Episode 1
Deliver Coffee Shop Orders

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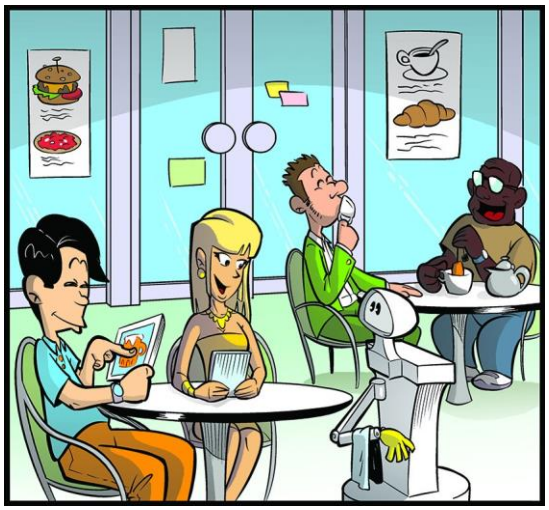
1. General Description



In this episode the robot will assist the staff of a coffee shop to take care of their customers. The robot is asked to recognize the status of all tables inside the shop, report the number of free tables, take orders from the unserved customers and deliver objects to and from the customers' tables.

2. Main scientific challenge

This episode aims at benchmarking some of the key functionalities required by an autonomous service robot to operate inside a restaurant or coffee shop. The main functionalities evaluated here are **people perception** and **object perception**. However, additional side functionalities such as navigation and speech recognition are also required to successfully execute the episode.

Recent advancements in social service robots have led to the introduction of robots in public places such as shopping malls or restaurants for interaction with customers. Several studies have already demonstrated the positive impression of customers when assisted by service robots [1,2,3]. Service robots can approach and interact with customers without causing or receiving social stress [4]. Catering service robots for restaurants and shops has been the topic of multiple research work [5,6,7]. The effectiveness of such robots is currently demonstrated with the rise of robot waitering systems in the market. A catering robot can assist human servers at peak hours by handling the manual work at a fast pace and reducing the customer response time.

Over the past years, in the context of the RoboCup@Home competition and of the European Robotics League - Consumer Service Robots (ERL Consumer), multiple benchmarks were defined which evaluated the performance of people perception and object perception of service robots operating inside domestic environments. In particular, the Restaurant test in RoboCup@Home [9], performed since 2012, aimed at benchmarking solutions for a service robot to learn a new environment, receive orders from customers and deliver such orders. This

test mostly focussed on manipulation, on-line mapping and human-robot interaction. Through the definition of the present episode for the SciRoc smart city competition, we aim at steering and improving the existing contributions of teams on people and object perception. The SciRoc episode will also provide a dynamic and uncertain environment represented by a public space populated by naive users. Teams participating in the ERL Consumer and RoboCup@Home competitions are expected to be able to directly benefit from their existing solutions and experience to successfully showcase their robots in a real coffee-shop-like environment.

3. Platforms allowed

A mobile service robot that is equipped with a tray, a planar surface or any other way of transporting a few small items (such as a cup of coffee, glass of water, mug, small plate with cake, etc) is required. No manipulators are needed for this episode as objects are placed on to the mobile tray by the coffee shop staff and customers.
In addition, robots must have a noticeable emergency stop button to shut off all motors in case of an emergency.

4. Scenario Setup

An arena representing an ordinary coffeeshop, consisting of multiple tables and chairs, will be used. It will contain a minimum number of 6 tables to accommodate customers and 1 counter for the staff to place and remove objects. A minimum area of approximately 45 m^2 is expected for this episode, however, the actual required dimensions might differ based on the size of the furniture used for the episode. The actual number of tables and chairs along with the detailed floor plan and shop dimensions are communicated to the teams before the competition. Each of the tables will have a unique identification number.

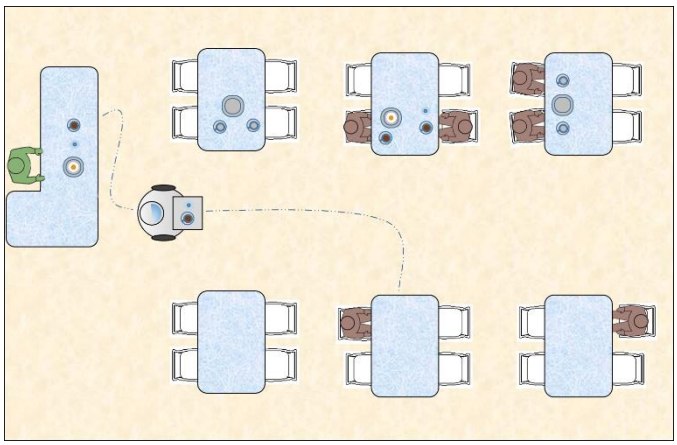


Figure1: Example of a possible layout of tables and customers for a trial of the episode.

Common tableware and merchandise found at ordinary coffee shops will be used as the objects to be perceived and carried by the robots. Objects can contain actual liquid in them such as a cup of coffee or a glass of water. The detailed description of all objects will be provided to the participating teams 3-4 weeks before the competition and the actual objects are provided to the teams during the setup days. A menu will be placed on all the tables for the visiting customers which will contain the list of all items that can be ordered.

For every trial of the episode, an unknown number of volunteers acting as coffee shop customers are randomly seated at different tables. The volunteers can compose of team members, members of the technical or organization committee or public upon filling a consent form. The number of people and their locations are randomly generated by the referees with the help of a random generator right before the trial begins.

5. Smart City Data Hub Interaction

The Smart City data hub will provide the links to the competition. The interface will receive activity from the robot required for the benchmarking and scoring. This data hub is part of data acquisition and management infrastructure live sensors and robotic teleoperation for different functions of the city (transport, environment, energy, water, etc.). The data gathered by the robots in this episode, such as the status in the scenario, the start and end of activities within the task are communicated to the infrastructure to contribute to the smart city data platform.

Teams are notified before the competition by the competition organizers about the data and communication protocols, and which messages are required to track progress in the competition.

6. Procedure

This section describes the step-by-step procedure for a complete trial of the episode. A single trial consists of three phases that are executed sequentially without any interruption. A robot can automatically proceed to the next phase at any time if it is unable to execute or fully complete a phase. The robot must announce the start of a new phase and the robot's objective before execution of a task to allow the referee and the audience to better understand its behaviour.

Preparations and start of the trial

- The robot is positioned at the starting location, near the counter.
- Several volunteers acting as customers will enter the shop and are randomly seated at different tables by the referee.
- A restaurant employee (played by a member of the OC/TC), will take and deliver the orders for some of the tables and soon realizes that it requires help with other tables.
- The trial begins at the scheduled time, when the employee asks the robot for assistance. The start signal can be either a single press of a button on the robot or a simple voice command.

Phase 1: Recognizing the shop's status

- The robot starts by navigating around to recognize the status of all the tables at the shop. For every table, the robot must identify and announce through speech the following information:
    1) the table's status:
        a) Needs serving: The table has customers but no objects on the table.
        b) Already served: The table contains both customers and objects.
        c) Needs cleaning: The table has objects but no customers.

d) Ready: The table is ready to accept new customers, i.e. no objects and no customers.

2) The number of customers at the table, if any.

In addition to speech, the table's status and number of customers per table must be stored on to a text file on the robot. The referee will request the file to be examined, if needed, after the termination of the trial. Additionally, teams are requested to communicate this info automatically to the MK digital hub.

Phase 2: Serving an order

- The robot approaches one of the tables that is waiting to be served. Alternatively, if the robot was unable to correctly identify the shop's status in Phase 1, it can wait to receive a waving gesture from one of the customers before approaching to that table.
- The robot asks the customers of the table to select their orders from the menu. (3 items will be selected). As HRI is not the main focus of the episode, this selection procedure is left open for the teams to decide and can be anything as simple as asking the customers to communicate the item numbers through speech, QR code, or to click on the items from a user interface display on the robot. [1]
- Once the order is placed, the robot navigates to the counter and communicates the order to the assistant behind the counter. The order is then placed on the counter by the assistant with one of the items missing or being incorrect.
- The robot must identify the wrong/missing item and .
- The order is then placed on the robot's tray and the robot must deliver it to the correct table.
- The customers pick the items, and the robot moves back to the default location.

Phase 3: Greeting and guiding a new customer to the table

- A new customer will enter the shop and will wait to be guided to a table.
- The robot must automatically detect the presence of the new customer in the shop, approach and greet the customer, and then guide the customer to a ready table.
- The robot moves back to the default location indicating the end of the trial.

7. Timing

The maximum allowed time for a single trial is 15 minutes. The time stops when the robot moves back to its default location and announces that it has completed the trial. Note that the trial execution time is an important element in this episode and faster solutions are better in case of ties in the number of achievements.

The participating teams must have their robots ready in the default location sharply at the time communicated in the schedule. After 2 minutes from the scheduled time, the referee will start the test, i.e. s/he starts the timer (no delays for any reason). If the robot is still not ready, there will be no penalty, but the time will run on. During this period the team can start the test at any moment, but the end time will not be postponed.

[1] A natural human-robot interaction is preferred and is expected to draw the attention of the general audience/volunteers who will be determining the award of "Best Robot by Audience".

Within the first 5 minutes from the start of the trial, the team can request for a restart. In this case the team is allowed to enter the arena, position the robot back on the default location and perform any operation on the robot. The restart can be done only once for each trial. Any score achieved before the restart will be cancelled and the time will not be stopped during the restart procedure.

8. Score

Achievements

- The robot correctly reports all the tables that need serving.
- The robot correctly reports the status of all the tables.
- The robot correctly reports the number of customers for all tables with customers.
- The robot reaches an unserved table and asks for the order.
- The robot correctly understands and informs the order of the customer to the counter.
- The robot correctly recognizes the wrong or missing item and corrects the order.
- The robot delivers the order to the right table.
- The robot detects and greets the new customer entering the shop.
- The robot guides the customer to a ready table.

Penalizing behaviours

- The robot hits any of the furniture and objects. (one penalty for each hit)
- The objects on the tray drop or spill due to the movement of the robot
- The robot requires multiple repetition of the speech command

Disqualifying behaviours

The episode is immediately stopped and any score achieved so far will be cancelled if:

- The robot hits a human.
- The robot hits and damages the furniture and/or objects.

Competition Stages and the Final scores

The competition is arranged in two stages: 1) Competition Days, 2) Final. The top 2 teams in the ranking of the Competition Days qualify for the final to be held on the last day of the competition. The final ranking for assigning the first, second and third place will be determined by the performance in the final. During the competition days, several runs will be available to each team (let this number be M). Notice that M is the number of slots available for each team, it may differ from the actual number of performances of each team, if teams are not ready to attend some runs. During the Final, only one run will be performed.

Aggregate score of the Competition days. The aggregate score for each team for the M episodes performed during the Competition days will be determined according to the score system of the European Robotics League as follows:

- select the best N trials of the team
- determine the median of the scores of the N trials selected.

Let n be the position of the median in the ordered list of team scores, i.e., n = (N + 1) / 2 (when N is odd), then N (and consequently n) are determined according to the number of episodes scheduled M, according to the following table

M	N	n
6-9	5	3
10-12	7	4
13-15	9	5

In case of tie score for the access to the Final, the policy for tie breaking is described below. If such policy does not break the tie, all teams with the same score will enter the Final.

The policy for tie braking is:

- average task completion time for the first n-1 highest scores

Evaluate Social Robot

Apart from the above scoring system which is used to determine the rankings for the best robot in this episode, we will collect questionnaires from the public who volunteer in the episode to determine an extra award for the “most social robot”. A questionnaire will be used for this purpose:

	5 Yes, very much	4 Yes, a little	3 Neutral	2 No, not much	1 No, not at all	Not Applicable
Have you perceived friendliness interacting with the robot?						
Have you perceived social relationships with the robot?						
Have you perceived enough safety while interacting with the robot?						
Have you perceived a feeling of ease (comfortable) interacting with the robot?						
Could you understand well when the robot was talking?						
Did the robot face the person whom it was interacting with during this episode?						
Do you feel the robot’s distance during interaction was suitable?						
Was it easy to communicate your order to the robot?						

9. Detailed instructions for referees

The referees/organizers must prepare a schedule to ensure an equal access of the arena to the participating teams for the setup days. Also, they must make sure that all objects on the menu are provided to the teams during the setup days for training purposes. The referees must check the robots and approve their safety mechanism before the actual trials of the competition.

Once the arena has been built, and before allowing the teams to access the arena, the referees must mark the location of all tables, wall partitions and other furniture to ensure they are placed back on their default locations for the actual trials.

A competition schedule for the competition trials must be prepared in advance.
Time slots of 20 minutes (15-minute trials + 5 minutes of preparation and team exchange) is expected for every trial. Each team must be given an equal opportunity to perform multiple trials (minimum 3 to maximum 9 trials based on the time availability and the number of participating teams).

A minimum number of two referees and up to 10 volunteers acting as customers are required for execution of the test. The referees are expected to carefully study the rules and procedure of the benchmark before the competition. The volunteers will be selected from the members of the teams and other interested audience. When using a member of the public, a consensus form must be given to them prior to the trial and a user evaluation form is to be given to them after the trial. Referees should try to initialize the scenario before the trial and assign roles to all volunteers. The roles that require interaction with the robot, for example the customer to be served or the new customer entering the shop, should be assigned to the general audience as they are the ones filling the user-evaluation forms.

For every trial, the referees must prepare the scenario according to the description provided in the ‘’Procedures’’ section by distributing a random number of customers (between 5 to 10 customers) and some objects (from the list of possible objects) on the tables. The distribution difficulty among different trials must not vary significantly.

To begin a trial, one of the referees can stand at the counter. He/she has the responsibility of starting and stopping the benchmark, keeping track of the time and placing and removing the objects from the counter. The second referee will always maintain a distance behind the robot, always ensuring the safe operation of the robot and scoring the achievements and penalties using the provided score sheets.
At the end of a trial the referees cross check the score with each other, record the execution time on the score sheet, and confirm the score with the team leader of the participating team.

10. Detailed instructions for teams

Teams need to show the safety mechanisms of their robots and to demonstrate their use once before the competition begins. They also need to communicate to the organizers the required information for operating the robot. For example, how should the referee start the robot, what is the preferred method of human-robot interaction, how to speak to the robot or how to use the robot’s user interface to input orders and where/how to place objects on the robot.

During the competition, teams must prepare their robots outside the arena and can only enter the arena at the assigned times. They must follow the schedule of the trial and comply with the timings described in the ‘’Timing’’ section. Once the referee signals the end of the trial, the participating team must immediately remove the robot from the arena to allow the next team to enter.

Teams are kindly requested to log and store the robot’s Internal data for every trial and to provide it to the organizers after the end of trials. This data will not be used during the competition, but it is used to produce and publish datasets for the benefit of the robotics community. This data must be expressed in the reference frame of the test bed which will be clearly marked on it. There are no restrictions about the framerate and data can be saved at the rate they are acquired or produced. Only data relevant to the episode is expected to be logged and can be in the format of rosbag, the following data is expected to be logged:

1. Images processed for object perception and the calibration info for the images
2. point cloud used to recognize an object
3. The audio signals of the conversation with the customers/staff.
4. The 2D robot pose at the floor level and trajectories planned by the robot
5. Laser scans and odometry used for estimating the pose.
6. tf topics on the robot.

11. Ethical issues

Volunteers involved in the episode, to act as customers, will be selected by the referees among team members, members of TC/OC or adult customers in the MK shopping mall. In case of using real customers from the mall they will be informed about the episode, its procedure, how to interact with the robot for communicating the order and about the safety procedures.
The customers will be invited to sign a consensus form where they declare to have been informed about the above-mentioned information and that they volunteer to participate in the episode.

12. Safety procedures

Teams are responsible to describe safety procedures of the robots used during the challenge. A document describing such procedures and risk analysis must be submitted at registration time and will be used by referee at any time to guarantee safety when using the robot and to instruct customers participating to the episode.

References

[1] Barnett, W., Foos, A., Gruber, T., Keeling, D., Keeling, K., and Nasr, L. 2014. Consumer perceptions of Interactive Service Robots: A Value-Dominant Logic perspective. In The 23rd IEEE International Symposium on Robot and Human Interactive Communication (2014), 1134–1139. DOI=http://doi.org/10.1109/ROMAN.2014.6926404.

[2] Gross, H. M., Boehme, H., Schroeter, C., Mueller, S., Koenig, A., Einhorn, E., Martin, C., Merten, M., and Bley, A. 2009. TOOMAS: Interactive shopping guide robots in everyday use - Final implementation and experiences from long-term field trials. In IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) 2009 (2009), 2005–2012.

[3] Kanda, T., Shiomi, M., Miyashita, Z., and Ishiguro, H. 2010. A communication robot in a shopping mall. IEEE Trans. Robot. 26, 5, 897–913.

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[5] Yu, Q., Yuan, C., Fu, Z., & Zhao, Y. (2012). An autonomous restaurant service robot with high positioning accuracy. Industrial Robot: An International Journal, 39(3), 271-281.

[6] Jyh-Hwa, T., & Kuo, L. S. (2008, July). The development of the restaurant service mobile robot with a laser positioning system. In Control Conference, in Proc. 27th Chinese Control Conference, Kunming, China, 2008, pp. 981-987

[7] Acosta, L., González, E., Rodríguez, J. N., & Hamilton, A. F. (2006). Design and implementation of a service robot for a restaurant. International Journal of Robotics & Automation, 21(4), 273.

[8] Cheong, A., Lau, M. W. S., Foo, E., Hedley, J., & Bo, J. W. (2016). Development of a robotic waiter system. IFAC-PapersOnLine, 49(21), 681-686.

[9] RoboCup@Home 2012 Rulebook. Available online at https://athome.robocup.org/rules/

Appendix A. Score sheet

Team: _____ **Execution Time: _____**

Trial number: _____

Achievements:

- ☐ The robot correctly reports the tables that need serving.
- ☐ The robot correctly reports the status of all the tables.
- ☐ The robot correctly reports the number of customers for all tables with customers.
- ☐ The robot detects and reaches an unserved table asking for the order.
- ☐ The robot correctly understands and communicates the order to the counter.
- ☐ The robot correctly recognizes the wrong or missing item and corrects the order.
- ☐ The robot delivers the order to the right table.
- ☐ The robot detects and greets the new customer entering the shop.
- ☐ The robot guides the customer to an unoccupied table.

Penalizing behaviours:

- ☐ The robot hits any of the furniture and objects. Number of hits: _____
- ☐ The objects on the tray drop or spill due to the movement of the robot
- ☐ The robot requires multiple repetition of commands/answers

Disqualifying behaviours:

- ☐ The robot hits a human.
- ☐ The robot damages objects and furniture

Notes:

_____
_____
_____
_____

Appendix B. Referee/audience application:

This section describes some of the recommended features for the referee application and the display for the audience.

Referee's interface:

- Checklist showing the preparation steps needed before starting the trial (Section 9)
- Menu to select the team's name and the trial number
- Timer showing the execution time
- Button to start the trial/timer
- Possibility to select the phase number and robot's current objective
- Possibility to tick/cross the table state and customer number results for each table.
- List of achievements and penalties to tick or cross.

Public interface:

- Team name and trial number
- Current phase and objective of the robot
- Results for estimation of the table's status and the number of customers per table
- List of achievements with the next aimed achievement highlighted
- Current score and time

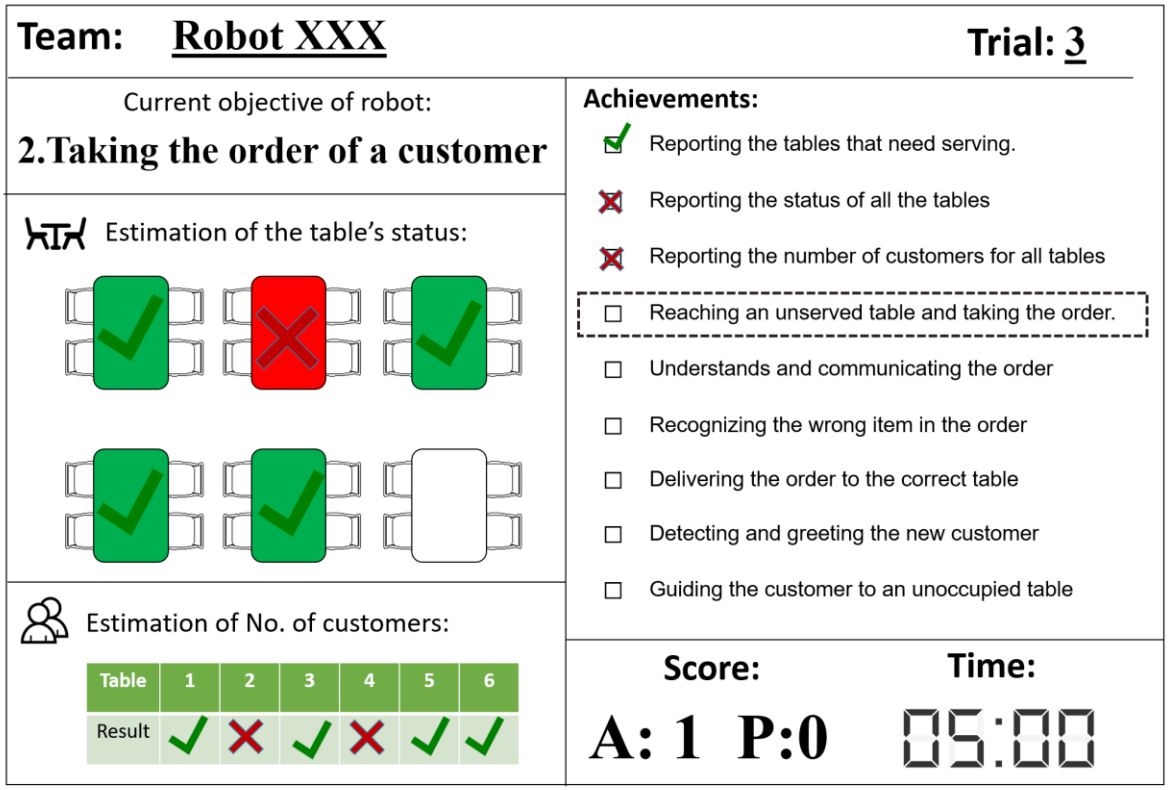

Figure 2: Example of the display to show the status of the episode to the public

Questions and Answers:

This section contains a list of questions asked by competition teams with their corresponding answer, available to all competitors.

Episode 3, Phase 3, the information about greeting a new customer is a bit sparse. Is there going to be a dedicated waiting area that we will need to check, or can the new customer

enter the shop from many different places? If it is a dedicated waiting area, can we assume that it will be mostly empty during the previous phases, and should we be continually monitoring it or will it only become occupied when phase 3 commences? If it is not a dedicated waiting area, can we assume that all the other customers from phase 1 and phase 2 will remain seated and at their tables?

In phase 3, a new customer enters the shop and stands somewhere near the shop entrance until the robot approach, greet and guide him/her to an empty table. This new customer will enter sometime after the start of phase 3. However, the exact time of arrival or the exact waiting location of the customer is not known beforehand.

For Episode 3, do we need to consider people moving/walking in the coffee shop, or is the episode crafted so that the robot will not be obstructed whilst carrying out the phases?

The robot needs to be capable of safe navigation inside the shop and avoid obstacles or humans that might appear in its path.

For Episode 3, when the employee places the order on the table, can we assume a somewhat friendly, unoccluded placement of items, or should we be handling an adversarial placement of objects?

You can correctly assume the employee as a friendly co-worker of the robot who will not try adversarial placement of objects ;)

For Episode 3, there is not too much information about how the items are loaded onto the robot by the employee or how they are unloaded by the customers. Will it be placement of a whole tray, or will it be item by item? Do we need to automatically detect when items have been placed/removed, or can we use keyword commands to signal that on/off-loading is complete?

This is entirely left to the teams. The team can instruct the referee at the counter (who is acting as the employee) prior to the trial on how to place the items and how to communicate that he/she has finished placing all the objects. This can be anything from a speech command, press of a button on the robot, hand gesture or any other approach you may like. The robot is expected to interact and instruct the customers (who might be real customers at the mall with no prior experience with the robot) to take the items from the robot.

Will we receive photos and a description of the coffee shop environment in advance? e.g., an approximated metric map similar to local/major tournaments. This is to have an idea of the type of environment, e.g. for navigation and localisation, so we can prepare better.

Once the arena design is complete, we will try to circulate a simple 2D layout of the arena indicating the arena size, table numbers, table dimensions, and the location of the counter. However, this will still be an approximate layout and subject to changes when building the arena.

In phase 2, are we allowed to ask the referee to let the robot know he/she has finished placing the objects on the counter? E.g., pressing a 'confirm' button on the touchscreen UI.

This is because there could be less than three objects on the counter, so we would wait some timeout when only two objects are placed, and we would avoid that if possible.

Yes. The is entirely left to the teams. The team can instruct the referee at the counter (who is acting as the shop assistant) on how to communicate he/she has finished placing the objects. It can be a speech command, press of a button on the robot, hand gesture or any other approach.

In phase 2, can items be repeated in the order? E.g.: can customers order three water bottles? or there is only one instance of each object?

The order will compose of three different items (no repetition).

In phase 2, are we required to complete multiple orders, or only one order? From the description it seems that the robot must go to a table that needs serving, and once executed this order proceed to phase 3, implying there will only be one table that needs serving.

The robot only needs to serve one of the tables waiting to be served and then proceeds to phase 3. (there can be multiple tables waiting to be served but the robot only needs to serve one of them)

Where could we buy or otherwise obtain the Costa objects that will be used during the challenge? We wish to collect part of the data before leaving for MK given the very short time for preparation given to the teams.
All the products can be found at any Costa coffee shop. We will also provide them to the teams during the setup days.

We would like to know more about the informations that comes in the menu from the DataHub APIs

the item list is in the rulebooks folder:
https://drive.google.com/open?id=1ZGeLsoDNQn4wxGbJ-UWAi_8UKsIdSfuDKNXxYLo-nvM

Every item has an associated ID and label. These are the exact values you will find in the DH.
Quick reminder of the structure of the product in the menu:

```
{
        "@id": "string",
    "@type": "Product",
    "label": "string",
    "descriptions": "string",
    "price": "string"
}
```