RoboCup@Home

Rules & Regulations

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Chapter 1

Introduction

1.1 RoboCup

RoboCup is an international joint project to promote AI, robotics, and related fields. It is an attempt to foster AI and intelligent robotics research by providing standard problems where a wide range of technologies can be integrated and examined. More information can be found at http://www.robocup.org/.

1.2 RoboCup@Home

The *RoboCup@Home* league aims to develop service and assistive robot technology with high relevance for future personal domestic applications. It is the largest international annual competition for autonomous service robots and is part of the RoboCup initiative. A set of benchmark tests is used to evaluate the robots abilities and performance in a realistic non-standardized home environment setting. Focus lies on the following domains but is not limited to: Human-Robot-Interaction and Cooperation, Navigation and Mapping in dynamic environments, Computer Vision and Object Recognition under natural light conditions, Object Manipulation, Adaptive Behaviors, Behavior Integration, Ambient Intelligence, Standardization and System Integration. It is collocated with the RoboCup symposium.

1.3 Organization

1.3.1 Executive Committee

The *Executive Committee* (EC) consists of members of the board of trustees, and representatives of each activity area. Members representing the @Home league:

- Dirk Holz (University of Bonn, Germany)
  `holz@ais.uni-bonn.de`

- Luca Iocchi (University of Rome "La Sapienza", Italy),
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1.3.2 Technical Committee

The *Technical Committee* (TC) is responsible for the rules of each league. Members of the RoboCup@Home Technical Committee for 2013:

- Fariborz Mahmoudi (Qazvin Azad University, Iran)
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- Mohan Rajesh Elara (Singapore University of Technology and Design, Singapore)
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The Technical Committee also includes the members of the Executive Committee.

1.3.3 Organizing Committee

The *Organizing Committee* (OC) is responsible for the organization of the competition. Members of the RoboCup@Home Organizing Committee for 2013:

- **Chair:** Sven Wachsmuth (Bielefeld University, Germany)
  `swachsmu@techfak.uni-bielefeld.de`

- **Local Chair:** Maja Rudinac (Delft University of Technology, the Netherlands)
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1.4 Infrastructure

1.4.1 RoboCup@Home Mailinglist

The official *RoboCup@Home mailing list* can be reached at
<div align="center">

`robocup-athome@lists.robocup.org`
</div>

You can register to the email list at:
<div align="center">

http://lists.robocup.org/listinfo.cgi/robocup-athome-robocup.org
</div>

1.4.2 RoboCup@Home Web Page

The official *RoboCup@Home website* that also hosts this rulebook can be found at
<div align="center">http://www.robocupathome.org/</div>

1.4.3 RoboCup@Home Wiki

The official *RoboCup@Home Wiki* is meant to be a central place to collect information on all topics related to the RoboCup@Home league. It was set up to simplify and unify the exchange of relevant information. This includes but is certainly not limited to hardware, software, media, data, and alike. The *wiki* can be reached at
<div align="center">http://robocup.rwth-aachen.de/athomewiki.</div>
To contribute, i.e. to add/edit/change things you need to create an account and log in.

1.5 Competition

The competition consists of 2 *Stages* and the *Finals*. Each stage consists of a series of *Tests* that are being held in a daily life environment. The best teams from *Stage I* advance to *Stage II* which consists of more difficult tests. The competition ends with the *Finals* where only the five highest ranked teams compete to become the winner.

1.6 Awards

The RoboCup@Home league features the following *awards*.

1.6.1 Winner of the competition

There will be a 1st, 2nd, and 3rd place award.

1.6.2 Innovation award

To honor outstanding technical and scientific achievements as well as applicable solutions in the @Home league, a special *innovation award* may be given to one of the participating teams. Special attention is being paid to making usable robot components and technology available to the @Home community.

   The executive committee (EC) members from the RoboCup@Home league nominate a set of candidates for the award. The technical committee (TC) elects the winner. A TC member whose team is among the nominees is not allowed to vote.

   There is no innovation award in case no outstanding innovation and no nominees, respectively.

1.6.3 Winner of the Technical Challenge

In parallel to the regular competition, the RoboCup@Home league features a technical challenge. The winner of the technical challenge is given a special *award for winning the technical challenge*.

   As with the innovation award, the award for winning the technical challenge is not given in case no team shows a *sufficient performance*. The decision which team wins the technical challenge, and if the award is given at all, is conducted by the Technical Committee (TC).

Chapter 2

Concepts behind the competition

A set of conceptual key criteria builds the basis for the RoboCup@Home Competitions. These criteria are to be understood as a common agreement on the general concept of the competition. The concrete rules are listed in Chapter 3.

2.1 Lean set of rules

To allow for different, general and transmissible approaches in the RoboCup@Home competitions, the rule set should be as lean as possible. Still, to avoid rule discussions during the competition itself, it should be very concrete leaving no room for diverse interpretation.

If, during a competition, there are any discrepancies or multiple interpretations, a decision will be made by the Technical Committee and the referees on site.

2.2 Autonomy & mobility

All robots participating in the RoboCup@Home competition have to be *autonomous* and *mobile*.

An aim of RoboCup@Home is to foster mobile autonomous service robotics and natural human-robot interaction. As a consequence humans are not allowed to directly (remote) control the robot. This also includes verbally remote controlling the robot.

Furthermore, the specific tasks must not be solved using *open loop control*.

2.3 Aiming for applications

To foster advance in technology and to keep the competition interesting, the scenario and the tests will steadily increase in complexity. While in the beginning necessary abilities are being tested, tests will focus more and more on real applications with a rising level of uncertainty. Useful, robust, general, cost effective, and applicable solutions are rewarded in RoboCup@Home.

2.4 Social relevance

The competition and the included tests should produce socially relevant results. The aim is to convince the public about the usefulness of autonomous robotic applications. This should be done by showing applications where robots directly help or assist humans in everyday life situations. Examples are: Personal robot assistant, guide robot for the blind, robot care for elderly people, etc. Such socially relevant results are rewarded in RoboCup@Home.

2.5 Scientific value

RoboCup@Home should not only show what can be put into practice today, but should also present new approaches, even if they are not yet fully applicable or demand a very special configuration or setup. Therefore high scientific value of an approach is rewarded.

2.6 Time constraints

Setup time as well as time for the accomplishment of the tests is very limited, to allow for many participating teams and tests, and to foster simple setup procedures.

2.7 No standardized scenario

The scenario for the competition should be simple but effective, available world-wide and low in costs. As uncertainty is part of the concept, no standard scenario will be provided in the RoboCup@Home League. One can expect that the scenario will look typical for the country where the games are hosted.

The scenario is something that people encounter in daily life. It can be a home environment, such as a living room and a kitchen, but also an office space, supermarket, restaurant etc. The scenario should change from year to year, as long as the desired tests can still be executed.

Furthermore, tests may take place outside of the scenario, i.e., in an previously unknown environment like, for example, a public space nearby.

2.8 Attractiveness

The competition should be attractive for the audience and the public. Therefore high attractiveness and originality of an approach should be rewarded.

2.9 Community

Though having to compete against each other during the competition, the members of the Robocup@Home league are expected to cooperate and exchange knowledge to advance technology together. The *RoboCup@Home mailing list* can be used to get in contact with other teams and to discuss league specific issues such as rule changes, proposals for new tests, etc. Since 2007 there is also the *RoboCup@Home Wiki* (see 1.4.3) which serves as a central place to collect information relevant for the @Home league. Every team is expected to share relevant technical, scientific (and team related) information there and in its *team description paper* (see 3.1.4).

All teams are invited to submit papers on related research to the RoboCup Symposium which accompanies the annual RoboCup World Championship.

2.10 Desired abilities

This is a list of the current desired technical abilities which the tests in RoboCup@Home will focus on.

- Navigation in dynamic environments

- Fast and easy calibration and setup
  The ultimate goal is to have a robot up and running out of the box.

- Object recognition

- Object manipulation

- Detection and Recognition of Humans

- Natural human-robot interaction

- Speech recognition

- Gesture recognition

- Robot applications
  RoboCup@Home is aiming for applications of robots in daily life.

- Ambient intelligence, e.g., communicating with surrounding devices, getting information from the internet etc.

Chapter 3

General Rules & Regulations

These are the general rules and regulations for the competition in the RoboCup@Home league. Every rule in this section can be considered to implicitly include the term *"unless stated otherwise"*, meaning that additional or contrary rules in particular test specifications have a higher priority than those mentioned herein in the general rules and regulations.

3.1 Team Registration and Qualification

3.1.1 Registration and Qualification Process

Each year there are four phases in the process toward participation:

1. *Intention of Participation* (optional)

2. *Preregistration*

3. *Qualification* announcements

4. Final *Registration* for qualified teams

Positions 1 and 2 will be announced by a call on the *RoboCup@Home mailing list*. Preregistration requires a *team description paper*, a *video* and a *website*.

3.1.2 Qualification Video

As a proof of running hardware, each team has to provide a *qualification video*. As a minimum requirement for qualification, we consider showing the robot(s) successfully solving at least one test of the current or last year's rulebook.

3.1.3 Team Website

The *Team Website* has to contain photos and videos of the robot(s), a description of the approaches, and information on scientific achievements, relevant *publications*, team members, and previous participation in RoboCup.

The information on the team website has to be in English and should be designed for a broader audience.

3.1.4 Team Description Paper

The *team description paper* (TDP) should at least contain the following sections:

- Name of the team

- contact information

- website

- team members

- description of the hardware, including photo(s) of the robot(s)

- description of the software

Preferably, it should also contain the following:

- the focus of research and the contributions in the respective fields,

- innovative technology (if any),

- re-usability of the system for other research groups

- applicability of the robot in the real world

The TDP has to be in English, up to eight pages in length and formatted according to the guidelines of the RoboCup International Symposium. It goes into detail about the technical and scientific approach.

3.1.5 Qualification

During the *qualification process* a selection will be made by the organizing committee. Taken into account and evaluated in this decision process are:

- The information on the team website and the qualification video,

- the information in the *team description paper*, and

- the information in the *RoboCup@Home Wiki* (added by the team).

(Additional) evaluation criteria are:

- the performance in previous competitions,

- the relevant scientific contributions and publications, and

- the contributions to the RoboCup@Home league.

For getting considered in the evaluation, be sure to insert your team's name when adding information to the *RoboCup@Home Wiki*.

3.2 Scenario

If not mentioned otherwise, all tests take place in the *RoboCup@Home arena*. In addition, particular tests are situated outside the arena, e.g., in a previously unknown public place. The following rules are related to the *RoboCup@Home arena* and its contents.

3.2.1 RoboCup@Home arena

The *RoboCup@Home arena* is a realistic home setting consisting of inter-connected rooms like, for instance, a living room, a kitchen, a bath room, and a bed room.

3.2.2 Walls, doors and floor

The indoor home setting will be surrounded by high and low *walls*. These walls will be built up using standard fair construction material.

1. **Walls:** Walls have a minimum height of 60 cm. A maximum height is not specified, but should be chosen so that the audience is able to watch the competition.
   Walls will be fixed and are likely to be not modified during the competition (see Section 3.2.4).

2. **Doors:** There will be at least two entry/exit *doors* connecting the outside of the scenario. If not mentioned otherwise, these doors are used as starting points for the robots (see Section 3.6.8). At least one of the entrances will be a door with a handle (not a knob).

3. **Floor:** The floor of the arena as well as the doorways of the arena are even. That is, there will be no significant steps or even stairways. However, minor unevenness such as carpets, transitions in floor covering between different areas, and minor gaps (especially at doorways) must be expected.

4. **Appearance:** Floor and walls are mainly uni-colored but can contain texture, e.g., a carpet on the floor, or a poster or picture on the wall.
   Although being unlikely at the moment, transparent elements are also possible.

3.2.3 Furniture

The arena will be equipped with typical objects (furniture) that are not specified in quantity and kind. The minimal configuration consists of

- a small dinner table with two chairs,

- a couch,

- an open cupboard or small table with a television and remote control,

- a cupboard or shelf (with some books inside), and

- a refrigerator in the kitchen (with some cans and plastic bottles inside).

A typical arena setup is shown in Figure 3.1(a).

(a) Typical arena   (b) Typical objects

Figure 3.1: Scenario examples: (a) a typical arena, and (b) typical objects.

3.2.4 Changes to the arena

Since the robots should be able to function in the real world the scenario is not fixed and might change without further notice.

1. **Major changes:** Changes will primarily influence the position of objects such as furniture inside the arena while walls are likely to stay fixed. Multiple changes may take place up to completely restructuring the internals of the apartment. The position of named locations (see Section 3.2.8) are not changed when used in a test, e.g., as navigation goal.
   In addition, passages may be blocked and cleared, respectively. One hour before a test slot begins no *major changes* will be made.

2. **Minor changes:** In contrast to major changes, *minor changes* like, for instance, slightly moved chairs cannot be avoided and may happen at any time (even during a test).

3.2.5 Predefined objects

Some tests in the RoboCup@Home league involve the manipulation of objects. These objects resemble items usually found in household environments like, for instances, soda cans, coffee mugs or books. An example of objects used in a previous competition can be seen in Figure 3.1(b).

1. **Definition:** The TC will compile a list of 25 objects. There are no restrictions on object size, appearance or weight. However, it can be expected that the selected objects are easily manipulable by a human using a single hand.

2. **Object classes:** Each object will be assigned to an *object class*. The objects 'lemonade' and 'ice tea' may be of class 'beverage' for example.

3. **Object (class) locations:** Each object (class) will be assigned to an *object location*. Objects of class 'drink' may be usually found on the 'kitchen table' for example.

4. **Announcement:** The TC makes the set of objects (and their names, classes, and usual locations) available during the setup days.

5. **Known vs. unknown**: These objects are used as the *known objects* in the test specifications; *unknown objects* are not taken from the set of *predefined objects*.

6. **Placement:** In manipulation tasks, the objects will be positioned at *manipulation locations* and less than 15 cm away from the border of the surface they are located at. There will be at least 5cm space around each object.

3.2.6 Predefined locations

Some tests in the RoboCup@Home league involve *predefined locations*. These may include places like a 'bookshelf' or a 'dining table', as well as certain objects such as a 'television', or the 'front door'.

1. **Definition:** The TC will compile a list of predefined locations. There are no restrictions on which parts of the arena will be selected as a predefined location.

2. **Location classes:** Each location will be assigned to a *location class*. The objects 'couch' and 'arm chair' may be of class 'seat' for example.

3. **Announcement:** The TC makes the set of locations (and their names and classes) available during the setup days.

4. **Position:** The positions of locations are *not* necessarily fixed (see Section 3.2.4).

5. **Manipulation locations:** The TC will mark 20 locations out of the set of predefined locations as being *manipulation locations*. Whenever a test involves manipulation, and if not mentioned otherwise, the object to manipulate will be placed one of the manipulation locations.

3.2.7 Predefined rooms

Some tests in the RoboCup@Home league involve a *predefined rooms*.

1. **Definition:** The TC will compile a list of room names.

2. **Announcement:** The TC makes the set of rooms available during the setup days.

3.2.8 Predefined (person) names

Some tests in the RoboCup@Home league involve *predefined names* of people.

1. **Definition:** The TC will compile a list of 20 predefined names. The names are 50 % male and 50 % female, and taken from the (current) most common first names in the United States.
   In order to ease speech recognition, it is tried to select names to be phonetically different from each other.

2. **Announcement:** The TC makes the set of names available during the setup days.

3. **Assignment:** When a test involves interacting with persons (using a person's name), all involved persons are assigned names by the referees before the test.

Typical names are, for example, James, John, Robert, Michael and William as male names; Mary, Patricia, Linda, Barbara and Elizabeth as female names.

3.2.9 Wireless network

For wireless communication, an *arena network* is provided. The actual infrastructure depends on the local organization.

- To avoid interference with other leagues, this WIFI has to be used for communication only. It is not allowed to use the above or any other WIFI network for personal use at the venue.

- During the competitions, only the active team is allowed to use the *arena network*.

- The organizers cannot guarantee reliability and performance of wireless communication. Therefore, teams are required to be ready to setup, start their robots and run the tests even if, for any reason, network is not working properly.

3.3 Robots

3.3.1 Autonomy & Mobility

Robots that participate in the RoboCup@Home league need to be *autonomous* and *mobile*. Any deviations reported to the TC, may result in a penalty for the team (see Section 3.7.2).

3.3.2 Number of robots

1. **Registration:** The maximum *number of robots* per team that can be registered for the competitions is *two* (2).

2. **Regular Tests:** Unless stated otherwise, only one robot is allowed per test. For different tests different robots can be used.

3. **Open Demonstrations:** In the Open Challenge, the Demo Challenge and the Finals both robots can be used simultaneously.

3.3.3 Size and weight of robots

1. **Dimensions:** The dimensions of a robot should not exceed the limits of an average door, which is 200 cm by 70 cm in most countries.
   The TC may allow the qualification and registration of larger robots, but due to the international character of the competition it cannot be guaranteed that the robots can actually enter the arena. In case of doubt, contact the local organization.

2. **Weight:** There is no specific weight restriction. However, the weight of the robot and the pressure it exerts on the floor should not exceed local regulations for the construction of buildings which are used for living and/or offices in the country where the competitions is being held.

3. **Transportation:** Team members are responsible for quickly moving the robot out of the arena. If the robot cannot move by itself (for any reason), the team members must be able to transport the robot away with an easy and fast procedure.

3.3.4 Emergency stop button

1. **Accessibility and visibility:** Every robot has to provide an easily accessible and visible *emergency stop* button.

2. **Color:** It must be coloured red, and preferably be the only red button on the robot. If it is not the only red button, the TC may ask the team to tape over or remove the other red button.

3. **Robot behavior:** When pressing this button, the robot and all parts of it have to stop moving immediately.

4. **Inspection:** The emergency stop button is tested during the *robot inspection* procedure (see Section 4.1).

3.3.5 Start button

1. **Mandatory start button:** Every robot has to provide a *start button* that can be used to start tests when needed (see Section 3.6.7).

2. **Definition:** The start button can be any "one-button procedure" that can be easily executed by a referee. This includes, for example, the release of the *emergency button* (Section 3.3.4), a hardware button different from the *emergency button* (e.g., a green button), or a software button in a Graphical User Interface.

3. **Inspection:** The start button for a robot should be the same for all the tests and must be announced in the *robot registration* form and tested during the *robot inspection* procedure (see Section 4.1).

4. **Penalty for using start button:** If a team needs to use the start button in a test where opening the door is the start signal (see Section 3.6.7), it receives a penalty of *50 points*.

3.3.6 Appearance and safety

Robots should have a nice product-like appearance, be safe to operate and should not annoy its human users. The following rules apply to all robots and are part of the *robot inspection* procedure (see Section 4.1).

1. **Cover:** The robot's internal hardware (electronics and cables) should be covered in an appealing way. The use of (visible) duct tape is strictly prohibited.

2. **Loose cables:** There may not be any loose cables hanging out of the robot.

3. **Safety:** The robot may not have sharp edges or other things that could severe people.

4. **Annoyance:** The robot should not permanently make loud noises or use blinding lights.

3.3.7 Audio output plug

1. **Mandatory plug:** Either the robot or some external device connected to it *must* have a *speaker output plug*. It is used to connect the robot to the sound system so that the audience and the referees can hear and follow the robot's speech output.

2. **Inspection:** The output plug needs to be presented to the TC in the *robot inspection* procedure (see Section 4.1).

3. **Audio during tests:** Audio (and speech) output of the robot during a test have to be understood at least by the referees and the operators.

   - It is the responsibility of the teams to plug in the transmitter before a test, to check the sound system, and to hand over the transmitter to next team.
   - Do not rely on the sound system! For fail-safe operation and interacting with operators make sure that the sound system is not needed, e.g., by having additional speakers directly on the robot.

3.4 External devices

1. **Definition:** Everything which is not part of the robot is considered an *external device*.

2. **Inspection:** In general, external devices are not allowed unless presented and explained to the Technical Committee during the *robot inspection* procedure (see Section 4.1).

3. **Supervision:** In regular tests, external devices may only be used under supervision by referees and after approval by the TC. The devices have to be brought to the arena for every test, and removed quickly after the test.

4. **Open demonstrations:** For the Open Challenge, the Demo Challenge, and the finals, external devices are allowed, still their use needs to be announced beforehand.

5. **Wireless devices:** All *wireless devices* including bluetooth devices, walkie-talkies, and anything else that uses an RF signal to operate need to be announced to the *Organizing Committee (OC)*. The use of any wireless device not approved by the TC is strictly prohibited.

6. **Artificial landmarks:** *Artificial landmarks* and *markers* are not allowed.

7. **Computing devices:** External computers for decentralized computations are allowed, but have to be inside the arena, i.e., not on its periphery.

8. **Wireless LAN:** The use of networks other than the *arena network* (see Section 3.2.9) is strictly prohibited.

9. **External microphones:** *External microphones*, hand microphones, and headsets are not allowed. Using an *on-board microphone* is mandatory for communication with the robot.

3.5 Organization of the competition

3.5.1 Stage system

The competition features a *stage system*. It is organized in two stages each consisting of a number of specific tests. It ends with the finals.

1. **Stage I:** The first days of the competition will be called *Stage I*. All qualified teams can participate in Stage I. The *Open Challenge* is the open demonstration in Stage I.

2. **Stage II:** In case of more than 10 teams, only the best *50% of teams* (after Stage I) advance to *Stage II*. Here, more complex abilities or combinations of abilities are tested. The *Demo Challenge* is the open—but scoped—demonstration in Stage II.

3. **Final demonstration:** The best *five teams* (after Stage I and Stage II) advance to the final round. The final round features only a single open demonstration.

In case of having no considerable score deviation between a team advancing to the next stage and a team dropping out, the TC may announce additional teams advancing to the next stage.

3.5.2 Number of tests

1. In Stage I, the *maximum number of tests* that a team can participate in is *six (6)*.

2. In Stage II, the *maximum number of tests* that a team can participate in is *three (3)*.

3. None of the tests is mandatory, except for the Robot Inspection and Poster Session (Section 4.1).

4. Teams have to indicate to the organizing committee in which tests they are going to participate. Otherwise, they are automatically added to all test schedules and may receive a penalty when not attending (see Section 3.7.1).

3.5.3 Schedule

1. **Tests:** The organizing committee (OC) provides schedules for all tests and teams.

2. **Slots:** The tests will be held in *test slots* of approximately two hours.

3. **Preparation:** The organizing committee (OC) provides schedules for all teams to organize the access to the arena between test slots. In these *preparation slots* the teams may conduct calibration procedures, remap the arena if necessary, or conduct test runs. Preparation slots are inserted whenever possible, but may not be available before all test slots.

4. **Arena access:** One hour before a test slot, only the teams participating in that slot are allowed in the arena. This rule only applies when not having organized *preparation slots*.

3.5.4 Score system

1. **Stage I:** The maximum total score per test in Stage I is *1000 points.*

2. **Stage II:** The maximum total score per test in Stage II is *2000 points.*

3. **Special tests:** Tests may specify a maximum total score deviating from the general maximum total scores.

4. **Minimum score:** The minimum total score per test in Stage I and Stage II is *0 points.* That is, if the total score for a test is below zero, the team does not receive any points.

5. **Penalties:** An exception to the *minimum score* rule are penalties. Both penalties for not attending (see Section 3.7.1) and extraordinary penalties (see Section 3.7.2) can cause a total negative score.

6. **Partial scores:** All tests—except for the open demonstrations—are rewarded on a partial scoring basis.

   6.1. Tests are split into designated parts.

   6.2. Each part is assigned a certain number of points.

   6.3. A team that successfully passes a designated part of the test receives points for that part.

   6.4. In case of partial success, referees (and TC members) may decide to only award a percentage instead of the full partial score.

   6.5. The total score for a test is the sum of partial scores.

   6.6. Partial scores can be negative (e.g. to penalize failures etc.).

3.5.5 Open Demonstrations

1. **Stage I:** The *Open Challenge* is the open demonstration in Stage I.

   1.1. To participate in the Open Challenge, a team needs to participate in at least one regular Stage I test.

   1.2. Teams can demonstrate freely chosen abilities.

   1.3. The performance is evaluated by a jury consisting of the team leaders of all other teams.

   1.4. The Open Challenge is described in Section 4.7.

2. **Stage II:** The *Demo Challenge* is the open demonstration in Stage II.

   2.1. To participate in the Demo Challenge, a team needs to participate in at least one regular Stage II test.

   2.2. The scope (and topic) of the Demo Challenge are defined by the TC on a yearly basis.

   2.3. Teams can demonstrate freely chosen abilities, but according to the scope.

   2.4. The performance is evaluated by the Technical Committee.

2.5. The Demo Challenge is described in Section 5.3.

3. **Finals:** The competition ends with a final demonstration.

   3.1. The concept of the final demonstration is the same as that of the Open Challenge, but the performance evaluation is different.

   3.2. The are two juries—an *external* consisting of three or more people not from the RoboCup @Home league, and an *internal* formed by the Executive Committee. Both juries have different sets of evaluation criteria.

   3.3. Members of the external jury are selected by the Executive Committee on site.

   3.4. The demonstration in the finals does not have to be different from the one shown in the Open or Demo Challenge. It does not have to be the same either.

3.6 Procedure during Tests

3.6.1 Safety First!

1. **Emergency Stop:** At any time when operating the robot inside and outside the scenario the owners have to stop the robot immediately if there is a remote possibility of dangerous behavior towards people and/or objects.

2. **Stopping on request:** If a referee, member of the Technical or Organizational committee, an Executive or Trustee of the federation tells the team to stop the robot, there will be no discussion and the robot has to be stopped *immediately*.

3. **Penalties:** If the team does not comply, the team and its members can be excluded from the ongoing competition immediately by a decision of the RoboCup@Home Technical Committee. Furthermore, the team and its members can be banned from future competitions for a period not less than a year by a decision of the RoboCup Federation Trustee Board.

3.6.2 Maximum number of team members

1. **Regular Tests:** During a regular test, the maximum number of team members allowed inside the arena is *two* (2). The only exceptions are tests that require for more team members in the arena.

2. **Setup:** During the setup of a test, the number of team members inside the arena is not limited.

3. **Open Demonstrations:** During the Open Challenge, the Demo Challenge and the final demonstration, the number of team members inside the arena is not limited.

4. **Moderation:** During a regular test, one team member *must* be available to host and comment the event (see Section 3.6.12).

3.6.3 Fair play

Fair Play and cooperative behavior is expected from all teams during the entire competition, in particular:

- while evaluating other teams,

- while refereeing, and

- when having to interact with other teams' robots.

This also includes:

- not trying to cheat (e.g. pretending autonomous behavior where there is none),

- not trying to exploit the rules (e.g. not trying to solve the task but trying to score), and

- not trying to make other robots fail on purpose.

Disregard of this rule can lead to penalties in the form of negative scores, and disqualification for a test or even for the entire competition.

3.6.4 Robot Autonomy and Remote Control

1. **No touching:** During a test, the participants are not allowed to make contact with the robot(s), unless it is in a "natural" way and/or required by the test specification.

2. **Natural interaction:** The only allowed means to interact with the robot(s) are gestures and speech.

3. **Natural commands:** Only general instructions are allowed. Anything that resembles direct control is prohibited.

4. **Remote Control:** Remotely controlling the robot(s) is strictly prohibited. This also includes pressing buttons, or influencing sensors on purpose.

5. **Penalties:** Disregard of these rules can lead to penalties in the form of negative scores, and disqualification for a test or even for the entire competition.

3.6.5 Collisions

1. *Touching*: Robots are allowed to gently *touch* objects, items and humans. They are not allowed to crash into something. But since the "safety first" rule (Section 3.6.1) supercedes all other rules, it is suggested to not touch anything. The OC/TC/EC and the RoboCup Trustees all have the right to immediately stop a robot, and to disqualify a team for the duration of the competition, or longer, in case of dangerous behavior. Furthermore, referees can recommend to disqualify a team in which case EC/TC decides.

2. *Major collisions*: If a robot crushes into something during a test, the robot is immediately stopped. Additional penalties may apply.

   3. **Robot-Robot avoidance:** If two robots encounter each other, they both have to actively
      try to avoid the other robot.

      3.1. A robot which is not going for a different route within a reasonable amount of time
           (e.g., 30 s) is removed.

      3.2. A non-moving robot blocking the path of another robot for longer than a reasonable
           amount of time (e.g., 30 s) is removed. In this context, "moving" refers to any kind
           of motion or action required in the test. For example, a robot standing still but
           manipulating an object does not need to stop manipulating and move away, even
           when blocking the way of another robot for the duration of the manipulation.

3.6.6 Removal of robots

Robots not obeying the rules are stopped and removed from the arena.

   1. It is the decision of the referees and the TC member monitoring the test if and when to
      remove a robot.

   2. When told to do so by the referees or the TC member monitoring the test, the team has to
      immediately stop the robot, and remove it from the arena without disturbing the ongoing
      test.

3.6.7 Start signal

   1. **Opening the door:** Unless stated otherwise, the cue for the robot to enter the arena and
      start the test is the opening of the door by a referee.

   2. **Start button:** If the robot is not able to automatically start after opening the door, the
      team may start the robot using a start button.

      2.1. Using a start button needs to be announced to the referees. It is the responsibility of
           the team to do so before the test starts.

      2.2. There is a penalty of *50 points* for using a start button.

      2.3. For tests where using a start button is defined to be start signal no penalty applies.

3.6.8 Entering and leaving the arena

   1. **Start position:** Unless stated otherwise, the robot starts outside of the arena.

   2. **Entering:** The robot has to autonomously enter the arena.

   3. **Success:** The robot is said to *have entered* when the door used to enter can be closed
      again, and the robot is not blocking the passage.

3.6.9 Gestures

Hand gestures may be used to control the robot in the following way:

   1. **Definition:** The teams define the hand gestures by themselves.

2. **Approval:** Gestures need to be approved by the referees and TC member monitoring the test. Gestures should not involve more than the movement of both arms. This includes e.g. expressions of sign language or pointing gestures.

3. **Instructing operators:** It is the responsibility of the team to instruct operators.

   3.1. The team may only instruct the operator when told to so by a referee.

   3.2. The team may only instruct the operator in the presence of a referee.

   3.3. The team may only instruct the robot for as long as allowed by the referee.

   3.4. When the robot has to instruct the operator, it is the robot that instructs the operator and *not* the team. The team is not allowed to additionally guide the operator, e.g., tell the operator to come closer, speak louder, or to repeat a command.

4. **Receiving gestures:** Unless stated otherwise, it is not allowed to use a speech command to set the robot into a special mode for receiving gestures.

3.6.10 Referees

1. **Setup:** Unless stated otherwise, each test is monitored by two referees and one member of the Technical Committee.

2. **Selection:** The two referees

   - are chosen by EC/TC/OC,
   - are announced together with the schedule for the test slot,
   - and have to referee all teams in that slot.
   - Referees may not be from one of the teams in the slot.

3. **Not showing up:** Not showing up for refereeing (on time) will result in a penalty (see Section 3.7.2).

4. **TC monitoring:** The referee from the TC acts as a main referee.

5. **Referee instructions:** Right before each test, referee instructions are conducted by the TC. The referees for all slots need to be present at the arena where the referee instructions are taking place. When and where referee instructions are taking place is announced together with the schedule for the slots.

3.6.11 Operator

1. **Default operator:** If not mentioned otherwise, the robots are operated by the monitoring TC member, a referee, or by a person selected by the TC.

2. **Fallback/custom operator:** If the robot fails to understand the command given by the default operator, the team may continue with a custom operator.

   - The custom operator may be any person chosen by the team (and willing to do so); including the referees or the monitoring TC member.
   - A penalty may be involved when using a custom operator.

3.6.12 Moderator

1. **Providing a moderator:** For each regular test (i.e., not for the open demonstrations), all participating teams need to provide a team member as moderator for the duration of their performance.

2. **Responsibilities:** The moderators have to:
   - explain the rules of the test,
   - comment on the performance of their team,
   - not interfere with the performance,
   - speak in English,
   - and obey the instructions by the monitoring TC member.

3. **Competitive tests:** In competitive tests (tests in which two teams directly compete against each other), the moderation has to be done by the two teams together.

3.6.13 Time limits

1. **Stage I:** Unless stated otherwise, the time limit for each test in Stage I is *5 minutes*.

2. **Stage II:** Unless stated otherwise, the time limit for each test in Stage II is *10 minutes*.

3. **Setup time:** Unless stated otherwise, all time specifications, e.g., setup time and time for instructing operators, are within the total test time.

4. **Scores:** When the time is up, the team has to immediately remove their robot(s) from the arena; no more points can be scored. In special cases, the monitoring TC member may ask the team to continue the test for demonstration purposes (points cannot be scored).

3.6.14 Restart

1. **Number of restarts:** A team may request one (1) restart during a test, unless stated in otherwise. There are tests in which a restart is not allowed.

2. **Procedure:** In case a restart is allowed, the team may request the restart at any time. The complete test is then restarted from the beginning (e.g., with entering the arena). The referees may rearrange the locations of objects/persons if necessary.

3. **Time:** The time is neither restarted nor stopped.

4. **Score:** The score of the second run (after the restart) counts. If it is lower than the score of the first run (before the restart), the average score of first and second run is taken.

5. **Forced restart:** The referees and the monitoring TC member may force the team to do a restart:
   - if the robot is doing nothing or nothing reasonable for *one minute*, or
   - when the robot fails to understand a command for *five times*.

3.7 Special penalties and bonuses

3.7.1 Penalty for not attending

1. **Automatic schedule:** All teams are automatically scheduled for all tests.

2. **Announcement:** If a team cannot participate in a test (for any reason), the team leader has to announce this to the OC at least *30 minutes* before the test slot begins.

3. **Penalties:** A team that is not present at the start position when their scheduled test starts, the team is not allowed to participate in the test anymore. If the team has not announced that it is not going to participate, it gets a penalty of *500 points*.

3.7.2 Extraordinary penalties

1. **Penalty for inoperative robots:** If a team starts a test, but it does not solve any of the partial tasks (and is obviously not trying to do so), a penalty of *-100 points* is handed out. The decision is made by the referees and the monitoring TC member.

2. **Extra penalty for collision:** In case of major, (grossly) negligent collisions the TC may disqualify the team for a test (the team receives *0 points*), or for the entire competition.

3. **Not showing up as referee or jury member:** If a team does not provide a referee or jury member (being at the arena on time), the team receives a penalty of *500 points*, and will be remembered for qualification decisions in future competitions.
   Jury members missing a performance to evaluate are excluded from the jury, and the team is disqualified from the challenge (receives *0 points*).

3.7.3 Bonus for outstanding performance

1. For every regular test in Stage I and Stage II, the @Home Technical Committee can decide to give an extra bonus for *outstanding performance* of up to 10% of the maximum test score.

2. This is to reward teams that do more than what is needed to solely score points in a test but show innovative and general approaches to enhance the scope of @Home.

3. If a team thinks that it deserves this bonus, it should announce (and briefly explain) this to the Technical Committee beforehand.

4. It is the decision of the TC if (and to which degree) the bonus score is granted.

Chapter 4

Tests in Stage I

- Stage I starts with the robot inspection and poster session (RIPS). Participation in RIPS is mandatory.

- Stage I features the following regular tests:
    1. Follow me
    2. Cocktail Party
    3. Clean up
    4. Emergency

- The open demonstration in Stage I is the open challenge. Participating in the open challenge requires participating in at least one regular test.

- In addition to the regular tests, the technical challenge is conducted in Stage 1. Participating in the technical challenge requires participating in at least one regular test.

4.1 Robot Inspection and Poster Session

Each robot has to register itself and get approval to participate in the competition. In parallel, the team gives a short poster presentation of their recent research.

4.1.1 Robot inspection

1. **Location:** The inspection is taking place at a designated registration desk within the arena (announced beforehand).

2. **Inspectors:** The robots are inspected by the technical committee (TC).

3. **Task:**

   3.1. The robots enter through the designated entry door, and move to the registration desk. The robots need to face the registration desk from within 2 m distance.

   3.2. At the registration desk, the robots introduce themselves (stating their name and that of the team) and hand over the registration form.

   3.3. When told to do so by the inspectors, a team member commands the robot(s) to leave the arena.

   3.4. The robots leave through the designated exit door. While leaving, the inspectors hit the emergency button, and release it afterwards so that the robots leave the arena.

4. **Registration form:** The registration needs to be filled out by every team (one per team) and signed by the team leader.

5. **Re-inspection:** If the robot is not approved in the inspection, it is the responsibility of the team to get the approval (later). Robots are not allowed to participate in any test before passing the inspection by the TC.

6. **Checked aspects:** It is checked if the robots comply with the rules (see Section 3.3), checking in particular:

   - size and weight

   - emergency button and start button

   - robot speaker system (plug for RF Transmission)

   - use of external devices (including wireless network)

   - appearance of the system (no visible cables, no duct tape etc.)

7. **Autonomous registration:** The registration is considered autonomous and successful if the robot completely follows the above task (without any intervention or help by a human) up to the point where the emergency button is hit.

4.1.2 Poster teaser session

1. **Presentation:** In parallel to the robot inspection, the team gives a poster presentation on their research focus, recent results, and their scientific contribution.

2. **Evaluation:** The presentation and the poster are evaluated by a jury consisting of members of the other teams. Each team has to provide *one* person (preferably the team-leader) to follow and evaluate the entire poster session. Not providing a person results in no score for this team in the open challenge.

3. **Criteria:** For each of the following *evaluation criteria*, a maximum of *10 points* is given per jury member:

    3.1. Quality of appearance of the poster

    3.2. Quality of the poster content

    3.3. Scientific value

    3.4. Poster presentation and Questions

4.1.3 OC instructions

2h before test:

- Specify and announce which doors will be used as entry door and exit door.
- Specify and announce the location of the registration desk.
- Specify and announce where the poster teaser session takes place.

Any time before the test:

- Prepare and distribute registration sheets (external devices etc., place for notes and signatures of TC and team leader).
- Prepare and distribute poster session evaluation sheets.

4.1.4 Score Sheet

The maximum time for this test is *5 minutes.*

Action	Score
Registration (up to pressing emergency button)	
Autonomous registration (one robot)	*400*
Autonomous registration (two robots)	*2 × 200*
Leaving the arena (after releasing the emergency button)	
Autonomously leaving (one robot)	*100*
Autonomously leaving (two robots)	*2 × 50*
Neat Appearance	
No wires hanging out of the robot, e.g., no functional wire has to be tied to the robot, no duct-tape, internals covered, etc.	*200*
Poster session	
Arithmetic mean of scoring from evaluation sheets × 30	*300*
Special penalties & bonuses	
Not attending (see sec. 3.7.1)	*-500*
Outstanding performance (see sec. 3.7.3)	*100*
Total score (excluding penalties and bonuses)	*1000*

4.2 Follow Me

The robot has to safely follow an unknown person through a public space.

4.2.1 Focus

This test focuses on tracking and recognizing a previously unknown person, basic interaction and signaling capabilities, and safe navigation in unknown environments and narrow spaces with other people walking around or blocking the way.

4.2.2 Setup

1. **Location:** The test takes place outside the arena in a public space.

2. **Operator:** A "professional" operator is selected by the TC to test the robot.

3. **Other people:** There are no restrictions on other people walking by or standing around throughout the complete task.

4. **Path:** A path is setup (but *not* announced) beforehand. The complete path is divided into three sections by two intermediate time points (ITPs).

4.2.3 Task

1. **Start:** The robot starts at a designated starting position, and waits for the "professional" operator. When the referees start the time, the team is allowed to (briefly) instruct the operator. After the instruction, the operator steps in front of the robot and tells it to follow (no start signal).

2. **Memorizing the operator:** The robot has to memorize the operator. During this phase, the robot may instruct the operator to follow a certain setup procedure.

3. **Following the operator:** When the robot signals that it is ready to start, the operator is walking—in a natural way—on the designated path. The robot needs to follow the operator. The robot deals with different obstacles (single persons, tight elevator rooms, and small crowds) in different sections. Each section has a separate time measurement, but the complete task needs to be performed within the overall task time.

   1st section (from start to first ITP): Two persons block the direct passage on the way to the first ITP (at different positions). The operator guides the robot around the persons. One of the persons starts walking when the robot approaches, and crosses the way between robot and guide. Right in between, the walking person stops for 3 s before walking away.

   2nd section (between first and second ITP): The operator guides the robot into a small tight room (e.g., an elevator). There is not enough space to freely operate in this room (e.g., $1\,\mathrm{m} \times 2\,\mathrm{m}$). Other people may already be in there causing that operator and robot have to leave in reverse order (of entering). The team may choose among the following options and instruct the operator accordingly when the test starts.

1. The operator enters first, and commands the robot to exit when leaving. The robot is expected leave the room (the door should be cleared), wait for the operator, and automatically follow the guide again. No further command is given to tell the robot that it should follow again.
2. The operator commands the robot to enter first, and exits first when leaving. The robot is expected to enter the room (the door should be cleared), wait for the operator, and automatically follow when the operator leaves the room again.

Both commands must be naturally spoken commands such as "leave the elevator". Remotely controlling the robot in the form of specifying positions, orientations or movements is not allowed. Between entering and leaving the room, the door is shut for at least 5 s. In case the room is not directly accessible, the time is stopped while waiting.

3rd section (between second ITP and finish line): A small crowd of people (4-5) will be waiting outside the room, blocking the way between the second ITP and the finish line. The operator sneaks through the crowd and waits for the robot on the other side. The robot cannot pass through the people and needs to autonomously navigate around the group. While waiting, the operator is allowed to signal the robot where it is standing (e.g., by waving or by making a sound), but it is not allowed to move back. After the robot is following the operator again, the operator proceeds to the finish line.

4.2.4 Additional rules and remarks

1. **Preparation:** The robot needs to wait for at least 1 min before the operator appears in front of the robot. During this waiting time the team is not allowed to touch the robot.

2. **Natural walking:** The operator has to walk "naturally", i.e., move forward facing forward. If not mentioned otherwise, the operator is not allowed to walk back, stand still, signal the robot or follow some re-calibration procedure.

3. **Asking for passage:** The robot is allowed to (gently) ask individual persons to step aside, but it is not allowed to blindly shout at groups of people.

4. **Disturbances from outside:** If a person from the audience (severely) interferes with the robot in a way that makes it impossible to solve the task, the team may repeat the test immediately.

5. **Instruction:** The robot interacts with the operator, *not* the team. That is, the team is only allowed to (very!) briefly instruct the operator

   - how to the tell the robot to follow,
   - how to visually/acoustically signal it (e.g., waving or calling the robot's name), and
   - how to command the robot into or out of the tight room (ITP 2); the operator is allowed to indicate both the entry and exit of the elevator only by a single command.

6. **Calling the operator back:** When the robot has lost the operator, it may call the operator back once per section (loosing the points for that section).

7. **Time measurement:** The time of the first section (from start to first ITP) is started
   when the operator steps in front of the robot.

4.2.5 OC and Referee instructions

Any time before the test:

- Define the path and ITPs where the time is measured.
- Select the "professional" operator(s).

During the test:

- Show the path and the ITPs to the operators.
- Take the (accumulated) time at each ITP and at the finish line.
- Check that the elevator door is closed for the specified time.
- Check save operation of the robot; the robot needs to be stopped immediately if a
  person is going to be touched by the robot

4.2.6 Score Sheet

The maximum time of the test is *8 minutes.*

Action	Score
Points for the three sections	
for the best time Δt_1 achieved in section 1, less points are given for longer times (see Normalization)	*300*
for the best time Δt_2 achieved in section 2, less points are given for longer times (see Normalization)	*300*
for the best time Δt_3 achieved in section 3, less points are given for longer times (see Normalization)	*300*
Additional points	
completing the full task	*100*
Special penalties & bonuses	
Not attending (see sec. 3.7.1)	*-500*
Outstanding performance (see sec. 3.7.3)	*100*
Total score (excluding penalties and bonuses)	*1000*

Scoring remarks: The score is based on the (accumulated) time taken at each ITP (intermediate time point) and at the final goal point (e.g. $t_1 = 125sec, t_2 = 305sec, t_3 = 425sec$). Then the time intervals needed for each section are computed (e.g. $\Delta t_1 = 125sec, \Delta t_2 = 180sec, \Delta t_3 = 120sec$). The scores are then normalized with regard to the best time interval achieved for this section (e.g. $\Delta t_1^{min} = 100sec, \Delta t_2^{min} = 90sec, \Delta t_3^{min} = 120sec$). In the example a complete score of $240 + 150 + 300 + 100 = 790$ points is achieved:

Normalization: If a team needs more time in a section than the best team, the score for that section i is computed by

$$\text{normalized score for section } i = 300 \times (\Delta t_i^{min}/\Delta t_i)$$

where $\Delta t_1 = t_1 - 0, \Delta t_2 = t_2 - t_1, \Delta t_3 = t_3 - t_2$, and $\Delta t_1^{min}, \Delta t_2^{min}, \Delta t_3^{min}$ are the minimum time intervals achieved by a team.

4.3 Cocktail Party

The robot has to learn and recognize previously unknown persons, and deliver drinks.

4.3.1 Focus

This test focuses on human detection and recognition, manipulation, safe navigation and human-robot interaction with unknown persons.

4.3.2 Task

1. **People setup:** 5 people are distributed in a predefined "party room" either sitting or standing, some of them forming groups of 2 or 3 people.

2. **Entering:** The robot enters the arena and navigates to the party room.

3. **Getting called:** Three out of 5 persons are assigned drink orders by the referees. The robot waits for being called by the persons (also through waving). The persons call simultaneously for the robot. The robot has to approach one of the calling persons then do the learning procedure and take the order. The robot can decide to skip the detection of the calling and ask one person to walk in front of it. In this case, the referees determine the person to approach the robot. The calling person introduces her/himself by name before giving the order of a drink. The robot leads the dialogue to learn the person and retrieve her/his drink order.

4. **Taking the order:** The calling person gives order of a specific drink to the robot. The robot can request for more orders or start to fetch the object from a different room. In the first case, the robot searches for the remaining calling persons. During the search process, the robot is allowed to either ask persons to call for it again, or to ask persons to come to it and to give a new order. In both cases the robot may call into the room.

5. **Getting the drinks:** The robot has to navigate to a designated location in another "storage room" where drinks are stored. The robot may grasp any number of drinks, e.g., all the drinks ordered, or just one, and return to the party room.

6. **Delivering the drinks:** While the robot fetches drinks, the persons may change their places within the party room (on request of the referees). The robot has to search for persons, recognize found persons, and deliver the correct drink if there is an order for the recognized person. If the robot comes to the place the person ordered and the person is not there, then it could call the person loud, the person should respond (either sound or waving hand) and the robot must go to that place (check the person identity).

7. **Leaving the arena:** After delivering all the drinks, the robot has to leave the arena.

4.3.3 Additional rules and remarks

1. **Repeating names:** The robot may ask to repeat the name if it has not understood it.

2. **Misunderstood names:** If the robot misunderstands the name, the understood (wrong) name is used in the remainder of this test.

3. **Misunderstood order:** If the robot does not understand the order, it can continue with an own assignment of drinks to persons or with a wrong, misunderstood assignment.

4. **Approaching non-calling persons:** If the robot approaches a person that is not calling and asks for an order, the person indicates that she/he does not want to order anything. No points can be scored for understanding names or orders, or for grasping or delivery for a non-calling person.

5. **Changing places:** After giving the order (when the robot is not in the party room), the referees may re-arrange the persons including their body posture. That is, a sitting person may change to a standing posture and vice versa.

6. **Positions and orientations:** All persons roughly stay where they are (if not asked to move by the referees), but they are allowed to move in certain limits (e.g. turn around, make a step aside). They do not need to look at the robot, but are requested to do so, when instructed by the robot.

7. **Asking for help:** If the robot fails to grasp a drink, the robot may ask for help and a referee can hand over the object (loosing points for grasping). The robot has to clearly indicate that it has recognized the correct drink, e.g., by facing the drink, naming it and telling its rough position (e.g., leftmost, rightmost etc.) relative to the other drinks on the table.

8. **Correct delivery:** The drinks do not have to be handed over to the user. Putting them on the ground or asking the user to grab them from some kind of tray is allowed. When taking a drink from the robot, a sitting person may stand up in order to get it. However, in case the robot is carrying more than one object at a time, a delivery is only considered successful when there is an easily comprehensible mapping from grasped objects to recognized persons. The robot must be close to the person (within 1 m) for delivery and indicate uniquely which person it addresses by calling it by name and either facing her/him or pointing at her/him (e.g., with object in hand). When putting all the drinks on a tray, the robot has to name the correct drink and indicate its rough position relative to the others.

9. **Empty arena:** During the test, only the robot and only 5 persons are in the arena. The door opener, the referees and other personnel that is not assigned as test persons will be outside the scenario.

10. **Calling instruction:** The team needs to specify before the test which ways of getting the attention of the robot are allowed. This can be waving, calling or both of them. The robot can also decide to skip this part, by asking for persons to get close to it.

11. **Announcement of locations:** Both the locations of the drinks and the rooms where the test takes place are announced beforehand. Note that there may be more objects at the drink location than the ordered drinks.

4.3.4 Referee instructions

The referees need to
- select 5 people and their names from the list of person names (see Section 3.2.8),
- arrange (and re-arrange) persons in the party room,
- place 5 drinks at the pick location in the storage room,
- select the ordering 3 persons and the orders to give,
- in case the robot skips the calling detection, select the ordering person to approach the robot,
- write down the understood names and drinks during an order and update the order accordingly.

4.3.5 OC instructions

2h before test:

- Specify and announce the rooms where the test takes place.
- Specify and announce the location where the drinks are placed.

4.3.6 Score Sheet

The maximum time for this test is *10 minutes*.

Action	Score
Taking the orders	
Detecting the calling persons	*3 × 150*
Understanding and repeating the correct person and drink names (half points are given if either of the names is incorrectly understood)	*3 × 100*
Grasping drinks	
Grasping an ordered drink (and successfully lifting it up to at least *5 cm* for more than *10 seconds*)	*3 × 200*
Delivering drinks	
Delivering the *correct ordered drink*	*3 × 200*
Leaving the arena	
Autonomously leaving the arena within the time limit	*50*
Penalties	
Talking to the wrong person (using wrong name)	*-50*
Talking to something that is not a person	*-150*
Special penalties & bonuses	
Not attending (see sec. 3.7.1)	*-500*
Using start button (see sec. 3.3.5)	*-100*
Outstanding performance (see sec. 3.7.3)	*200*
Total score (excluding penalties and bonuses)	*2000*

4.4 Clean Up

The robot has to clean up a room in the apartment that is messed up with objects.

4.4.1 Focus

This test focuses on object detection, recognition, and manipulation, as well as safe navigation and systematic searching.

4.4.2 Setup

1. **Location:** One room in the apartment is used for this test. The room is not known beforehand. Delivery places are defined (beforehand) for each object class (Section 3.2.5).

2. **Objects:** The room contains 15 *known* objects from the set of predefined objects (Section 3.2.5). The room also contains 10 *unknown* objects, i.e., not from this set.

3. **Object distribution:** Both known and unknown objects are randomly distributed in the room. Possible object locations range over all different human-reachable heights (e.g., floor, seating, tables, shelves).

4.4.3 Task

1. **Entering and command retrieval:** The robot should enter the arena and wait for further commands.

2. **Searching for objects:** When told to do so by an operator (team member), the robot moves to the designated room, and starts searching for objects.

3. **Grasping objects:** Any object found by the robot may be grasped by it. Before or right after grasping the object, the robot has to announce which object it has found or that the object is unknown.

4. **Putting objects back:** After grasping the object, the robot has to deliver known objects to the location that is defined beforehand for that object category (Section 3.2.5). Unknown objects have to be brought to the trash bin which is included in the set of predefined locations (Section 3.2.6).

   - If a table top or shelf is defined, it must be placed on the table or in the shelf, respectively.
   - If a place on the floor is defined, it must be placed not more than 50cm away from a defined reference point, in case of a bin it must be inside the bin.
   - The object has to be safely placed at its assigned location and must stay there for at least 10sec.

5. **Handling objects multiple times:** Scores can only be gained a single time for each specific object.

4.4.4 Additional rules and remarks

1. **Command:** The command given to the robot is "Clean up the *room*" where *room* is the replaced by the actual room name. If needed, the command may be extended to start or end with the robot's name.

2. **Collisions:** Slightly touching the objects is tolerated. Driving over the objects or any other form of a major collision is not allowed, and the referees directly stop the robot (Section 3.6.1).

3. **Asking for help:** In case the robot is not able to grasp or place an object, it may ask for help (a *"hand over"*).

   3.1. For a "hand over", the robot has to clearly indicate to a referee what needs to be done.

   3.2. A "hand over" instead of grasping requires that the robot is positioned close to the object, faces it and (correctly) names it.

   3.3. A "hand over" instead of placing requires that the robot is positioned close to the location, faces it and (correctly) names it.

   3.4. The robot may only manipulate one object via a hand-over at a time.

   3.5. Whenever a hand-over is used, you must not use another hand-over to retrieve or place another object!

4.4.5 Referee instructions

The referees need to

- place the objects in the selected room.

- make sure that the delivery places are accessible (and clearly specified).

- help the robot if requested.

4.4.6 Score sheet

The maximum time for this test is *8 minutes.*

Action	Score
Penalties involved per object grasped and placed	
Successfully grasping and placing an object at the correct location	*1000*
Placing an object at a wrong location	*-600*
Penalty for "hand over" instead of autonomous grasping	*-400*
Penalty for "hand over" instead of autonomous placing	*-200*
Additional penalties	
Indicating wrong information when asking for help.	*-100*
Special penalties & bonuses	
Not attending (see sec. 3.7.1)	*-500*
Using start button (see sec. 3.3.5)	*-100*
Outstanding performance (see sec. 3.7.3)	*100*
Total score (excluding penalties and bonuses)	*1000*

Normalization: If a team achieves more than *1000 points* (without outstanding performance), the scores of all teams are normalized. That is, the team with maximally achieved score gets *1000 points*, the other teams accordingly less.

4.5 Emergency situation: fire in the apartment

The robot has to properly react to an emergency situation in the house. The main story of this test is: there is a fire in the kitchen, the robot has to discover the danger, then search for people in the environment, notify them and guide them to the emergency exit.

4.5.1 Focus

The test focuses on automatic detection of events related to safety and security, human-robot interaction in order to improve safety and security in the house, implementation of a complex behavior containing several possible cases.

4.5.2 Setup

1. **Location:** The test takes place inside the arena.

2. **Objects in the arena:** A "fire/smoke machine" (e.g., a humidifier or a similar device) will be placed in a random position and turned on in the kitchen by the referees before the test starts. This device will be available before the test for the teams to tune the perception of the smoke, but it will covered during the test so that perception must be focussed on the smoke and not on the device itself.

3. **People in the arena:** The referees decides number and location of people in the arena (a similar setting for all the teams not known before the test).

4.5.3 Task

Robots participating in this test are required to implement a behavior summarized with the following pseudo-code. This behavior includes different cases. We require teams to implement the entire behavior even though only a part of it may be actually executed during the competition. The exact situation will be decided by the TC before the test, but it will not be announced to the teams.

```
MAIN TASK
enter the apartment
go to the kitchen
detect fire/smoke(1)
search for a person in the apartment (including the kitchen)
WHILE (person found in the apartment)
    SAVE(person)
    search for another person in the apartment
END WHILE
send a report to Fire Dept. (2)
exit the apartment
END TASK

PROCEDURE  SAVE(person)
```

```
    ask the person if s/he is OK (i.e., s/he can move)
    IF (answer is NO OR no answer)
        register person position
    ELSE
        ask the person if s/he knows the way to the exit
        IF (answer is NO)
            guide the person to the exit (3)
        END IF
    END IF
END PROCEDURE
```

4.5.4 Additional rules and remarks

(1) Fire/smoke is correctly detected if the robot looks and points at it from a close distance (less than 1 m) and clearly announces that fire/smoke has been found. If fire/smoke is not automatically detected in 1 minute (after the robot enters the kitchen) the robot can proceed to the next step of the behavior (assume a fire alarm sends a proper signal to the robot).

(2) Sending a report to the Fire Dept. is implemented by producing a PDF file with relevant information about the situation that occurred. This file should include for example:
- map of the environment
- fire location in the map
- images of the source of fire
- number and state of people (OK or need assistance) found in the apartment
- position and images of people who require assistance in the map

Each person detection must be documented as an image of the person at his/her original designated location and must be included in the report.

These information must be compiled into a PDF file that is collected by the referee on a USB stick immediately after the test is finished with no manual processing. A USB stick must be mounted on the robot before the test starts and the report should be saved in this stick within the time of the test. When the test finishes the referees will collect the stick from the robot (without any manual intervention by the team members). This report will be evaluated by TC/referees (possibly also by experts from the Rescue league). Evaluation will be based only on correctness, completeness, and usefulness of information provided.

(3) The robot can guide the person to any exit in the arena. The robot can stop about one meter before the exit and indicate the exit to the person. It is not necessary for the robot to actually exit itself. Guiding a person means that the robot has to check the current position of the person being guided. The robot should not move more that 2 meters away from the person. The person will always follow the robot, i.e., s/he will not deviate from the robot's path, with a constant slow velocity. However, it is responsibility of the robot (and not of the person) to keep a proper distance.

4.5.5 OC and Referee instructions

Before the test session:
- Define the specific situation (i.e., number, position and status of each person).

Before each test:

- Place and activate the fire/smoke machine and place the persons in the apartment.

During the test:

- Take the time when the robot enters the kitchen and check that he proceed with searching for people not before 1 minute is elapsed from that time.
- Check that the robot clearly announces the automatic detection of fire/smoke
- Count the number of times talking to something that is not a person

4.5.6 Score Sheet

The maximum time for this test is *7 minutes.*

Action	Score
Detecting fire/smoke	
Automatic detection of fire/smoke	*200*
Saving persons (see below for handling of multiple persons)	
Person found and robot correctly asking for his/her status	*200*
Talking to something that is not a person	*-100*
Correctly understanding the answers of the person	*150*
Correctly guiding the person to an exit	*150*
Exit the arena	
If the robot exit the arena after all the persons have been saved	*100*
Report	
Up to 200 points (decided by TC/referees) are awarded for usefulness/completeness of information in the PDF report	*200*
Special penalties & bonuses	
Not attending (see sec. 3.7.1)	*-500*
Using start button (see sec. 3.3.5)	*-100*
Outstanding performance (see sec. 3.7.3)	*100*
Total score (excluding penalties and bonuses)	*1000*

Saving multiple persons: In case multiple persons are saved, the best achieved partial score for a positive item is obtained. Negative scores are accumulated, while no total negative score can be achieved in this test. Example: Finding all five persons, correctly talking to them and guiding one of them to the exit gives 500 points. Guiding all of them to the exit gives additional 100 points if the robot exits the arena afterwards (i.e., total 600 points). If the TC/referees award 50 points for the PDF report (total 650 points), but the robot also talked 7 times to something that was not a person, the robot scores total 0 points in the test.

4.6 Technical Challenge: Furniture-Type Object Perception

4.6.1 Concept and this year's focus

The aim of the *technical challenge* is to focus on a particular capability of a domestic service robot, and to compare the teams' performances in a realistic benchmarking setup. Every year, a new capability and a new challenge is selected to pick up recent state-of-the-art problems and progressively set harder goals. The definition, the setup on site and the evaluation of the teams' performances is done by the technical committee (TC).

There are no points for the technical challenge for the running competition. Instead, there is an award for winning the technical challenge (see Section 1.6.3).

The focus of the 2013 technical challenge is furniture-type object perception—an important capability for mobile manipulation robots in everyday environments. In preceding years, the rules mainly focused on small-size object perception on table-tops, while the recognition of larger objects has been mostly neglected. Typically in everyday environments, however, the configuration of furniture such as tables and chairs or decorations is not static, but changes from small displacements up to re-arrangements. Robots should therefore not only rely on a static environment map with semantic annotations, but need capabilities to perceive larger objects on-the-fly.

4.6.2 Arena setup

- The TC selects a room to be rearranged and announces the room at least one day before the technical challenge.

- 10 furniture pieces are *known*, i.e., they are standard equipment in the arena since the beginning of the competition. The TC will announce the 10 known furniture pieces and assign labels to the objects at least one day before the technical challenge.

- 2 furniture pieces are *unknown*, i.e., they are not shown to the competitors in advance to the technical challenge.

- The particular arrangement is not announced beforehand.

- The arrangement is modified between the individual entries.

4.6.3 Task

When the test starts, the robot has to drive into the designated room, position itself one meter from the door, and search for the known furniture pieces. It shall recognize the objects from this position, i.e., it logs images that it annotates with the recognized objects. To demonstrate the successful detection of the objects, the robot is required to approach each of the objects at a distance closer than 1 m. It must indicate the object by facing or pointing at it, and announce its label. If the object is obstructed by other objects, larger distances are allowed but with a maximum distance of 0.5 m to the obstructing objects. The robot logs the detection from the search position in a verifiable, visual form, i.e., either by dumping an annotated RGB(-D) image of the object, or by dumping a rendered image of a 3D point cloud. In both cases the image must be augmented with a 2D bounding box and an object label that unambiguously refers to

the bounding box (e.g., by using distinct colors and placing the text in the lower left corner of the bounding box). The annotation must also be provided in text form in a separate log file for each image, i.e., bounding box top left pixel position in image, width and height in pixels, and object label. The bounding box should contain all points belonging to the object and will be compared to ground truth specified by the TC.

4.6.4 Evaluation and scoring

1. **Time:** The total time in this challenge is *5 minutes*.

2. **Correct detection and recognition:** For every correctly detected and recognized object in an annotated image, **+2 points** are awarded. For announcing an object correctly according to the procedure in Sec. 4.6.3, **+1 point** is awarded. In the annotated image, the object is only correctly detected, if the intersection of detected and ground truth bounding box is at least 80% area of the ground truth. For correct recognition, the detected object bounding box must be unambiguously annotated with the correct label of the object (see 4.6.3). Ground truth is specified by the TC.

3. **Incorrect recognition:** Confusing objects, i.e., labelling an object falsely in the logged images is penalized with **-1 point**. In addition, a wrong robot announcement (Sec. 4.6.3) is penalized with **-1 point**.

4. **Incorrect detection:** Detecting an object where there is none is penalized with **-1 point**. An object is falsely detected, if the robot announces an object where there is none, or if the bounding box does not intersect with a ground truth bounding box by at least 20% area of the ground truth.

4.6.5 Additional rules and remarks

1. **Publication:** Mandatory for the participation in the technical challenge is the publication of the used approach (source and documenting technical paper) not later than six month after the competition. The team must send a notification to the official mailing list (`robocup-athome@lists.robocup.org`) when the above information is published. In case the source is not published within that period, the team is banned from future competition(s).

2. **Logging:** For further analyzing the own performance and those of the other teams, all object recognitions are logged (as specified in Sec. 4.6.3). In addition, we encourage teams to also log sensory data that is used for the recognition in common formats (e.g., PNGs for RGB-D images, PCD for point clouds, ROS bag files). The logged data is then collected, and distributed to the teams.

4.7 Open Challenge

During the *Open Challenge* teams are encouraged to demonstrate recent research results and the best of the robots' abilities. It focuses on the demonstration of new approaches/applications, human-robot interaction and scientific value.

4.7.1 Task

The Open Challenge consists of a demonstration and an interview part. It is an open demonstration which means that the teams may demonstrate anything they like. The performance of the teams is evaluated by a jury consisting of all team leaders.

1. **Setup and demonstration:** The team has a maximum of *seven minutes* for setup, presentation and demonstration.

2. **Interview and cleanup:** After the demonstration, there is another *three minutes* where the team answers questions by the jury members.
   During the interview time, the team has to undo its changes to the environment.

4.7.2 Presentation

During the demonstration, the team can present the addressed problem and the demonstrated approach.

- A video projector or screen, if available, may be used to present a brief introduction to the demonstration.

- For the presentation, the team can show up to two slides with the above content and the team's evaluation.

- The team can also visualize robot's internals, e.g., percepts.

4.7.3 Changes to the environment

1. **Making changes:** As in the other open demonstrations, teams are allowed to make modifications to the arena as they like, but under the condition that they are reversible.

2. **Undoing changes:** In the interview and cleanup team, changes need to be made undone by the team. The team has to leave the arena in the *very same* condition they entered it.

4.7.4 Jury evaluation

1. **Jury of team leaders:** All teams have to provide *one* person (preferably the team-leader) to follow and evaluate the entire Open Challenge.

2. **Evaluation:** Both the demonstration of the robot(s), and the answers of the team in the interview part are evaluated.
   For each of the following *evaluation criteria*, a maximum of *10 points* is given per jury member:

    2.1. Overall demonstration

    2.2. Human-robot interaction in the demonstration

    2.3. Robot autonomy in the demonstration

    2.4. Realism and *usefulness for daily life* (Can this robot become a product?)

    2.5. Novelty and (scientific) contribution (+contribution to the community)

    2.6. Difficulty and success of the demonstration

    A jury member is not allowed to evaluate and give points for the own team.

3. Normalization and outliers:

    3.1. The points given by each jury member are scaled to obtain a maximum of *2000 points* (i.e., multiplied by $200/6$).

    3.2. The total score for each team is the mean of the jury member scores. To neglect outliers, the N best and worst scores are left out:

$$\text{score} = \frac{\sum \text{team-leader-score}}{\text{number-of-teams} - (2N + 1)}, \quad N = \begin{cases} 2, & \text{number-of-teams} \geq 10 \\ 1, & \text{number-of-teams} < 10 \end{cases}$$

4.7.5 Additional rules and remarks

- There is no fixed start signal in this test.

- Not providing a team member for the jury (on time) results in no score for this team in the open challenge. In severe cases, additional penalties may apply (see Section 3.7.2).

- An EC, TC, or OC member (not necessarily the same person for all teams) guides through the open challenge, moderates the interview part of the challenge, and takes the time(s).

Chapter 5

Tests in Stage II

- Stage II features the following regular tests:
    1. E-GPSR
    2. Restaurant
    3. Demo challenge

- The open demonstration in Stage II is the demo challenge. Participating in the open challenge requires participating in at least one regular test.

5.1 Enduring General Purpose Service Robot

This test evaluates the abilities of the robot that are required throughout the set of tests in stages I and II. In this test the robot has to solve multiple tasks upon request over an extended period of time (30-45 minutes). That is, the test is not incorporated into a (predefined) story and there is neither a predefined order of tasks nor a predefined set of actions. The actions that are to be carried out by the robot are chosen randomly by the referees from a larger set of actions. These actions are organized in three categories with different complexity. Scoring thereby depends on the complexity class.

5.1.1 Focus

This test particularly focuses on the following aspects:

- No predefined order of actions to carry out (to get away from state machine-like behavior programming)

- Increased complexity in speech recognition

- Environmental (high-level) reasoning

- Robust long-term operation

5.1.2 Task

1. **Entering and command retrieval:** The robot is started at a designated position within the arena where it has to wait for further commands.

2. **Command generation:** A command is generated randomly, depending on the command category chosen by the team (see below).

3. **Command categories:** The team may choose from the following three categories:

    3.1. **Category I:** The command is composed by three actions, which the robot has to show it has recognized. The robot may repeat the understood command and ask for confirmation. If it can't recognize the command correctly, it can also ask the speaker to repeat the complete command.

    3.2. **Category II:** The robot gets a command that does not include all the information being necessary to accomplish the task. The actual commands will be under-specified by, for example:

        - only giving the class of the object ("bring me a drink") or location ("go to the table"), and not the actual object or location, or

        - not providing the location (or its class).

        The robot can ask questions to retrieve the missing information about the task, but is not required to. In the questions the robot has to make clear what it has already understood, e.g., tell the operator that it has understood to bring a particular beverage can, but not where can is located in the arena. The robot may also simply start searching.

    3.3. **Category III:** The command contains erroneous information. The robot should be able to realize such an error while trying to carry out the task, get back to the operator, and clearly state **why** it wasn't able to accomplish the task. There are extra points if the robot is able to solve the problem by an alternative, reasonable solution (see score sheet).

4. **Task assignment:** The robot is given the command by the operator and may directly start to work on the task assignment.

5. **Task execution:** The robot must stop the execution of a task and return to its designated position within 5 minutes. Otherwise the robot must be moved to its designated position immediately. If a restart is still available to the team, it can be restarted at the designated position.

6. **Returning:** After accomplishing the assigned task, the robot has to move back to its designated position to wait and retrieve the next command (i.e., go back to **1.** without the need of re-entering the arena). The robot can work on at most three commands.

7. **Timing:** The total time allotted to the robot for command retrieval and task execution is 10 minutes. If the robot is not at its designated position after the time has expired, it must be moved at its designated position immediately.

5.1.3 Additional rule and remarks

1. **Number of Teams and Scheduling:** In each test slot, 3 teams will be competing in the arena concurrently. The robots will be tested in an interleaved fashion: The robots will retrieve commands and execute the task one after the other. As stated above, each robot will have a maximum amount of 5 minutes per command (including time for retrieving the command and executing it), and 10 minutes at maximum in total to retrieve and work on

at most three commands. To facilitate a fluent and untroubled performance of the robots, the other robots must always return or being returned to their designated position before the next robot will be given a command. If a robot moves from its designated position while another robot is working on a command, it must be immediately disabled and moved to its designated position. If a restart is still available to the team, it can be restarted at its designated position. To carry the robot, at most two team members are allowed in the arena, and the robot must be moved as quickly as possible. To start or restart the robot, at most one team member may operate the robot. The team members moving and operating the robots must leave the arena immediately after the robot is placed or started.

2. **Referees:** Since the score system in this test involves a subjective evaluation of the robot's behavior, the referees are EC/TC members. One referee is assigned to each team to judge performance, to measure the time for working on a command, and to keep track of the overall operating time of the robot.

3. **Category selection:** For every of the three commands given to the robot, the team chooses the desired command category. Points are scored per category with the total score of the test being the sum of the maximal number of points scored in each category (see score sheet).

4. **Operator:**
   - The person operating the robot is one of the referees (default operator).
   - If the robot appears to consistently not be able to understand the operator, the referees ask the team to continue with a custom operator (Section 3.6.11).
   - With the custom operator, the team can only score 50 % of the points for the respective command.

5. **Restarts/Changing/Charging batteries:** The team may install a charging station at the designated position of the robot, if it does not hinder the other robots. However, the robot must connect itself with the charging station after carrying out a command. Changing batteries or manually connecting the robot with the charging station is allowed during a restart. The general rules for restart apply.

5.1.4 OC and Referee instructions

2h before test:
   - Specify and announce the designated position for each team

During the test:
   - Generate random sentences by an automatic sentence generator

5.1.5 Score Sheet

The maximum overall time for this test is *10 minutes* per team. The maximum time for working on a command is *5 minutes*.

Action	Score
Command Category I	
Performing the first command correctly	*200*
Performing the first and second command correctly	*200*
Successfully solving the complete task and returning to designated position	*200*
Command Category II	
Asking reasonable questions to obtain missing information	*300*
Solving half of the task or more (showing that the robot has understood the command and works on the test)	*200*
Completely solving the task and returning to designated position	*400*
Command Category III	
Solving the task up the point where the error occurred	*300*
Indicating that a problem has occurred while executing the task	*200*
Returning to the designated position and explaining what went wrong	*300*
Giving an alternative solution to the problem	*200*
Penalty for own operator	
Reduction of points for every command provided by a team member	*0.5 × -1*
Total Score	
$\max (\text{Cat. I}) + \max (\text{Cat. II}) + \max (\text{Cat. III}) = 2500$	
Special penalties & bonuses	
Not attending (see sec. 3.7.1)	*-500*
Outstanding performance (see sec. 3.7.3)	*250*
Total score (excluding penalties and bonuses)	*2500*

5.2 Restaurant

5.2.1 Focus

The focus of this test is mobile manipulation in a real environment, such as a restaurant or shopping mall. Since the environment is initially unknown, this test requires online SLAM, i.e., mapping the shop in a guide phase and using the map instantaneously for localization and navigation in a navigation/manipulation phase.

5.2.2 Task

1. **Guide phase:**

   1.1. A robot is guided through the environment by one of the team members where the robot is shown *five locations*, two of which are *object shelves* and the other three are *delivery locations*. Each shelve contains several objects of the same class. All locations have an associated label that the user needs to specify to the robot.

   1.2. After reaching all five locations, the user guides the robot to a (predefined) *ordering location*.

2. **Navigation and manipulation phase:**

   2.1. At the *ordering location*, the user places a delivery order of *three* objects, in total, to *two* delivery locations, e.g., "Bring objects A and B to location 1, and object C to location 2".

   2.2. The robot has to retrieve the objects from their corresponding shelf and bring them to the respective delivery locations.

   2.3. After carrying out the delivery order, the robot returns to the *ordering location*.

5.2.3 Additional rule and remarks

1. **Safety!** This test takes place in a public area. That is, there may be people standing, sitting or walking around the area throughout the test. The robot is expected to not even slightly touch anything and is immediately stopped in case of danger.

2. **Referees and guidance:** For safety reasons, the referees in this test are TC members. One of the referees follows the robot and is always in reach of the emergency button.

3. **Start:** The start signal in this test is pushing the start button (see sec. 3.3.5).

4. **Order:** The way the user provides such information to the robot is up to the robot's team.

5. **Location:** This test can be arranged in any real restaurant or shopping mall. If this is not possible, the test can be conducted in an arbitrary room containing the appropriate locations. The only requirement is that this room is not part of the arena and that the teams do not know the room beforehand.

   The exact location, including the shelve and delivery locations, will be defined by the technical committee on site (and in corporation with the local organization).

6. **Natural walking:** The operator has to walk "naturally", i.e., move forward facing forward. If not mentioned otherwise, the operator is not allowed to walk back, stand still, signal the robot or follow some re-calibration procedure.

7. **Disturbances from outside:** If a person from the audience (severely) interferes with the robot in a way that makes it impossible to solve the task, the team may repeat the test immediately.

5.2.4 Score Sheet

The maximum time for this test is *10 minutes*.

Action	Score
Guide Phase	
Reaching a *location* in the guide phase	*5 × 50*
Navigation Phase	
Reaching a (task-relevant) *location* in the manipulation phase	*4 × 100*
Grasping the correct objects	
Successfully grasping a correct object from a shelf	*3 × 250*
Delivering the correct objects	
Successfully delivering the correct object to the correct location	*3 × 200*
Special penalties & bonuses	
Not attending (see sec. 3.7.1)	*-500*
Outstanding performance (see sec. 3.7.3)	*200*
Total score (excluding penalties and bonuses)	*2000*

5.3 Demo Challenge

During the *Demo Challenge* teams are encouraged to demonstrate recent research results and the best of the robots' abilities. In contrast to the open challenge (Section 4.7), it is not a completely open but scoped demonstration. Teams are encouraged to pick up problems within the scope of the challenge, and to demonstrate new abilities and applications. The scope of the demo challenge changes every year.

5.3.1 This year's focus

The scope of this year's demo challenge is health care. That is, the demonstration should focus on people who require care, such as senior citizens and children. Whatever is demonstrated should be within the scope and *new*, i.e., nothing that has already been demonstrated in the previous tests or in previous competitions.

Possible tasks include, but are not limited to:
- eating aid
- rehabilitation aid
- mobility aid
- hair-washing aid
- setting up and/or cleaning up a table
- making the bed
- catering drinks or delivering medicines
- carrying a person
- other elderly-care
- playing with children or baby-sitting
- conversational partner robot

5.3.2 Task

The Demo Challenge is an open demonstration which means that the teams may demonstrate anything they like (within the scope of the focus). The performance of the teams is evaluated by a jury consisting of all members of the technical committee.

The procedure for the challenge and the timing of slots is as follows:

1. **Setup and demonstration:** The team has a maximum of *ten minutes* for setup, presentation and demonstration.

2. **Interview and cleanup:** After the demonstration, there is another *thee minutes* where the team answers questions by the jury members.
   During the interview time, the team has to undo its changes to the environment.

5.3.3 Presentation

1. **Elevator pitch:** At the beginning of the demonstration, the team has to briefly (maximum *one minute*) describe the addressed problem, what the robot is about to do, and the importance of the task with respect to the problem and the scope of the challenge.

2. No presentation: The rest of the demonstration should not feature a presentation, and on its own should make sense to the audience and the jury.

5.3.4 Changes to the environment

1. Making changes: As in the other open demonstrations, teams are allowed to make modifications to the arena as they like, but under the condition that they are reversible.

2. Undoing changes: In the interview and cleanup team, changes need to be made undone by the team. The team has to leave the arena in the *very same* condition they entered it.

5.3.5 Jury evaluation

1. Jury: The jury is constituted of members of the technical committee.

2. Evaluation: Both the demonstration of the robot(s), and the elevator pitch are evaluated. The jury can give a maximum of *1500 points* for factors such as

2.1. complexity of the task and performance,

2.2. marketability/story,

2.3. safety,

2.4. human-robot-interaction, and

2.5. usability/appearance.

The actual scoring is not just normalized over all jury members, but discussed within the technical committee after the Demo Challenge.

5.3.6 Additional rules and remarks

1. Abort on request: At any time during the demonstration, the jury may interrupt and abort the demonstration

1.1. if nothing is shown: in case of longer delays (more than *one minute*), e.g., when the robot does not start or when it got stuck;

1.2. if nothing *new* is shown: the demonstrated abilities were already shown in previous tests (to avoid dull demonstrations and push teams to present novel ideas).

2. Team-team-interaction: An extra bonus of up to *500 points* can be earned if robots from two teams (4 robots maximum, 2 from each team) successfully collaborate (robot-robot interaction).

- This bonus is earned for both teams.
- The robot(s) of the other team must only play a minor role in the total demonstration.
- It must be made clear that the demonstrations from the two teams are not similar, otherwise the points cannot be awarded.
- In case a team receives two (or more) bonuses, the maximum bonus will be taken.
- The collaboration is possible even if one of the two teams has not reached Stage 2.
- The team which does not participate in Stage 2 receives no points for this test.

Chapter 6

Finals

The competition ends with the Finals on the last day, where the five teams with the highest total score compete. The *Finals* are conducted as a final open demonstration. This demonstration does not have to be different from the other open demonstrations—open challenge and demo challenge. It does not have to be the same either.

6.1 Final Demonstration

In the final demonstration, every team qualified for the Finals can choose freely what to demonstrate. The demonstration is evaluated by both a league-internal and a league-external jury.

6.1.1 Task

The procedure for the demonstration and the timing of slots is as follows:

1. **Setup and demonstration:** The team has a maximum of *ten minutes* for setup, presentation and demonstration.

2. **Interview and cleanup:** After the demonstration, there is another *five minutes* where the team answers questions by the jury members.
   During the interview time, the team has to undo its changes to the environment.

6.1.2 Evaluation and Score System

The demonstration is evaluated by both a league-internal and a league-external jury. The final score and ranking are determined by the two jury evaluations and by the previous performance (in Stages I and II) of the team.

1. **League-internal jury:** The league-internal jury is formed by the Executive Committee. The evaluation of the league-internal jury is based on the following criteria:

   1.1. Scientific contribution
   1.2. Contribution to @Home
   1.3. Relevance for @Home / Novelty of approaches
   1.4. Presentation and performance in the finals.

   It is expected that teams present their scientific and technical contributions in both *team description paper* and the *RoboCup@Home Wiki*. In addition, finalist teams may provide a printed document to the jury (max 2 pages) that summarizes the demonstrated robot capabilities and contributions.

The influence of the league-internal jury to the final ranking is 25 %.

2. **League-external jury:** The league-external jury consists of people not being involved in the RoboCup@Home league, but having a related background (not necessarily robotics). They are appointed by the Executive Committee. The evaluation of the league-external jury is based on the following criteria:

    2.1. Originality and Presentation (story-telling is to be rewarded)
    2.2. Usability / Human-robot interaction
    2.3. Multi-modality / System integration
    2.4. Difficulty and success of the performance
    2.5. Relevance / Usefulness for daily life

    The influence of the league-external jury to the final ranking is 25 %.

3. **Previous performance:** 50 % of the final score are determined by the team's previous performance during the competition, i.e., the sum of points scored in Stage I and Stage II.

6.1.3 Changes to the environment

1. **Making changes:** As in the other open demonstrations, teams are allowed to make modifications to the arena as they like, but under the condition that they are reversible.

2. **Undoing changes:** In the interview and cleanup team, changes need to be made undone by the team. The team has to leave the arena in the *very same* condition they entered it.

6.2 Final Ranking and Winner

The winner of the competition is the team that gets the highest ranking in the finals.

There will be an award for 1st, 2nd and 3rd place. All teams in the Finals receive a certificate stating that they made it into the Finals of the RoboCup@Home competition.

Abbreviations

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