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D6.2 - RoCKIn Competition 2015

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D3.2 - Report on Progress of the Competition and Benchmark Activities

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Executive Summary

The goal of RoCKIn ("Robot Competitions Kick Innovation in Cognitive Systems and Robotics") is to speed up the progress towards smarter robots through scientific competitions. Two challenges have been selected for the competitions due to their high relevance and impact on Europe's societal and industrial needs:

- domestic service robots (RoCKIn@Home) and
- innovative robot applications in industry (RoCKIn@Work).

Both challenges have been inspired by activities in the RoboCup community, but RoCKIn is improving and extending them by introducing new and prevailing research topics, such as natural interaction with humans and networking mobile robots with sensors and actuators spread over the environment, in addition to specifying concrete benchmark criteria for assessing progress.

Two Competition Events were organized during the project lifetime, running the two challenges with their respective test beds. This report focus on the second and last RoCKIn Competition Event.

The **RoCKIn Competition 2015 took place in Lisbon from 17 to 23 November 2015** (see Figure 1) during the European Robotics Week 2014 (ERW2014) with the following schedule outline:

- 17-18 November: assembly of the competitions team areas and arena;
- 19-20 November: team arrival and set up days;
- 21-23 November: competition days, open to the public.

Figure 1 – RoCKIn 2015 at Parque das Nações (Lisbon).

This year, **9 teams participated in RoCKIn@Home, and 3 teams participated in RoCKIn@Work 2014, in a total of 12 teams and 93 participants from 10 countries** (France, Germany, Greece, Ireland, Israel, Italy, Mexico, Portugal, Spain, United Kingdom).

An infrastructure consisting of the RoCKIn@Home and RoCKIn@Work arenas and team areas, the test bed components (objects, machines, furniture), the benchmarking components (Motion Capture System and the Referee Boxes, to name but the most relevant ones), was set up by the RoCKIn partners and the IST-ID subcontractor Dr. Bredenfeld UG company, over an area of 835 m^2 in the Portugal Pavilion of the *Parque das Nações*. **Special emphasis was again put on the data acquisition for benchmarking and on the scoring procedures** as crucial aspects of the RoCKIn approach to competitions.

The event was witnessed by Jon Agirre, Bruno Siciliano, Bill Smart and Manuela Veloso, members of Rockin's Advisory Board, who wrote a short report on specific topics individually requested – summarized in the final project report – and by Herman Bruyninckx, Alessandro Saffiotti and Tijn van der Zant, members of Rockin's Advisory Board, who wrote a report on the progress of the competitions – corresponding to Deliverable D3.2, annex to this document.

A significant amount of communication and PR materials was prepared and disseminated, namely brochures, leaflets, banners and polo t-shirts, including merchandising materials (pens, mugs, key chains) as well. Badges, bags and trophies were designed and produced for the participants. Thanks to the support of Lisbon Town Hall, posters were distributed in 30 exhibitors of a circuit in Lisbon, and a promotion video was displayed in the large digital screens of Lisbon's Tourism Association spread all over the town, during the 7 days of the event. A large banner was produced to signal the event at the Portugal Pavilion (see Figure 2), thanks to the University of Lisbon (whose banner is usually there in the same place).

The *Agência Nacional para a Cultura Científica e Tecnológica – Ciência Viva* agency is recognized all over Portugal as the leading and most prestigious institution in the dissemination of Science and Technology. The Opening and Closing + Awards Ceremonies took place at their Knowledge Pavilion (KP) Auditorium, as well as one of the satellite events. Also SAPO, a very well-known and popular Portuguese Internet service provider, supported RoCKIn 2015 as the Media partner, providing a considerable dissemination of the event in their widely read Web pages, and Internet access to all teams and organizers (no wireless Internet access in the venue, only WiFi for the competitions).

Figure 2 – RoCKIn 2015 banner at the Portugal Pavilion.

This year, three satellite events were co-located with RoCKIn 2015:

- **ROBOT2015 – 2nd Iberian Robotics Conference**: jointly organized by SPR – *Sociedade Portuguesa de Robótica* and SEIDROB-GTROB – *Sociedad Española de Investigación y Desarrollo en Robotica-Grupo de Robótica de CEA*. The conference took place at the Hotel Tivoli, near the Portugal Pavilion, and had approximately 150 participants. RoCKIn 2015 Opening Cocktail was held jointly with (and was paid by) ROBOT2015 Farewell Cocktail.
- **EU Robotics Clusters Workshop**: organized by the French agency Madeeli and by the Institute for Systems and Robotics, a research unit at *Instituto Superior Técnico*, University of Lisbon. The main focus of this workshop was bringing together innovative Portuguese robotics companies, along with end-users and investors, to help establish a Robotics Cluster in Portugal and provide opportunities for technology transfer - turning academic research into industrial products.
- **RoCKIn-RoboCup Meeting**: jointly organized by RoCKIn and the RoboCup Federation. The meeting aimed to discuss how RoCKIn's work on benchmarking and designing robot competitions can be integrated in the future into RoboCup.

The following institutions were **partners/sponsors** of the event:

- **Institutional Partner**: *Câmara Municipal de Lisboa* (Lisbon Town Hall)
- **Media Partner**: SAPO
- **Other partners**:
    - Shadow Robot Company (Best Team Award)
    - ARTICA (Best @Home and @Work Teams Awards)
    - Ciência Viva – free usage of the KP Auditorium for Ceremonies
    - MEO Arena - discount on the Portugal Pavilion rent, which they manage
    - *Associação de Turismo de Lisboa* (ATL - Lisbon's Tourism Association) – free display of promotion video in the large digital screens
    - University of Lisbon – area to install a large banner (produced by INNO) and audio-visual staff hours and equipment
    - SMARTIF - home automation network used in the RoCKIn@Home arena.

Overall, **the RoCKIn Competition 2015 can be considered a successful event** from the viewpoint of: the increased number of teams, the significant increase in the performance of the top teams across the two Challenges, the maturation of the scoring and benchmarking system – including the acquisition of data by the Motion Capture System and by the teams on board their robots –, and the interaction with the Referee Boxes.

Figure 3 – RoCKIn 2015 venues: Portugal Pavilion (left) and Knowledge Pavilion (right).

1 Preparation of the Event

1.1 Venue selection

The RoCKIn Competition 2015 was initially planned to take place in the Knowledge Pavilion at no cost. However, after the 2014 Competition, the available space was found to be insufficient for the two arenas plus the team area. An area extension based (as in 2015) on an external tent was studied, but the costs/quality ratio was not satisfactory. Therefore, with the previous consultation and agreement of the Project Officer, a decision was taken to use the available difference between the budgeted and actual cost of IST-ID subcontract with Dr. Bredenfeld UG (~18 K€) to rent four large exhibition rooms of the Portugal Pavilion, also located at the *Parque das Nações*, and conveniently close to the Knowledge Pavilion, where Ceremonies and one of the satellite events were kept to take place in the Auditorium. The competitions took place in the Portugal Pavilion. Outside views of both buildings can be found in Figure 3.

The selected space proved to be ideal for the competitions, providing a very quiet and pleasant atmosphere, with considerable space, good technical support, and perfect location at the heart of one of Lisbon's most popular leisure areas.

1.2 Infrastructure set up

The competition infrastructure consists of the following main elements:

- **Management structure and information channels** (between committees and teams; with stakeholders, the media, satellite-event organizers and visitors)
- **Communication materials** for visitors, teams, experts and distinguished guests
- **Hardware and software to support the competition execution**
- **Arenas and team areas**.

In the following subsections, we describe in detail the preparation of each of these elements that took place between April and November 2015.

1.2.1 Management structure and Information channels

Preparing a competition requires a management structure and a communication infrastructure that supports exchange of relevant information among all the intervening people. In RoCKIn 2015, similarly to the 2014 edition, the management structure included project partners, competition organizing,

technical committees, team leaders, participants, visitors, media representatives and satellite-event organizers. Communication with the MEO Arena staff took place regularly through IST-ID.

The Executive Committee (EC) is represented by the coordinators of each RoCKIn partner and is mainly responsible for the overall coordination of RoCKIn@Home and RoCKIn@Work competitions and especially for their dissemination in the scientific community. The RoCKIn Coordinator also played the role of overall Chair of the RoCKIn Competition 2015.

The Technical Committees (TCs) for RoCKIn@Home and RoCKIn@Work were responsible for updating the competition rules and also for the adherence of the teams to these rules. Other responsibilities included the qualification of teams (together with the Executive Committee), scheduling the tests, assigning and instructing referees, handling general technical issues, deciding about giving awards – in case the number of participants is lower than the thresholds specified in the rulebook –, as well as resolving any conflicts during an on-going competition (together with the Executive Committee, and with the possible advice of the RoCKIn Experts, if necessary). The members of the committee were further responsible for maintaining the RoCKIn@Home and RoCKIn@Work Infrastructures during the event.

The Organizing Committees (OCs) for RoCKIn@Home and RoCKIn@Work were responsible for the actual implementation of the competition, i.e. providing everything that was required to perform the various tests. Specifically, this meant supporting the test arena(s) set up, providing any kind of objects (e.g. manipulation objects), recording and publishing (intermediate) competition results and any other kind of management and advertisement duties before, during and after the competition.

Regarding information channels, part of the information was made available to the relevant stakeholders through web pages periodically updated:

- Web page (http://rockinrobotchallenge.eu/rockin2015.php) for participants and visitors (including public, robotics professionals and the media), including live streaming during the competition days through the SAPO channel at http://videos.sapo.pt/N8JBWsCjZkU3AzkRYEUf , and regularly updated details such as the schedule of competitions and satellite events, as well as interviews with the participating teams
- Password-protected web page (http://rockincompetition.eu) for team application and registration of the qualified teams, with the Call for Participation and a page listing all qualified

teams' information, including affiliation, web page and logo, and the Team Description Paper (http://rockincompetition.eu/teams, also linked from the 'Teams' tab in http://rockinrobotchallenge.eu/rockin2015.php).

- Wiki page (http://thewiki.rockinrobotchallenge.eu/) – thorough new version with respect to 2014 – where detailed technical information about the rules for the qualified teams and a list of FAQ concerning the task and functionality benchmarks for the two challenges was regularly updated, including the list of all data to be logged by the teams during the competitions for later benchmarking processing .

More interactive channels were based on e-mail lists for easy communication between organizers and participants:

- Organizing and Technical committees:
  - oc.tc-at-home@rockinrobotchallenge.eu
  - oc.tc-at-work@rockinrobotchallenge.eu

- Team Leaders:
  - tl_athome@rockincompetition.eu
  - tl_atwork@rockincompetition.eu

- Information for interested people (subscribing the e-list from the competition web page):
  - rockin-at-home@rockinrobotchallenge.eu
  - rockin-at-work@rockinrobotchallenge.eu

1.2.2 Communication materials

A comprehensive set of communication materials to be distributed to visitors and displayed at the venue was produced by INNO, based on contents prepared by IST-ID. They are listed on Table 1.

Materials to be distributed to the qualified teams are listed on

Table 2.

Table 1 – Communication materials.

Item	Distribution	Image
Brochure (English)	All qualified teams, Experts, AdBoard member, invited people, media, visitors	
Leaflet (English, Portuguese)	All qualified teams, Experts, AdBoard member, invited people, media, visitors	
Roller banners	Venue	
Banners	Venue	
MUPIs, posters	Around the town	

T-shirts	All participants, Experts, AdBoard member, organizers	
Merchandising	All qualified teams, Experts, AdBoard member, invited people, media, visitors	

Table 2 – Materials for qualified teams.

Item	Image
Bags	
Badges	
Trophies (competition awards)	

1.2.3 Hardware and software to support the competition execution

The TC and OC members for both leagues were also involved in the development and/or update of the software and hardware required for the competitions, namely: the Scoring and Benchmarking Boxes, the RoCKIn@Home Referee, the RoCKIn@Work Central Factory Hub, as well as preparing and writing scripts for the Task Benchmarks (TBM) and Functionality Benchmarks (FBM) execution.

Figure 4 – USB pen for storage of data acquired by the teams during each trial.

Figure 5 – Deli Man and postman uniforms.

A non-exhaustive list of items resulting from this work and related activities for RoCKIn@Home 2015 follows (work carried out for the 2014 Competition and re-used in 2015 not listed):

- Replacement of the 2014 “Object Manipulation” FBM by the new 2015 “Navigation” FBM. The rationale for the replacement was to have the teams focused on a functionality which is used as part of the actual code of most of the TBMs. This reduces the amount of required code development, encourages the participation in FBMs, and produces valuable input for benchmarking studies concerning the impact of FBM performance on TBM performance, using the competition datasets.

- Upgrade of the 2014 Referee, Scoring and Benchmarking Box (RSBB) and of the benchmarking / Motion Capture System (MCS) software to include the new “Navigation” FBM.
- Update of sentence and lexicon examples for “Speech Understanding” FBM.

A non-exhaustive list of items resulting from this work and related activities for RoCKIn@Work 2015 follows (work carried out for the 2014 Competition and re-used in 2015 not listed):

- Introduction of the new 2015 “Control” FBM. The rationale for the introduction of a new FBM (there was a “Planning and Scheduling” FBM designed for 2014 that was not enforced that year and that was discarded in 2015) was to respond to a suggestion of one of the RoCKIn Experts (Herman Bruyninckx) about the need to include benchmarks about dynamic functionalities [4]. The new FBM also helped the teams to focus on a functionality which is used as part of the actual code of most of the TBMs. This reduces the amount of required code development, encourages participation in FBMs and produces valuable input for benchmarking studies concerning the impact of FBM performance on TBM performance, using the competition datasets.
- Upgrade of several modules of the Central Factory Hub and of the benchmarking / Motion Capture System (MCS) software, including the adaptation to the requirements of the new “Control” FBM.

1.2.4 Competitions venue, arenas and team areas

The set up of the competition arenas and respective infrastructure for the RoCKIn Competition 2014, mostly based on the materials designed and constructed in 2014, was executed again by IST-ID’s subcontractor Dr. Bredenfeld UG (see Figure 6), through regular tele-conference and e-mail contacts, which included MEO Arena staff in some occasions.

Figure 6 – Dr. Bredenfeld UG rented truck to transport arenas and infrastructure from Magdeburg to Lisbon.

IST-ID rented four rooms (including tables, chairs, electrical power and air conditioning) in the Portugal Pavilion, with a total area of 1255 m^2, with the following distribution:

- Visitor's reception area, with exhibition booths from the Institute for Systems and Robotics (from IST, U. Lisbon – ISR/IST) and The Shadow Company (one of 2015 sponsors) – *Sala Viagem* I (220 m^2)
- Arenas area – *Sala Viagem* II (435 m^2)
- Teams area, with two or three tables per team (depending on the number of team's members) and one chair per team member, access to Internet and power – *Sala Viagem* III (400 m^2)
- Organization office (also used for the RoCKIn-RoboCup meeting) – *Sala Livraria* (200 m^2).

There was also some extra large space to store empty boxes and other equipment.

The furniture inside the RoCKIn@Home arena was acquired at IKEA (see last year report [4]) and is almost the same as the furniture installed in the RoCKIn@Home test bed at IST-ID. The RoCKIn@Work 2015 arena is also an almost exact replica of the BRSU RoCKIn@Work test bed. See Figure 7 for a global view of the layout in 2015. Several devices and objects were taken by some of the partners to Lisbon for the competition, e.g.: home automation device network, home objects, IP camera for visitors' recognition, visitor's uniforms, and mail packages (IST-ID – from its test bed – see Figure 5), RoCKIn@Work MCS, drilling machine and conveyor belt, quality control camera (BRSU – from its test bed), RoCKIn@Home MCS and several objects for benchmarking purposes (POLIMI).

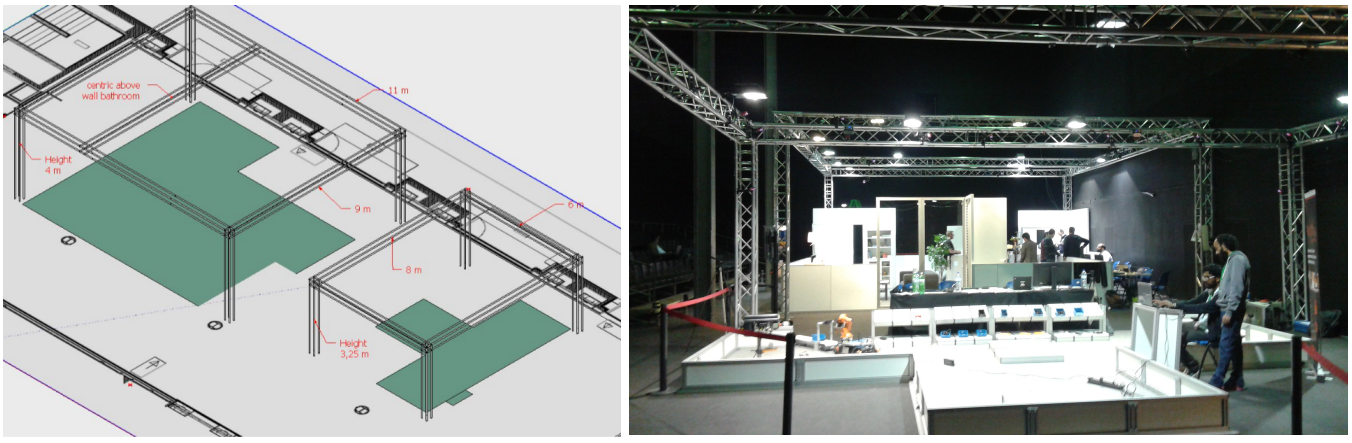

Figure 7 – (left) Layout of the arenas room for RoCKIn Competition 2015; (right) view of the actual arenas form the @Work side.

Figure 8 – Overview of the team area.

1.3 Team qualification process

1.3.1 Team selection

The selection of participating teams in RoCKIn 2015 took place in four major steps:

1. **Intention to participate**: call out on 10 March 2015, deadline 31 May 2015 – with the goal of having an initial idea of the number of potential participating teams and number of team members. 24 teams pre-registered.
2. **Application**: call out on 10 March 2015, deadline 31 August 2015 – open to teams who declared their intention to participate and to any other teams. Applications were made by filling an online form (prepared by subcontractor Dr. Bredenfeld UG), with the required submission materials: i) team name and affiliation; ii) number of team members, with status (e.g., professor, post-doc, PhD student, MSc student); iii) competition [RoCKIn@Home / RoCKIn@Work]; iv) Team Description Paper (TDP), with max 6-pages 2-column, describing the team technical approach and research challenges. 16 teams applied (11 @Home / 5 @Work).
3. **Qualification decision**: on 19 September 2015, after assessing the received applications, the EC, together with the TC, took a decision on the qualified teams for the RoCKIn Competition 2015 in a Flash Meeting (video-conference). 9 teams were selected for RoCKIn@Home, 5 teams were selected for RoCKIn@Work. 1 team that had applied to RoCKIn@Home was not accepted based on lack of quality of the TDP and lack of evidence of potential for performance. Two other teams were accepted in RoCKIn@Home, conditioned to sending better evidence of potential performance within a short deadline. After that deadline, only one of these latter teams was accepted, leading to a final total of 10 teams @Home and 5 teams @Work.
4. **Final Registration**: the qualified teams registered on the web, between 10 and 30 September 2015, having the opportunity to revise their information and TDP contents. Thirteen of the qualified teams registered – two teams withdrew their application. During the event, the Mexican Donaxi@Home team also did not show up, due to financial problems.

All the Calls were published in major robotics e-lists worldwide and also sent to the e-mails of the teams who participated in the 2013, 2014 and 2015 RoCKIn Camps, as well as in the 2014 Competition. Personalized e-mails were also sent to several coordinators of major research Robotics labs in Europe.

1.3.2 Team travel support

This year, thanks to the offer of partners UNIROMA1, KUKA and INNO to shift part of their budget to fund team participation, a total of 30,800.00€ was made available for travel support, distributed by the volunteering partners as follows:

- INNO: 15,000.00 €
- UNIROMA1: 5,000.00 €
- KUKA: 10,800.00 €

On April 2015, this amount (plus the 7% flat-rate) was transferred to IST-ID by each of the partners, with the prior approval of the Project Officer. IST-ID interacted with the selected teams to execute the financial support procedures, including reimbursements of accommodation and travel bookings.

Table 3 – Travel support assignment to teams.

Challenge	Team Name	Affiliation	Travel Support (€)
RoCKIn@Home	Homer@UniKoblenz	University of Koblenz-Landau, Germany	2,000.00
RoCKIn@Home	Watermelon	University of León, Spain	1,000.00
RoCKIn@Home	BARC	University of Birmingham, United Kingdom	4,500.00
RoCKIn@Home	URSUS	University of Extremadura, University of Malaga, University of Castilla La Mancha, Spain	4,000.00
RoCKIn@Home	ROSolution	Piraeus University of Applied Sciences, Greece	3,000.00
RoCKIn@Home	Trinity Robotics	Trinity College Dublin, Ireland	2,500.00
RoCKIn@Work	smARTLab@work	University of Liverpool, UK	2,500.00
RoCKIn@Work	LUHbots	Leibniz University Hanover	5,000.00
TOTAL			**24,500.00**

Travel support was awarded to 8 of the 14 registered teams. The amount per team was based on the number of team members, travel cost to Lisbon, and quality of application (see Table 3). Two non-European, three partner-affiliated teams and one team representing an EU-funded project were not considered eligible for travel support. The LUHbots team decided to withdraw after assignment of travel

support had been announced. Therefore, 19,500.00 € of available travel support were used with the teams. An additional ~450.00 € was used to support the travel of one of the participants in the RoCKIn-RoboCup meeting, with the agreement of the consortium.

2 RoCKIn 2015 Week in Lisbon

2.1 Competition Organization

2.1.1 TBMs and FBMs

The list of TBMs for RoCKIn@Home 2015 was (details in the rulebook [1]):

- TBM1 - "Getting to Know My Home"
- TBM2 - "Welcoming Visitors"
- TBM3 - "Catering for Granny Annie's Comfort"

The list of FBMs for RoCKIn@Home 2015 was (details in the rulebook [1]):

- FBM1 - "Object Perception"
- FBM2 - "Navigation"
- FBM3 - "Speech Understanding"

The list of TBMs for RoCKIn@Work 2015 was (details in the rulebook [2]):

- TBM1 - "Assemble Aid Tray for Force Fitting"
- TBM2 - "Plate Drilling"
- TBM3 - "Prepare Box for manual Assembly Step"

The list of FBMs for RoCKIn@Work 2015 was (details in the rulebook [2]):

- FBM1 - "Object Perception"
- FBM2 - "Object Manipulation"
- FBM3 – "Control"

2.1.2 TC and OC composition

The 2015 RoCKIn@Home and RoCKIn@Work Technical and Organizing Committee members are listed in Table 4 and Table 5, respectively.

Table 4 – RoCKIn @Home 2015 Technical and Organizing Committees composition.

RoCKIn@Home Committee	Name	Role / Responsibility
Technical Committee (TC)	Pedro Miraldo (IST-ID)	TC+OC Chair
	Luca Iocchi (UNIROMA1)	TBM1
	Andrea Bonarini (POLIMI)	TBM2

	Matteo Matteucci (POLIMI)	FBM1
	Gerhard Kraetzschmar (BRSU)	N/A - could not attend
Organizing Committee (OC)	João Mendes (IST-ID)	FBM2
	Emanuele Bastianelli (UNIROMA1)	FBM3
	Pedro Resende (IST-ID)	TBM3
	Graham Buchanan (INNO)	"Dr. Kimble" (TBM2) / Live video Director

Table 5 – RoCKIn @Work 2015 Technical and Organizing Committees composition.

RoCKIn@Work Committee	Name	Role / Responsibility
Technical Committee (TC)	Tim Friedrich (KUKA)	TC+OC Chair
	Rhama Dwiputra (BRSU)	FBM1
	Matteo Matteucci (POLIMI)	FBM2
	Alberto Pretto (UNIROMA1)	TBM2
Organizing Committee (OC)	Francesco Amigoni (POLIMI)	TBM3
	Frederik Hegger (BRSU)	TBM1
	Tiago Veiga (IST-ID)	FBM3
	Graham Buchanan (INNO)	Live video Director

2.1.3 Benchmarking and data acquisition

Giulio Fontana and Enrico Piazza (POLIMI) supervised all the activities concerning benchmarking, scoring, and acquisition of ground-truth and team performance data.

During the competition two kinds of data were acquired: external and internal (with respect to the robot system under evaluation). By comparing internal with external data (e.g., robot self-localization estimates *vs* MCS ground-truth in RoCKIn@Home FBM2, robot object recognition *vs* ground-truth in Object Perception FBMs for both Challenges) we will compute objective metrics regarding the robot performance and achievements in specific functionalities (e.g., way-point navigation, object recognition, speech understanding), as it was already done last year. Moreover, existing datasets (from the RoCKIn Competition 2014 and the RoCKIn Field Exercise 2015), already available in the RoCKIn Wiki at http://thewiki.rockinrobotchallenge.eu/index.php?title=Datasets, will be complemented with the data from the RoCKIn Competition 2015.

At the time of writing this report, we have not yet investigated all the data collected during the 2015 Competition, but we expect this to be done in the upcoming weeks so as to be presented during the review meeting.

Both in RoCKIn@Home and RoCKIn@Work, the RSBB and CFH Referee Boxes were used for many of the TBM and FBM runs. In FBMs, they were instrumental to ensure the synchronization and automatic execution of the tests. In TBMs, the Referee Boxes were also used to detect (by checking the team connection status) situations when teams were not saving their data for benchmarking in the USB pen connected to the running robot (see Figure 4).

2.2 Communication and Public Relations

A considerable amount of effort was put on communication and PR for the RoCKIn Competition 2015, similarly to what happened in 2014. SAPO, a very well-known and popular Portuguese Internet service provider, supported RoCKIn 2015 as the Media partner, providing a significant dissemination of the event in their widely read Web pages (http://www.sapo.pt), live streaming of the 3 competition days in the SAPO Web channel (http://videos.sapo.pt/N8JBWsCjZkU3AzkRYEUf) and in a cable TV channel in "MEO Kanal", available to all subscribers of the MEO TV+Phone+Internet Service Provider MEO (http://kanal.pt/720801). The Lisbon Town Hall enabled free advertising the event with large posters in 30 MUPIs and free display of a promotion video in the ATL large digital screens visible all over town. The event Web page (http://rockinrobotchallenge.eu/rockin2015.php) also provided relevant information for the press and visitors, including the location, schedule, results, access to the live streaming and a personalized interview with each of the participating teams. The last day of the event coincided with the beginning of the European Robotics Week 2015 (ERW 2015), and RoCKIn 2015 was one of ERW 2015 top-listed events (https://ec.europa.eu/digital-agenda/en/node/80811).

Figure 9 – RTP Media covering RoCKIn 2015.

The (very popular in the UK) TV station MANOTO TV also made a thorough coverage of the event, to be aired soon in their "Tech Show" program.

A list of media appearances follows:

- *RoCKIn 2015 põe robôs em luta*, RTP (Portuguese Public television) Media – see Figure 9
- *RoCKIn. A competição internacional de robótica passou por Lisboa*, Flávio Nunes, Observador
- *RoCKIn 2015 - Competição internacional de robôs*, Agenda Cultural de Lisboa (Town Hall Lisbon Cultural Agenda)
- *Competição internacional de robôs no Parque das Nações*, Lisbon Town Hall Web page
- *RoCKIn 2015: Gyro on its way to Germany*, Artica Press Release
- *Super competição de robôs chama jovens à Expo este fim de semana*, OJE

2.3 Satellite Events

Similarly to what was done in 2014, three Satellite Events were co-located with RoCKIn Competition 2015 (see Table 6), so as to foster the dissemination of the project to academia and industry stakeholders (ROBOT'15 Conference), as well as, in this particular case:

i) to promote technology transfer from the competitions to innovative Portuguese robotics companies, simultaneously encouraging (with the support of the French Agency Madeeli and the Lisbon Town Hall) to establish a Robotics Cluster in Lisbon/Portugal – through the Workshop on EU Clusters, consisting of elevator pitch presentations of about 15 companies and a discussion panel with the presence of representatives from a large end-user institution, a venture-capital investor company, a research unit and the Portuguese Robotics Society;

ii) to discuss, in a private RoCKIn-RoboCup meeting, concrete details of transferring some of the lessons learned and methods developed on benchmarking and on the rules of scientific competitions from RoCKIn to RoboCup, so as to keep the introduced innovative features sustainable after the RoCKIn project lifetime – five RoboCup Executive Committee members (from the @Home and @Work leagues) and four RoboCup Trustees (three of them also RoCKIn members) attended this meeting, together with other ten RoCKIn representatives (including the project Coordinator), Experts and Participants. The minutes of the meeting can be found in Annex B.

Table 6 – RoCKIn Competition 2014 list of satellite events organized and funded by institutions from the Toulouse region.

Event name	Purpose	Organizer
ROBOT'15: Second Iberian Robotics Conference	Scientific event with presentations from academia and industry researchers (not just from Spain and Portugal: a total of 118 high quality papers were selected for publication, with a total number of authors over 400, from 21 countries)	SPR – Sociedade Portuguesa de Robótica, and SEIDROB-GTROB – Sociedad Española de Investigación y Desarrollo en Robotica - Grupo de Robótica de CEA
Workshop on EU Robotics Clusters	Bringing together innovative Portuguese robotics companies, along with end-users and investors, to help establish a Robotics Cluster in Lisbon/Portugal and provide opportunities for technology transfer - making academic research into industrial products.	Madeeli, Lisbon Town Hall, IST and ISR
RoCKIn-RoboCup Meeting	To discuss how RoCKIn's work on benchmarking and designing robot competitions can be integrated into RoboCup@Home and @Work leagues. The meeting was reserved to RoboCup (Trustees, Execs) and RoCKIn participants.	RoCKin and RoboCup Federation

2.4 Competition Deployment

2.4.1 Schedule and daily progress

The RoCKIn Competition 2015 took place in Lisbon from 17 to 23 November 2015, with the following schedule outline:

- 17-18 November: assembly of the competitions team areas and arenas (see Figure 10), as well as of the Referee Boxes, MCS and rest of the competition infrastructure;
- 19-20 November: team arrival and set up days;
- 21-23 November: competition days, open to the public (disassembly in the last day).

Figure 10 – The RoCKIn@Home (left) and RoCKIn@Work (right) 2015 arenas.

The competition schedule from 21 to 23 November was quite intense, with trials running from 08:00 in the morning till 20:00 in the afternoon (except in the last day – the finals day – with only 3 teams per Challenge, where the competitions ended at 12:00). The venue facilities were available for the teams all night from the first setup day, and all teams took full advantage of all those hours for preparation and new developments. This intensity is the result of the distinctive RoCKIn approach to benchmarking through competitions – teams had to repeat several times their TBM and FBM trials over the competition days, to increase the statistical significance of their performance results. In turn, this helped increasing the improvement rate over the competition days.

The progress of most teams over the days was steady and, in the last day of competitions, the top teams managed to overcome most of the steps in both Challenges TBMs. The progress of the teams which participated in the RoCKIn Competitions 2014 and 2015 was very significant and noticeable. Opposite to last year, all teams could interface without troubles with the Referee Boxes, mostly as a result of the lessons learned during the RoCKIn Field Exercise 2015. This, together with the smooth atmosphere proportioned by the venue, led to a very successful overall performance.

Figure 11 – Several moments of the competitions during RoCKIn Competition 2014: (left to right, top to bottom) the BARC@Home team robot handles the DeliMan visitor; the HOMEr robot interacts with Granny Annie; the SocRob@Home robot attempts to grasp an object; b-it-bots@Work team performing the "Control" FBM.

This year, the first competition day was dedicated to the FBM trials, and the remaining days focused on TBMs. Only the top three teams of each Challenge (provided their performance was satisfactory) made

it to the Finals round in the final day. A decision was taken, and communicated well in advance to all team leaders, that participation in all FBMs corresponding to functionalities used by the teams in the TBMs they registered in, would be mandatory. The purpose of this decision was two-fold:

- to enforce the good practice of re-using in a TBM (e.g., "Catering for Granny Annie's Comfort") most of the code implementing a benchmarked functionality (e.g., object manipulation), which is relevant for that TBM;
- to increase the significance and quality of the FBM and TBM data acquired, to perform the study of the impact of a FBM performance in the performance of the TBMs where that FBM is used.

For full technical details on the infrastructure of the competition, including Referee Boxes, Motion Capture System, Home Automation Network in @Home, and networked devices in @Work, please check the RoCKIn Wiki at http://thewiki.rockinrobotchallenge.eu/.

2.4.2 Presentation to visitors

One of the most important RoCKIn goals is the dissemination to the general public. Robotics is certainly an appealing topic to introduce science and technology research to the citizens, showing them the value of the public investment through research funding and encouraging young people to pursue their studies and careers in related areas. During RoCKIn Competition 2015, special care was put on the explanation of what was happening during the competitions. One Portuguese commentator kept describing (in Portuguese and English) the robot features and trial events, while frequently asking clarification to team leaders and keeping the audience engaged through questions on robotics science and technology. This commentator (Filipe Jesus) is an Electrical and Computer Engineer, Major in Control and Robotics, who was a former researcher at ISR/IST and a former member of the SocRob RoboCupRescue team.

Figure 12 – RoCKIn@Home (left) and RoCKIn@Work 2015 participants and robots.

2.4.3 Participating teams

In Lisbon, nine teams participated in RoCKIn@Home, and three teams participated in RoCKIn@Work 2015, in a total of twelve teams and ninety three participants from ten countries (France, Germany, Greece, Ireland, Israel, Italy, Mexico, Portugal, Spain, United Kingdom). Table 7 shows the details of the participating teams.

Some facts are worth highlighting:

- The number of teams, participants and countries increased with respect to 2014.
- The participation in TBMs and FBMs significantly increased with respect to 2014.
- One team (EARS@Home) participated representing the European FP7 EARS ("Embodied Audition for RobotS") project, following contacts made between the RoCKIn and EARS Coordinators, initially triggered by a recommendation of Anne Bajart, the Project Officer for RoCKIn and EARS, and used the "Speech Understanding" FBM as a case study of some of the project results.
- Two other teams showed some of the results of European FP7 projects, which are coordinated by their institutions: BARC ("STRANDS", U. Birmingham) and SocRob@Home ("MOnarCH", ISTR/IST), in some of their Challenge TBMs and FBMs.
- The Aldebaran Robotics company was part of the EARS@Home team.

Table 7 – List of RoCKIn 2015 participant teams.

Challenge	Team Name	Affiliation	# team members	Participation in Benchmarks
RoCKIn@Home	BARC	University of Birmingham, United Kingdom	8	All TBMs and FBMs
	EARS@Home	FAU Erlangen-Nürnberg, Humboldt-Universität zu Berlin (Germany), Ben-Gurion University of the Negev (Israel), Aldebaran Robotics (France)	5	TBM1, TBM2, and all FBMs
	Homer@UniKoblenz	University of Koblenz-Landau, Germany	5	All TBMs and FBMs
	PUMAS	Universidad Nacional Autonoma de Mexico (UNAM), Mexico	6	All TBMs and FBMs
	ROSolution	Piraeus University of Applied Sciences, Greece	5	TBM1, TBM2, and all FBMs

	SocRob@Home	IST / University of Lisboa, Portugal	12	All TBMs and FBMs
	Trinity Robotics	Trinity College Dublin, Ireland	13	All TBMs and FBMs
	URSUS-Team	Robolab / University of Extremadura, University of Castilla-La Mancha, University of Málaga, Spain	12	TBM1, TBM2, and all FBMs
	Watermelon	University of León, Rey Juan Carlos University, Spain	4	TBM2, TBM3, and all FBMs
RoCKIn@Work	b-it-bots	Bonn-Rhein-Sieg University of Applied Sciences, Germany	8	All TBMs and FBMs
	SmARTLab@Work	University of Liverpool, UK	4	TBM1, TBM3, and FBM1, FBM2
	SPQR@Work	Sapienza University of Rome, Italy	11	All TBMs and FBMs

2.4.4 Scores and Awards

Similarly to the 2014 edition, scoring and benchmarking were separately handled for the RoCKIn Competition 2015. TBM scoring was based on the sets of achievements, penalizations and disqualifying behaviours explained in [1,2,3], while FBM scoring is specific for each FBM [3]. Benchmarking was introduced in subsection 2.1.3, and the acquired datasets will help in the future to determine the best way of benchmarking TBMs from the FBM benchmarking results, by calculating the impact of FBM performance in TBM performance. The participation of teams in the Benchmarks is listed on Table 7.

The RoCKIn Competition 2015 awarded prizes were:

RoCKIn 2015 Best Team: Homer@UniKoblenz, University of Koblenz-Landau, Germany

RoCKIn@Home:

- Best Team 2015: ***ex-aequo*** Homer@UniKoblenz, University of Koblenz-Landau, Germany and SocRob@Home, Institute for Systems and Robotics, Instituto Superior Técnico, Portugal
- 3rd Place Team 2015: BARC, University of Birmingham, UK
- Task Benchmark 1 Best Team (Getting to know my home): Homer@UniKoblenz, University of Koblenz-Landau, Germany

- Task Benchmark 2 Best Team (Welcoming Visitors): SocRob@Home, Institute for Systems and Robotics, Instituto Superior Técnico, Portugal
- Task Benchmark 3 Best Team (Catering for Granny Annie's Comfort): SocRob@Home, Institute for Systems and Robotics, Instituto Superior Técnico, Portugal
- Functionality Benchmark 1 Best Team (Object Perception): BARC, University of Birmingham, UK
- Functionality Benchmark 1 Runner-up (Object Perception): PUMAS, Universidad Nacional Autonoma de Mexico, Mexico
- Functionality Benchmark 2 Best Team (Navigation): Homer@UniKoblenz, University of Koblenz-Landau, Germany
- Functionality Benchmark 2 Runner-up (Navigation): SocRob@Home, Institute for Systems and Robotics, Instituto Superior Técnico, Portugal
- Functionality Benchmark 3 Best Team (Speech Understanding): EARS@Home, FAU Erlangen-Nürnberg, Humboldt-Universität zu Berlin (Germany), Ben-Gurion University of the Negev (Israel), Aldebaran Robotics (France)
- Functionality Benchmark 3 Runner-up (Speech Understanding): URSUS-Team, Robolab / University of Extremadura, University of Castilla-La Mancha, University of Málaga, Spain

RoCKIn@Work:

- Best Team 2015: smARTLab@Work, University of Liverpool, UK
- Task Benchmark 1 Best Team (Preparing Assembly Aid Tray for Force Fitting): smARTLab@Work, University of Liverpool, UK
- Task Benchmark 2 Best Team (Plate Drilling): *Not Awarded*
- Task Benchmark 3 Best Team (Fill a Box for Manual Assembly): smARTLab@Work, University of Liverpool, UK
- Functionality Benchmark 1 Best Team (Object Perception): smARTLab@Work, University of Liverpool, UK
- Functionality Benchmark 1 Runner-up (Object Perception): b-it-bots@work, Bonn-Rhein-Sieg University of Applied Sciences, Germany
- Functionality Benchmark 2 Best Team (Manipulation): smARTLab@Work, University of Liverpool, UK
- Functionality Benchmark 2 Runner-up (Manipulation): b-it-bots@work, Bonn-Rhein-Sieg University of Applied Sciences, Germany
- Functionality Benchmark 3 Best Team (Control): b-it-bots@work, Bonn-Rhein-Sieg University of Applied Sciences, Germany
- Functionality Benchmark 3 Runner-up (Control): smARTLab@Work, University of Liverpool, UK

The number of awards was determined by the TC of each of the Challenges according to the rules, i.e., taking into account the number of participating teams and their performance in each of the TBMs and FBMs.

2.5 Experts Board Report

The RoCKIn consortium invited four of RoCKIn's Advisory Board members, to attend RoCKIn Competition 2015 and share his views with the consortium:

- Jon Agirre Ibarbia, Tecnalia, Spain
- Bruno Siciliano, University of Naples Federico II, Italy
- Bill Smart, Oregon State University, USA
- Manuela Veloso, Carnegie-Mellon University, USA

Jon Agirre, Bill Smart and Manuela Veloso were plenary speakers in the ROBOT'15 Conference.

The members of RoCKIn's Expert Board,

- Alessandro Saffiotti (AS), Örebro University, Sweden
- Herman Bruyninckx (HB), University of Leuven, Belgium
- Tijn van der Zant (TZ), University of Groningen, The Netherlands

were also invited to write independent reports on the RoCKIn Competition 2015, as planned in RoCKIn's DoW. The reports written by RoCKIn Experts are attached in Appendix A. The following is a summary of the reports main remarks:

Progress with respect to last year:

- The benchmarking infrastructure, both software and hardware, is now working smoothly, not interfering negatively with the teams' work, rather leading to a very intense and focused work atmosphere.
- The progresses in team performance are large and visible. Not only the results in the TBMs and FBMs were much better, but the attitude was much more professional.
- "RoCKIn has made a big leap. (…) What is really amazing is to see how the teams have evolved into groups of people who can seriously work at a complex machine. I think that this is more at RoCKIn than at RoboCup. The easy going atmosphere and less pressure to perform because the test can be done again might give rise to more professional behavior and less panic programming/hacking." (TZ).

Sustainability after the project is over and relation with RoboCup:

- "Hopefully the technology of the benchmarking in the @Home setting can be transferred to the RoboCup Federation. Already in RoboCup there are discussions how to incorporate the measuring systems." (TZ).
- "There are interesting differences between the scoring system in RoCKIn@Home and the one in RoboCup@Home. The latter is much more subjective: roughly put, the given tasks must be completed in a way that is regarded as "satisfactory" by human judges. RoCKIn attempts at building a much more objective scoring system, and explicitly avoids subjective judgments. Two different philosophies about what and how to evaluate inspire these two scoring systems: one

puts human's judgment and satisfaction as the ultimate goal, while the other seeks indicators that can be objectively measured. It would be interesting compare these two approaches in a more extensive way. Perhaps one may find that the quantities measured in RoCKIn are effective indicators of human's satisfaction? Or perhaps one may find that these are two orthogonal dimensions and both of them should be considered? Maybe including additional user oriented metrics like acceptability, usability, or perceived utility?" (AS).

Interest of the general public:

- "With respect to the general public, I have found this competition a bit less successful than what I had expected. The number of visitors was rather small, and I did not notice any school visit. Presence from the mass media was also limited. (…) The public dimension should be taken into account at all stages: from deciding the schedule, to designing the venue, to setting the rules." (AS).
- Provide a real-time display of the benchmarking information to the public watching the event, which turns out to be informative data for the audience but also for the participants.
- Reduce the dead-times between interesting and live robot trials; increase the frequency and level of explanation of what is happening to the public, namely by the team members themselves.

Benchmarking:

- "I suggest to stimulate research groups to use the visual data or to use this for a Kaggle.com competition. The grounded data can be used for training the visual systems. This could lead to a setup where only 'normal' cameras are used. These visual systems are bootstrapped by the grounded system that is in use in the @Home scenario. For the test data set a part of the data is not published but is used to benchmark the trained visual systems. Once there are well trained visual systems that only 'normal' cameras are required the costs of the setup would be reduced by a large margin." (TZ).
- This is the time to advance towards the introduction of the semantic level, using semantic tags, i.e., "all data [*should*] be accompanied with semantic meta data that described the intention of the robot actions, as well as the progress that the robot is making in this intention, at least according to what its own executor process assesses as progress" (HB), including the logging of the associated tolerances regarding the error of what the robot accomplishes with respect to the desired goal(s).
- A mixed-teams approach to solving some of the challenges would force improving the semantic level of the robots' code.
- The cost of the benchmarking infrastructure is high – solutions to minimize it (e.g., promoting local tournaments at the site of reference test beds where the equipment is available; touring the infrastructure through several sites in Europe) should be sought. Moreover, guidelines on how to set up the equipment and some standard software to work with the data would be very useful to boost technology transfer.

Impact on research:

- RoCKIn set a research agenda, focusing on specific challenges with specific performance metrics, and also pushed the state of the art in terms of experimental methodology in robotics research. “What is perceived as a competition by the teams, is in fact a meta-experiment run by the RoCKIn partners. The scoring system is used by the RoCKIn team as working hypothesis about what can be a “meaningful” evaluation metric, and the validity of this hypothesis is verified against the results of the competition. A good example of this method is the matrix “functions × tasks”.” (AS)
- RoCKIn Challenges and their rules seem to be less important than the actual benchmarking process. This is a change of paradigm in competitions in a direction that encourages the development of better research and better professionals in Robotics.

“RoCKIn has created little gems, some of them will shine very brightly in the future.” (TZ).

3 Conclusions and Future Actions

The RoCKIn Competition 2015 was a significant step-ahead from the viewpoint of the technical stability of the infrastructure (Referee Boxes, Benchmarking System, including the Ground-Truth System), the rules, and the team performance.

Most of the actions proposed last year [4], following the experience with the RoCKIn Competition 2014 and the RoCKIn Experts recommendations were successfully carried out:

- the Referee Boxes were improved (e.g., to include automatic scoring and easy manual input of scoring points by the referees, saving online data and logging; to include auto-detection of whether a robot is connected and saving its benchmarking data) and their code made public to encourage current and future teams to start using them much before the 2015 competition (in particular during the RoCKIn Field Exercise 2015, held in Peccioli, March 2015). An application helping the teams figuring out the code needed to interface with the Referee Boxes and checking whether the code is interacting with the Referee Box correctly (including the automated FBM tests) was also produced and made public. In the RoCKIn Competition 2015, using the Referee Boxes was made mandatory for all teams during all the competition days;
- the RoCKIn@Home and RoCKIn@Work Referee Boxes were installed in the IST-ID and BRSU test beds, respectively, and the test bed availability as a Robotics Innovation Facility (ECHORD++-style) was advertised. Currently, any team can now access it by travelling to the site or

replicating the test bed infrastructure at its premises, so as to benchmark its approaches to the RoCKIn@Home and/or RoCKIn@Work challenges;

- during the RoCKIn Field Exercise 2015 (March 2015), a hands-on workshop was organized where teams learned to interact with the Referee Boxes and the ground-truth system – and, in general, with the RoCKIn infrastructure;
- new FBMs, better aligned with the TBMs in the same Challenge, were introduced in RoCKIn@Home ("Navigation") and RoCKIn@Work ("Control"), replacing prior FBMs where that alignment was not evident;
- the datasets acquired during the RoCKIn Competition 2014 (including ground-truth) and RoCKIn Camp 2015 were made available to the Robotics community at large;
- all well-known measures to reduce communication failures and latencies were implemented as part of the competition infrastructure, after being tested during the RoCKIn Camp 2015, and no major WiFi problems were registered during the event;
- several measures were taken to increase the attractiveness of RoCKIn to top research groups Europe-wide. These included:
    - providing travel support for some teams to participate in the 2015 Competition
    - increasing RoCKIn presence in major conferences and industrial fairs, displaying images, videos and diagrams of its benchmarking infrastructure and procedures – videos scripting the TBMs in both Challenges were produced and made available online in the project Web page
    - the RoCKIn Web page was fully re-designed so as to improve the project visibility, impact and ease of access to information.

Future actions are already being taken so as to extend the project legacy past its lifetime:

- transferring the RoCKIn@Home and RoCKIn@Work rules and benchmarking methods to the new European Horizon 2020 Coordination Action RoCKEU2, that will start on 1 February 2016;
- promoting (under RoCKEU2) more regular and scientific-experiment-oriented competitions and reducing the cost of setting up the infrastructure, by creating a system of points awarded to teams that participate in Local Tournaments (head-to-head with the local team in one of the reference test beds) and in Major Tournaments (e.g., RoboCup, RoboCup German Open, Portuguese Robotics Open) – integrated in the existing league infrastructure for @Work and @Home;

- providing regular travel support to some of the teams willing to participate in the RoCKEU2 tournaments mentioned in the previous item;
- dialoguing with the RoboCup Federation and the RoboCup@Home and RoboCup@Works Technical Committees to discuss the transfer of some of the RoCKIn features (e.g., networked robot systems, benchmarking infrastructure, methods and metrics) to future RoboCup editions, under the RoCKIn/EC branding;
- promoting (under Horizon 2020 Research and Innovation Actions and other possible instruments) research progress on topics relevant to Robotics at large, but mostly induced by needs found during the RoCKIn experience, e.g., methods and metrics to benchmark robot tasks and functionalities, including adding semantic meaning to data; real-time middleware for robot systems; more dynamic and fault-tolerant methods for systems integration; better GUIs to display in real-time the information about the robot system performance.

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Appendix A - Expert Board Reports on the 2015 Competition Event

Herman Bruyninckx

Report to the Rockin Coordination Action

Herman Bruyninckx
KU Leuven

22 November 2015

I have witnessed the Rockin event in Lisbon, on November 22-23, 2015, and below I list my remarks about the evolution of the project compared to last year's event in Toulouse. These remarks are not in any particular order of importance.

1 Maturation of infrastructure

The whole benchmarking infrastructure, both hardware and software, was working smoothly, with only the expected amount and intensity of human operation and involvement. This has improved the comfort for both the participants and the project collaborators. Congratulations.

2 Consolidation of project

The just-mentioned maturation has a nice side effect, in that it indeed becomes possible to give the Rockin efforts a more permanent and self-sustainable life, via an (apparently already envisaged) consolidation in permanent experimentation stations, in cooperation with other infrastructure investments, such as the RIFs of Echord, EuRoC, etc. This can hopefuly lead to a *de facto* standardisation, of data and semantics. But please, do not make the error to couple these two aspects (the meaning of the data, and the computer-readable representation of the data) with a particular choice of software; more in particular, ROS is not the right software infrastructure for keeping lots of data, in a discoverable and multi-client way, and making them available to the public; a lot of more professional data storage and querying software (most of it in *open source*) has become available the last couple of years: iRODS, MongoDB, Apache Spark and Samza, RethinkDB, HDF5 server, etc.

3 Bring in semantics level

Up to now, all benchmarking is only dealing with numerical information, and all meaning is added only in the head of the participants and project collaborators. It is time to bring in the semantics level into the Rockin infrastructure. This is a huge challenge, so small steps should be taken first. For example, let all data be accompanied with semantic meta data that described the *intention* of the robot actions, as well as the *progress* that the robot is making in this intention, at least according to what its own executor process assesses as progress. Of course, no standard semantic tags already exist to describe these things, but the Rockin project is *the* outspoken opportunity to start introducing them. One could, for example, start with a simple set of `Move` tags:

- `Move`: the instantaneous desired transformations between joint space and Cartesian space motions; in order for this data to make sense later on, a *kinematic model* standard has to be included into the meta data too.
- `MoveTo`: the desired target frame in the world that the robot wanted to reach during the currently logged motion task.
- `MoveAlong`: as `MoveTo`, but with multiple "waypoints" in between, where the robot need not stop but can pass through.
- `MoveConstrained`: as `MoveAlong`, but now with frame locations in the environment that have to be *avoided*.

It might be good (I think, even necessary...) to log also the *tolerances* that the robot controllers allow their robots to use during the Move tasks; that is, what errors between the specified and the actual frame locations are considered to be "good enough" for the motion to be classified as successful.

4 Stimulate controlled touching of objects

It is not optimal that one still expect that robots should move around in home or work environments without touching anything in the environment to help in their navigation, or in their approaching target objects. So, let robots touch objects, in controlled ways; this "level of control" should, of course, be logged in the benchmarks. Given positive scores to such controlled (and semantically appropriate) touching can give another boost to the evolution in hardware and software infrastructure of the robots.

5 Realtime display for public

Showing a realtime display of (a selection of) the benchmarking information to the public present in the test arena, would add a lot of value to the experience of that public. But it would also allow participants to get a better understanding of the other teams' performance.

Again, displaying the raw data is necessary, but it only becomes interesting when also the above-mentioned intention and tolerance meta data is displayed, so that the public has, at each moment, a good idea about *what* the robots want to do. And about how they plan to do it. And why they decided to do what they now intend to do. And maybe about what were possible alternatives. And about how they evaluate their own execution. Etc.

6 Robot permanency for public

Another small change that can help increase added value for the public, is that teams have to agree on a schedule where there is *always* (at least) one robot up and running, with one or two people available to show/explain to the public what is inside the robot, and how it is designed. Now there are too many and too long dead times. Sharing this burden over all teams makes it doable; and explaining what one is trying to achieve with a robot is a very useful social skill for participants too.

7 Mixed-teams approach

For all of the issues above, "benchmarking" should become a big driver. This can be stimulated by adding challenges where mixed teams have to participate, so they have "to speak the same language". So, the frames in which the spoken dialogues with the users have to be interpreted have to be extended and pushed down into all(?) of the code of the robot, and up again to let the robot explain its actions.

I think that only making it mandatory that teams can work together in the same chalenge will give the necessary boost to more semantic representations. Without it, only code "rules"...

8 Derived benchmarks

More realistic "derived benchmarks" can be introduced, that is, not directly based on the numerical logging data, but statistics collected by combining several data sources together. For example, the quality of a robot in an @Work situation is determined by its performance over several hours and tasks (and not really in one short-lived task), in the context of the current production requirements of the factory (e.g., because rush orders have to be treated differently than *max-throughput* or *min-costs* orders).

9 Bugs

I think there is a "bug" in the *sine wave following* challenge in @Work, in that mechanical play is interpreted as bad control, which is unfair. I also think this challenge should be done via *visual servoing*, and not via offline programming and online frame calibration.

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RoCKIn-2015: Second RoCKIn Competition
Expert Report by Alessandro Saffiotti

Foreword

The RoCKIn-2015 Competition was held at the *Parque das nações* in Lisbon, Portugal, on November 20–23, 2015. As I did last year, I have attended, and enjoyed, the entire event, as well as a connected meeting with representative from the RoboCup federation.

In this short note, I report my general impression of this event from four points of view: the organization; the technological progress achieved, mostly related to the participating teams; the scientific progress achieved, mostly related to how the evaluation has been conceived and carried out; and the impact on the robotics community as well as on the general public. Because of my background and interest, I have focused my attention mostly on the *@Home* part, so my comments are most relevant to that.

About organization

The first RoCKIn competition in 2014 was admittedly perceived both by the teams and by the organizers as something like "a test" – to try out the mechanisms of the competition, that will be used "for real" in the 2015 edition: the rules, the benchmarks, the referee box, the ground truth system, and the overall understanding.

This strategy has apparently worked out very well. In the 2015 edition the entire competition **ran extremely smoothly**, with only occasional needs for clarifications, and with hardly any technical problem. The participating teams and the organizers gave the impression to act as one, cohesive team that had been working together for a long time. The mechanisms to collect log files and ground truth worked naturally, the rules seemed to be clear to everybody, the schedule was demanding but well kept. When talking to the team, I did not hear any complains about possible technical problems or misunderstandings. The feeling was that the infrastructure is now working fully reliably in the background, and the spotlight can point without distractions where it should: on evaluating the technical performance of the robots.

The venue was open 24 hours, and several teams did work overnight. I have heard some concerns on whether this is a good idea or not. Arguments against included the obvious one that this gives a "hidden suggestion" to team members to overwork. But also that this may be counter-productive to the performance of the robots: first, because teams may be tempted to leave more things unfinished before they leave from home;

second, because some may be tempted to use the extra time to make some "brilliant" last-minute improvement, and we all know how dangerous this can be!

On the technological progress

RoCKIn did push the state of the art in terms of robotic technology. It did so by **setting a research agenda**, by prompting the teams to work on specific challenges with specific performance metrics in mind.

The performance of most teams was very good, and the one of the top teams was just impressive. The progress made since last year is considerable. This shows that the bar has been put at about the right level: a bit beyond the state of the art, but not so high that real progress cannot be made from one year to the next. As in the previous year, there was a large gap between the performance (and participation) in the *@Home* and the *@Work* sections, but progress has been steep in both.

In the *@Home* section, the top teams had shown excellent **navigation and mapping** capabilities. I was glad to see that RoCKIn did push development in general functionalities, and not in *ad-hoc* solutions tailored on its challenges: in this sense, I see that RoCKIn has helped to push the state of the art in robot technology forward.

Teams also showed good progress in **manipulation** in partly unknown and uncontrolled environments: I especially appreciated the fast and precise grasping of team Homer. **Speech recognition**, on the other hand, remained elusive, and teams seem to have payed less attention to it. This may reflect a general attitude in robotics, where speech is often (wrongly) regarded as an easy "add-on" functionality. Few groups treat speech as an integral part of the robot's (hardware and software) design. In this respect, the participation of the EARS@Home team might have sent the right message to the other teams.

The other area that remains critical is **system integration**. Even the top robots were relatively brittle, which may suggest that system integration was a bit *ad-hoc*: this impression was confirmed talking with the teams. Specialized FSM solutions were preferred to the use of task planners, which would have been more general of course more complex. The start-up time of the robots was very long, suggesting that many things had to be started and connected manually. A more systematic and general approach to system integration could be encouraged, for instance, by giving points for the speed of start-up, modification, and re-start. Perhaps if we had another RoCKIn competition next year we would see progress in this direction.

I have observed **the *@Work* section** less intensively, but I have noticed good progress compared to last year. Surprisingly, none of the teams seem to have payed any attention to execution monitoring. It was often the case that a grasp failed or an object was placed improperly, but these were neither noticed nor corrected by the robot, leading of course to a failed task. Opposite to the *@Home* section, the bar in *@Work* seems to have been placed too high. The challenges seem to extend too much beyond the current capabilities, and as a result teams did not reach a sufficient degree of performance to make a meaningful evaluation and comparison.

On the scientific progress

RoCKIn did push the state of the art in terms of **experimental methodology** in robotic research.

The work on benchmarking and evaluation is one of the strong scientific contributions of RoCKIn, and probably the one that will give RoCKIn its strongest impact. This may be my interpretation, but I think that what is perceived as a competition by the teams, is in fact a meta-experiment run by the RoCKIn partners. The scoring system is used by the RoCKIn team as working hypothesis about what can be a "meaningful" evaluation metric, and the validity of this hypothesis is verified against the results of the competition. A good example of this method is the matrix "functions $\times$ tasks". The entries of this matrix were initially assumed as a *a-priori* guess about the correlations between functionalities and tasks; but now these entries begin to be validated against the competition data, which show if those correlations really exist. I regard this as a **novel and very promising methodological approach** to empirical evaluation of complex systems – whether they are robotic systems or not.

There are interesting differences between the scoring system in RoCKIn@Home and the one in RoboCup@Home. The latter is much more subjective: roughly put, the given tasks must be completed in a way that is regarded as "satisfactory" by human judges. RoCKIn attempts at building a much more objective scoring system, and explicitly avoids subjective judgments. **Two different philosophies** about what and how to evaluate inspire these two scoring systems: one puts human's judgment and satisfaction as the ultimate goal, while the other seeks indicators that can be objectively measured. It would be interesting compare these two approaches in a more extensive way. Perhaps one may find that the quantities measured in RoCKIn are effective indicators of human's satisfaction? Or perhaps one may find that these are two orthogonal dimensions and both of them should be considered? Maybe including additional user oriented metrics like acceptability, usability, or perceived utility?

About impact

RoCKIn has been smartly designed so as to produce impact both in the robotics research community and in the general public. I think that it has been as effective as possible, but **further actions will be needed** to prolong its impact and to make sure that the heritage of RoCKIn is properly taken over after the end of the project.

With respect to the robotics community, RoCKIn has adopted a strong open policy, which I very much appreciate: the collected log files and ground truth data are (or will soon be) openly available to the entire community; and there are plans to make open, fully instrumented test facilities accessible for use by the robotic community at large – I understand that one of these will be at IST, and I hope that there will be more. It is very important that these repository and open test facility live well after the end of RoCKIn.

A meeting has been organized at the venue between RoCKIn and part of the **RoboCup Federation** – in particular, RoboCup@Home and RoboCup@Work. The

intention was to streamline the process by which certain outcomes from RoCKIn will be imported and used within RoboCup. While the intention of the meeting was excellent, I couldn't help but notice a hint of resistance by part of the RoboCup Federation. There was general (but not unanimous) consent that the RoCKIn ground truth system would be a useful addition in RoboCup, but there was also a clear statement that ground truth should not be used as a basis for scoring the teams. This is related to the difference between the two evaluation philosophies mentioned above. Despite these slight divergences, I expect that a substantial part of the work done in RoCKIn will be taken on-board by RoboCup, in one form or another, and will help to improve the scientific profile and acceptability of the latter.

With respect to the general public, I have found this competition a bit less successful than what I had expected. The number of visitors was rather small, and I did not notice any school visit. Presence from the mass media was also limited. Robotic competitions have a fundamental role to play in informing and educating the general public about the reality of robotic research, trying to correct the too many misconceptions about robots and robotics. I believe a much stronger effort should be placed in ensuring that the public outreach is extensive and carefully prepared. This should probably be one of the top priorities for future competitions.

To be effective, the **public dimension** should be taken into account at all stages: from deciding the schedule, to designing the venue, to setting the rules. As an example of the first point, it might be good to open the venue to the public only at certain times, and organize the most exciting activities at those times. As an example of the second point, the venue should be designed to maximize excitement, stimulate curiosity, and make explanations readily available. The venue in Lisbon was very dark with a narrow entrance, giving the impression of entering a secret sect – quite the opposite of the feeling that we should convey. For the third point, one might consider adding rules or scoring points related to the entertaining value of robots. Or, why not, a new task to "interact with the public"!

Sincerely,

Prof. Alessandro Saffiotti

Tijn van der Zant

RoCKIn Competition 2015 report

From benchmark to breakthrough

TIJN VAN DER ZANT

December 27, 2015

RoCKIn Competition 2015 report

From benchmark to breakthrough

Contents

Introduction

This is a report about the RoCKIn benchmark/competition in Lisbon in 2015. It contains a personal point of view from someone who has been intimately involved in RoboCup (since 1999) and especially RoboCup@Home (cofounder in 2006). It means that this report is biased towards that particular kind of experience and point of view. For these and other reasons I decided to let the experience 'sink in' and try to get a more neutral point of view. I probably will not succeed in the neutral point of view, which is both a weakness and a strength w.r.t. the opinions vented in this report.

RoCKIn has made a big leap. The process of setting up a new benchmark has its up and downs. Luckily the organization is well experienced due to their work for the RoboCup Federation. I still fully support this project and I am eager to see the follow up. What is really amazing is to see how the teams have evolved into groups of people who can seriously work at a complex machine. I think that this is more at RoCKIn than at RoboCup. The easy going atmosphere and less pressure to perform because the test can be done again might give rise to more professional behavior and less panic programming/hacking.

What would be really interesting is to read the final report with the recommendations from the RoCKIn organization. Hopefully the technology of the benchmarking in the @Home setting can be transferred to the RoboCup Federation. Already in RoboCup there are discussions how to incorporate the measuring systems.

Answers to the Expert Board Questionnaire: Update for 2015

What is your overall impression about the technical level of the competition and the advances w.r.t the state of the art on robotics research and development introduced by the participating teams?

There are two questions. One regarding the competition and one regarding the teams.

Competition

It seems that the running of the competition and measuring the robots and the tests are completely under control. It still takes a while to do the setup and it is my impression that the equipment is rather expensive. This means that to gain traction it should be possible to rent the equipment or to use a budget system. This is probably the biggest hurdle to roll out the benchmarking system.

A suggestion would be to have the system 'tour' around Europe. The laboratory/university/company can rent the system but gets a discount if other groups in the (relative) neighborhood can also use it and actually use it. A standard procedure should be made available to have mini-RoCKIn competitions so that the setup time and costs are minimized. For the university/lab/group hosting the event this would considerably increase the visibility of their research and impact on society.

Teams

The teams have shown remarkable progress. Whereas last year (2014) I was not impressed, this year all teams showed professional behavior. The people were in Lisbon to do a job. Although many persons are still students, there was little 'student' behavior. I think that this is the single most important outcome of the RoCKIn project: **International benchmarks and competitions create the best professionals!** The participants are the new workforce of high-tech Europe. If all the students had the opportunity to give their best and grow while being allowed to make a mistake here and there, Europe would be the leading continent in just about everything. From

personal experience I know that my extra-curricular work in the robot laboratory was the more important for my career than anything else.

What was the (positive or negative) impact of the RoCKIn competition rules in the (lack of) success of the teams in achieving the advanced results mentioned in the previous item?

Last year I was not completely positive about the rules. Now I think that the rules do not matter that much. RoCKIn had its own style of creating a benchmark. It is more important that there are several initiatives so that participants can choose. Nobody is the same, which implies that there should be a choice.

Clearly the tests are about the big problems facing robotics nowadays. In ten years there will be completely different tests. **It is not about the tests; it is about the process.** And international benchmarks and competitions are, probably, the most stimulating ways to boost the process of learning and gaining valuable skills. The participants have learned how to collaborate in a team, which is often more difficult than the technical problems. It is an experience they will never forget. Later, they will realize that this was the time and place where they learned essential skills that will help them during the rest of their careers.

Do the task benchmarks and functionality benchmarks contribute to a scientifically grounded performance evaluation process? Comment on the role of the benchmarking and scoring procedures, methods and metrics introduced by RoCKIn on this. Suggest improvements on such procedures, methods and metrics.

I think that the methods used in @Home are definitely useful for gathering grounded data. It is exciting to see the measuring system in the early, although well developed, stage. Hopefully the data will be provided to the public. I would suggest to contact Kaggle.com to see whether this can be made into a competition.

Furthermore, I suggest to stimulate research groups to use the visual data or to use this for a Kaggle.com competition. The grounded data can be used for training the visual systems. This could lead to a setup where only 'normal' cameras are used. These visual systems are bootstrapped by the grounded system that is in use in the @Home scenario. For the test data set a part of the data is not published but is used to benchmark the trained visual systems. Once there are well trained visual systems that only 'normal' cameras are required the costs of the setup would be reduced by a large margin. This would speed up the dissemination of the RoCKIn project.

Another idea for a competition is to also have software agents use the recorded data and score the robots using the RoCKIn rules. Setting up this competition would require some extra work besides brushing up the data, but not a lot of extra work. It would certainly entice teams to use the data set. Also, in a future RoCKIn project these software agents can take over part of the role of the referee. In RoboCup@Home these agents would get a warm welcome. It also requires that the software agents understand the situation at hand and can lead to new areas of research.

How did teams perform overall regarding over-engineering particular solutions for the specific challenges versus developing more general research solutions? Please point out the positive and negative aspects and suggest measures to improve towards a more balanced approach.

I have not read the research papers from the teams and also I have not looked at their code. From an external view I can only say that I've seen familiar robots and people who also participate in RoboCup@Home. This implies that there might be general solutions to the research problems.

What is more important that the participants have gained real experience on how to run a robot project. The general solutions are probably not in the software or in the hardware, but in the way people approach these kind of problems when they face them next time.

Were the competition rules too demanding or too conservative concerning the current state of the art in service and industrial robotics? In which aspects?

In the first year it was difficult to say, especially because not so many teams were preforming well. But this year most teams were performing very well. So it seems that the rules are working just fine. I would suggest to increase the level of difficulty for those tests where most teams were performing very well, or where a team scored all possible points.

Should the competition rules be changed to foster more disruptive research? If so, how? And how should they be changed to improve technology transfer, if needed? Are these two aspects impossible to balance or can we find ways to prepare competition rules that succeed in pushing forwards disruptive research that simultaneously addresses the market needs so that companies are interested in developed technology?

Change for disruptive research

Probably by having one or two very difficult tests. The tests at the moment are a bit conservative in my opinion, but if you are a team member participating your point of view is probably different than mine. Still, I would suggest two very difficult benchmarks so that the excellent teams can demonstrate their competence. This would allow new teams to get up and running and would allow the best teams to differentiate on the difficult tests.

Technology transfer

To make the technology transfer work the following aspects useful:

1. The costs of the equipment should be reduced.
2. There should be international consensus on how to set up the test equipment.
3. There should be a guide on how to set up the equipment.
4. There should be some standard software for working with the data.

Basically, what I am saying is that the follow up project should focus on dissemination and getting more groups on board. RoCKIn has demonstrated that they have a viable approach. The next years the focus should be less on the capturing of the data and more on the other aspects such as dissemination of the work and stimulating others to work with the data.

What impressed you the most during this year's RoCKIn competition? And if you feel something did not work well, how would you change it in the future?

What impressed me the most was the growth in the professional behavior of the participants. Last year most teams were chaotic, this year most teams were organized. This is knowledge that a person cannot learn sitting in the class

room. It cannot be told but has to be experienced. It is the same as working with robots, it cannot be told but requires hands on experience. A participant thus learned two very important skills that can only be learned doing a project such as RoCKIn. These skills are: building robots and work as a team.

Ideas for the future

1. Go for RoCKIn 2 (and 3 and …).
2. Provide a low cost hardware infrastructure with open source software, besides the current setup.
3. Disseminate! Tell the world! Turn the data into a Kaggle.com competition and get free publicity.
4. Provide the setup to other groups for rent (including installation).
5. Give a demonstration at the world championships of RoboCup in Leipzig

Conclusions

It is known that these kind of initiatives can be a success, and RoCKIn clearly is. The European Union should support more of these initiatives. These initiatives are where our future tech leaders are formed. We need these people to become the best and RoCKIn provided a place to grow. These places are still too scarce. This is learning by doing. And it is not only doing, but the participants are self-motivated which speeds up their own development process. The participant come home and can apply the lessons learned new projects and teach people they will work with during the rest of their careers. RoCKIn has created little gems, some of them will shine very brightly in the future.

Appendix B – Minutes of the RoCKIn-RoboCup Meeting

RoCKIn RoboCup Meeting

Before the start of the competition in Lisbon, on Friday, November 20th 2015, we organized a meeting with the well defined goal of transferring some of the achievements, in terms of tools, methodologies and challenges back into RoboCup competitions. This is a key dissemination action to forward the outcomes of RoCKIn; in order to make it successful we invited members of the Executive and Technical Committees of RoboCup@Home and RoboCup@Work, representatives of the Benchmarking Service Robotics developed in China and of the RoboCup Logistics League, in addition to the members of the Board of Experts and of our Advisory Board, that joined the overall event.

Overall, we had the following participants (RoCKIn members are marked with (R)):

- Alessandro Saffiotti (Orebro Univ. Sweden)
- Manuela Veloso (Carnegie Mellon University, USA)
- Loy Van Beek (Technical Univ. Eindhoven, Netherlands), RoboCup@Home
- Sven Wachsmuth (Univ. Bielefeld, Germany), RoboCup@Home
- Yingfeng Chen, (USTC Hefei, China), Benchmarking Service Robotics
- Sebastian Zug (Otto-von-Guericke Universität Magdeburg, Deutschland), RoboCup@Work League
- Tim Niemüller (TN)(RWTH Aachen, Deutschland), RoboCup Logistics League
- (R) Pedro Lima (Istituto Superior Tecnico, Lisbon, Portugal)
- (R) Pedro Miraldo (Istituto Superior Tecnico, Lisbon, Portugal)
- (R) Daniele Nardi (Sapienza Univ. Rome, Italy)
- (R) Luca Iocchi (Sapienza Univ. Rome, Italy)
- (R) Matteo Matteucci (Politecnico di Milano, Italy)
- (R) Andrea Bonarini (Politecnico di Milano, Italy)
- (R) Fredrik Hegger (Hochschule Bonn-Rhein-Sieg, Deutschland)
- (R) Gerhard K. Kraetzschmar (Hochschule Bonn-Rhein-Sieg, Deutschland) (via Skype)
- (R) Nico Hochgeschwender (Hochschule Bonn-Rhein-Sieg, Deutschland)
- (R) Sven Schneider (Hochschule Bonn-Rhein-Sieg)
- (R) Tim Friedrich (KUKA Roboter GmbH)

The meeting was arranged in two sessions :

Session 1 (all participants) 3:00pm – 4:00pm

- Introduction (Pedro Lima and Daniele Nardi)
- Presentation of the RoCKIn Approach to Benchmarking (Matteo Matteucci)

This first section provided an overview of RoCKIn goals and approach to benchmarking and created a common basis for the subsequent discussion. For the details the reader is referred to the RoCKIn deliverables.

Session 2 (parallel working groups) 4:00pm – 6:00pm

- @Home (chaired by Luca Iocchi)
- @Work (chaired by Tim Friedrich)

Below we briefly report the activities and outcomes of the working groups.

@Home

Participants:

- Pedro Lima (Istituto Superior Tecnico, Lisbon, Portugal)
- Pedro Miraldo (Istituto Superior Tecnico, Lisbon, Portugal)
- Daniele Nardi (Sapienza Univ. Rome, Italy)
- Luca Iocchi (Sapienza Univ. Rome, Italy)
- Andrea Bonarini (Politecnico di Milano, Italy)
- Fredrik Hegger (Hochschule Bonn-Rhein-Sieg, Deutschland)
- Alessandro Saffiotti (Orebro Univ. Sweden)
- Manuela Veloso (Carnegie Mellon University, USA)
- Loy Van Beek (Technical Univ. Eindhoven, Netherlands), RoboCup@Home
- Sven Wachsmuth (Univ. Bielefeld, Germany), RoboCup@Home
- Yingfeng Chen, (USTC Hefei, China), Benchmarking Service Robotics

Before starting the discussion of specific items brief presentation providing an update to the current state of the art of RoboCup@Home and of Benchmarking Service Robots, were given by:

- Loy Van Beek (Technical Univ. Eindhoven, Netherlands), RoboCup@Home
- Yingfeng Chen, (USTC Hefei, China), Benchmarking Service Robotics

Similarities and differences

RoCKIn	RoboCup
Benchmarking Fully developed on both tasks and functionalities. Data logs and ground truth data acquired to post-processing of robot performance during the tests.	Benchmarking Focus on the evaluation of the integrated system. Functionalities already identified, but not specifically benchmarked.
Scoring and Ranking - Based on Achievements (performance equivalence class) - Achievements are worth "more" than penalties (first the class is checked, then the penalties) Best performance?	Scoring and Ranking - Points (positive/negative) - Take into account even small differences (for example time (seconds)) Average (best of 2 out of 3)
Environment Specified in great detail Reference Facilities created and existing ones used.	Environment Loosely specified and changing form year to year according to local culture and materials.
Networked Devices - Static cameras - Light control	No networked devices
Objects Easily purchasable objects (IKEA) known before the competition Data sets of images	Objects Real objects (unknown before the competition)
Speech Focus on speech understanding (Frame and lexicon definition) Corpus collection available for testing	Speech No definition of frames and lexicon Unknown speaker Very noisy environment
Refbox	NO RefBox

The above table summarizes the analysis of similarities and differences between RoCKIn and RoboCup@Home. The analysis started with the presentation of Loy Van Beek and summarizes the discussion that was held during the session. In particular, staring from these concepts we have decided for a few items to be implemented already in RoboCup@Home 2016 as illustrated below.

Outcomes

We have discussed to bring into RoboCup@Home 2016 the following items, that are currently under discussion within the Technical Committee that is defining the rulebook for 2016 competition.

1. The benchmarking setting.

Although already in RoboCup@home 2015 there were some tests with the goal of evaluating single functionalities, in 2016 this can be done in a more systematic way, by:

a) asking for log of internal data during the tests;

b) using some form of ground truth to measure performance.

2. Referee Box

A specific work for adapting the RoCKIn@Home RefBox for RoboCup@Home has been started by the group at University of Bielefeld with the goal of experimenting and using it since RoboCup 2016.

3. RoboCup@Home Camps and Workshops

Camps and Workshops are important to increase performance and robustness of the developed systems and to improve knowledge sharing and possibly code sharing. The RoboCup@Home Execs and Technical Committee will discuss ways of implementing Camps and Workshops as follow up of the ones organized during the RoCKIn project.

Additional contributions from RoCKIn@Home to RoboCup@Home can be discussed for future years. In particular, increasing the focus on benchmarking, on data collection, and on a more detailed performance analysis of the robots executing tasks is a major goal that however requires more time for the implementation.

@Work

Participants:

- (GK)(Gerhard K. Kraetzschmar Hochschule Bonn-Rhein-Sieg, Deutschland) (via Skype)
- (SZ) Sebastian Zug (Otto-von-Guericke Universität Magdeburg, Deutschland)
- (TN) Tim Niemüller (RWTH Aachen, Deutschland)
- (NH) Nico Hochgeschwender (Hochschule Bonn-Rhein-Sieg, Deutschland)
- (SS) Sven Schneider (Hochschule Bonn-Rhein-Sieg)
- (TF) Tim Friedrich (KUKA Roboter GmbH)

Similarities and differences

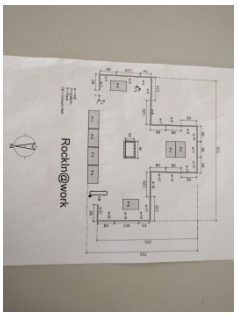
RoCKIn	RoboCup
Benchmarking - One of the key elements of RoCKIn - Not only decide a "winner", but see the competition as experiment - Evaluate the robots performance on objective criteria	No benchmarking
Scoring and Ranking - Based on Achievements (performance equivalence class) - Achievements are worth "more" than penalties (first the class is checked, then the penalties)	Scoring and Ranking - Points (positive/negative) - Take into account even small differences (for example time (seconds))
No complexity levels (all teams have to solve the same tasks)	Different complexity levels - Can be chosen by team (change score)
Only real walls	Real walls + virtual walls (barrier tape)
Networked Devices - Conveyor belt - Drilling machine - Force fitting machine	Networked devices - Conveyor belt (can be operated manually)
Objects are very complex - e.g. the shaft nut is very difficult to detect with 3D-perception - Shape/size is very different between parts - e.g. faulty and perfect plate are very hard to distinguish	Objects are "simpler" - Bigger (makes them easier to detect and to manipulate) - Not as much variety between objects
Central Factory Hub (CFH)	RefBox

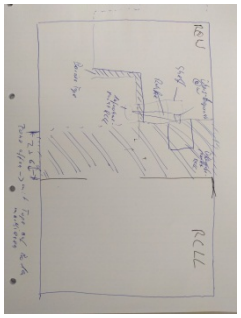
The table above describes some general similarities and differences between RoCKIn@Work and RoboCup@Work. The discussion between the parties started with a short introductory round. Following this new developments on the RefBox side were presented by SZ. Because the discussion became very technical already, GK suggested to move on to another topic. It was briefly talked about different ways to moderate the event, because the scenario and tasks are not interesting enough to a broad audience, as long as they don't know what exactly the robot is doing. It was mentioned that a professional moderator would be the best choice, but timeslots would need to be assigned to both @Work and RCLL to minimize interference between speakers. After this GK presented an idea, which came up in conferences earlier this year, where the subject was to create a scenario that would cover different RoboCup leagues and how an integration of those would be possible (e.g. buy something online (@Home) -> process order (@Work) -> handle order, further refine order (RCLL) -> pack order (Amazon Picking). The idea behind this is not to change the leagues, but think about a way they could interact with each other. The current RoboCup2016 layout (@Work | RCLL | @Work; arenas next to

each other) was discussed, because representatives of both leagues were present and therefore constraints from each league could be taken into consideration. The participants agreed that a CrossChallenge between @Work and RCLL could create a good starting point and serve as example how different leagues could interact with each other. Because GK had to leave it was decided to present him with an example of a CrossChallenge scenario, further to be discussed by the other participants. While brainstorming ideas for such a scenario, most of the above similarities/differences between RoCKIn@Work and RoboCup@Work, as well as RCLL were taken into account.

Outcomes

It became clear that one of the major differences, the benchmarking system of RoCKIn, could not be integrated this year, because the preparation of RoboCup2016 had already progressed too far. Everyone agreed that RoboCup@Work needed some changes to become more interesting, therefore it was decided that the arena setup should become more like the one used in RoCKIn@Work (basically the RoCKIn arena should be used), all objects from RoCKIn@Work should be presented in the rulebook (but only a few actually used) and the idea to have more networked devices should be developed further. Between the @Work and RCLL testbed a "Challenge Zone" should be created, that could be entered by both @Work and RCLL teams, but doesn't interfere with testing in the main testbed (see pictures below).





The idea is to have a robot in @Work transmitting an assembly task to RCLL and receiving a finished product. The task should be transmitted via the CFH/RefBox (they share the same code base). The finished product could be placed in the @Work arena over a slide (starting at one of the MPS from RCLL and ending on a shelve in @Work) to overcome the height differences between the robots.