

WRS Future Convenience Store Challenge  
IROS 2022 Trial

Stock and Disposal Task

Rulebook

2022/10/01

## Revision History

October 1, 2022

- Clarified the regulation on when a team member manipulates the system during a demonstration in Section 2.3.
- Updated the products for the task in Section 4.1.
- Deleted the restriction for the weight of the mobile robot in Section 4.4.1.
- Revised minor points.

July 1, 2022

- Revised the regulation of markers for products in Section 3.7.1.

March 1, 2022

- Revision of the regulation for IROS 2022 Trial.
- Minor revision.

March 1, 2020

- Clarified the number of team members working in renovation time.
- Added the rule of tie break.
- Added notification of robot's avoidance motion by voice, etc. in Section 3.6.
- Added restrictions when unique display cases have pull-out shelves.
- Added restrictions when mobile robots and/or infrastructure are separated.

April 24, 2019

- First draft

## 0. Terminology

Term	Definition
Mobile Robot	A robot that can move autonomously.
Infrastructure	Unique infrastructure that can be installed inside the convenience store to support the robot's tasks. This equipment includes markings, IC tags, sensors, actuators, and auxiliary tools attached to products, etc. Infrastructure consisting of sensors and actuators can also be considered as stationary robots.
Manipulator	Robot arms, end effectors, and other equipment for manipulation tasks which can be installed on a mobile robot or as part of the infrastructure.
Product(s) or Item(s)	Article(s) for sale in the convenience store.
Disposal Item(s) or Disposal Product(s)	Expired product(s) that should be removed from the Display Cases and discarded.
Customer	Person who visits the store to purchase products.
Container	Box-like repository for holding and transporting multiple products.
Product Display Area	Section of the convenience store where display cases or shelves are installed.
Aisle	Section of the convenience store for customers and robots to come and go.
Backyard	Section of the convenience store where customers are not allowed.
Home Area	Area located in the Backyard and used as a standby area for the mobile robot before starting the task.
Display Cases	Shelves for displaying products. At the start, multiple products are mixed in these cases.
Chief Judge	Judge who declares the start of the task and issues instructions to the participants.
Assistant Judge	Judge who assists the Chief Judge by performing measurements for scoring, catching rule violations, etc.
Operator	Team member who starts the robot operation inside

	the competition field. After starting the robot, the operator leaves the competition field.
Safety Observer	Team member who manages the safety of the system inside the competition field and performs operations such as emergency stop. This team member may be the same as the Operator.

## 1. Overview

This challenge aims to develop technologies to automate the stocking of products and the collection of expired items in a convenience store. Participants in this competition will develop a robot system that autonomously moves and performs these tasks, as well as the infrastructure they deem necessary to install inside the convenience store. In this challenge, the participants will use their developed robots and infrastructure to compete in stocking and disposal demonstrations inside a simulated convenience store.

In this challenge, participants use the backyard area, the home area, aisles, and display cases. The layout of the store is provided in a separate document.

The following tasks will be performed in the demonstration:

- Stock task: Place the products stored in the container located in the Home area into the designated place on the display cases.
- Disposal task: Straighten the products already placed in a display case, collect the disposal items and carry them to the Home area.

In addition, the proposed system must contribute to energy saving in general, and/or to work efficiency.

## 2. Flow of the Competition Task

The flow of the task in the mandatory order is:

- (1) Renovation time (participants install their equipment)
- (2) Setting time (time for judges to set up)
- (3) Stock and disposal demonstration (time for the robot to perform the tasks autonomously)

(2) is the time for the judges to prepare for the task, so it does not count toward the time allotted for the competition. Each team will have a maximum of 15 minutes to complete (1) and (3). Participants can allocate the time to these two phases as they prefer.

### 2.1. Renovation Time

Participants will be able to do the following three tasks. Up to 10 team members can do the renovation work.

#### (a) Receive and renovate the products

Once renovation time begins, participants will receive two containers: one will contain the products for the stock task (hereinafter, the display container) and the other will contain the products for the disposal task (hereinafter the disposal container). The display container will contain 9 products in total belonging to 9 different types. The disposal container will contain 18 products in total belonging to 9 different types. Participants can alter the products as necessary by adding infrastructure. The products for the stock task should be placed in the standard display container or in a container brought by the team, and then placed in any location, which includes the robot itself, within the home area (the initial position for the demonstration). The disposal products should be placed in the disposal container and then given back to the judges.

#### (b) Renovate the store

Participants can install infrastructure inside the competition field, replace the display shelf, and so on, as necessary. No infrastructure may be installed outside the competition field.

#### (c) Place the mobile robot and prepare to start

Place the mobile robot in the Home area along with the display container,

and stand by to start the system.

Once all these works are done, participants must exit the store and declare the end of their renovation time. Then, the assistant judge stops the timer. After that, only the operator and the safety observer (one person for each role or one person for both) will be allowed to enter the competition field.

## **2.2. Setting Time**

The chief judge or competition staff will announce the 9 target products that will become disposal products. The operator, under the supervision of the assistant judge, will enter labels to the system to identify the disposal products. Then, the judge will take the 18 items in the disposal product container and place them in the display case.

## **2.3. Product Stocking and Product Disposal Demonstrations**

After the chief judge announces the start of the demonstration, the assistant judge will resume the timer.

Once the system starts, the operator will leave the competition field, and after that, no one is allowed to control the mobile robot or take any actions that will influence the operation of the system. If any team members operate the system during the demonstration, the team would be disqualified as penalty.

However, the safety observer may stay in the competition field to monitor the robot's operation and press the emergency stop switch if necessary. However, the safety observer must not get within 1.5m of the mobile robot, and they must try not to block the view of the judges or the audience.

After 15 minutes have passed, or when the operator declares the task finished or withdraws from the task, the demonstration time finishes.

### 3. Details of the Challenge

The score of the challenge is as shown in below;

- Straightening preexisting products (2 points for each): 36 points.
- Stocking new products (2 points for each): 18 points.
- Disposal item transport: 5 points.
- Stopping work when a customer gets close: 15 points.

Additionally, novel ideas or technical challenges about infrastructure for the products will be scored.

If there are multiple teams with the same score, the team with the least number of retries is the winner. If the number of retries does not give an advantage, the team with the shortest working time is the winner. If there is still a tie, the judging committee will determine the ranking.

#### 3.1. Display Case

The display case is made of five shelves. The tasks will use the first (hereafter top), third (hereafter middle) and fifth (hereafter bottom) shelves, while the second and fourth shelves will not be used. The top shelf will contain three kinds of rice balls, the middle shelf will contain two kinds of sandwiches and food pouches, and the bottom shelf will contain drinks and two kinds of lunch boxes.

#### 3.2. Initial State of the Display Case and Straightening Preexisting Products

When the demonstration begins, there are 18 products in the shelf in a non-straightened state: 2 items per each of the 9 types of products. Straightening means that after the products are removed from the shelves by customers, the products behind them must be brought forward until they are at the front of the display case. Of the 18 items, 9 are near their expiration date and must be collected as disposal products.

The system must check the label of each product, remove disposal products from the shelf, and straighten the remaining products.

Points are earned by arranging products in their designated positions and removing the disposal products from the shelf, as follows:

- 2 points are awarded for each disposal item stored in the disposal container.

- 2 points are awarded for each remaining product straightened up in the correct position.

If all preexisting products are processed correctly, a total of 36 points will be awarded.

### **3.3. Stocking New Products**

This recreates a situation where newly arrived products must be placed on the display case. The display container placed in the Home area and containing new products is transported to the display case. Then, the new products should be placed in their correct locations in the target shelves.

The display container will contain 9 items: three kinds of rice balls, two kinds of sandwiches and lunch boxes, one deli food pouch, one drink. Each product must be placed behind the products of the same type already stored on the display shelf. It is allowed to stack up the lunch boxes, in which case the new one should be below the already stored one.

Each correctly placed product will be worth 2 points. The maximum score of 18 points can be obtained by correctly placing all the products from the display container.

### **3.4. Initial Positions of the Mobile Robot and Display Container**

The display container and the mobile robot must be within the Home area to be a valid initial state. In the initial state, the display container can be placed on the mobile robot.

### **3.5. Disposal Product Transport**

Disposal product transport will be deemed a success if one or more of the disposal items can be brought back to the Home area when the demonstrations have finished, which will score 5 extra points.

### **3.6. Stopping the Work when a Customer Gets Close**

If a customer gets close to the display case during the stock and disposal work, the system should temporarily stop working and move away from the front of the display case so that the customer can access the products. When the system detects the customer (role-played by a judge), it should quickly stop working and ensure the customer has access to the products.

The following functions will award extra points, if they can be

demonstrated during the demonstration time:

- If a customer gets close to the system (within 1m), the system must temporarily stop any moving parts immediately and notify the customer detection by voice (or another evident modality): 5 points.
- If the customer stops near the display case for more than 3 seconds, the system must move away after the notification by voice (or another evident modality) so that the customer can access the products (e.g., move away from the front of the display case, return the drawer shelves to the original state): 5 points.
- Resume the task from the moved-away state after the customer has left. The system must resume the task after notifying this by voice (or another evident modality): 5 points.

### 3.7. Infrastructure for Products

In this task, additional points will be awarded for novel and feasible ideas and technologies for infrastructures that are applied to products. The additional points are applied to each product. 1 point is awarded if your ideas satisfy the following requirements. Additionally, if your idea satisfy both of them, 2 points are awarded to the correctly manipulated products after the demonstration.

#### 3.7.1. Marker for Product

Major design change of products by pasting markers are not recommended, from the viewpoint of practical use. Additional points will be awarded for challenging efforts in infrastructure for products with the aim of developing novel ideas and technologies as described below:

- Marker-less ideas or technologies for products.
- Robot friendly packages for products, which do not use traditional visual markers.

#### 3.7.2. Case for Product

If the products are placed into special robot friendly cases, the manipulation ability for products is increased, and the efficiency of manipulation is also improved. However, the approach leads to increasing cost because of the additional process for production. Moreover, the shape change is not a good approach because the shape of the product is often optimized to considering

distribution. If the products are not placed into a special case, the grasping and manipulation strategy becomes technically challenging. From this viewpoint, innovative ideas for products cases or packages will be awarded with additional points. Furthermore, additional points are also awarded for proposals for cases with a robot friendly design and keep the manufacturing process for products.

Based on the above viewpoints, additional points are awarded as described below.

- No use of cases or other infrastructure for products.
- Robot friendly packages which can keep the manufacturing process.

### **3.8. Retry**

If there is an abnormality during the demonstration and the emergency stop switch is activated or the operator verbally requests a retry, the task will be stopped, and the demonstration should be retried from the initial state. If a retry is requested after the products in the display case have been touched by the robot, the judge will rearrange the products in the display case.

The timer will not be stopped during the preparations in a retry. If the demonstration is performed several times due to retries, only the score of the final attempt will be taken into account.

## 4. Specifications and Restrictions

### 4.1. Products for the Task

There are 9 types of products for this task: plum rice balls, salmon rice balls, egg sandwiches, cabbage lettuce sandwiches, food pouches, drinks, and deep-fried chicken lunch boxes and other lunch boxes. Examples of each product are outlined below. The competition organizers will prepare the products. Please note that some of these products may not be used for the task on the day of the challenge due to changes in the product availability. Alternative products with similar specifications will be used in the event of a change. These changes will be announced on the official website of the competition.

#### 4.1.1. Rice Balls type 1

- Product name: Plum Rice Ball.
- Outer dimensions: approx. H80 x W100 x D40 mm.
- Weight: approx. 110g.

#### 4.1.2. Rice Balls type 2

- Product name: Salmon Rice Ball.
- Outer dimensions: H80 x W100 x D40 mm.
- Weight: approx. 110g.

#### 4.1.3. Rice Balls type 3

- Product name: Tuna Rice Balls.
- Outer dimensions: H80 x W100 x D40 mm.
- Weight: approx. 110g.

#### 4.1.4. Sandwiches type 1

- Product name: Egg Sandwich.
- Outer dimensions: approx. H130 x W90 x D60 mm.
- Weight: approx. 130g.

#### 4.1.5. Sandwiches type 2

- Product name: Cabbage Lettuce Sandwich.
- Outer dimensions: approx. H130 x W90 x D60 mm.
- Weight: approx. 130g.

#### 4.1.6. Food Pouch

- Product name: Hamburger Steak.
- Outer dimensions: approx. H150 x W160 x D65 mm.
- Weight: approx. 215g.

#### 4.1.7. Drink

- Product name: Café Latte (240 ml).
- Outer dimensions: approx. H105 x  $\phi$  75 mm.
- Weight: approx. 260g.

#### 4.1.8. Lunch Box 1

- Product name: Deep-fried Chicken Lunch Box (L).
- Outer dimensions: approx. H50 x W205 x D165 mm.
- Weight: approx. 417g.

#### 4.1.9. Lunch Box 2

- Product name: Nori (seaweed) Lunchbox.
- Outer dimensions: H40 x W210 x D145 mm.
- Weight: 410g.

#### 4.1.10. Adding Auxiliary Tools to Products

Participants can innovatively modify the geometry and materials of the containers and packages of products including attaching markings such as bar codes or IC tags to more easily manipulate the products. However, auxiliary tools that harm the presentation of the products and their attractiveness to customers, interfere with storage or stocking, cannot be used in microwave ovens or are unsanitary are prohibited. Participants must set up auxiliary tools during the renovation time.

## 4.2. Container

### 4.2.1. Standard Container Specifications

- Sanko SN Container C#32S.
- Outer dimensions: W690 x D441 x H136 mm.
- Inner dimensions: W629 x D380 x H120 mm.

#### 4.2.2. Usage Restrictions for Unique Containers

Participants can create their own containers to use instead of the standard containers. However, the following requirements must be satisfied:

- Products used for the stocking task must all fit inside the container.
- The containers must be stackable.
- The size must be equivalent to the standard container (outer dimensions: approx. W760 x D480 x H150 mm).

### 4.3. Display Case

#### 4.3.1. Standard Display Case Specifications

- Slit-type system fixture (gondola shelving).
- Outer dimensions: H1500 x D454 x W950 mm.
- Five display shelves (D400 x W900 mm): approx. 200 mm between shelves.
- The first shelf from the top is the top shelf, the third shelf is the middle shelf, and the fifth shelf is the bottom shelf.
- The heights of each shelf are: 500 mm, 700 mm, 900 mm, 1100 mm, 1300 mm from the floor, respectively.
- Each shelf is transparent and has a transparent front rail to prevent products from falling (H35 mm).
- Both sides of the display case have a side mesh.

#### 4.3.2. Usage Restrictions for Unique Display Cases

Participants can create their own display cases to use as infrastructure instead of the standard display cases. However, the following requirements must be satisfied:

- Outer dimensions: within H2000 x D2000 x W2000 mm.
- The display cases must not protrude into the aisles.
- The display cases must have five or more shelves (D400 x W900 mm).
- The minimum height of the bottom shelf is 300 mm, and the maximum height of the top shelf is 1500 mm.
- The shelves must have 150 to 250 mm of space between them.
- Each shelf must be transparent, or it must be possible to see the shelf below it if there are no products on the shelf (mesh, netting, etc.). There must be measures in place to keep products from falling.
- The products displayed on the shelves must be accessible to customers.
- The display case cannot be secured to the ceiling, floor, or walls of the

venue.

- When using drawer-type shelves, the shelves must be stowed at the beginning and end of the demonstration.
- Note that if the shelves are not stowed at the beginning or end of the demonstration, no score will be awarded for actions on the non-compliant shelves.

## 4.4. Mobile Robot and Infrastructure Restrictions

### 4.4.1. Hardware Restrictions

- There are no restrictions for the number of mobile robots.
- Each mobile robot must occupy less than 1 m x 1 m of floor space and all of the mobile robots must fit into the Home area.
- A mobile robot must have a maximum size of 1 m<sup>2</sup> in its initial position and during movement. Please note that the container will be considered as part of the robot if the container is built into the robot. However, the robot may exceed this maximum size temporarily while unloading the container, stocking products, or collecting disposal items.
- Infrastructure can be installed anywhere inside of the convenience store but different restrictions apply according to the area of the store. Please see the documents provided for more information.
- If the mobile robot or infrastructure separates during the demonstration, the team members should remove any separated objects from the field after the demonstration has finished.

### 4.4.2. Software Restrictions

- The mobile robots and infrastructure must operate autonomously after the start of the task. However, participants may monitor the internal status remotely to know the state of their system.
- Mobile robots are prohibited from moving outside of the convenience store.

### 4.4.3. Energy Source Restrictions

- Participants should prepare an energy source for their mobile robots.
- A power supply within AC100 V/1500 W is planned as the energy source for participants to use.
- Any energy source deemed to be dangerous or inappropriate for use will not be allowed.

#### 4.4.4. Venue Restrictions

- Participants are prohibited from intentionally dirtying or damaging the convenience store.
- Infrastructure must be removed immediately after the task ends to return the venue to its original state.
- The convenience store has no ceiling.

#### 4.4.5. Safety Restrictions

- Systems must have an emergency stop switch.
- The emergency stop switch must be separate from the switch used to start the system.
- The emergency stop switch must be located in a place where it can be safely pressed while the system is in motion or activated remotely.
- When activating the emergency stop remotely, only a wired push-button emergency stop switch may be used, and it must be located more than 1.5 m away.
- If the emergency stop switch is pressed, all of the movable parts included in the system must immediately stop operating.
- The design must prevent the system from tipping over at all times, including during an emergency stop.
- Measures must be taken to shield any area with a danger of pinching the arms and legs of people in the vicinity.
- Hot areas and sharp edges must not protrude.
- Energy sources utilizing fire or high temperatures are prohibited.
- Any laser used in the system must be class 1 or lower.
- Products and parts of robots must not eject anything.

## 5. Other

This rulebook is subject to change without notice.