Partner Robot Challenge Real Space

Rules & Regulations

Version: 2018 Rev-2.0
Last Revision Date: September 17, 2018

About this Rulebook

This is the official rulebook of the Partner Robot Challenge (Real Space) 2018 competition. It is written by the Service Category Technical Committee members.

Acknowledgments

We would like to thank all the people who contributed to the World Robot Summit Service Category Technical Committee members with their feedback and comments. We also like to thank the members of RoboCup@Home community.

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Chapter 1 Introduction

1.1 Service Robotics Category

The Competition will be helpful to solve social problems stemming from rapidly aging population and declining birth rates through technology that works alongside humans to provide a variety of services.

As we enter the age in which robots will become a part of people's lives, there is a need for robots that can perform a variety of services in cooperation with humans. There is a need for service robots that can work safely and reliably with people and for technologies that create the environment necessary for developing such robots. These include AI learning through which humans and robots engage in advanced communication, Big Data information-sharing through clouds, collection and use of information gathered through IoT technology, etc. Human resource development (training) is indispensable in the development of robotic technology and social implementation of robots.

1.2 Partner Robot Challenge

The concept of Partner Robot Challenge is to foster the collaboration between human and robot. Not limited to assistance for handicapped person, but also in domestic home environment with living children and elderly person, it is targeted to realize a rich collaborative living environment for human and robot. It is not the aim of this competition for the robot to complete the task alone, but with the communication and workload sharing with human user, this challenge competes the technologies for smooth collaboration between human and robot. The focus on human-robot collaboration is the uniqueness of this competition.

Chapter 2 Partner Robot Challenge (Real Space)

2.1 Concept

The concept behind the competition is adapted from the roles of a home assistant. A home assistant is trained to aid or assist human on daily house chores. Apart from physical work assistance, the home assistant can also maintain friendship and social companionship with human. The fundamental concept of this challenge is to develop a robot that resembles a home assistant as a partner to support human.

In the competition, the robot is to compete for the task as a home assistant. Not limited to the support for handicapped person, the robot is anticipated to be able to perform a wide range of tasks as a partner to elderly person and normal healthy person too.

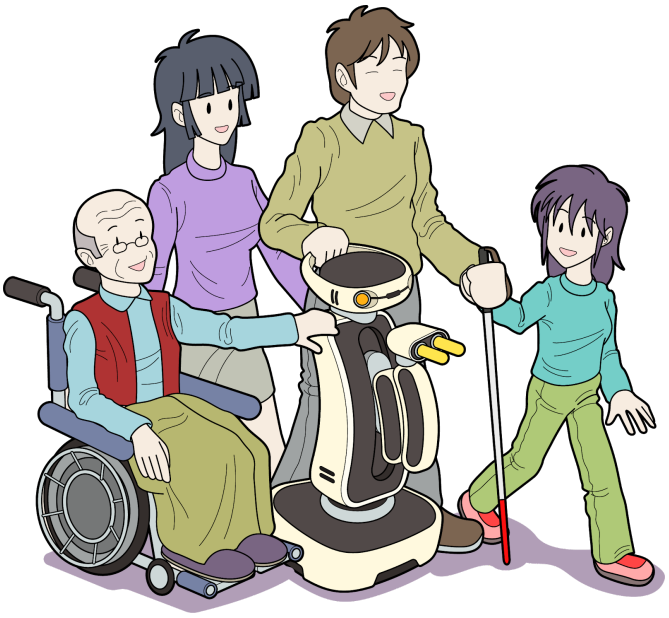

Figure 2.1: Partner Robot Challenge

2.2 Competition

The competition is divided into 2 parts, where the first part is Skill Tests and the second part is Final.

The objective of the Skill Tests is to test the fundamental skills of the robot to accomplish basic functions of a home assistant, such as serving items, searching items, and tidy-up the environment. The robot (with human collaboration) is required to perform such tasks within a set of defined rules and environments in order to acquire scores for the competition.

The competition ends with the Final where only the five highest ranked teams compete to become the winner. In Final, there isn't any specific task to accomplish, but the participating teams are supposed

to demonstrate their robots' best abilities as a partner robot to support human. The teams are encouraged to demonstrate their latest research development on new approaches, applications of the assistance robot in an interesting scenario setting.

2.3 Standard Robot Platform

HSR by Toyota Motor Corporation will be used as the Standard Platform Robot for the Partner Robot Challenge (Real Space).

2.3 Awards

The Partner Robot Challenge (Real Space) features the following awards.

2.3.1 Winners of the Competition

There will be a 1st, 2nd, and 3rd place awards for the winners of the competition.

All teams will take part in Skill Tests. Based on the ranking of the team scores from Skill Tests, the top half of the teams will proceed to Final. The total scores of the teams are calculated based on the sum of team scores from Skill Tests and Final, with a 50% + 50% distribution. The 1st, 2nd, and 3rd place awards are determined based on the ranking of the team total scores.

2.3.2 Academic Society Awards

There are also two awards from Japanese academic societies:

- Robot Society of Japan (RSJ) Award
- Japanese Society for Artificial Intelligence (JSAI) Award

Chapter 3 General Rules

3.1 Robots and External Devices

3.1.1 Robot Modification

As a Standard Platform Robot, HSR will be used in this competition, and any modification of the robot hardware is prohibited.

Only during Final, robot modification is allowed based on the contract agreement of TOYOTA.

3.1.2 Additional Laptop for HSR

In the Partner Robot Challenge (Real Space), teams may use the additional laptop connected to the Toyota HSR via Ethernet cable, safely located in the TOYOTA HSR Mounting Bracket provided by TOYOTA for this purpose.

The additional laptop for WRS Partner Robot Challenge (Real Space) 2018:

- The PC can be attached to the HSR using the attachment provided by Toyota.
- The PC is a product that is being marketed.
- The PC cannot be modified at all.

The referees may run random checks anytime during the competition prior to the test to verify that the laptop in the TOYOTA HSR Mounting Bracket has no additional hardware plugged in, and matches the authorized specifications.

Figure 3.1: TOYOTA HSR Mounting Bracket

3.2 Competition Arena

3.2.1 Mock-up Home Environment

Full sized mock-up home environment consisting inter-connected rooms will be setup as the competition arena. There will be a living room, a kitchen, a dining room and a bedroom in the home environment. There rooms are equipped with related furniture and objects.

3.2.2 Objects

Household items are prepared for the object recognition and manipulation interactions in the competition tasks. The available objects can be divided into 2 main groups:

1. **Known objects**: Household items that can be grasped or handled, and will be announced before the competition.
2. **Unknown objects**: Household items that can be grasped or handled, but will not be announced before the competition.

A set of samples of the known objects will be available for each team during the setup days for practice purpose.

Chapter 4 Preparation for Competition

4.1 Competition Setup

There will be 2 days before the start of the competition tasks as setup days, to let the teams fine tune their robot on the actual competition arena.

4.2 Team Leaders Meeting

A team leaders meeting will be conducted every day at 18:00 to discuss on the details of the next day competition tasks among the referees and all team leaders.

4.3 Robot Inspection

The referees may run random checks anytime during the competition prior to the test to verify that there is no additional hardware attached on the standard platform robot, and matches the authorized specifications.

Chapter 5 Skill Tests

5.1 Bring Me

Description: Go get an object from a designated room.
Time: 5 + 10 + 25 minutes per trial.

5.1.1 Objectives

- Based on the operator's instruction, the robot is tasked to find and get 4 objects from a list of known objects and 1 unknown object.

5.1.2 Technical Focus

Object memory, HRI, semantic mapping, object perception and manipulation.

5.1.3 Settings

Team
- In this competition task, 2 teams will be tested in parallel.

Environment
- An apartment with dining room, kitchen and living room.
- There are 4 areas, with 8 known objects and 2 unknown objects in each area.
- Therefore, a total of 32 known objects and 8 unknown objects are placed in the environment.
- Among them, the robot is required to go search and get 4 known objects and 1 unknown object.
- The 4 areas:
    - Area 1 Dining table
    - Area 2 Wall shelf in living room (without drawer or opening door)
    - Area 3 Cabinet in living room (with drawer)
    - Area 4 Refrigerator in kitchen (with opening door)
- The furniture opening doors will have easy-to-operate handles.
- 3 areas are pre-defined for the robot to return the objects.

Objects
- Known objects – data for object recognition, location information and frequently used daily goods announced to participants in advance.
- Unknown objects - with pre-announced object recognition data (announce before start), no location information, daily goods with complex shape.

Person
- The robot operator will be selected by the team.

5.1.4 Before the Competition - Setup Day

- Teams are given the time to create/adjust map data in the actual apartment setting (no objects are placed) during the setup days.

5.1.5 Before the Competition - Right Before the Competition

- Memorize Phase and Search Phase are performed in sequential.

Memorize Phase

- The time of 5 minutes is given to memorize one unknown object.
- Once the Memorize phase has started, the robot must operate autonomously.
- An unknown object is placed on the table by the operator.
- The robot may use its gripper to pick up the object.
- The robot may also instruct the operator to move the object.
- However, modeling equipment may not be used.
- After memorizing, when asking the operator the name of the object, the operator will say the name of the object.
- The operator can use QR code to replace verbal instruction.

Search Phase

- The referee sets objects in each of the 4 designated areas right before the competition (random objects for all teams).
- The robot is able to autonomously move around the room for 10 minutes before the start of the competition to check the position of the objects (it is also possible to open the chest and fridge, and to observe inside, but touching the objects are prohibited).
- During the Search Phase, the operator will be sitting on a chair at a designated location.
- The robot gets ready at a predetermined position near the operator.

5.1.6 During the Competition

- The robot goes search and gets an object instructed by the operator. Each task is completed when the operator receives the object that had been handed over from the robot or when the robot brings the object to the designated area/location
- The maximum time limit for the robots to complete the entire tasks is 25 minutes.
- During the competition, the robot will operate autonomously.
- Once the task had started, the team can restart the robot any number of times. The robot emergency stop button will be pressed for restarting. On each restart, the robot can only start to operate after 3 minutes from the moment the team member declares that it is ready to start after the restart. There is no penalty on points.
- Instruct Phase and Bring Me Phase are performed in sequential for each object separately or multiple objects together.

Instruct Phase

- The operator instructs the robot on the known objects for Area 1 to 4, followed by one unknown object for a total of five objects.
- The operator instructs the robot by voice.
    - If the robot could not hear the instruction, the robot can:
      - request having the instruction repeated.
      - request the operator to show the QR code to the robot.

Bring Me Phase

- The operator will be waiting at one of the 3 predetermined return areas.
- After getting the object, the robot brings the object to the predetermined return area, where the operator is located.

5.1.7 Scores

- Grasped the instructed known object: 5 points x 4 units
- Delivered the instructed known object to the operator: 20 points x 4 units
- Delivered the instructed known object to the return area without the operator: 10 points x 4 units
- Grasped the instructed unknown object: 30 points x 1 unit
- Delivered the instructed unknown object to the operator: 20 points x 1 unit
- Delivered the instructed unknown object to the return area without the operator: 10 points x 1 unit
- Subtotal: Maximum 150 points
- If any time remains, add 5 points per minute
- Average score of 2 best trials among all 3 trials.

5.1.8 Bonus Challenges

- Bonus points can be given if the team opts for the bonus challenges:
    - Opening the cabinet drawer
    - Opening the refrigerator door

5.1.9 Score Sheet

Performance	**Score**
Known Objects	
Grasped the instructed known object	5 x 4
Delivered the instructed known object to the operator OR Delivered the instructed known object to the return area without the operator	20 x 4 10 x 4
Unknown Objects	
Grasped the instructed unknown object	30 x 1
Delivered the instructed unknown object to the operator OR Delivered the instructed unknown object to the return area without the operator	20 x 1 10 x 1
Special Bonuses	
If any time remaining, add 5 points per minute	5 x time
Bonus challenge	20 x task

Total score (excluding bonuses) 150
Average score of 2 best trials among all 3 trials.

5.2 Tidy Up Here

Description: Tidy up the objects to the original positions in a room.
Time: 12 (Stage 1) + 12 (Stage 2) minutes per trial.

5.2.1 Objectives

- Tidy up objects from the incorrect positions to a predetermined tidy up space.
- Stage 1: Put scattered toys in order on the toy shelf in the children's room.
- Stage 2: Clean up scattered objects in the living and dining rooms, by asking the human operator whether to discard or to tidy the objects.

5.2.2 Technical Focus

- Stage1: Semantic mapping, object perception and manipulation
- Stage2: HRI, semantic mapping, unknown object perception and manipulation

5.2.3 Settings

Environment

- The furniture positions will be announced in advance (including the room layout, furniture arrangement, furniture models, etc.)
- Each stage is carried out in the following rooms:
    - Stage 1: Children room
    - Stage 2: Living room, dining room
- The operator sends instructions from the kitchen.
- Storage places:
    - Stage 1: Toy storage (children room)
    - Stage 2: Coffee table, wall shelf, rubbish bin (living room); food cabinet, kitchen unit, refrigerator (dining room)

Objects

- Known objects - with pre-announced object recognition data, location information, frequently used daily goods and toys, about 45 units without deformable objects.
    - Daily goods for living room and dining room: 30 units
    - Toys for children room: 15 units (5 categories, each category has 3 units)
- Unknown objects - without pre-announced object recognition data, no location information, including deformable objects, e.g. clothing, food, paper, etc., about 10 units.

Tidy Up

- The name and location of the tidy up spaces are defined, such as wall shelf, refrigerator, rubbish bin, food cabinet, toy storage (stuffed animals, small vehicles, cards, musical instruments), etc.
- Known objects are given with pre-announced information on tidy up spaces (toys are on toy storage, foods are in refrigerator, etc.).
- For unknown objects, the robot inquires the operator to get information on tidy up space (by voice or QR code), or by the robot own judgement (e.g. toys are to put into toy storage or refrigerator?).
- The furniture opening doors will have easy-to-operate handles.

5.2.4 Before the Competition

- Teams are given the time to create/adjust map data in the actual apartment (no objects are placed), and to memorize unknown objects.
- Each team will be given setup time in turn during the setup day.
- Right before the competition, the referee sets the rooms into messy condition (within a specified error tolerance range)
- Area 1. Children room (work plan, object manipulation): for Stage 1
    - 15 objects (toys) are lying on the floor (likes after a child playing)
- Area 2. Living, dining space (unknown object, HRI): for Stage 2
    - 10 objects (5 known objects, 5 unknown objects (3 undeformable and 2 deformable objects)) on the table or sofa in messy condition.

5.2.5 During the Competition

- The robot enters the room in messy condition, tidy up each stage in 12 minutes.
- Each stage starts with the instruction “Tidy up xxx” by the operator in the kitchen.
- If the robot is stuck during the competition, it can be restarted as many times as needed. But after the robot has been stopped by the operator, the robot cannot operate within 1 minute (to prevent repeatedly fine adjustments).
- When the task of each stage is completed or time limit is up, the robot returns to the kitchen and informs the operator the tidy up is completed.
- The teams can select the stage(s) to be implemented: Stage 1 only, stage 2 only, both stage 1 and stage 2.
- Stage 1
    - Start the competition with “Tidy up the children room” by the operator.
    - Perform tidy up.
    - End the competition with the robot reports the completion of task or time is over.
- Stage 2
    - Start the competition with “Tidy up living and dining rooms” by the operator.
    - Perform tidy up.
    - The robot can ask the operator the tidy up space.
    - End the competition with the robot reports the completion of task or time is over.

5.2.6 Scores

- Stage 1
    - Tidy up object into the toy storage: 3 points x 10 units
    - Tidy up object into the correct box within the toy storage: 2 additional points x 10 units
    - Report back to the kitchen within the time limit: 2 points
- Stage 2
    - Tidy up object to the correct place: 5 points x 10 units
    - Inquire the human operator whether to discard or the tidy up space of the objects: 6 points x 5 units
    - Tidy up object is unknown object (undeformable): 3 additional points x 3 units
    - Tidy up object is unknown object (deformable): 3 additional points x 2 units
    - Report back to the kitchen within time limit: 3 points

    - Subtotal: Maximum 150 points
    - If any time remaining, add 3 points per minute
- Average score of 2 best trials among all 3 trials.

5.2.7 Difficulty Adjustments

- In Stage 2, instruction from the operator of tidy up space is done by presenting the QR code (score x 0.7).

5.2.8 Additional Conditions

- The use of tools (cart etc.) is allowed.
- Deliver multiple objects at the same time by using tools.
- However, no actuator, sensor, etc. is allowed (passive devices).

5.2.9 Data Recordings

The following data may be required by the referee to support scoring.

- Recognized object images.
- List of manipulated objects.

5.2.10 Bonus Challenges

- Bonus points can be given if the team opts for the bonus challenges:
    - Opening the house door
    - Opening the cabinet drawer
    - Opening the refrigerator door

5.2.11 Score Sheet

Performance	**Score**
Stage 1	
Tidy up object into the toy storage	3 x 10
Tidy up object into the correct box within the toy storage	2 x 10
Report back to the kitchen within the time limit	2
Stage 2	
Tidy up object to the correct place	5 x 10
Inquire the human operator whether to discard or the tidy up space of the objects	6 x 5
Tidy up object is unknown object (undeformable)	3 x 3
Tidy up object is unknown object (deformable)	3 x 2
Report back to the kitchen within the time limit	3
Special Bonuses	
If any time remaining, add 3 points per minute	3 x time
Bonus challenge	20 x task

Total score (excluding bonuses) 150
Average score of 2 best trials among all 3 trials.

Chapter 6 Final

6.1 Show Me the Future

The purpose of the Final is to enable the participating teams to demonstrate their robots 'best abilities as a partner robot to support human without any rule restriction. The teams are encouraged to demonstrate their latest research development on new approaches, applications of the assistance robot in an interesting scenario setting.

The Final aims to demonstrate the concept of future barrier-free (handicapped person, elderly person, healthy person) robotic home environment. A team must to have at least a team member to play the role of an elderly person in the demonstration.

6.2 Task

The Final 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 team of juries selected by the Service Robotics Competition Committee.

- Setup and demonstration: The team has a maximum of 10 minutes for setup, presentation and demonstration.
- Interview and cleanup: After the demonstration, there is another 5 minutes of interview time, where the team answers questions by the jury members.

6.2.1 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 what will be shown.
- The team can also visualize robot's internals, e.g., percepts.

It is important to note that the jury may decide to end the demonstration if there is nothing happening or nothing new is happening.

6.2.2 Changes to the Environment

- 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.
- 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.

6.3 Evaluation

6.3.1 Evaluation and Jury

- The performance of the teams is evaluated by a team of juries selected by the Service Robotics Competition Committee. The team of juries is comprised of professionals with technical or general backgrounds.
- Both the demonstration of the robot(s), and the answers of the team in the interview part are evaluated. Scores will be given based on the following evaluation criteria:
    - **Technical jury**:
        - Novelty and scientific contribution (and contribution to the community)
        - Human-robot interaction and robot autonomy
        - Difficulty and success of the demonstration
        - Presentation and performance
    - **General jury**:
        - Overall demonstration
        - Usability / Human-robot interaction
        - Realism and usefulness for daily life (can this robot become a product?)
        - Relevance / Social impact

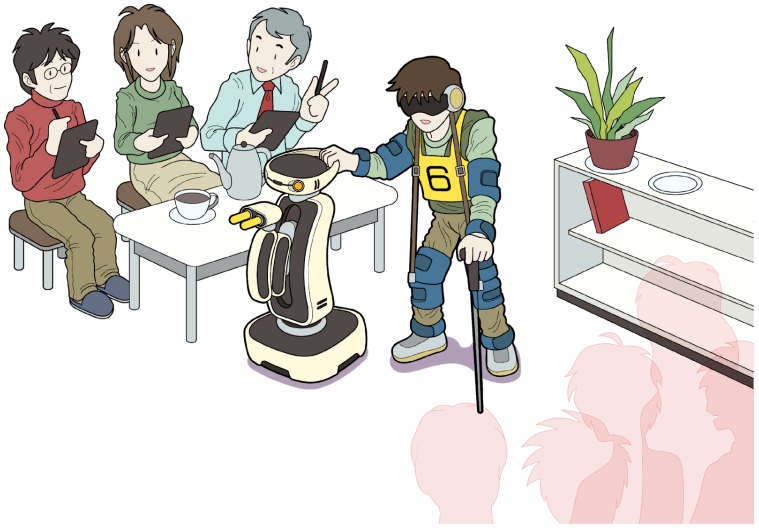

Figure 6.1: Show me the future

6.3.2 Score Sheet

Technical Jury

Performance	**Score**
Novelty and scientific contribution (and contribution to the community)	25
Human-robot interaction and robot autonomy	25
Difficulty and success of the demonstration	25
Presentation and performance	25

Total score 100

General Jury

Performance	**Score**
Overall demonstration	25
Usability / Human-robot interaction	25
Realism and usefulness for daily life (can this robot become a product?)	25
Relevance / Social impact	25

Total score 100