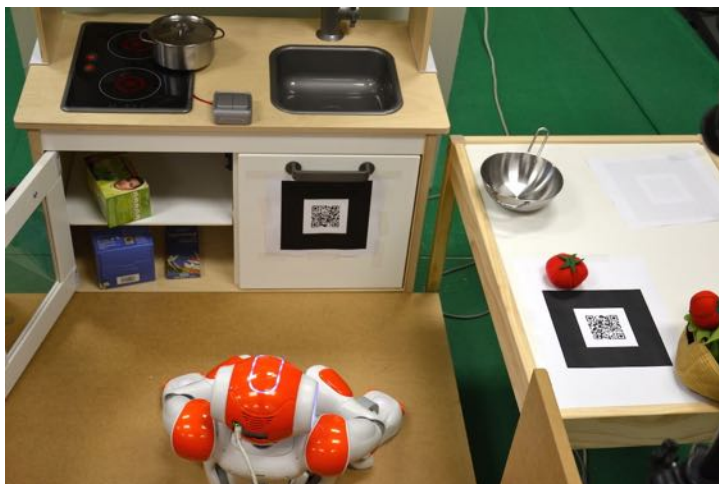
Fig 1. The kitchen overview.

Due to the fact that the original buttons to control the fire were too small, a modification was done in the fire control unit to install bigger switches for an easier manipulation by the robots. This location was always the same for all the robots. Although some landmarks were used, the teams were allowed to use extra landmarks in the furniture, but not in the objects.

Vision is a requirement for solving the challenge, but off-the-shelf techniques can be readily used: colored blob segmentation, database image recognition, or landmark recognition are widely available algorithms in many computer vision frameworks. Besides identifying the objects in the task, landmarks can help to solve the localization problem of the robot. Even in a small environment, the uncertainty added by the walking motion makes it impossible to rely on open-loop motions for the manipulation tasks, thus imposing the need for vision-based closed-loop algorithms.

Initially, nine teams applied for participating in the competition. They came from four different continents (Africa, America, Asia and Europe). Nevertheless, some problems prevent the teams to participate during the competition in Madrid. Unfortunately, due to different problems, some teams had to pull out. So, in the final Challenge, the qualified teams (Fig. 2) came from Colombia, Mexico, Spain (three teams, two from Barcelona and one from Madrid) and Sweden. Almost all the teams used the NAO robot, except two of them, one from Catalonia with a DARwIn-OP, and other one from Madrid, which used also a DARwIn-OP robot provided by the Ro-Botica company.

Fig. 2. Participants in the Humabot Challenge, held in November 18-20 in Madrid, during the IEEE Humanoids Conference.

The challenge consisted of three independent tests: switching off the kitchen fire, making a shopping list, and preparing a meal. Each test was graded over 20 points. Grading was performed on the day of the finals according to the robot's behaviour in the real room and not in a simulation. Each team had the right for two attempts per test, lasting 3 minutes each. The best grade of the two attempts was retained as the score. In addition, for each of the tests, a bonus was awarded based on the success and speed of the task, and a penalty was issued if the team must intervene on the robot during its attempt.

During the first day of the competition, all the teams had free-access to the scenario, in order to test their algorithms in the final scenario. Although the kitchen model was well-known and easy to buy for all the participants, the ambient lights conditions were different and all the teams needed to adjust their algorithms in the real environment. It is noticeable that during these trial tests, some teams got better results than during the final competition. For instance, in Fig. 3, the robot was able to identify the tomato toy, grasp it and put it into the cooking pan (all the objectives in the 3rd test). Nevertheless, during the competition, this robot was unable to do it.
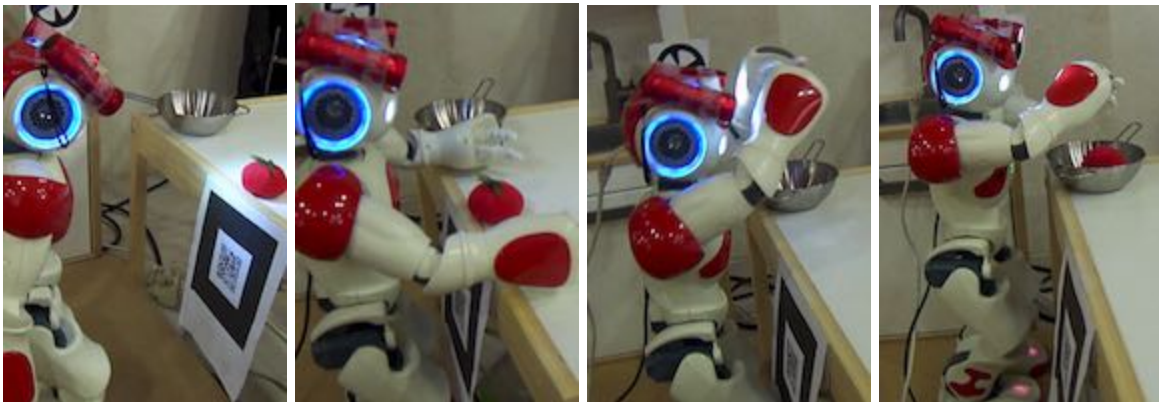

Fig. 3. Snapshots of a trial test previous to the competition:
the robot approaches the table (1), moves both end-effectors towards the tomato (2), grasps it (3) and
drops it into the pan (4).

The first test consisted on a safety task: one of the fires in the kitchen was lit, and the robot ought to put it off (Fig. 4). The lit fire was selected at random, and two switches allowed the robot to control each fire independently. The relationship between the fires and switched was known in advance, as well as the relative position of the elements. Markers were allowed in the furniture, for simplifying the localization problem. There were two rounds on this test, and only two teams were able to switch off the fire during the competition. Other robots suffered from bad precision in the localization of the robot with respect to the kitchen, which resulted in the hand of the robot not making contact with the switch.

Fig. 4. Snapshots of the first test by the UPC team: the robot approaches the kitchen (1), detects the lit fire (2), moves its end-effector towards the button (3), and switches it off (4).

The second test consisted on the identification of the missing objects in the shelves, for making a shopping list. A set of known objects was given in advance, but the lighting conditions (with no specific lights) were hard. Nevertheless, all the teams succeeded in identifying at least one of the missing objects, yet false positives were also produced. As a result, the final scores for this test were low due to the penalties of such false positives.

Finally, the third test was the most demanding one, because it required real grasping of an object. As it was aforementioned, the robot ought to grasp a tomato toy, made of soft tissue, and put it inside a metallic pan. The relative position of the objects was known in advance, approximately, and landmarks were allowed on the table. Nevertheless, the uncertainty in the walking motion, as well as the limited precision of the visual-based localization, led to the failure of all the teams in this test during the competition. It is worth noting that several teams succeeded in completing the task during the training phase, just some minutes before the real competition. But three rounds were allowed, and no robot was able to grasp the tomato, let alone put it in the pan.

Based on the results of the three tests, the winner team was the Swedish team FIA Robotics, from Linkoping University; the second place was for dotMEX, from CINESTAV (Mexico); and the third prize went to the Spanish team UC3M RO-BOTICA from Madrid. In Fig. 5 all the participating team members and jury are shown.

Fig. 5 . Photo with all the participants and jury (first row, left-right): Pedro J. Sanz, Francisco Blanes, Enric Cervera

Lessons to learn. The organization of a humanoids competition is always a hard work. But when this competition is international and is the first edition, difficulties arise requiring an extra effort. Some of the main positive aspects and limitations have been highlighted along the previous work description. Other issues like the social impact should be mentioned here, thanks to dissemination media (e.g. press, radio, TV channels, etc.) in cooperation with the big Conference of HUMANOIDS. Anyway, maybe one of the best benefits of this kind of competition would be, without doubt, the new skills that team members are able to reach.

It is noticeable that some teams suffered a negative impact after competition starts because some unexpected problems arose that were impossible to fix in due time. Letting apart technical problems, an important limitation observed in several teams was the unsuitable expertise for undertaking some required tasks, like visually guided grasping. In fact, this skill was the responsible of the most critical point during the challenge, making impossible to succeed in the 3rd test for all the teams. Bearing in mind, that no team was able to obtain any mark in this 3rd test it is clear that a new strategy for evaluation would be necessary. One suggestion would be to start with an initial step associated to a more simple skill like touching the tomato with the hand. Which is a probe that a visually-guided algorithm is running in a suitable manner.

In the future, this competition could be regarded as a benchmark for middle-scale service humanoids. An online laboratory with the required elements is being set up, and it should be shortly available to the research community. The online robot should be able to remotely execute the user's code, and feedback would be provided by video and audio streaming, and the output of the program. An experimental version is available at http://www.robotprogramming.net in an initiative sponsored by IEEE-RAS, for the Creation of Educational Materials in Robotics and Automation.

In any case, from our point of view, the continuity of the HUMABOT Challenge will depend mostly of the new edition of the HUMANOIDS Conference (Korea, 2015) and their organizers.

For more information and details, please visit our website http://www.irs.uji.es/humabot/

Acknowledgments

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