

Preparation and dish Up of an English Breakfast with Robots (PUB.R) challenge

SCENARIOS AND RULES¹

DATES:

MAY 29, 2023 – JUNE 2, 2023

VENUE:

EXCEL LONDON

ROYAL VICTORIA DOCK, 1 WESTERN GATEWAY
LONDON, E16 1XL

Authors:

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¹The organizers can change, refine, and develop the following rules till the first day of the competition. Please visit regularly <https://lcas.lincoln.ac.uk/wp/events/the-pub-r-competition/> for the latest version.

²MC, FdD, MH and ES are with the University of Lincoln. FF and FI are with University of Cambridge.

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1 Competition overview

Within the framework of the 2023 edition of the ICRA conference, we invite teams to test the design and control of their robots in the **P**reparation and dish **U**p of an English **B**reakfast with **R**obots (PUB.R) competition. The competition will showcase the last advancements in food handling and preparation, by challenging traditional robotics domains, including navigation, manipulation, and scene understanding, but also proposing novel scientific challenges, such as robotic food tasting, communication, creativity, and art.

Teams may comprise any combination of students, academic members, private partners, government institutions, etc., without restriction on 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.

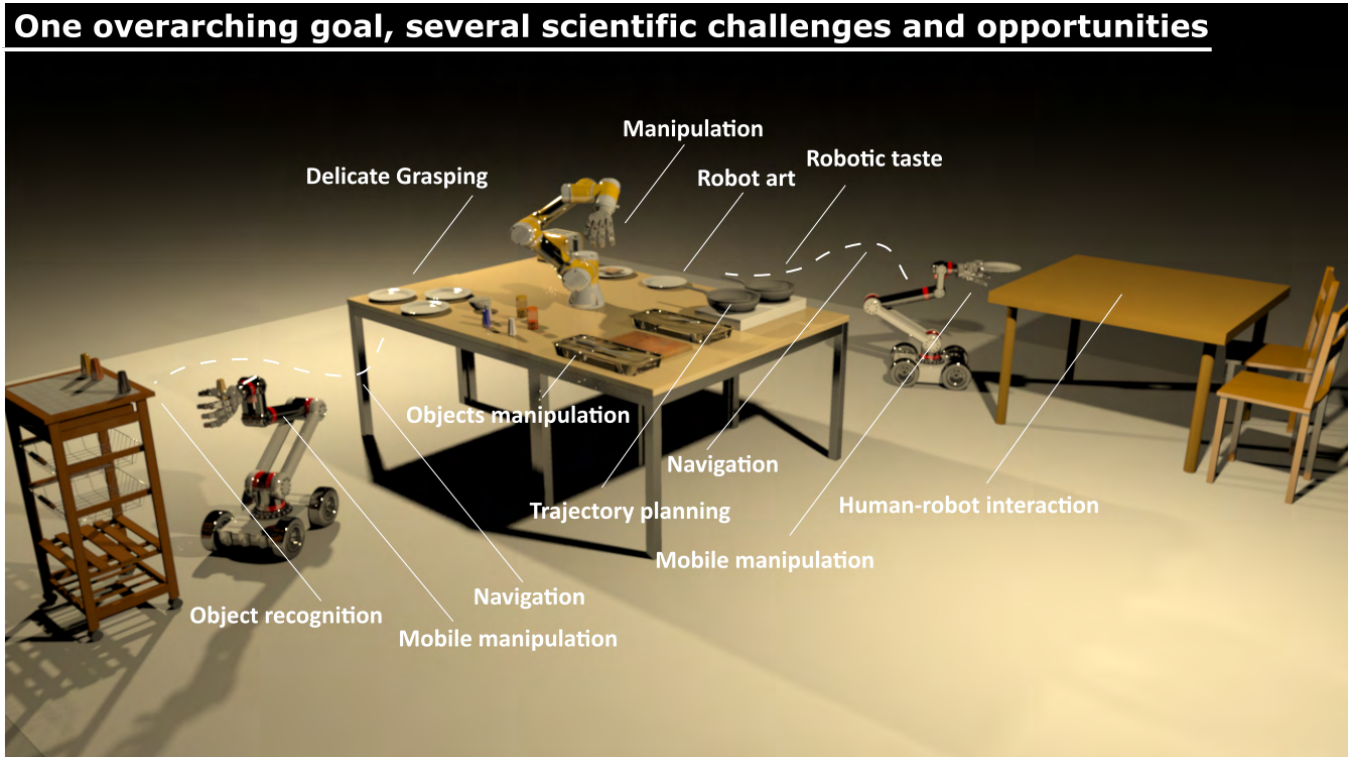


Figure 1: The PUB.R Competition includes three different scenarios: shopping, serving and cooking.

The PUB.R competition comprises three different scenarios (see Fig.1): *Shopping*, *Cooking*, and *Serving*, each challenging different research aspects, integrated in a single overarching goal. In the first scenario (**Shopping**), a subset of spices and sauces should be collected from a pantry area, and brought to the cooking station to prepare the desired recipe. In the second scenario (**Cooking**), the food has to be prepared, cooked and arranged on the plate, by taking into consideration taste and appearance of the final dish. In the last scenario (**Serving**), a robot has to serve the meal to a table for judging preparation and plate arrangement, it has to explain the dish, and to answer simple questions. **For all scenarios, teams are invited to bring their own robot.** However, a Tiago robot and a Baxter will be provided, if requested. Due to the limited availability, the organisers cannot provide a robot for each single requesting teams for exclusive use during the setup and competition days; i.e., it is possible that a robot needs to be shared among multiple teams.

Each scenario is split down into tasks: points are awarded by executing partially or completely each task. The team that will earn the maximum number of points will be considered the winner of the PUB.R Competition 2023.

The official information and interpretation about rules will be available on the PUB.R Competition website <https://lcas.lincoln.ac.uk/wp/events/the-pub-r-competition/>.

Rules (including this document) and scenarios could be subject to minor changes. Please check regularly the PUB.R Competition 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, Francesco del Ductetto, FDelDuctetto@lincoln.ac.uk.

2 Venue and schedule

The PUB.R Competition 2023 will take place at the ExCel London, Royal Victoria Dock, 1 Western Gateway, London, E16 1XL (Fig. 2), from Thursday, the 1st of June 2023 to Friday the 2nd of June 2023. Preparation, tests, and refinements will be scheduled from Tuesday, the 30th of May 2023, to Wednesday the 31st of May 2023.

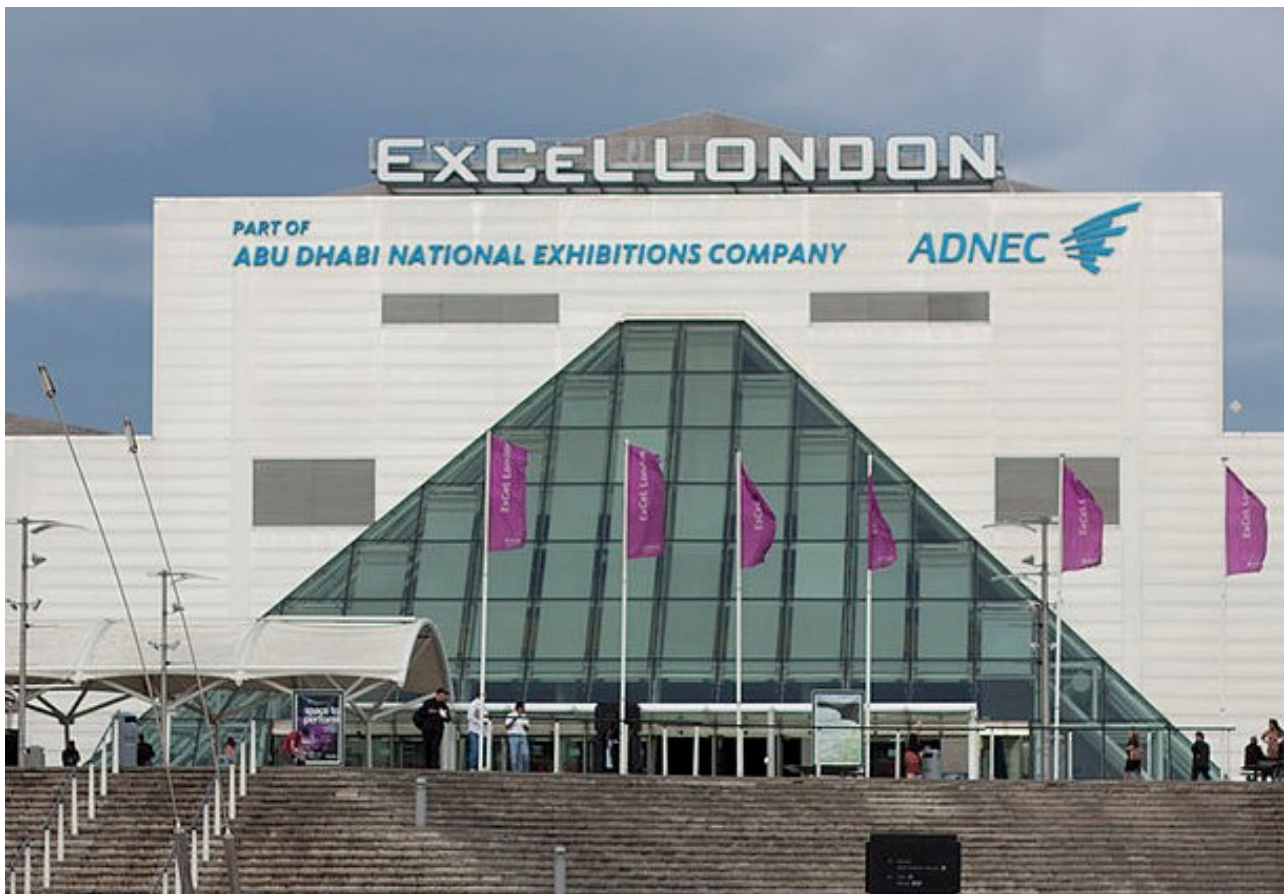


Figure 2: The ExCel Exhibition Centre will host the ICRA conference and the competitions.

Space will be provided for each team to prepare and refine their robots; the actual space size, allocation, and facilities provided will be confirmed early April 2023. Tentative equipment comprises:

- 1 Table (standard size, about 140x70cm)
- 2 Chairs
- Power mains (Any electric outlet, extension or cabling you will need to supply or go through our supplier)

The committee will evaluate additional equipment upon request. However, teams should consider to bring all the materials and equipment they might need.

Day	Date	Event
1	May 29, 2023	Teams' arrival and registration
2	May 30, 2023	Pre-competition trials
3	May 31, 2023	Pre-competition trials
4	June 1, 2023	Competition day1
5	June 2, 2023	Competition day2 and award ceremony

Table 1: Preliminary schedule of the competition.

3 Submission and Registration 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://lcas.lincoln.ac.uk/wp/events/the-pub-r-competition/> and fill the online form: <https://forms.office.com/e/he4zwaZdDJ>. The form should be submitted before **April 14, 2023** and it should 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 **April 15, 2023**.

Participants will be requested to confirm their participation by **April 21, 2023**.

3.1 Skills to be shown/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. For the pre-selection phase, We ask teams to explain their your approach to solving at least one of the tasks proposed in the competition, and to show it via a video.

3.2 Registration

Any member of the teams will need to be registered to receive a pass to enter the competition hall. A confirmation email is sufficient to register, and it should be sent to mcalisti@lincoln.ac.uk before **April 21, 2023**. The competition pass will only give access to the competition hall: if you wish to gain access to the full conference, teams' members need to have a valid conference registration. Please refer to ICRA2023 webpage <https://www.icra2023.org/welcome> to register to the conference.

4 Restrictions

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

Robots can be either tethered or untethered. Teams are required to submit a technical description of their robot to evaluate potential safety issues. Any robot considered unsafe by the judges will be promptly communicated, and unresolved breaches will result in the disqualification of the team.

Feature	Manipulator	Mobile robot
Robot maximum dimensions:	3.5m spherical workspace	3.5m spherical workspace (fixed)
Robot maximum weight:	25kg	100kg
Power supply (if tethered):	230VAC mains, 8kW max	230VAC mains, 8kW max

Table 2: Restrictions

The hot ingredients have to be touched always with kitchen utensils (teams are invited to bring their own, even bespoke ones for their robot. Team bespoke solutions are subject to logistic and safety checks).

The kitchen utensils provided by the organizers can mount mechanical interfaces to help the grasp. Teams should bring their own interfaces.

For safety reasons, only the pans and knife provided by the organizers can be used.

Pans and knife can mount mechanical interfaces, as for the other utensils.

Keep in mind that the organizers are not responsible for the damage to persons or objects. Teams are responsible for all the safety requirements of their robot(s), and for the safety of their actions during the competition.

5 The PUB.R Competition 2023

The PUB.R Competition is composed of three scenarios, described in detail in the next sections. Each scenario is split into tasks that are scored based on the difficulty of the task and the number of attempts required to complete it. **The Shopping scenario will contribute to 20% of the total score, the Cooking scenario 50%, and the remaining 30% will be assigned to the Serving scenario.** The team that earns the maximum number of points will be considered the winner of the ICRA 2023 PUB.R Competition.

During a trial, teams will have **40 minutes** during 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) can participate in the trial and are allowed to operate inside the competition field, together with at least one judge who will supervise the execution of the trials.

Teams are challenged to show the autonomous behavior of their robots, however they can decide to perform some tasks manually: in such case the TL will solve the task in place of the robot, but points will not be awarded. 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 makes a request, the judges will allow the team to interact with the robot and to prepare it for the next attempt. A maximum number of three attempts for each task can be performed, after which the task is considered not completed and the task should be executed manually by the operators. **Points for a specific task will be multiplied by 0.5 on the second attempt, and by 0.25 on the third. Qualitative criteria will be used to determine, on each task, if it is completely solved, or partially solved. In the latter case, points will be multiplied by 0.5.** Scores and task details are reported in Sec.6.

The scenarios can be solved with a single robot, or with multiple robots. Teams are invited to bring their own robot(s), but robotic platforms (2 Tiagos and 1 Baxter) will be made available to the team, upon request.

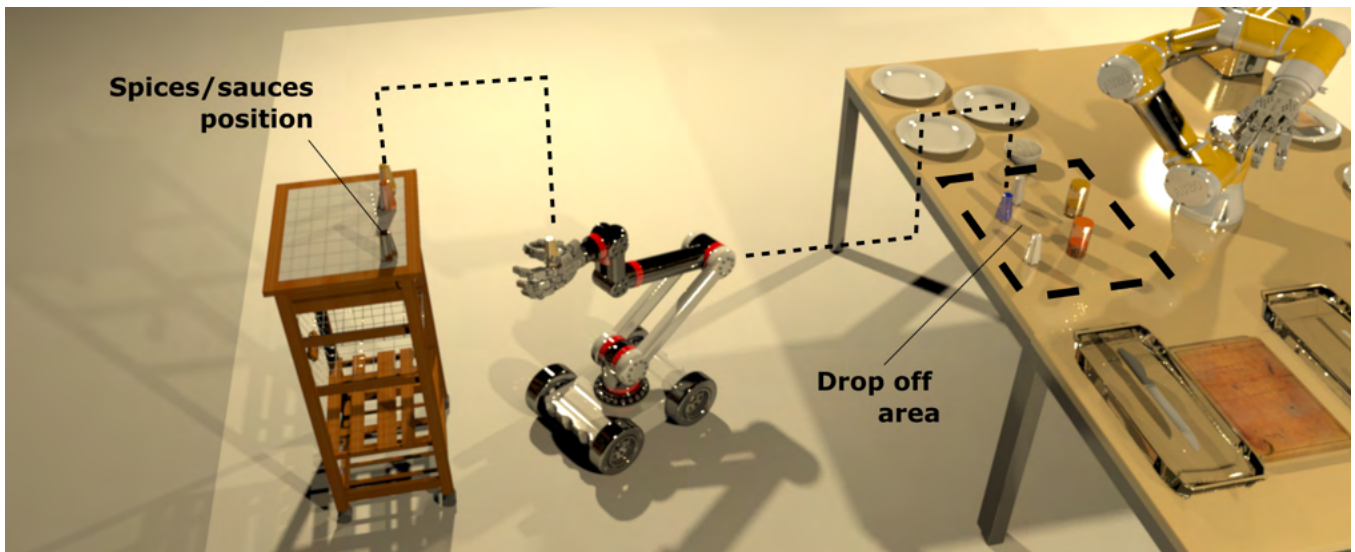


Figure 3: In the shopping scenario, sauces and spices should be collected from a pantry area and delivered to the cooking table.

5.1 Shopping

In the shopping scenario, the robot is given the possibility of collecting the sauces and spices that it intends to use for preparing the dish. The sauces and spices will be located in a “pantry area” on a spice table, which is a few meters away from the cooking area. Therefore, it is necessary that the robot is able to reach the pantry, collect the required ingredients and bring them to the “raw ingredients” area. Sauces are stored in squeeze bottles and spices in spice shakers without lids, each positioned in front of a printed label with their name (or Aruco markers). The specific models and pictures of the containers will be provided in advance to the teams. The list of such ingredients is shown in Table 3.

The robot is expected to pick Ketchup and Brown sauce, and up to three additional spices declared in advance by the TL. The full list of task, points awarded and accomplishment criteria are reported in Table 4.

Ketchup	Pepper
Brown sauce	Salt
Coriander	Parsley
Cumin	Chili flakes
Turmeric powder	Garlic powder

Table 3: The sauces and spices available in the pantry to be used for cooking and seasoning the dish.

5.2 Cooking

In the cooking scenario, **the robot is expected to cook one toast, plus four additional ingredients** selected by each team at the beginning of the competition. At most two of the additional ingredients have to be hot (i.e., cooked), with the remaining ones being prepared cold. Some ingredients can be prepared both hot and cold, however a specific preparation of one ingredient cannot be repeated more than once during the same trial. The hot ingredients have to be touched always with kitchen utensils (teams are invited to bring their own, even bespoke ones for their robot).

The organizers will provide a set of standard tools including a spatula, a spoon, and whiskers, but we are open to team-invented solutions (team bespoke solutions are subject to logistic and safety checks).

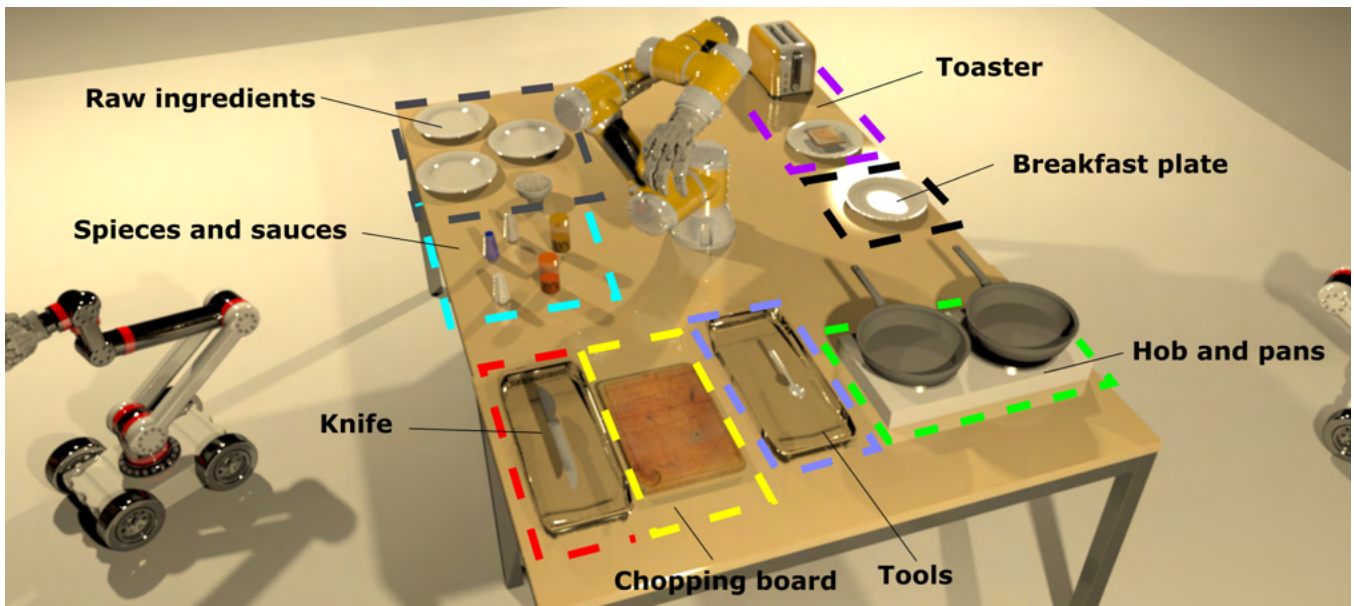


Figure 4: The cooking scenario is divided in three main sectors: raw ingredients and spices area, chopping area, cooking area; and dish-up area. Approximate position of each element will be provided to the teams.

However, for safety reasons, only the knife and pans provided by the organizers could be used. The kitchen utensils provided by the organizers can mount mechanical interfaces to help the grasp. Teams should bring their own interfaces. Exact models of the tools provided by the organizers can be retrieved in the Appendix, Sec. 7.

Each ingredient should be cooked/prepared according to the the list of tasks presented in Tables 5–7. Additional steps can be used by the teams, to ensure a proper dish-up or to follow bespoke procedures, but to standardise the points, only the accomplishment of the listed tasks will award points.

The ingredients will be provided on the “raw ingredients” designated area without labels. Therefore, the robot must detect them to be able to prepare them. The robot can cook/prepare the different ingredients in any preferred order. However, once it has started preparing an ingredient it needs to continue with it, performing all the listed tasks for that specific ingredient before moving on with the next ingredient.

The spices and sauces collected during the Shopping scenario, Sec. 5.1, can be used at any moment and any number of times during the *cooking* phase. In order to ensure that the ingredients are properly cooked and well seasoned the teams are encouraged to bring and use additional tools (not provided by the organisation team), like food thermometers and “taste” sensors.

At the end of the scenario, the cooked/prepared ingredients with the condiments should all be present on the plate, ready to be served to the judges. The composition of the ingredients in the plate and its aesthetic is evaluated in the Serving scenario, Sec. 5.3.

It is worth to be mentioned that, if logistic issues will prevent the employment of hobs, toasters, or other cooking devices, ingredients to prepare a cold breakfast will be selected, and the equipment will be adapted by taking into account such limitations.

5.3 Serving

During the serving scenario, the robot needs to successfully serve the food to the judges. The scenario consists of two parts that have to be performed sequentially. In the first part, the robot needs to pick up the plate with the breakfast prepared during the previous scenario. The robot and the team are not allowed

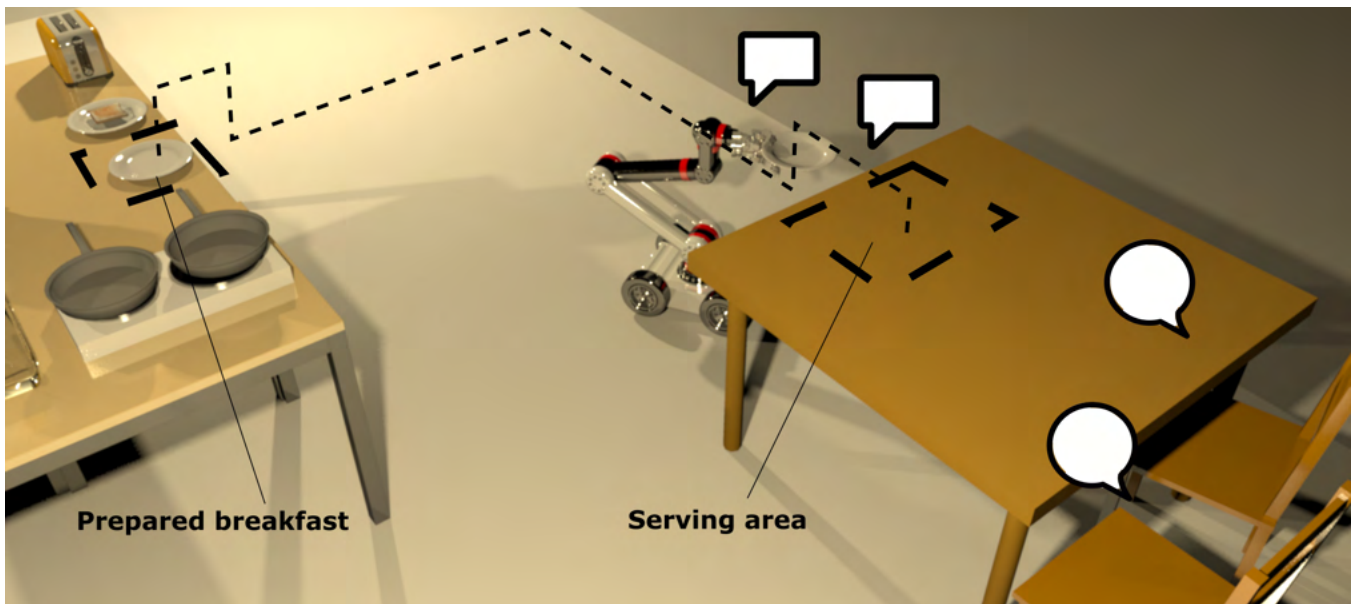


Figure 5: The serving scenarios will include a navigation and mobile manipulation task, followed by a human-robot interaction part.

to alter the plate between the *Cooking* and *Serving* scenarios, for example adding ingredients/condiments or altering the plating arrangement.

In the second part, judges ask four open ended questions about the dish as a whole, for example asking “Can you please describe the dish?”, or about the specific ingredients, for example “Does the breakfast contain tomatoes?”. The complete list of tasks and points is reported in Tab. 8.

The prepared plate will be evaluated by a panel of judges in terms of its visual pleasantness, creativity, technical difficulties, and correctness of cooking. The judges can award up to half the points available for this scenario. Established professional of robotic kitchens, academics, and chefs might be part of the judging committee for this scenario.

6 Task lists and score

List of tasks and points assigned, divided by scenarios, are presented hereafter.

Task	Partial condition	Pts
Navigate in front of the spice table	From 1 to 10cm outside the arm task space	7
Grasp and lift the Ketchup	Correct object grasped, but slip after lifting	4
Grasp and lift the Brown sauce	Correct object grasped, but slip after lifting	4
Grasp and lift the correct spice (1)	Correct object grasped, but slip after lifting	5
Grasp and lift the correct spice (2)	Correct object grasped, but slip after lifting	5
Grasp and lift the correct spice (3)	Correct object grasped, but slip after lifting	5
Move Ketchup	Object fell during motion	4
Move Brown sauce	Object fell during motion	4
Move the correct spice (1)	Object fell during motion	4
Move the correct spice (2)	Object fell during motion	4
Move the correct spice (3)	Object fell during motion	4
Navigate in front of the ingredients area	From 1 to 10cm outside the arm task space	7
Place Ketchup in the ingredients area	Placement outside the area	5
Place Brown sauce in the ingredients area	Placement outside the area	5
Place the spice (1) in the ingredients area	Placement outside the area	5
Place the spice (2) in the ingredients area	Placement outside the area	5
Place the spice (3) in the ingredients area	Placement outside the area	5

Table 4: The task list, qualitative criteria for partial success, and points for the **shopping** scenario. Even if the team decide to navigate multiple times from the pantry area to the cooking area, points for navigation are awarded once. Spices and sauces will be in two rows: if team decide to pick them from the rear row, they will add 2 points for each sauce/spice "grasp and lift" from the second row.

Task	Partial condition	Pts
Toast		
Pick and lift a slice of toast	Toast grasped but not lifted	9
Move the toast	Object fell during motion	5
Insert it in the toaster slot	Partially inserted	7
Move down the toaster lever	Lever not fully lowered	5
Pick and lift the toast from the toaster	Toast grasped but not lifted	6
Move the toaster and place it in the serving plate	Placement outside the plate	4
Beans (cold)		
Pick and lift the bowl	Bowl grasped but not lifted	8
Move the bowl	Object fell during motion	7
Pour the beans into the serving plate	Placement outside the plate	5
Place the bowl back in place	Placement outside the plate	2
Cheddar cheese		
Pick and lift the knife from the tool holder	Knife grasped but not lifted	5
Cut a slice of cheddar cheese	Cheese cut but slice not fully separated	8
Place the knife back in the tool holder	Placement outside the tool holder	2
Pick and lift the cheddar slice	Slice grasped but not lifted	8
Move and place the cheddar slice into the serving plate	Placement outside the plate	5
Tomato (cold)		
Grasp and lift the tomato	Tomato grasped but not lifted	7
Move it and place on the chopping board	Object fell during motion	5
Pick and lift the knife from the tool holder	Knife grasped but not lifted	5
Cut the tomato in two parts	Tomato cut but halves not fully separated	8
Place the knife back in the tool holder	Placement outside the tool holder	2
Grasp and lift the tomato (1st half)	Tomato grasped but not lifted	7
Move and place the 1st half into the serving plate	Placement outside the plate	4
Grasp and lift the tomato (2nd half)	Tomato grasped but not lifted	7
Move and place the 2nd half into the serving plate	Placement outside the plate	4

Table 5: The task list, qualitative criteria for partial success, and points for the **cooking** scenario. This table is for the toast and for the cold preparations.

Task	Partial condition	Pts
Beans (hot)		
Turn on the hob	No partial condition	4
Pick and lift the bowl	Bowl grasped but not lifted	8
Move the bowl	Object fell during motion	7
Pour the beans into the pan	Beans outside the pan	5
Place the bowl back in place	Placement outside the area	2
Execute at least one stirring action on the beans	Stir started but not completed	5
Grasp and lift the pan from the handle	Pan grasped but not lifted	8
Move the pan	Object fell during motion	7
Pour the beans into the serving plate	Placement outside the plate	7
Place the pan back on the hob	Placement outside the hob	4
Turn off the hob	No partial condition	4
Egg		
Turn on the hob	No partial condition	4
Pick and lift the bowl	Bowl grasped but not lifted	8
Move the bowl	Object fell during motion	7
Pour the egg into the pan	Egg outside the pan	5
Place the bowl back in place	Placement outside the area	2
Execute at least one stirring action on the egg	Stir started but not completed	5
Grasp and lift the pan from the handle	Pan grasped but not lifted	8
Move the pan	Object fell during motion	7
Pour the egg into the serving plate	Placement outside the plate	7
Place the pan back on the hob	Placement outside the hob	4
Turn off the hob	No partial condition	4
Vegan sausage		
Turn on the hob	No partial condition	4
Pick and lift the sausage	Sausage grasped but not lifted	6
Move and place it into the pan	Object fell during motion	6
Pick and lift the cooked sausage with the tool	Sausage touched but not lifted	7
Move and place the sausage into the serving plate	Placement outside the plate	8
Turn off the hob	No partial condition	4
Vegan bacon		
Turn on the hob	No partial condition	4
Pick and lift the bacon	Bacon grasped but not lifted	6
Move and place it into the pan	Object fell during motion	6
Pick and lift the cooked bacon with the tool	Bacon touched but not lifted	7
Move and place it into the serving place	Placement outside the plate	8
Turn off the hob	No partial condition	4

Table 6: The task list, qualitative criteria for partial success, and points for the **cooking** scenario. This table is for hot ingredients that do not require cutting.

Task	Partial condition	Pts
Tomato (hot)		
Grasp and lift the tomato	Tomato grasped but not lifted	7
Move it and place on the chopping board	Object fell during motion	5
Pick and lift the knife from the tool holder	Knife grasped but not lifted	5
Cut the tomato in two parts	Halves not fully separated	8
Place the knife back in the tool holder	Placement outside the tool holder	2
Grasp and lift the tomato (1st half)	Tomato grasped but not lifted	7
Move and place the 1st half into the pan	Placement outside the pan	4
Grasp and lift the tomato (2nd half)	Tomato grasped but not lifted	7
Move and place the 2nd half into the pan	Placement outside the pan	4
Turn on the hob	No partial condition	4
Pick and lift the cooked tomato (1st half)	Tomato grasped but not lifted	9
Move and place it into the serving plate	Object fell during motion	8
Pick and lift the cooked tomato (2nd half)	Tomato grasped but not lifted	9
Move and place it into the serving plate	Object fell during motion	8
Turn off the hob	No partial condition	4
Mushroom		
Grasp and lift the mushroom	Mushroom grasped but not lifted	7
Move it and place on the chopping board	Object fell during motion	5
Pick and lift the knife from the tool holder	Knife grasped but not lifted	5
Cut the mushroom in two parts	Halves not fully separated	7
Place the knife back in the tool holder	Placement outside the tool holder	2
Grasp and lift the mushroom (1st half)	Mushroom grasped but not lifted	6
Move and place the 1st half into the pan	Placement outside the pan	4
Grasp and lift the mushroom (2nd half)	Mushroom grasped but not lifted	6
Move and place the 2nd half into the pan	Placement outside the pan	4
Turn on the hob	No partial condition	4
Pick and lift the cooked mushroom (1st half)	Mushroom grasped but not lifted	8
Move and place it into the serving plate	Object fell during motion	7
Pick and lift the cooked mushroom (2nd half)	Mushroom grasped but not lifted	8
Move and place it into the serving plate	Object fell during motion	7
Turn off the hob	No partial condition	4

Table 7: The task list, qualitative criteria for partial success, and points for the **cooking** scenario. This table is for hot ingredients that require cutting.

Task	Partial condition	Pts
Navigate in front of the cooking table	From 1 to 10cm outside the arm task space	7
Grasp and lift the serving plate	Plate grasped but not lifted	8
Navigate with the plate to the judges' table	From 1 to 10cm outside the arm task space	8
Place the plate onto the judges' table	Placed outside correct area	7
Reply in natural language to the first question	Question understood but wrong answer	5
Reply in natural language to the second question	Question understood but wrong answer	5
Reply in natural language to the third question	Question understood but wrong answer	5
Reply in natural language to the forth question	Question understood but wrong answer	5
Judges subjective evaluation	No partial condition	50

Table 8: The task list, qualitative criteria for partial success, and points for the **serving** scenario.

7 Appendix

7.1 Floor plan

The PUB.R Competition area will be divided in set-up, and competition zones, respectively where the teams could refine their robots, and where the robots will compete. The cooking station, while in operation, will be surrounded by transparent protective elements. An overhead view of the competition area is presented in Fig. 6.



Figure 6: Overview of the competition area. To the left, the set-up area for the teams; to the right, the competition area.

The PUB.R competition wants to highlight the autonomous behaviour of the competing robots, along the whole pipeline of a meal preparation. Therefore, exact locations of the objects are not provided. However, overall dimensions are reported in Fig. 7.

7.2 Equipment, components and materials

The object that will be used during the competition are reported in Fig. 8. We selected mostly objects easy to purchase, and that can be employed by teams during preparation.

7.3 Provided Robots Specifications

In the following sections, you can find the details about the robots that are available to request for use during the setup and competition days.

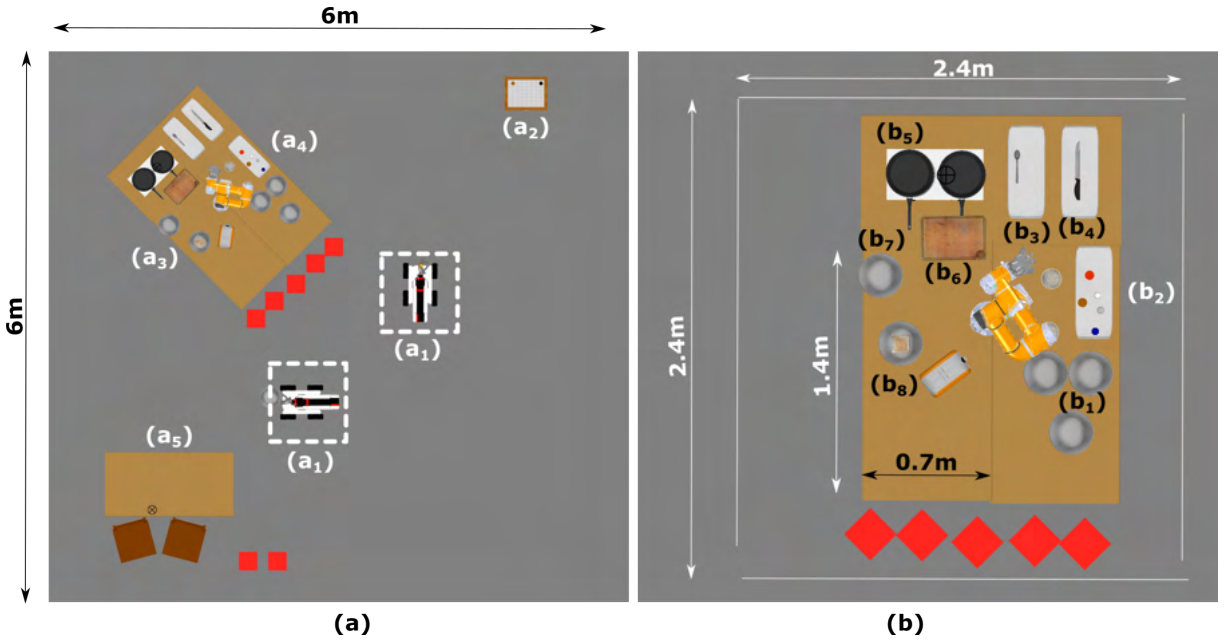


Figure 7: Approximate sizes of the competition zone, and objects position. In picture (a), the starting positions of the robot for the shopping and serving scenario are reported as (a1), the spice table (a2), the prepared breakfast (a3), the dropping area for the spices (a4), and the judges table (a5). In picture (b), the cooking tools/appliances will be placed as reported: the ingredients area (b1), the spices area (b2), the tools (b3) and knife (b4) position, the hobs (b5), the chopping board (b6), the serving plate (b7), and finally the toasts and the toaster (b8).

#	element	category/description	supplier
1	HEMLAGAD	Frying pan, black, 24 cm, for induction hobs	IKEA
2	DIREKT	3-piece kitchen utensil set, black/stainless steel	IKEA
3	OFTAST	Bowl, white, 11 cm	IKEA
4	OFTAST	Plate, white, 25 cm	IKEA
5	ÄNDLIG	3-piece knife set, light grey/white	IKEA
6	TILLREDA	Portable induction hob, 2 zones white	IKEA
7	LEGITIM	Chopping board, white, 34x24 cm	IKEA
8	HÅLLBAR	Bin with lid, light grey, 10 l	IKEA
9	UPDATERA	Tray with knife rack, white/anthracite,	IKEA
10	STÖDJA	Utensil tray	IKEA
11	TILLÄMPAD	Tongs, stainless steel (2 pieces)	IKEA
12	Russell Hobbs 26060 2 Slice Toaster	Toaster with Extra Wide Slots and High Lift Feature	amazon
13	Plastic bottles	Keleily Sauce Squeeze Bottle 500ml with Cap (1 set)	amazon
14	ROSNONG 24 Spice Jars with Lids	24 Spice Jars with Lids (1 Set)	amazon

Figure 8: Object name, description and verified supplier.

7.3.1 TIAGo

The organisers will provide 2 TIAGo robots³, each with a 7-DOF arm and a parallel gripper as an end-effector as shown in Figure 9. Additionally, the robot has a mobile base with a laser scan and sonar sensors for localisation and navigation, an RGBD camera for machine vision, microphones and speakers for speech

³<https://pal-robotics.com/robots/tiago/>

interactions.

A detailed Handbook document is available to consult at <https://lcas.lincoln.ac.uk/nextcloud/index.php/s/SYw6fQGkswTj8eB> for specific details about the robot's hardware and software configuration. Please note that only the standard PAL Robotics software packages are installed on the robot; for example, the "Advanced Navigation package" or the "Facial Perception Premium Software package" are not installed.

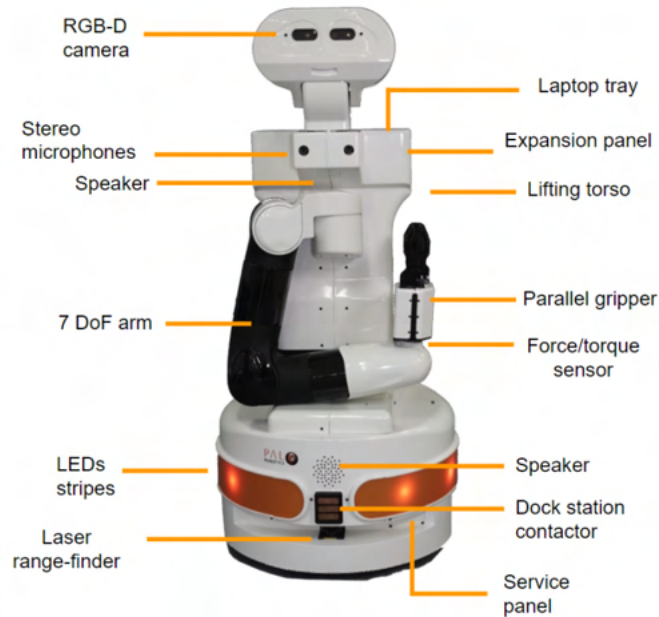


Figure 9: The TIAGo robot model provided for the competition.

The robot's PC is a Ubuntu 20.04 machine and runs ROS noetic software packages for the default robot capabilities. The competitors are not allowed to install any software on the robot's PC, nor to modify any internal configuration or start-up configuration without prior consulting the organisers. This restriction is enacted to ensure the robot and its basic functionalities remain stable throughout the competition for the multiple teams using it. Any additional software developed by the teams must run on your external computing device (laptop or a PC) that can be connected to the robot via WiFi or Ethernet. Remote communication with the robot ROS nodes in execution on the robot board can be done using the standard ROS mechanisms, also described in the TIAGo Handbook.

7.3.2 Baxter

Baxter is a collaborative manufacturing robot built by Rethink Robotics. The robot has 7-DOF two-arm, two electric parallel jaw gripper and an animation face as shown in Figure 1. The compliance of the arms is achieved through a series of elastic actuators incorporated into all 14 arm joints. Each joint has force, position, and torque sensor and control. The robot has three integrated camera. Two cameras are in the cuff of the arms with an IR sensor to measure distance and one camera is in the head. Only two cameras can be powered on at once. If the teams give prior notice, additional RGB-D cameras (Asus Xtion or Realsense) can be provided in the competition. The robot has 3-axis accelerometer inside each cuff and a sonar sensor around the head.

Detailed hardware, setup information, running the robot, and explanation of the example programs can be found at Rethink robotics wiki: <https://sdk.rethinkrobotics.com/wiki/Home>. The robot's PC is a Ubuntu 14.04 machine and runs ROS indigo software packages for the default robot capabilities. Robot simulator and MoveIt! packages are already installed on the robot's PC. The robot runs ROS kinetic packages with Python version 2.7. Usage of any other ROS versions by teams needs to run on

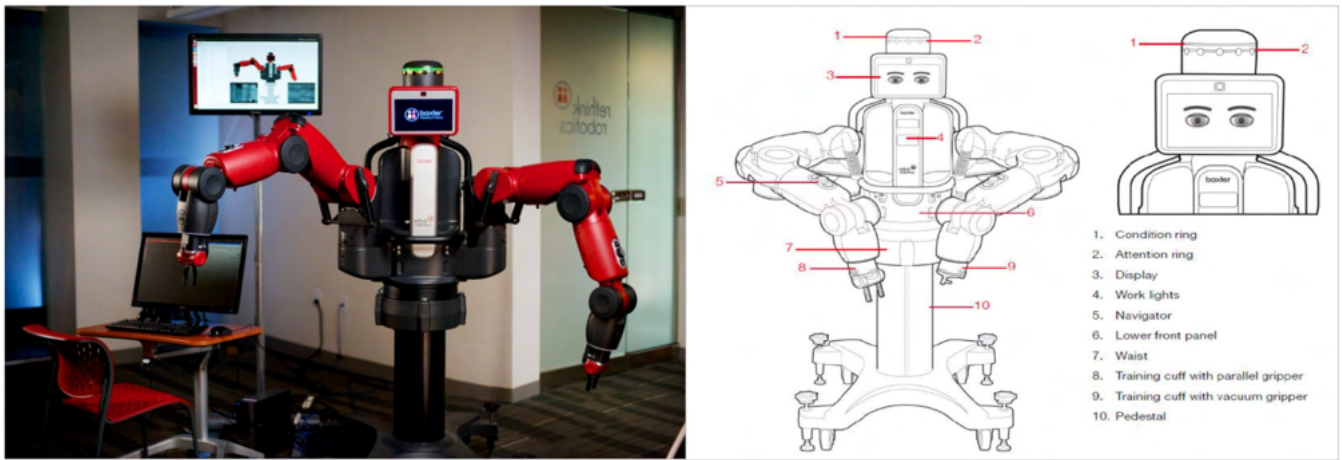


Figure 10: The Baxter robot model provided for the competition.

an external computing device (laptop or PC) that can be connected to the robot via Ethernet. For example, installation guidelines for ROS noetic on your development computer can be found at the link: <http://robinsonia.com/?p=494>. Competitors can then run external software on their PC and interface with the robot hardware. Note that some python 2.7 – python 3 incompatibilities may occur when using the ROS noetic version; the organisers will not be able to offer technical support in solving these issues.