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# Partner Robot Challenge Real Space

Rules & Regulations

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## About this rulebook

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

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## Chapter 1

# Introduction to World Robot Summit

## 1.1 World Robot Challenge

### 1.1.1 Service Robotics Category

The Competition will be helpful to solve social problems stemming from rapidly aging population and declining birthrates 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.

#### Partner Robot Challenge(Real Space)

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 User story

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.

### 2.2 Competition

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

The objective of Skills Challenge 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,



Figure 2.1: Partner Robot Challenge



applications of the assistance robot in an interesting scenario setting.

## 2.3 Awards

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

### 2.3.1 Winner of the competition

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



# Chapter 3

## General Rules

### 3.1 External Devices

#### 3.1.1 Official Standard Laptop for HSR

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

#### Technical Specifications

The technical specifications for the Official Standard Laptop in the Partner Robot Challenge(Real Space) are the following:

- Brand and model: DELL Alienware 15 or 17
- CPU: Core-i7 series
- RAM: 16GB or 32GB
- GPU: NVIDIA GeForce GTX 1070 or 1080
- Storage: Unrestricted.

No other brands or models will be accepted. There are no constraints regarding the software installed in the OSL but no additional hardware is allowed. 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

## Chapter 4

# Preparation for competition

- 4.1 Set Up
- 4.2 Team leaders meeting
- 4.3 Welcom reception
- 4.4 Poster



## Chapter 5

# Skill tests

## 5.1 Bring Me

Go get an object from a designated room.

### 5.1.1 Objectives

- Based on the operator 's instruction, go get an instructed object from a list of 4 known objects and one previously presented unknown object.
- If the instructed object is handed over to the operator, or enters a designated area in the vicinity of the operator (within the 2D projection of the floor), the task is considered completed.

### 5.1.2 Technical Focus

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

### 5.1.3 Settings

Environment

- An apartment with dining room, kitchen and living room together.
- There are 4 areas, with 8 known objects and 2 unknown objects in each area.
- Therefore, there will be total 32 known objects and 8 unknown objects in placed.
- 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 Shelf in living room (without drawer or opening door)
  - Area 3 Chest in living room (with drawer)
  - Area 4 Refrigerator in kitchen (with opening door)
- The furniture opening doors will have easy-to-operate handles.
- 3D map data is provided in advance (error tolerances are also presented), including the room layout, furniture arrangement, furniture models, etc.
- The areas with objects are also defined on the 3D map data. The area 's regions are slightly wider than the tidy up space of the Tidy-Up task (e.g. If it is a shelf, the exact location of the shelf board will not be specified).



## Objects

- Known objects - with pre-announced object recognition data, location information, frequently used daily goods, about 50 units.
- Unknown objects - with pre-announced object recognition data (announce before start), no location information, daily goods with complex shape.
- The list of objects does not include deformable objects (e.g. clothing, cords or strings, magazines, garbage, etc.).

### 5.1.4 Before the Competition - Setup Day

- 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 one hour in turn during the setup day.

### 5.1.5 Before the Competition - Right Before the Competition

- The time of 5 minutes is given to memorize one unknown object.
  - An unknown object is placed on the table by a staff.
  - The robot may pick it up, or instruct the staff to move it.
  - However, modeling equipment can not be used.
  - After memorizing, when asking the staff the name of the object, the staff will say the name of the object.
- The staff sets objects in each area right before the competition (random objects for all teams)
- Items are set somewhere on the table, shelf, chest or refrigerator (this is also a random place).
- The robot can autonomously moves around the room for 10 minutes before the competition to check the position of the objects (it is also possible to open the chest and fridge, and to observe inside, but not to touch the objects).
- The operator sits on a chair in the living room.
- The robot gets ready at a predetermined position near the operator.

### 5.1.6 During the Competition

- Go search and get an object instructed by the operator. Hand over the object or bring it to within the designated area to consider one task completion. The task is completed when the operator receives the object.
- There will be 5 tasks (5 objects) with 25 minutes total time limit.
- The robot operates autonomously after the competition started.
- The tasks started first with instructions on known objects for Area 1 to 4, and then followed by one unknown object for a total of five objects.
  - The operator shuffles the object cards, after selecting an object for each area.
  - The operator instructs the robot by voice.
  - If the robot could not hear the instruction, the robot can request to repeat it.
  - If the robot could not hear the instruction in one minute, the operator will show the object card to the robot (the card has the name of the object, the ID (QR code) written, and the picture of the object).
- After getting the object, the robot returns to the position of the operator, and informs the operator for the hand over/delivery.
  - When informed, the operator receives the object in random timing (within 20 seconds)
  - When the operator receiving the object and the robot is able to release the object within 5 seconds, there will be an additional point.
  - If the robot releases the object at its own timing, there will be no additional point.
  - If the robot puts the object in the designated area, there will be no additional point.
- 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).

### 5.1.7 Additional Conditions

- Additional devices can be added to the robot, according to the general rule (regulations of size, weight, place, etc.)

### 5.1.8 Scores

- Touched the instructed known object 4 unit x 5 points
- Delivered the instructed known object 4 unit x 10 points
- Touched the instructed unknown object 1 unit x 10 points
- Delivered the instructed unknown object 1 unit x 20 points
- Additional points for Delivery 5 unit × 5 points Sub total: 115 points (other task and necessary adjustment)
- If any time remaining, add 3 points per minute

### 5.1.9 Score sheet

## 5.2 Tidy Up Here

Tidy up the objects to the original positions in a room.

### 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 room.
- Stage 2: Clean up scattered objects in living and dining rooms, by confirming with human user whether to discard or tidy up 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

- 3D map data is provided in advance (error tolerances are also presented), 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, dining rooms
- The user issues instructions from the kitchen.

Objects

- Known objects - with pre-announced object recognition data, frequently used daily goods and toys, about 50 units.
- Unknown objects - without pre-announced object recognition data, food, books, etc.
- The list of objects includes deformable objects (e.g. clothing, magazines, garbage, etc.).

### Tidy Up

- The tidy up space is defined on the 3D map by name and QR code (such as bookshelf, washing basket, refrigerator, garbage canister, newspaper / magazine stocker, toy shelf (picture book, stuffed animals, small vehicles, cards, musical instrument boxes), etc.)
- Known objects are given with pre-announced information on tidy up spaces (toys are on toy shelves, books are on bookshelves, clothes are in laundry baskets, foods are in refrigerators, magazines are in stockers, etc.).
- For unknown objects, the robot inquires the user to get information on tidy up space (by voice or QR code), or by the robot own judgement (e.g. The magazine is to put on bookshelf or stocker? Is this burnable garbage or incombustible garbage?).
- 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 one hour in turn during the setup day.
- Right before the competition, the staff sets the rooms into messy condition (within the specified error tolerance range)
- Area 1. Children room (work plan, object manipulation): for Stage 1
  - 20 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) 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 user 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 user 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 user.
  - 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 user.
  - Perform tidy up.
  - The robot can ask the user 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 objects on the toy shelf x 3 points
  - Tidy up objects into the correct box x 2 additional points
  - Report back to the kitchen within time limit 3 points
- Stage 2
  - Tidy up objects to the correct place x 5 points
  - Unknown objects x 3 additional points
  - Deformable objects x 3 additional points
  - Tidy up space of the objects is within the furniture or household electric appliances x 3 additional points
  - Report back to the kitchen within time limit 3 points
- If any time remaining, add 3 points per minute

### 5.2.7 Difficulty Adjustments

- In Stage 1 and 2, put the QR code on tidy up space (score x 0.5).
- In Stage 2, instruction from the user 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

- Recognized object images.
- List of manipulated objects.

### 5.2.10 Advanced

- Tidy up an unknown object to the correct place without inquiry the user.
- Hand over the kitchenware to the kitchen user.
- Cooperation with smart speakers (through communication with smart speakers, lights are switched on when the robot goes to the children room).
- Categorized garbage before throw it away.



### 5.2.11 Score sheet



## Chapter 6

# Final

Show me the future

## 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 have at least a team member to play the role of an elderly person in the demonstration.

### 6.1.1 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 mainly evaluated by the Service Robotics Competition Committee. In addition, all team leaders will be involved in the evaluation.

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 judge members. During the interview time, the team has to undo its changes to the environment.

### 6.1.2 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 (max. 1 minute) introduction to what will be shown.
- The team can also visualize robot's internals, e.g., percepts.

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

### 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.

### 6.1.4 Judge evaluation

1. The performance of the teams is mainly evaluated by the Service Robotics Competition Committee. In addition, all team leaders will be involved in the evaluation.: All teams have to provide one person (preferably the team-leader) to follow and evaluate the entire Open Demonstration.
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 judge member:
  - Overall demonstration
  - Human-robot interaction in the demonstration
  - Robot autonomy in the demonstration
  - Realism and usefulness for daily life (Can this robot become a product?)
  - Novelty and (scientific) contribution (+contribution to the community)
  - Difficulty and success of the demonstration

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

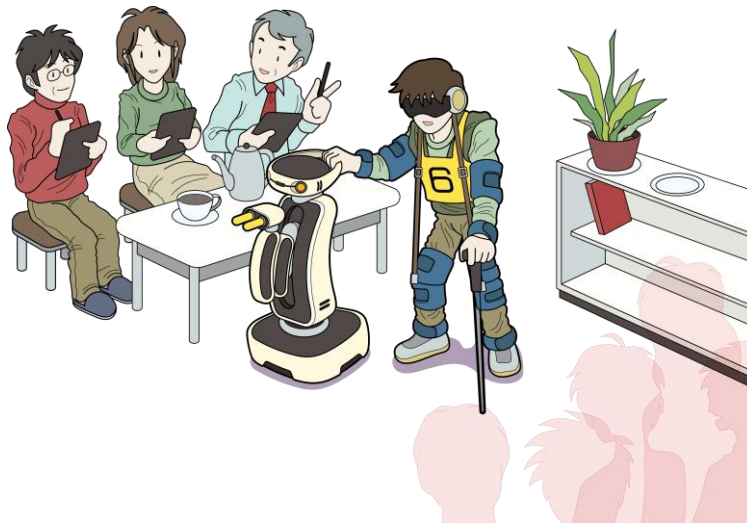


Figure 6.1: Show me the future