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RoboCup Brazil Open

RoboCup@Home

Rules & Regulations

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## About this Rulebook

This is the official rulebook of the @HOME competition for the RoboCup Brazil Open Competition 2022.

It has been written based on the official RoboCup@home rulebook (<https://github.com/RoboCupAtHome/RuleBook/>).

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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 @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 lighting conditions, *Object Manipulation*, *Adaptive Behaviors*, *Behavior Integration*, *Ambient Intelligence*, *Standardization* and *System Integration*. It is collocated with the ROBOCUP symposium.

### 1.3 RoboCup Brazil Open

The RoboCup Brazil Open @Home Virtual competition 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 virtual home environment setting. Focus lies on the following domains but is not limited to: *Navigation* and *Mapping* in virtual environments, *Computer Vision* and *Object Recognition*, *Object Manipulation*, *Adaptive Behaviors*, *Behavior Integration*, *Ambient Intelligence*, *Standardization* and *System Integration*.

### 1.4 Organization

**Executive Committee** The *Executive Committee* (EC) consists of members of the board of trustees and representatives of each activity area.

**Technical Committee** The *Technical Committee* (TC) is responsible for the rules of the league. Main focus is writing the rulebook and refereeing. Members of the *Executive Committee* (EC) are always members of the *Technical Committee* (TC) as well.

**Organizing Committee** The *Organizing Committee* (OC) is responsible for the organization of the competition. They create the schedule and provide information about the scenario.

## 1.5 Competition

The competition consists of Two *Stages*, and the *Finals*. Each stage comprises a series of *Tests*. The competition ends with the *Finals*.

## Chapter 2

# Concepts Behind the Competition

A set of key concepts apply to every ROBOCUP@HOME competition and the performed tests.

**Autonomy** All robots participating in the ROBOCUP@HOME competition have to be *autonomous*. This means no human is allowed to remote control the robot during a test. Furthermore, a test must not be solved using *Open Loop Control*.

**Applicability** The tests should reward useful, robust, general, cost effective, and applicable solutions. The tests should increase in difficulty and complexity each year.

**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.

**Social Relevance** The tests should show socially relevant results. The aim is to convince the public about the usefulness of autonomous robot applications in domestic settings by directly assisting and helping humans.

**Scientific Value** The tests should allow teams to show novel approaches with high scientific value.

**Time Constraints** Setup and test time is limited to allow for many participating teams and to emphasize the competition aspect of @HOME.

**Non Standard Scenario** In order to reward robust and general solutions, ROBOCUP@HOME has no standard scenario. It should resemble a typical domestic setting of the host country. Furthermore, tests may take place outside of the scenario, i.e., in an previously unknown environment like, for example, a nearby public space.

**Appeal** The competition should appeal to the audience and the public. Therefore high attractiveness and originality of an approach should be rewarded.

**Community** Although teams compete against each other, the members of the @HOME league are expected to cooperate and exchange knowledge to advance technology together. Every team is encouraged to share relevant technical, scientific, and team related information through the *Team Description Paper* (TDP) and by participating in the various communication channels.



## Chapter 3

# General Rules & Regulations

These are the general rules and regulations for the competition in the ROBOCUP@HOME league. They apply to every test unless a test description differs, in which case it overrides the general rule.

### 3.1 Team Registration and Qualification

In order to participate, a team must answer the *Call for Participation* (CFP) announced on the @HOME mailing list by sending in their *Application*. Then, they need to be selected in the *Qualification* phase and finally, complete their *Registration*.

#### 3.1.1 Application

An application consists of a *Team Video*, *Team Website*, and *Team Description Paper* (TDP).

**Team Video** The *Team Video* should show that the team has a running robot platform that is able to, at least partly, solve the tests in the last rulebook. Therefore, the video should focus on abilities required in *Stage I* and also include some skills required in *Stage II*. The video should be self-explanatory and designed for a general audience. Any editing, e.g. speed up, needs to be indicated. The video should not exceed 10 min and needs to be publicly uploaded.

**Team Website** The *Team Website* should be designed for a broad audience. Therefore, it should include scientific material, but also interesting media. The default language of the website needs to be English.

**Team Description Paper** The *Team Description Paper* (TDP) is describing the team's main research, including the scientific contributions, goals, scope, and results, as well as, describing the used hardware. It needs to be in English, up to eight pages long, and formatted according to the guidelines of the ROBOCUP Symposium. An addendum as the 9th page (after references) needs to include:

- Team Name
- Contact Information
- Website Url
- Team Member Names
- Photo(s) of the Robot(s) (unless included previously)
- List of External Devices (see [3.4](#))
- List of 3rd Party Software

### 3.1.2 Qualification

The *Organizing Committee* (OC) will select teams for *Qualification*. The selections will mainly be based on:

- The content on the *Team Website*, focusing on publications and open source resources
- Number and complexity of abilities shown in the *Team Video*
- Scientific value, novelty and contributions in the *Team Description Paper* (TDP)

Secondary evaluation criteria are:

- Performance in previous competitions
- Previous contributions to the @HOME community

### 3.1.3 Registration

Qualified teams can register at the ROBOCUP@HOME competition. In order to max out the number of participants, qualified teams *must* contact the *Organizing Committee* (OC) to confirm (or cancel) participation.

Confirming implies that the team has sufficient resources to complete *Registration* and attend the competition. Teams that fail to confirm their participation will be disqualified.

## 3.2 Audience Interaction

Some tests require direct interaction with the audience. In order to make all tests more appealing (see 2) and engaging, informing the audience about what is happening is important.

## 3.3 Scenario

Most tests take place in the ROBOCUP@HOME *Arena*. Some tests can take place outside, in a previously unknown public place (see 2). This section describes the *Arena* and how it is furnished, as well as, known information that is shared in all tests.

### 3.3.1 RoboCup@Home Arena

The ROBOCUP@HOME *Arena* is a realistic home setting consisting of inter-connected rooms. The minimal configuration consists of:

- Bedroom
- Dining Room
- Living Room
- Kitchen

An *Arena* is decorated and dressed to resemble a typical apartment in the hosting country, including all necessities and decorations one can find in a normal house.

### 3.3.2 Walls, Doors and Floor

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

- **Walls:** Walls have a minimum height of 60 cm. A maximum height is not specified, but the audience must be able to watch the competition.
- **Doors:** There will be at least two doors, leading in and out of the arena. Inside the arena, rooms are connected by doors (at least one). All doors have handles, not knobs. Doors can be closed during tests, robots are expected to open them or plan around.
- **Floor:** The floor and doorways of the arena are even. There will be no significant steps or even stairways. Minor unevenness such as carpets, transitions in floor covering between different areas, and minor gaps (especially at doorways) can be expected.
- **Appearance:** Floor and walls are mainly uni-colored but can contain texture, e.g., a carpet on the floor, a poster or picture on the wall.

### 3.3.3 Furniture

The arena will be furnished with items common in the host country.

The minimal configuration consists of:

- Bed,
- Couch
- Small Table
- Small Dinner Table with Two Chairs
- Two Trash Bins
- Television with Remote Control
- Cupboard with Drawers
- Bookcase
- Coat Rack

The *Arena*'s kitchen must have:

- Dishwasher
- Sink
- Powered Refrigerator (with some cans and plastic bottles inside).

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



Figure 3.1: Example ROBOCUP@HOME scenario.

### Cupboard

The cupboard can be any shelf-like furniture in which objects can be placed. At least one shelf must be lower than 90 cm.

### Fridge

Fridge must not be smaller than 120 cm. At least one powered and functioning fridge is required.

### 3.3.4 Objects

Some tests involve recognizing and manipulating objects (See Figure 3.1b). The *Technical Committee* (TC) will compile a list of at least 30 objects at the competition. This list contains a picture of the object, as well as, its official name and *Object Category*. Every *Object Category* has an assigned *Predefined Location* (see 3.3.6) where objects of that category can usually be found during tests. Each object is provided at the competition for training.

There are two types of objects:

1. **Known Objects:** Objects previously known by the robot.
2. **Unknown Objects:** Any other object that is not in the object list but can be grasped or handled (e.g. arena decorations).

Known objects include at least:

- **Tableware:** Dish, bowl, cup, and napkin (See Figure 3.2b).
- **Cutlery:** Fork, knife, and spoon.
- **Trash Bags:** Big plastic trashbags, preferably with handle.
- **Bags:** Lightweight. With stiff, vertical handles (See Figure 3.2a).
- **Trays:** Tray or basket, intended for two-handed manipulation (See Figure 3.2c).
- **Pourable:** An object whose content can be poured (e.g. jug).
- **Heavy Object:** Weight between 1.0kg and 1.5kg (e.g. water bottle).
- **Tiny Object:** A lightweight object, no bigger than 5cm (e.g. teabag).
- **Fragile Object:** An easy-to-break object (e.g. egg).

- **Deformable Object:** A flexible object that may appear in different shapes (e.g. cloth).



**Figure 3.2:** Example of objects

During the competition, objects can be requested based on their *Object Category*, physical attributes, or a combination of both. Relevant attributes to be used are:

- Color (e.g. red, blue, black with white dots, etc.).
- Relative estimated size (smallest, largest, big one, etc.).
- Relative estimated weight (lightest, heaviest).
- Relative position (left of, right most, etc.).
- Object description (is fragile, is container, can be poured, requires two hands, etc.).

**Remark:** Measurements are estimations and based on common sense. It is OK for robots to consider similar objects to be about the same size or weight. Don't bring a scale.

### 3.3.5 Changes to the Arena

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

1. **Major Changes:** Any furniture (*Predefined Location* or not) might be moved slightly between tests. It will not change rooms or move drastically inside a room. However, a couch or table may be rotated, moved to its side etc. Walls will stay in place and rooms will not change function. Passages might be blocked.
2. **Minor Changes:** Slightly moved chairs, slightly closed doors, or anything similar cannot be avoided and might happen at any time, even during a test.

Only during *Setup Days* (see 4), teams can make changes to the arena if something severely hinders the robots (e.g. high door steps). These changes must be agreed upon by all team leaders and in accordance with the *Technical Committee* (TC) on location.

During *Setup Days* and in between tests, teams can take objects from the *Arena* for training. A team may not take more than five objects at once and for longer than an hour. Teams may not modify any of the objects. At least half an hour before a test slot, all items must be returned to the *Arena*.

### 3.3.6 Predefined Rooms and Locations

Some tests involve a *Predefined Location*.

- **Rooms:** Each room has a function (e.g. kitchen, bed room).
- **Furniture:** Some furniture will be named and sorted into a location class (e.g. couch and arm chair are both in the seating class).
- **Doors:** Two doors leading in and out of the *Arena* will be named entrance and exit respectively.

### 3.3.7 Predefined Names

Some tests involve memorizing a person's name. All people in the arena have an assigned *Predefined Name* chosen from a list compiled by the *Technical Committee* (TC). This list has 20 names of which 25 % are male, 25 % female, and 50 % gender-neutral, taken from the list of most common used names in the United States <sup>1</sup>.

## 3.4 External Devices

Everything a team uses in a test that is not part of the robot is considered an *External Device*. An *External Device* must be authorized by the *Technical Committee* (TC) during *Robot Inspection* (see 4.3). The TC decides whether an *External Device* can be used freely or under referee supervision and determines its impact on scoring. Wireless devices, such as hand microphones and headsets, are not allowed with the exception of *External Computing*.

### 3.4.1 On-Site External Computing

Computing resources that are not physically attached to the robot are considered *External Computing*. They must be placed in the *External Computing Resource Area* (ECRA), which is announced by the *Technical Committee* (TC) during *Setup Days* (see 4), where a switch, connected to the *Arena Network*, will be available. During a *Test Block*, only two persons are allowed in the ECRA at any time, one team member each of the two teams up next. No peripherals (e.g. screens, mouses, keyboards) are allowed to be present. Laptops can only be placed if the team is up next and need to be removed as soon as the test finishes.

### 3.4.2 On-Line External Computing

Teams can utilize *External Computing* through the internet connection of the *Arena Network* (e.g. cloud services, online APIs). These must be announced to and approved by the *Technical Committee* (TC) one month prior to the competition.

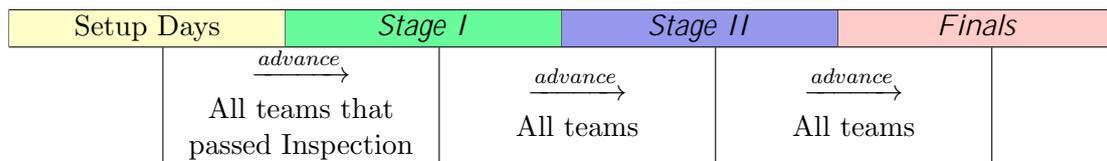
## 3.5 Competition Procedure

A ROBOCUP@HOME competition consists of the following stages:

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<sup>1</sup><https://www.ssa.gov/oact/babynames/decades/century.html>

1. **Poster Section:** Scientific presentation made by the team during *Setup Days*.
2. **Robot Inspection:** For security, robots are inspected during *Setup Days*. All registered teams must participate.
3. **Stage I:** First set of tests, assessing the robot's basic abilities .
4. **Stage II:** Second set of tests, assessing more complex abilities and behaviors.
5. **Finals:** An open demonstration, asking teams to showcase complex behaviors and novel approaches.



### 3.5.1 Team Leader Meeting

In the evening before each competition day, a *Team Leader Meeting* is held. Attendance from all teams participating in the next day's tests is mandatory. During the meeting, teams can ask questions and discuss the upcoming tests with the TC and OC. The starting time will be announced by the OC. Decisions made in the *Team Leader Meeting* are binding. The TC and referees on site will decide on anything coming up during or after a test.

### 3.5.2 Scoring System

Each test has a main objective and a set of bonuses. Bonuses are only given if at least 50% of the points for the main goal are achieved. Overall scoring in a stage is calculated as the sum of the maximum score obtained in each test. A team cannot get a negative score for a test.

**Note:** Once a scoresheet has been signed by the team leader or the scores have been published, the TC decision is irrevocable.

## 3.6 Test Procedure

### 3.6.1 Safety First!

Robots need to be safe when interacting with people and their environment.

- **Emergency Stop:** At any time, when operating the robot inside and outside the scenario, a team member has to stop the robot immediately if there is a remote possibility of dangerous behavior towards people and/or objects.
- **Stopping on Request:** If a referee, member of the TC, OC, or EC, 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*.

## Collisions

- **Slightly Touching:** Slightly touching objects is tolerated but unadvised.
- **Major Collisions:** If a robot crashes into something during a test, the robot is stopped immediately.
- **Functional Touching:** Robots are allowed to apply pressure to objects, push away furniture, and interact with the environment in general. However, the robot must clearly announce any collision-like interaction. Referees can still immediately stop a robot in case of suspicion of dangerous behavior.
- **Robot-Robot Avoidance:** If two robots encounter each other, they both have to actively try to avoid the other robot.
  1. A robot which is not going for a different route within a reasonable amount of time (30 s) is removed.
  2. A non-moving robot blocking the path of another robot for longer than a reasonable amount of time (30 s) is removed.

### 3.6.2 Arena Access

- **Setup Days:** During *Setup Days*, the number of team members inside the *Arena* is not limited.
- **Before Test Block:** 30 min before a *Test Block*, no team members are allowed inside the *Arena*.
- **Tests:** During a *Test Slot*, the maximum number of team members allowed inside the *Arena* is *one* (1) (*Volunteers* excluded).
- **Final Demonstrations:** During the *Finals*, the number of team members inside the *Arena* is not limited.

### 3.6.3 Fair Play

Fair play and cooperative behavior is expected from all teams during the entire competition.

- **Evaluating:** Evaluate other teams' performances fairly, especially as jury member.
- **Refereeing:** Apply all rules equally to all teams.
- **Volunteering:** Interact reasonably with other teams' robots and as instructed.

This especially means:

- **No Cheating:** Faking autonomous robot behavior and similar is highly punished.
- **No Rule Exploitation:** Do not exploit rules in ways that are obviously not intended. If you find an exploitable rule, inform the *Technical Committee* (TC) *before* the competition.

### 3.6.4 Robot Autonomy

Robots acting autonomously is among the key concepts of @HOME (see 2).

- **No Touching:** During a test, team members are not allowed to make contact with their robot. Contact by referees and volunteers is only allowed if it is in a *natural* way and required by the task.

- **Natural Interaction:** The default way to interact with a robot are gestures and speech.
- **No Remote Control:** Remotely controlling a robot is strictly prohibited. This also includes pressing buttons or influencing sensors on purpose.

**Note:** Disregard of the aforementioned rules can lead to penalties and disqualifications for a test, the competition, and future competitions.

### 3.6.5 Expected Robot Behavior

Unless stated otherwise, it is expected that the robot always behaves and reacts in the same way a polite and friendly human being would. A robot should always announce and describe what it is doing or planning to do.

### 3.6.6 Removal of Robots

Robots not obeying the rules are stopped and removed from the arena. It is the decision of the referees and the TC members monitoring the test if and when to remove a robot. When told to do so, the team has to immediately stop the robot and remove it from the arena without disturbing the ongoing test.

### 3.6.7 Start Signal

The default signal to start a test is opening the entrance door (see 3.3.6). Other start signals are allowed but must be authorized by the TC during *Robot Inspection* (see 4.3).

1. **Door Opening:** The robot is waiting behind the door, outside the arena and accompanied by a team member. The test starts when a referee opens the door.
2. **Start Button:** If the robot is not able to automatically start after the door is open, the team may start the robot using a *Start Button*.
  - 2.1. The procedure must be *very* easy to execute.
  - 2.2. It is allowed to use the robot's contact/pressure sensors (e.g. pushing the head or an arm joint).
3. **Alternative Start Signal:** Other means of starting the robot are allowed.
  - QR codes
  - Verbal instructions
  - Custom HRI interfaces (apps, software, etc.)

**Note:** Using a start signal other than the default one, may be penalized in some tests.

### 3.6.8 Referees

All tests are monitored by at least two *Referees*, ideally members of the TC, OC, or EC. At least one has to be a member of the TC and acting main referee.

### 3.6.9 Volunteers

Some tests require *Volunteers* to take part in a test and interact with the robot. Teams are asked to send members as volunteers for the duration of a *Test Block*. Larger teams are asked more frequently.

- **Announcement:** *Referees* will ask teams to select *Volunteers* at least 30 min before a *Test Block*.
- **Instruction:** Before each block, *Referees* will instruct the *Volunteers*.

**Note:** Not showing up on time for volunteering or moderation will result in a penalty (see ??).

### 3.6.10 Operators

Unless stated otherwise, robots are operated by a *Referee* or a *Volunteer*. If the robot fails to understand the default operator, the team may request to select their own *Custom Operator*. Penalty may apply when using a *Custom Operator*.

### 3.6.11 Time Limits

In accordance with 2, each test has a defined time limit.

- **Inactivity:** If the robot is stuck or not progressing the task, the robot is considered inactive and the main *Referee* can decide to end the test.
- **Requesting Time:** If the robot is doing time-consuming calculations or planning and only appears inactive, the robot has to announce what it is doing and for how long.
- **Setup Time:** Unless stated otherwise, there is no extra setup time. 60 s after the previous team has left the arena, the robot must be ready to enter.
- **Time's Up:** When the time is up, the team has to immediately remove the robot from the arena. No more additional score will be given.
- **Show Must Go On:** In special cases, the *Referee* may let the robot continue the test for demonstration purposes. No additional points will be scored.

### 3.6.12 Restart

Some tasks allow a single restart, a procedure in which the team is allowed to quickly fix any issue with the robot. Restarts can be requested only when the test permits it, and when the amount of remaining time is greater than 50% of the total. The procedure is as follows:

1. The team request a restart.
2. The robot is taken to the initial position (e.g. outside the arena) and gets fixed.
3. When the robot is ready, the team informs the referee.

The following rules apply:

1. **Number of Restarts:** When allowed, the maximum number of restarts is one (1).
2. **Early Request:** Restart is **NOT** allowed after the first 50% of the allotted time has elapsed.
3. **Time:** The timer is neither restarted nor stopped.

4. **One-Minute Setup** The team has 1 minute to fix the robot counting when the referee announces the restart. If the robot is not ready, the test is considered finished.
5. **Scoring:** If the score of the second attempt is lower than the score of the first one, the average score of first and second run is taken.

### 3.6.13 Procedure

To request human assistance while solving a task:

1. **Request Help:** The robot has to indicate loud and clear that it requires human assistance. It must clearly state:
  - 1.1. The nature of the assistance
  - 1.2. The particular goal or desired result
  - 1.3. How the action must be carried out (when necessary)
  - 1.4. Details about how to interact with the robot (when necessary)
2. **Supervise:** The robot must be aware of the human's actions, being able to tell when the requested action has been completed, as well as guiding the human assistant (if necessary) during the process.
3. **Acknowledge:** The robot must politely thank the human for the assistance provided.

### 3.6.14 Scoring

The amount of times a robot can request human assistance is not limited, but score reduction applies each time. The score for a goal or partial goal cannot be negative due to DEM reductions. Possible DEM requests are stated for each test with the corresponding score reductions. Other requests must be announced one day before the test in the *Team Leader Meeting* where the TC will decide on the scoring. In general, points will be deducted increasingly for:

1. **Partial Solutions:** The robot requests a partial solution (e.g. pointing to the person the robot is looking for or placing an object within grasping distance).
2. **Full Awareness:** The robot requests a whole step of the test to be completed but is able to track and supervise activity. This means detecting when something goes wrong and when the request is done.
3. **No Awareness:** The robot requests a whole step of the test to be completed and has to be told when the request is done.



## Chapter 4

# Setup Days

The first days at a ROBOCUP@HOME competition before the tests start are the *Setup Days*. This time is used by teams to assemble and test their robots and adjust to the local scenario. To foster knowledge exchange between teams, a *Poster Session* is held. To ensure safety and compliance with the rules, a *Robot Inspection* is conducted.

### 4.1 General Setup

Depending on the overall ROBOCUP schedule, the *Setup Days* last for one or two days.

- **Start:** They start when the venue opens for the first time.
- **Intention:** Teams setup their team area and robots.
- **Tables:** The LOC will setup and randomly assign team tables.
- **Arena:** The *Arenas* are available to all teams of the respective league. The OC may schedule special test or mapping slots in which arena access is limited. Note, that furnishing may not be complete yet.
- **Objects:** The delegation of EC, TC, OC and LOC will buy the objects (see 3.3.4). Note, that the objects may not be available at all times and not from the beginning.

### 4.2 Poster Session

The *Poster Session* is for teams to present their research to the @HOME community. Before the session a *Welcome Reception* is held. The time before and after the *Poster Session* is for teams to exchange knowledge and to get to know each other.

- **Time:** The *Poster Session* is held in the evening of the last setup day.
- **Place:** It takes place in the *Arena* and/or in the team area.
- **Welcome Reception:** Time for teams to gather for the *Poster Session*. Snacks and beverages (beers, sodas, etc.) are served.
- **Organization:** It is the responsibility of the OC and the LOC to organize catering and location. This includes:
  - Poster stands for each team or alternatives to present the posters.
  - Snacks and drinks.
  - Inviting officials, sponsors, LOC, and *RoboCup Federation* (RCF) trustees to the event.
- **Poster Presentation:** Each team gives a short presentation of their poster.

- **Discussion:** Afterwards, teams are free to look at the posters, ask questions and discuss the presentations.

### Poster Presentation

- **Time:** Each team has a maximum of five minutes to give a short presentation of their poster.
- **Evaluation:** The posters are evaluated by a jury consisting of one member (preferable the team leader) of each team. The evaluation should be based on the presentation, as well as, any questions and discussions.
- **Criteria:** For each of the following evaluation criteria, a maximum of 10 points is given per jury member:
  - Novelty and scientific contribution.
  - Relevance for ROBOCUP@HOME.
  - Presentation (Quality of poster, presentation style, and discussion).
- **Score:** The points given by each jury member are scaled to obtain a maximum of 100 points. 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. The points are added to a team's *Stage I* score:

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

- **Sheet collection:** Evaluation sheets are collected by the *Organizing Committee* (OC) at an announced time.

## 4.3 Robot Inspection

Passing the *Robot Inspection* is necessary for a robot to participate in any test.

- **Schedule:** The *Robot Inspection* is held during the last day of the *Setup Days*. A team order is announced by the *Organizing Committee* (OC) beforehand.
- **Procedure:** The inspection starts, like a regular test, with the opening of the entrance door. The robot needs to enter the *Arena* and drive to a designated inspection point. On command (team's choice) the robot leaves through the exit door.
- **Inspectors:** The robots are inspected by the *Technical Committee* (TC).
- **Checked aspects:** It is checked if the robots comply with the rules (see 3), checking in particular:
  - Emergency button(s).
  - Collision avoidance. An inspector steps in front of the robot.
  - Voice of the robot. It must be loud and clear.
  - Custom containers (bowl, tray, etc.).
  - External devices.
  - Alternative Human-Robot interfaces.
  - Robot speed and dimension.

- Start button.
- Other safety issues (duct tape, hanging cables, sharp edges etc.).
- **Re-Inspection:** If the robot is not approved, it is the responsibility of the team to get the approval later. This means, retrying directly after the regular *Robot Inspection* schedule or asking the TC to be inspected at a later time.
- **Time Limit:** No strict time limit is given since approval of external devices can take time. But, inactive robots and robots moving too slowly or not towards the inspection point are removed quickly.
- **Accompanying Team Member:** Each robot is accompanied by only one team member (team leader is advised).
- **OC instructions (at least 2h before the Robot Inspection):**
  - Announce the entry and exit doors.
  - Announce the location of the inspection point.



## Chapter 5

# Tests in Stage I

## 5.1 Navigation and Follow Me

### Description

The robot must navigate through a variety of waypoints and, at request, follow an operator from a safe distance avoiding hitting objects or any obstacles on the way. At the end of the test the robot must leave the arena.

**Main goal:** The main objective in this test is to evaluate whether the robot is able to navigate on the scenario and follow a person.

### Focus

This task focuses on *mapping*, *navigation*, *path planning* and *person tracking* and *obstacle avoidance*.

### Setup

- **Locations:**
  - This task takes place inside and outside the *Arena*.
  - The robot will start at front door.
  - The doors are open, except for the entry door.
- **People:**
  - There will be a operator who the robot must follow.
- **Furniture:**
  - All furniture are in their predefined locations.
- **Objects:**
  - Avoidable objects may be placed on the way between rooms.

### Procedure

1. The referee requests the team to move the robot to the start location.
2. The referee gives the start signal and starts the timer.
3. The team leaves the area after the start signal.
4. The referee follows the robot ready to press the emergency stop button.

5. **Entering the arena:** The robot starts outside the environment and must wait until the door opens.
6. **Waypoint 1 (door):** After entering the *Arena*, the robot must navigate to Waypoint 1, which may be any location and is reachable via several paths, all doors are open.
7. **Waypoint 2 (obstructed path):** After reaching Waypoint 1, the robot must navigate and reach Waypoint 2. The possible paths between Waypoint 1 and 2 are obstructed by an avoidable obstacle, meaning there will be space for the robot to avoid the obstacle and follow its path.
8. **Waypoint 3 (following a human):** After reaching Waypoint 2, the robot must wait for an operator to show up for the follow me task. After the human arrives the robot must memorize and follow him.
  - Memorizing the operator (training phase): The robot has to memorize the operator. During this phase, the robot may instruct the operator to follow a certain setup procedure and instruct the operator on what to do when the robot needs to stop following.
  - Following the operator (guiding phase): When the robot signals that it is ready to start, the operator starts walking –in a natural way– through a designated path. The robot needs to follow the operator until the operator asks the robot to stop doing so (Waypoint 3).
9. **Waypoint 3 (going back):** Upon reaching Waypoint 3, the operator will command the robot to stop following him, using the instructions given by the robot in the training phase. Then, the robot must navigate back to Waypoint 2.
10. **Leaving the arena:** The robot must leave the arena through the indicated door.

### Additional rules and remarks

- The teams can inform the operator of how to go through the start and stop following procedures before the task starts;
- The points for reaching a waypoint are only given if the robot had no collisions through its path. While following the robot may also keep a safe distance from the operator.

### Instructions:

#### To Referee

#### To OC

The OC needs to:

- **2 hours before the test:** Select and announce the robot start location.
- **2 hours before the test:** Define each of the waypoints for each trial of each team.
- **2 hours before the test:** Define each of the operator's paths for each trial of each team.

## Score sheet

**Maximum time:**

5 minutes

<b>Action</b>	<b>Score</b>	<b>1<sup>st</sup> try</b>	<b>2<sup>nd</sup> try</b>	<b>3<sup>rd</sup> try</b>
<b><i>Regular Rewards</i></b>				
Entering the arena	25	_____	_____	_____
Reaching waypoint 1	150	_____	_____	_____
Reaching waypoint 2	250	_____	_____	_____
Following the operator	400	_____	_____	_____
Reaching waypoint 3	150	_____	_____	_____
Leaving the arena	25	_____	_____	_____
<b><i>Score per try</i></b>	<b>1000</b>	_____	_____	_____
<b>Total Score</b>	<b>1000</b>	_____		

## 5.2 Speech Recognition & Audio Detection

### Description

The test is divided in two phases. First the robot must answer a set of questions to an operator at the first attempt without asking for confirmation. The operator is not allowed to move to the robot or shout to the robot.

**Main goal:** The robot must be able to recognize and answer to a specific set of questions without ask for confirmation.

### Focus

This task focuses on *voice recognition*.

### Setup

- **Locations:**
  - This task takes place inside the *Arena*.
  - The robot will start at a predefined location.
  - All doors of the apartment are open.
- **People:**
  - A "professional" operator is selected by the TC to test the robot.
- **Furniture:**
  - All furniture are in their predefined locations.
- **Objects:**
  - All objects are in their predefined locations.

### Procedure

1. The referee requests the team to move the robot to the start location.
2. The referee gives the start signal and starts the timer.
3. The team leaves the area after the start signal.
4. The referee follows the robot ready to press the emergency stop button.
5. A TC member will ask 5 questions from the set of 50 predefined questions in front of the robot.
6. The robot should answer the question without asking confirmation.
7. A question will only be asked once; there are no repetitions of a question.
  - The operator shall be standing still and facing to the robot.
  - The operator shall be between 0.75 and 1.0 meters away from the robot position.
  - The operator shall be between  $-60^\circ$  and  $60^\circ$  from the robot's center (front range).

### Additional rules and remarks

- **Continue rule:** Continue rule can not be used during this test.

- **Question timeout:** If the robot does not answer within 10 seconds, the question is considered as missing, and the referee will proceed with the next question.
- **Understanding the answer:** If the robot's answer is not understood by the operator, it is considered as incorrect, and the referee will proceed with the next question. It is thus advised that the robot provide answers such that it is clear that the robot understood the question. For example, if the question is "What is the capital of Germany?", instead of just answering "Berlin", it is advised that the robot answers something to the effect of "The capital of Germany is Berlin".
- **Log:** It is mandatory to store the recognition logs for later verification.
- Complex questions vary from each other only one word.
- Questions will be provided in the warm up day.

### Instructions:

#### To Referee

The referee needs to:

- Avoid shouting to the robot.
- Avoid getting closer to the robot.
- Speak to the robot loud and clear with plain standard English.
- Avoid repeating questions for the same robot.

#### To OC

The OC needs to:

- **2 hours before the test:** Select and announce the robot start location.
- **2 hours before the test:** Draw the set of questions for each team

## Score sheet

Maximum time:

5 minutes

Action	Score	1 <sup>st</sup> try	2 <sup>nd</sup> try	3 <sup>rd</sup> try
<b><i>Regular Rewards</i></b>				
Answer the question correctly	5×140	_____	_____	_____
<b><i>Bonus Rewards</i></b>				
Answer a complex question	5×60	_____	_____	_____
<b><i>Score per try</i></b>	1000	_____	_____	_____
<b>Total Score</b>	1000	_____		

## 5.3 Personal Recognition

### Description

An Operator is introduced to the robot, which needs to learn what the Operator looks like. Once the robot has gathered enough information about the Operator, the Operator mixes within a crowd and the robot needs to find the Operator. Once the robot has found its Operator, it must explain how it must state information about the Operator.

**Main goal:** The robot has to identify the Operator within a crowd and state information about the Operator and the crowd.

**Optional goal:** Identify the operator by your name.

### Focus

This task focuses on *people detection*, *people recognition*, *pose recognition* and *Human-robot interaction*.

### Setup

- **Locations:**
  - This task takes place inside the *Arena*.
  - The robot will start at a designated starting position.
- **People:**
  - A "professional" operator is selected by the TC to test the robot. This person may be different in each run.
  - The operator name will be chosen randomly from a list of common English names (see section 3.3.7).
  - There will be a minimum of three people in the crowd and a maximum of ten.
  - The operator will be facing forward and the other people will not be facing backwards.
  - The crowd will be located behind the robot at a distance between 2 and 3 meters apart.
- **Furniture:**
  - All furniture are in their predefined locations.
- **Objects:**
  - All objects are in their predefined locations.

### Procedure

1. The referee requests the team to move the robot to the start location.
2. The referee gives the start signal and starts the timer.
3. The team leaves the area after the start signal.
4. The referee follows the robot ready to press the emergency stop button.
5. The team is allowed to instruct the operator until the referees start the time.
6. The robot waits for the "professional" operator at the starting position.

7. The robot has to memorize the operator. During this phase, the robot may instruct the operator to follow a certain setup procedure.
8. **Optionally**, the robot may ask the operator for his/her name. Once the robot states it has finished memorizing the operator, it must wait for a Start Command.
9. The operator walks around and blends into the crowd
10. After the time elapses, the robot must turn about 180°, approach to the crowd and start looking for the operator.
11. *Optionally*, once the crowd has been located, the robot must greet the operator (navigation or with the manipulator).
12. Finally, robot must tell the size of the crowd .i.e. how many people there is in the crowd.

### Additional rules and remarks

- This test is not concerned with audio and voice recognition. Therefore, the start command may also be given by a single key press.
- 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.
- 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.
- The robot interacts with the operator, not the team. That is, the team is not allowed to instruct the operator.
- The robot needs to save an image log with bounding box.

### Instructions:

#### To Referee

The referee needs to:

- Check safe operation of the robot; the robot needs to be stopped immediately if a person is going to be touched by the robot.
- Choose operator name randomly.

#### To OC

The OC needs to:

- **2 hours before the test:** Select the "professional" operator.
- **2 hours before the test:** Select the crowd.

## Score sheet

**Maximum time:**

5 minutes

<b>Action</b>	<b>Score</b>	<b>1<sup>st</sup> try</b>	<b>2<sup>nd</sup> try</b>	<b>3<sup>rd</sup> try</b>
<b><i>Regular Rewards</i></b>				
Correctly Identify the operator (bounding box) .	$5 \times 100$	_____	_____	_____
Correctly State crowd's size (bounding box for each person).	$5 \times 100$	_____	_____	_____
<b><i>Bonus Rewards</i></b>				
Approach or point at the operator (with navigation or manipulator).	60	_____	_____	_____
Identify the operator by his name. (bounding box with his name)	40	_____	_____	_____
<b><i>Regular Penalties</i></b>				
False positive for person.	$\infty \times \{10$	_____	_____	_____
<hr/>				
<b><i>Score per try</i></b>	1100	_____	_____	_____
<b>Total Score</b>	1100	_____		

## 5.4 Manipulation and Object Recognition

### Description

The robot must reach a bookcase in which there are 10 objects at different shelves. The robot must then identify and grasp 5 of those objects and put those into a new, easy-to-reach shelf that the team may choose.

**Main goal:** The robot has to identify, grasp and correctly place several objects at different heights or positions.

**Optional goal:** Finding a hidden or occluded object

### Focus

This task focuses on *object detection*, *object recognition* and *object manipulation*

### Setup

- **Locations:**
  - This task takes place inside the *Arena*.
  - The robot will start at a random distance between 1.0m and 1.5m from the bookcase.
- **People:**
  - There is no people in this task.
- **Furniture:**
  - One of the bookcases in the apartment is used for this test.
  - The bookcase has at least 5 shelves between 0.30m and 1.80m from the ground.
  - One of the shelves is empty or will be made empty when the team chooses a shelf.
- **Objects:**
  - All objects are in their predefined locations.

### Procedure

1. The referee requests the team to move the robot to the start location.
2. The referee gives the start signal and starts the timer.
3. The team leaves the area after the start signal.
4. The referee follows the robot ready to press the emergency stop button.
5. The robot approaches the shelf from its nearby starting position and starts searching for objects.
6. **Optionally**, the robot can search for hidden or occluded objects.
7. Any object found by the robot may be grasped by it.
8. Before or right after grasping the object, the robot has to announce which object it has found.
9. After grasping the object, the robot has to safely place it on the empty shelf of the bookcase.
10. Scores can only be gained a single time for each specific object.

### Additional rules and remarks

- The objects are located as follows:
  1. 2 known object in an upper shelf.
  2. 4 known object in a middle shelf.
  3. 2 known object in a lower shelf.
  4. 2 alike object in a middle shelf.
- May be more than one object in each shelf to fit all objects in.
- Slightly touching the shelves or the bookcase is tolerated. Driving over the objects or any other form of a major collision is not allowed, and the referees directly stop the robot.
- Robots must create a PDF report file including the list of recognized objects with a picture showing the object and the object name/label. This file may be stored on a USB-stick on the robot which is given to the OC after the test. The PDF file name should include the team name and a timestamp. It must be unmistakable which label belongs to which object. Objects must also be recognizable in the report by a human (OC) so that it can be scored. An overview of the shelf with bounding boxes and labels attached to the bounding boxes is handy for the TC to score. False positives in the report (labeling an object which is not an object but e.g. the edge of the shelf) are penalized.

### Instructions:

#### To Referee

The referee needs to:

- Place the objects in the bookcase
- Make sure there is one empty shelf in the middle of the bookcase.
- Ask the team which shelf they want to be empty.

#### To OC

The OC needs to:

- **2 hours before the test:** Select and announce the robot start location.

## Score sheet

Maximum time:

5 minutes

Action	Score	1 <sup>st</sup> try	2 <sup>nd</sup> try	3 <sup>rd</sup> try
<b><i>Regular Rewards</i></b>				
Detection of object name.	5×40	_____	_____	_____
Detection of object class.	5×40	_____	_____	_____
Pick the object.	5×60	_____	_____	_____
Place the object in the empty shelf.	5×60	_____	_____	_____
<b><i>Bonus Rewards</i></b>				
Finding a hidden or occluded object.	100	_____	_____	_____
<b><i>Regular Penalties</i></b>				
False positive for object name.	∞×{20	_____	_____	_____
False positive for object class.	∞×{20	_____	_____	_____
Drop the object.	5×{30	_____	_____	_____
<hr/>				
<b><i>Score per try</i></b>	1100	_____	_____	_____
<b>Total Score</b>	1100	_____		