IN ROBOSOFT COMPETITION 2023

RoboSoft Competition 2023

Scenarios and rules[1]

Date:

7th April 2023

Venue:

NUS E7, National University of Singapore

15 Kent Ridge Cres, Singapore 119276

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[1] The organizers can change, refine, and develop the following rules till the first day of the competition. Please visit regularly https://softroboticsconference.org/ for the latest version.

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COMPETITION OVERVIEW

The RoboSoft Competition 2023 invites teams to test the design and control of their robots in challenging scenarios. The competition will showcase novelties of soft robots like resilience, body compliance, delicate contact, and deformability.

The principal aim of the competition is twofold: first, to challenge state-of-the-art soft robots; second, to push the performance of soft robots beyond the state-of-the-art to increase their impact value.

Teams may comprise any combination of students, faculty, industrial partners, private partners, or government institutions without restricting the number of participants per team. One member of the team must be elected as Team Leader (TL) and will act as contact point for the team.

The RoboSoft Competition 2023 is made of scenarios which focus on real-world robot applications. Rather than showcasing a range of capabilities, this year competition will focus on two specific challenges: "**in-pipe locomotion**" and "**food handling for trays preparation**". In the 2023 edition, we keep exploring the autonomy on our mobile robots or manipulators, to reflect the advancements Soft Robotics did over the past decade. **For both scenarios, teams are invited to bring their own robot**. However, a standard manipulator will be provided for the food handling scenario, if requested.

Each scenario is split down into tasks: points are awarded by executing partially or completely each task. The robot that will earn the maximum number of points will be considered the winner of the RoboSoft Competition 2023. Each team participates with one robot, but multiple entries of the same team with different robot designs are allowed.

The competition will be held in person, but participants are invited to connect remotely if they wish to showcase their robots performing the scenarios from their lab (without competing).

OFFICIAL INFORMATION

The official information and interpretation about rules will be available on the RoboSoft 2023 website https://softroboticsconference.org/).

Rules (including this documents) and scenarios are subject to change. Please check regularly the RoboSoft 2023 website for last updates.

In case of any question, participants are invited to read carefully this document, and for further specifications to contact the competition chairs Marcello Calisti, mcalisti@lincoln.ac.uk, Albert Causo, acauso@handplusrobotics.com. For specific logistic questions, please contact Dr. Albert Causo.

VENUE AND SCHEDULE

The RoboSoft Competition 2023 will take place at the **NUS E7 Building** in the National University of Singapore Campus at **15 Kent Ridge Cres, Singapore 119276** on **Friday, 7th April 2023.**

FIGURE 1: NUS E7 BUILDING. THE BUILDING LOCATIONS IS HERE: https://goo.gl/maps/32noeagmfNMwLd8j8

A preliminary schedule of the competition is shown below:

Day	Date	Events
1	5th April 2023 Wednesday	• Teams' arrival and registration • Team set-up and tests
2	6th April 2023 Thursday	• Team set-up and tests
3	7th April 2023 Friday	• Morning: RoboSoft Competition 2023 • Afternoon: Awards ceremony

While the competition itself will be held on Friday, 7th April 2023, the Teams have the option to arrive up to 2 days earlier to set-up and test their systems. Space will be provided for each team for this purpose; the actual space size, allocation, and facilities provided will be confirmed early January 2023.

The venue will be equipped with the following [TO BE CONFIRMED]:

- 1 Table per team
- 230 50Hz VAC power extension (max 13A)
- Internet (Wi-Fi)
- Portable compressor: 2.5HP, 8 Bar, 200L/min, 24L tank, 64mm nozzle diameter (shared equipment)

The committee will evaluate additional equipment upon request. However, teams should try to bring all the materials and equipment they need. Further information regarding schedule and facilities will be provided later.

The main phases of the application procedure are reported below, along with the most important dates.

SUBMISSION PROCEDURE

To ensure competent entries only, a selection phase will take place in which a technical committee will evaluate the eligibility of each robot. The technical committee will be supervised by the competition chairs, which will be possibly aided by experts.

To manifest your interest to participate, please visit https://softroboticsconference.org/ and fill the online form: https://forms.gle/Ze9sAkrxXFp3PjN88 (also available within the competition section of the Contribution tab). The form should be submitted before **10th February 2023**; and it will contain a technical description of the robot and a video (max 2 minutes, 10Mega). Videos should be privately uploaded online, and the access should be provided with a link within the online form. The video should demonstrate the skills of the robot at the current state of development, while the technical document will summarize the expected improvements to be shown at the competition.

The acceptance notification will be on **24th February 2023.**

Participants will be requested to confirm their participation by **15th March 2023.**

SKILLS TO BE SHOWN IN THE VIDEO / EVALUATION CRITERIA

Skills to be shown are directly related to scenarios and tasks: teams should demonstrate minimum capabilities of their robots allowing them to be competitive during the competition. A complete list is presented here, grouped by scenario:

1. Terrestrial race
    a. Locomotion inside a straight pipeline
    b. Locomotion inside a curved pipeline (minimum 45 degrees, arbitrary curvature)
2. Manipulation
    a. Picking of objects (by grasping, curling around, etc…)
    b. Compliance of the gripper

The evaluation criteria will be on a do-it basis, thus a simple video demonstrating the ability to perform one of the skills listed above grants the eligibility.

It is mandatory to demonstrate the softness of the submitted entries within the technical documents. To be as inclusive as possible, we will evaluate softness either as material and/or as structural compliance, but the soft/compliant parts have to be:

- Clearly enable the function of the robot; OR
- Clearly improve the capabilities of the robot

Final robots which differ significantly from the submitted entries will be disqualified.

Autonomy will not be evaluated at this stage, but please bear in mind that robots should exhibit autonomous behaviour during the competition, i.e. they could not be teleoperated (but for a

significant decrease of points, see below). Energy autonomy is not required; thus robots could be tethered for both processing or computational purposes. Bear in mind that, if the tether will generate any kind of troubles for locomotion or manipulation, it has to be considered as part of the robot.

RESTRICTIONS

Despite the competition is open to participants' creativeness, some restrictions are required due to logistic requirements.

Robot maximum dimensions: Locomotion (no restrictions, but it must be able to navigate inside the pipeline) – Manipulation (total robot set-up, including accessories, cannot take more than 2 x 3 meters).

Robot maximum weight: Locomotion (2kg) – Manipulation (none).

Power supply: 230VAC electric power supply will be provided, while other power sources will be evaluated on request. Please check the plug standard currently in use in Singapore.

Compressor: Portable compressor will be provided with the following specifications -- 2.5HP, 8 Bar, 200L/min, 24L tank, 64mm nozzle diameter

Robots can be either tethered or untethered.

Upon acceptance, teams will be required to submit a technical description of their robot to evaluate potential safety issues. Any robot considered unsafe by the judges will be disqualified.

Keep in mind that the organizers are not responsible to damage to persons or objects. Teams are responsible for all the safety requests their robot demands, or for the safety of their actions during the competition.

THE ROBOSOFT COMPETITION 2023

The RoboSoft Competition 2023 is composed of two scenarios described in detail in the next sections. During a trial, teams will receive a maximum time slot upon which they must complete the scenario or part of it (that is completing a certain number of tasks). Only two operators (one operator should be the TL himself) can participate in the attempts during the competition day, and are allowed to operate inside the competition field, together with at least one judge who will supervise the execution of the trials.

In this edition, teams are challenged to show the autonomous behavior of their robots: even if it is still possible to teleoperate the robot, overall points will be multiplied by 0.25 if the robot is teleoperated.

The execution of a task can be stopped at any moment by the judges, or the TL can request to stop the trial. This can happen for safety issues or because the operators consider the robot stuck. After the TL request, judges allow the team to physically interact with the robot and to repositioning it to perform another attempt. A maximum number of three (3) attempts for each task can be performed, after which the task is considered not completed and the robot should be moved by the operators to the next task. A fraction of the total points can be assigned to the robot in case the task is partially completed.

The number of trials required to complete a task also affects the scoring, i.e. the maximum score can be earned by completing the task with the first attempt, then the score decreases at each subsequent attempt. The complete scoring is reported in Scoring section.

TERRESTRIAL RACE

Generality:
The robot is deployed inside a pipeline which requires inspection. The pipeline has to be autonomously navigated, and the robot should exit the pipes to allow potential recovery of data.

Description:
The pipes are connected to create a maze () the robot has to autonomously navigate from start to exit. Five different joints are proposed: straight, curved, restrictions, junctions, flexibles, and polluted. The straight pipes have small apertures that can be used to recover or move the robot, from task to task:

Task1: The robot starts on a straight pipe.
Task2: A 45-degree turn.
Task3: A 90-degree turn.
Task4: A U-turn.
Task5: An obstructed sector: the diameter of the pipe is reduced of 50%.
Task6: A 90-degree turn upward, followed by another 90-degree.
Task7: A two junction: here the robot has to go straight initially, then turn to complete one of the branches proposed. It is not required to follow a specific order.
Task8: This part of the pipeline will have 5 mm silicone walls, so they will not provide a solid wall to push against.
Task9: This task comprises the movements on dirty sectors, to simulated realistic pipes, and it will conclude with the selection and exit from the last tract.

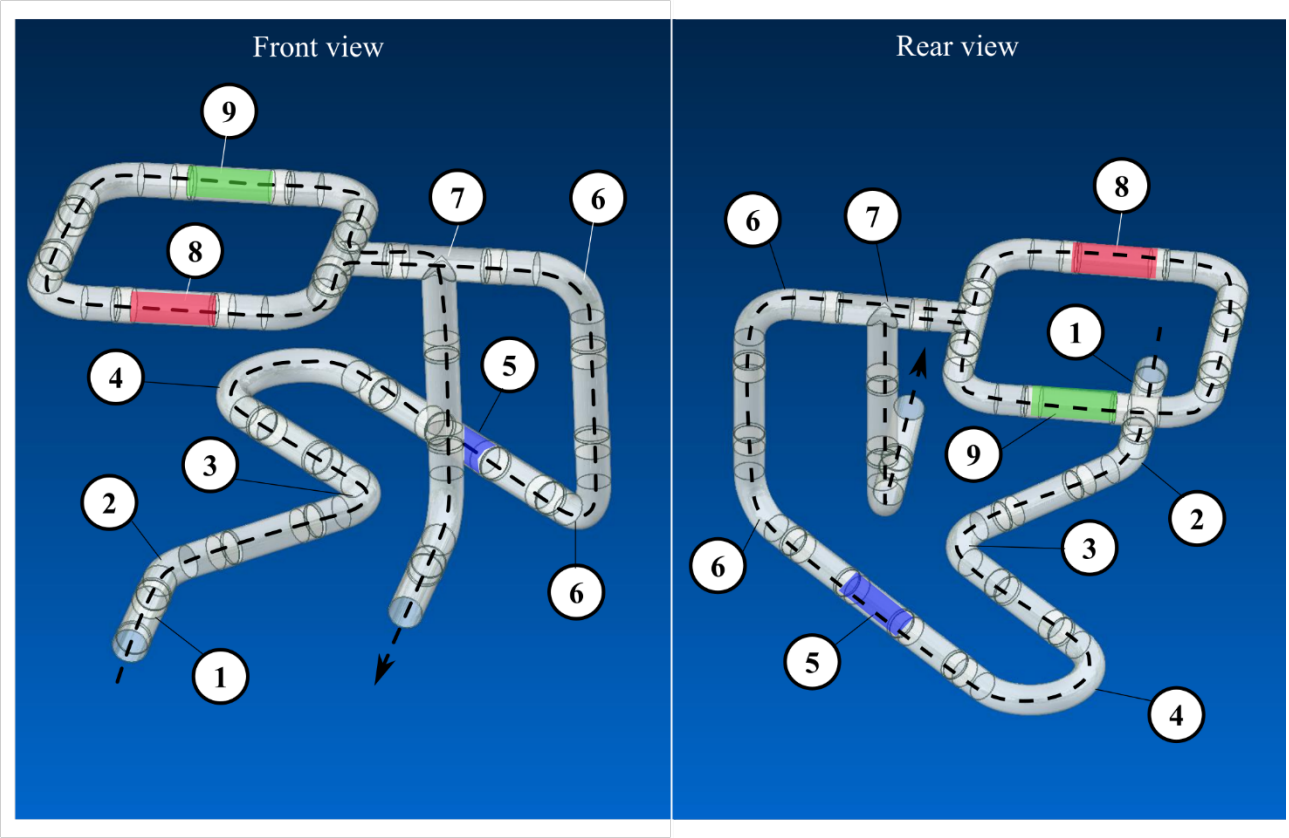

FIGURE 2: THE PIPELINE PROPOSED FOR THE LOCOMOTION SCENARIO. THE ROBOT HAS TO AUTONOMOUSLY NAVIGATE FROM THE ENTRANCE TO THE EXIT (INDICATED BY THE ARROW). THE TUBES HAVE APPROXIMATELY 10CM IN DIAMETER.

Material type used for the pipes, junctions, etc., will be disclosed soon. The whole track will be available as .igs and .stp files, to be downloaded from the Appendix.

MANIPULATION CHALLENGE : FOOD TRAY ASSEMBLY

INTRODUCTION:

The manipulation tasks for this year's competition focus on testing advances in gripper materials, grasping strategies, system integration with soft grippers, autonomy, and execution speed and repeatability. For this, the tasks would revolve around putting together a tray of food, a scenario applicable in healthcare, air travel, food & beverage, hospitality, and other service industries.

DESCRIPTION:

A robot must **assemble as many complete food trays** within a set time limit. The robot must use at least one "soft" component, such as but not limited to a gripper, and must be fully autonomous. The food tray **shall contain seven (7) types of food** selected from this list:

1. Sausages (cooked)
2. Meatballs (cooked)
3. Broccoli (florets, raw)

4. Carrots (sliced, 2-5mm thick, cooked)
5. Green Beans or French String Beans (cooked)
6. Spaghetti Noodles (cooked)
7. Cookies
8. Fried eggs (sunny side up)
9. Surprise Food Item 1 – Snack food locally available in Singapore*
10. Surprise Food Item 2 – Snack food locally available in Singapore*
11. Orange juice

*Surprise Food Items will be announced a few days before the competition. If they are included in the picking task, the surprise food items (#9-10) will randomly replace other foods in the list (#1-8).

THE PICKING TASK:

In no specific order, a robot must pick food items from one table and place them into particular containers on a tray. The robot may assemble up to 2 complete trays. For every item, please refer to the table below for the quantity, and specific considerations during picking/placing. Teams are allowed to decide on the picking strategy if there are no specific methods identified. Quantities listed on the table are just an indication and actual amounts will be revealed on the day of the competition. Each team will be given 30 minutes to complete the picking task.

S/N	Item	Quantity	Picking / Placing Requirements or Suggested Strategies
1	Sausages	5 pcs	Up to the team
2	Meatballs	5 pcs	Up to the team; the food must remain intact (in shape or constitution) after placing
3	Broccoli	5 pcs	Up to the team
4	Carrots	10 slices	Up to the team
5	Green beans	10 pcs	Up to the team
6	Spaghetti Noodles	200 grams	Up to the team
7	Cookies	3 pcs	Up to the team; the food must remain intact (in shape or constitution) after placing
8	Fried Eggs	3 pcs	Up to the team; the food must remain intact (in shape or constitution) after placing
9	Surprise Food Item 1	Surprise	Up to the team; the food must remain intact (in shape or constitution) after placing
10	Surprise Food Item 2	Surprise	Up to the team; the food must remain intact (in shape or constitution) after placing
11	Orange Juice	1/2 to 1/3 cup	The robot must pick up the carafe and pour the orange juice into a cup on the tray before returning it to its original location.

THE SET-UP:

There will be 2 tables – one to hold the food (Source Table) and another to keep the food trays to be assembled (Assembly Table). Please, refer to Figure 3 for the overall configuration and layout. The numbered shapes in both Tables refer to indicative location and not to actual shape nor measurement. Figure 4 below shows the actual layout of the Source and Assembly Tables. All parts used (tables, containers, trays, shelves, etc) are listed in "Table: Manipulation Set-up Components From Ikea".

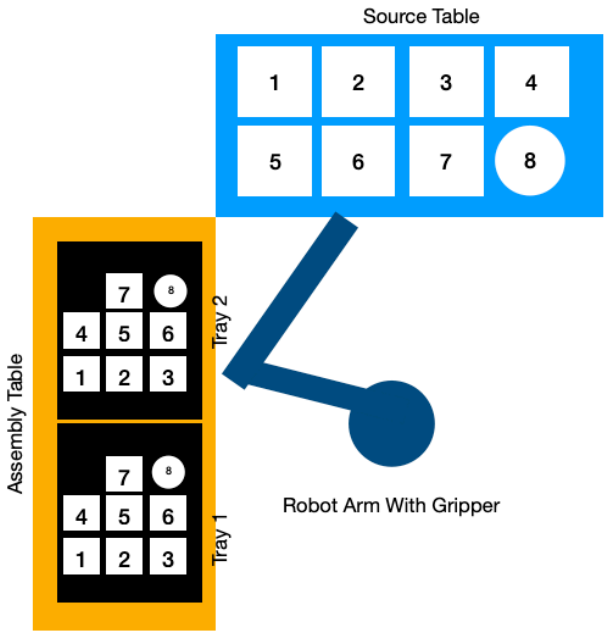

FIGURE 3: DIAGRAM OF THE MANIPULATION SET-UP

FIGURE 4: LAYOUT OF ASSEMBLY AND SOURCE TABLES

At the Source Table – the food and drink will be stored in food containers and jug either on the table or on the shelf on the table as shown in Figure 4. Each container will hold multiple units of the same food item. The layout (position) of the containers and the food assigned to each will be the same for the duration of the competition. Except for when there is Surprise food, which may replace food in any of the containers. The final layout, including the presence of the surprise food, will be announced a couple of weeks before the competition.

Here is a close-up of the Source Table:

FIGURE 5: DIFFERENT PERSPECTIVES OF THE SOURCE TABLE

At the Assembly table – two identical empty trays, with different sets of color plates/bowls/cups will be set-up on the Assembly Table. At the beginning of the picking run, the trays will be cleared and set-up (positioned) as shown in Figures 4 and 6. The plate itself may contain 2-3 food types, and the bowl may contain 1-2 food types. Each transparent plastic containers (side dish containers) will contain 1 food type. The cup is to be used for the juice only.

FIGURE 6: THE TWO TRAYS ON THE ASSEMBLY TABLE. THE COLOR OF THE PLATES TO USE ARE FIXED.

The whole layout set-up, including the positioning of the table, shelf, food containers, trays, plates, etc, on both the Source and Assembly **table will be set by the judges prior to each picking** according to the layout shown and **should not be modified by the participants at any time**. If during picking the robot accidentally moves any part of the set-up, the run will not be interrupted nor the set-up be returned to its starting state; the picking will be allowed to proceed to completion unless the

participant decides forfeits its turn. However, the judges reserve the right to reset the layout and restart the picking run on a case-by-case basis.

The tables' location and position to each other are fixed; the robot must be positioned such that it can reach both tables and the items on it. Participants are free to use any type of robot and base mounting. Figure 7 shows an example layout of a robot and the two tables. Participants may use mechanical positioners to precisely locate the robot and its base with respect to the two tables. However, such mechanical positioners must not be physically attached to either table.

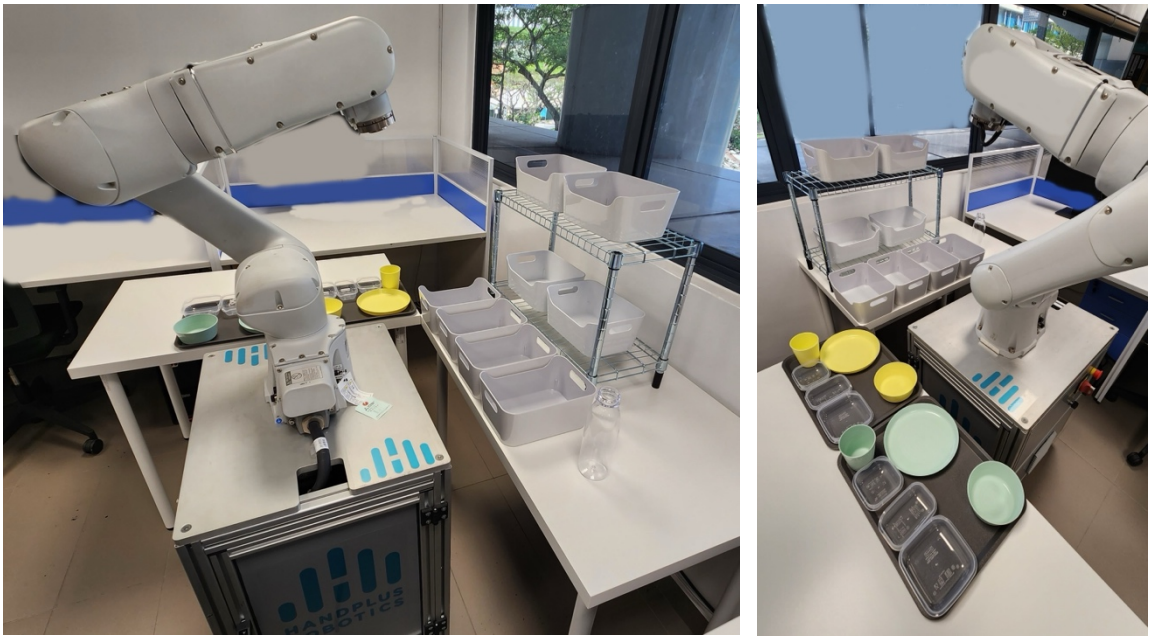

FIGURE 7: SAMPLE CONFIGURATION OF THE TABLES (SOURCE & ASSEMBLY) WITH ROBOT.

The robot may use cameras and other sensing methods to identify the items to be picked and placed into the tray. These cameras and sensors cannot be mounted, placed nor connected to the tables. Participants may choose to mount sensors onto the robot or separate holders (like tripods) that can be positioned around the table; these sensors holders should not block view or access to either the tables, the containers, shelf, and the trays.

Table: Manipulation Set-up Components from Ikea		
Component	**Purpose**	**Comments**
Omar Shelving (60 x 25 x 40 cm)	Shelf on Source Table	https://www.ikea.com/sg/en/p/omar-shelving-unit-galvanised-40483077/
Tillgang Grey 37x29cm	Tray	https://www.ikea.com/sg/en/p/tillgang-tray-grey-30419949/
Variera Box grey or white (24 x 17 cm)	Food container on Source Table	https://www.ikea.com/sg/en/p/variera-box-grey-70335108/#content (both grey and white are used in the set-up)
Ikea 365+ 0.7L Water Bottle	Orange Juice Container on Source Table	https://www.ikea.com/sg/en/p/ikea-365-water-bottle-striped-dark-grey-00512487/#content
Pruta Food Container, 17 pcs	Tray component	https://www.ikea.com/sg/en/p/pruta-food-container-set-of-17-transparent-green-30160964/

Kalas mug assorted	Cup for juice	https://www.ikea.com/sg/en/p/kalas-mug-mixed-colours-40378670/
Kalas plate assorted	Plates for food	https://www.ikea.com/sg/en/p/kalas-plate-mixed-colours-20378671/
Kalas bowl assorted	Bowls for food	https://www.ikea.com/sg/en/p/kalas-bowl-mixed-colours-60378669/
Linnmon Table Top (100x60 cm) + Adils Table Legs	Source and Assembly Tables' table top and legs	https://www.ikea.com/sg/en/p/linnmon-table-top-white-00361756 + https://www.ikea.com/sg/en/p/adils-leg-white-80217977

SCORING

Points are assigned for each completed part of the task. Additional points are awarded based on the number of attempts required to complete a part of the task. All scoring methods can be seen in the score tables.

TERRESTRIAL RACE

The scoring form for the Terrestrial Race is the following:

Task	***min***	***fair***	***good***	***I***	***II***	***III***
1	1	2	4	4	2	1
2	1	2	4	4	2	1
3	2	4	8	8	4	2
4	1	2	4	4	2	1
5	4	8	16	16	8	4
6	3	6	12	12	6	3
7	2	4	8	8	4	2
8	4	8	16	16	8	4
9	7	14	28	28	14	7

Points are assigned based on completion of part of the task:

	min	*fair*	*good*
Task1	The frontal part of the robot enters segment 1	The rear part of the robot enters enter segment 1	The rear part of the robot exits segment 1
Task2	The frontal part of the robot enters segment 2	The rear part of the robot enters enter segment 2	The rear part of the robot exits segment 2
Task3	The frontal part of the robot enters segment 3	The rear part of the robot enters enter segment 3	The rear part of the robot exits segment 3
Task4	The frontal part of the robot enters segment 4	The rear part of the robot enters enter segment 4	The rear part of the robot exits segment 4
Task5	The frontal part of the robot enters segment 5	The rear part of the robot enters enter segment 5	The rear part of the robot exits segment 5
Task6	The frontal part of the robot enters the vertical part of segment 6	The frontal part of the robot exits the vertical part of segment 6	The rear part of the robot exits segment 6
Task7	The frontal part of the robot passes the vertical part of the segment 7	The rear part of the robot passes the vertical part of the segment 7	The rear part of the robot exits segment 7
Task8	The frontal part of the robot enters segment 8	The rear part of the robot enters enter segment 8	The rear part of the robot exits segment 8
Task9	The frontal part of the robot exits segment 9	The frontal part of the robot enters the vertical part of segment 7	The rear part of the robot exits the pipeline structure

The maximum score achievable is 200 (all task solved with good level, and at the first attempt). No points are assigned if is no parts of the task will be completed.

MANIPULATION

The score for the manipulation challenge is based on the number of food items correctly placed into the target container (tray/plate/cup). Partial points will be given for incomplete food items for

multiple item picks. Penalties will be given for damaging food items. Bonus points can be earned for completing a tray and for completing the task below the target time.

TYPE OF POINT	BASIS	POINTS
Gain	Correctly placing food items into the correct target container	+3 points per item *e.g., a 5-item food means max score for picking all of it is 15 points. Successful pick & place of only 2 items garners only 6 points.*
Bonus	Complete picking of the required quantity of the food items without damaging any of it	+5 points
	Completing one tray within 10 minutes	+20 points
	Completing 2 trays within 20 minutes	+40 points
	Completing 2 trays within 15 minutes	+50 points
Penalties (no gains nor bonus assigned)	Substantial damage to a food item during picking or placing	-3 point per item
	Placing the item into the wrong target container/plate/bowl/cup	-1.5 point per item
	Dropping any food item outside of the source or target container/plate/bowl/cup (Items dropped but picked up and set aside by the robot before the end of the run will not earn penalty point)	-2 point per item
	Exceeding the quantity or volume of items picked	-1 point per item exceeding the limit

It is possible to have a negative score; the highest score possible has potentially no limit. A tray is considered complete if the correct quantity and type of food items are correctly placed in their right containers without any substantial damage to any of the food items.

APPENDIX

The Locomotion field will be based on the hamster tube available at https://www.alibaba.com/product-detail/High-quality-mouse-cage-accessories-PP_1600536010041.html?spm=a2700.galleryofferlist.normal_offer.d_title.342df564Rwdcc3.
Modifications to the tube will be made to provide the exact shape of the locomotion, as reported in the .iges file available at the competition webpage. Competitors might build their own field to test the robot, by considering that overall dimensions will be respect, but discrepancies are expected from the provided file.