Robotic Construction Challenge Rules

Release Notes

Date	Version	Changes
July 1, 2024	V1.0	First release

1. Introduction

The first Robotic Construction Challenge (RCC) will be held at IROS 2024, Abu Dhabi. For the construction target model, we choose the Capital Gate in Abu Dhabi, requiring participants to use building blocks to recreate the shape of the Capital Gate (Figure 1). Following this predefined construction rule, participants are allowed to use single or dual robotic arms to autonomously identify, locate, grasp, and stack each building block.

Teams will be ranked based on their scores and will receive corresponding rewards as recognition. Teams have the option to use either the on-site provided robotic arms or their own robotic arms. A maximum of two robotic arms can be used simultaneously for construction.

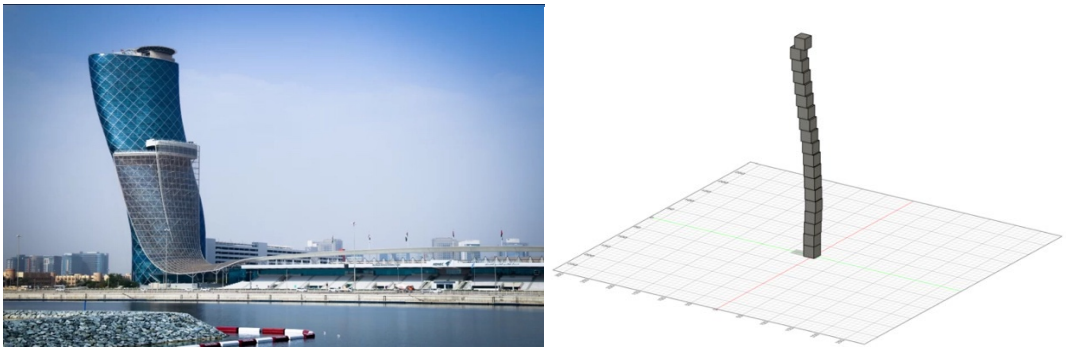

Figure 1. The Capital Gate in Abu Dhabi and its simulation construction.

2. Competition Environment

Workbench: Each team in the competition will be provided with a workbench (Figure 2). The workbench has a white surface and is marked with the assessment line, the initial placement position, and the picking area. Its dimensions are 30 cm × 30 cm × 0.2 cm.

Picking area: The picking area occupies two-thirds of the workbench, with an area of 30 cm × 20 cm. At the start of the competition, 15 selectable blocks will be randomly placed in this area. The blocks will not be stacked, and the distance between the centers of any two blocks will be no less than 5 cm.

Assessment line: The assessment line is black, 2 mm wide, and its centerline is positioned 3.25 cm from the center of the fixed first block and 2 cm away from the near edge of the workbench.

Initial placement position: The first block is fixed in the initial placement position, centered along the long side of the picking area, and is 3.25 cm away from the centerline of the assessment line. Subsequent blocks must be placed on top of the initial block.

Blocks: The blocks used in the competition are cubes with a side length of 2.5 cm (with a tolerance of ±2 mm). There are 8 blue blocks and 8 green blocks in total, one of which will be randomly selected as the first fixed block.

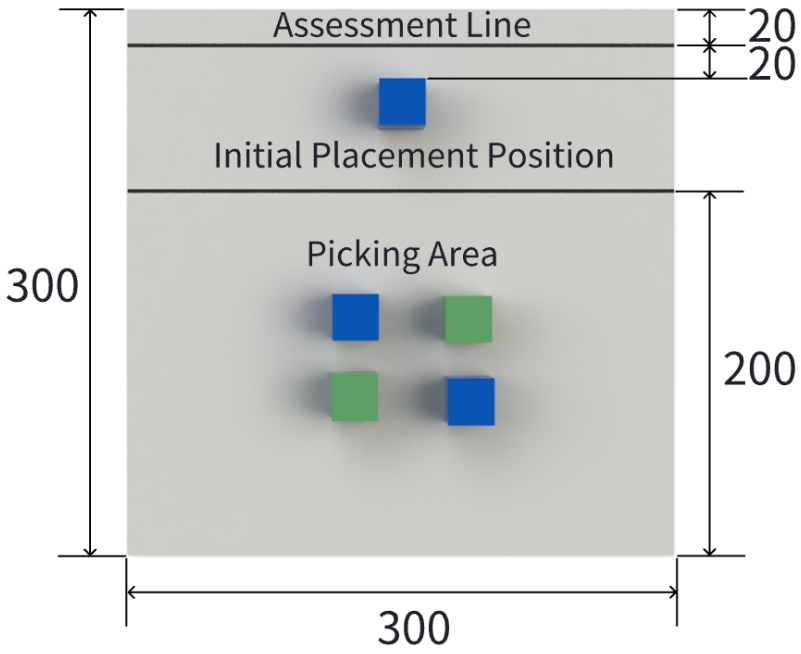

Figure 2. Top view of the workbench (dimensions are in millimeters).

3. Competition Requirements

1. Teams are allowed to use up to two arbitrary robotic arms, paired with any sensors and grippers, which must be fixed on the table and their top-down projection must not fall within the workspace area before the competition begins.

2. Teams must use the workbench and blocks provided on-site and place the blocks individually. After the competition starts, team members cannot intervene in the

automatic construction process of the robotic arms in any way.

4. Competition Mechanism

The construction task is limited to 10 minutes. Prior to commencement, 15 blocks will be randomly placed in the picking area on each workbench, with 1 block fixed at the initial placement position. After the robotic arms move from the initial pose, each arm shall automatically pick a block from the picking area. The block must be placed on top of the previous blocks and the robotic arm then returns to the picking area to pick the next block. This process is repeated until the round is over.

4.1 Scoring

- Criteria for Completion: The structure will be considered meeting the completion criteria if the vertical projection of any block overlaps with the assessment line for five consecutive seconds. At this point, the team must end the round and stop the movement of the robotic arms. The completion status will be judged from an overhead camera view installed above the workbench. Completion examples are shown in Figure 3 (the block placement area is below each black evaluation line).
- Criteria for End Time: End time will be measured in seconds, starting from the beginning of the competition until completion, the time limit is reached, or the team takes the initiative to announce the end of the construction.
- Criteria for Height: The construction height is measured in its first static state after the time ends by the number of blocks on the initial block.

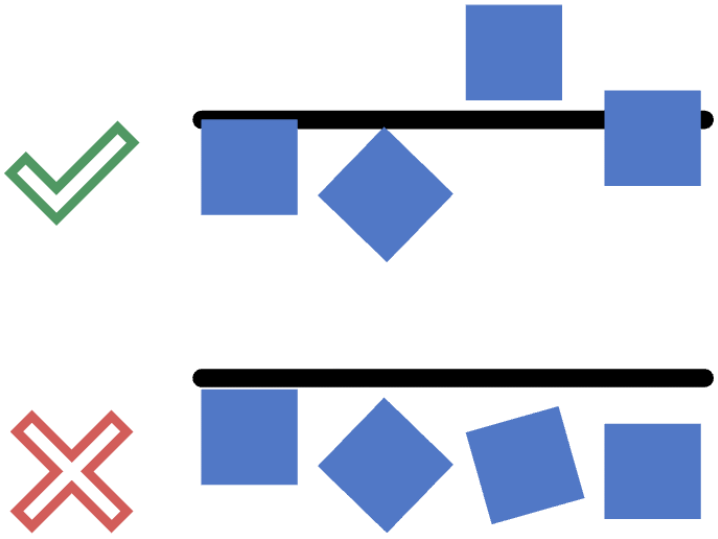

Figure 3. Examples of completion (√) or not (×).

Teams will be scored based on the following criteria:

- Meeting the completion criteria will score 20 points.

- Construction height earns 0 - 15 points.
- If teams have the same score based on the above criteria, the team with the lesser end time will receive a higher score.
- If there are still teams with the same score, the ranking will be determined by drawing lots.

Some ranking examples are listed in Table 1.

4.2 Precautions

- During the competition, if a collapse occurs, i.e., blocks above the initial fixed block start falling from a stationary position and land on the floor, the robotic arms can automatically resume construction without human intervention and can re-pick blocks that fall outside the picking area. To minimize the risk of blocks falling outside the workbench, teams are permitted to install a fence around the workbench that does not exceed 2 centimeters in height above the surface of the workbench.
- Each robotic arm is allowed to hold multiple blocks simultaneously before placing them one by one.
- Robotic arms are permitted to adjust the position of already placed blocks, but each arm can only pick up one topmost block at a time.
- If a robotic arm encounters any abnormal situation and is unable to continue construction, the team should promptly request termination of the competition. The result will still be scored.

Table 1. Ranking Examples

Ranking	Teams	Score		
		Completion	Height	End Time
1	O	20	15	500
2	P	20	10	300
3	E	20	10	400
4	N	0	12	310
5	Z	0	5	100
6	G	0	5	200

5. Competition Process

The challenge consists of two stages: Practice Stage and Competition Stage.

5.1 Practice Stage

The practice stage starts on 1 August 2024 and ends on 14 October 2024. During this phase, the main task of the participating teams is to develop algorithms in a simulator or real environment and practice to complete the challenge mission according to the rules.

For practice, we will provide participating teams with 1) a physical workbench, 2) 16 actual blocks needed for construction, 3) a URDF file of the provided robotic arms.

Teams can download the corresponding URDF file and practice in simulation in advance from the designated window of the organizing committee if they wish to use the provided robotic arm during the competition.

5.2 Competition Stage

The competition will be held on October 15 – 16, 2024, at ADNEC in Abu Dhabi, UAE. The competition consists of two rounds: the preliminary round and the final round. The official tournament process for both rounds is:

1. The organizing committee may assign different time slots to each participating team, who will compete according to their assigned slots.
2. Before each match begins, teams are allowed to enter the competition area to set up and perform necessary adjustments. After preparation is complete, all teams will start the match simultaneously. Judges will score the teams once the match is finished.
3. After all teams have completed their matches, the scores will be published.

The top four teams from the preliminary round will be selected to compete in the final round.

6. Challenge Schedule

The challenge schedule is listed in Table 2.

7. Participation

Participants need to form teams and complete the registration process through the designated registration website.

- Every team member is allowed to join only one team.
- Each team must have a minimum of one and a maximum of five members.

- Every team must have one registered team leader, who will be responsible for managing the team's progress in the competition, liaising with the committee, and submitting competition reports, among other tasks.
- Each team can have one supervisor who must be a faculty member of the team's college or university with teaching and research qualifications in 2024.

Table 2. Challenge Schedule

Schedule	Activities	Notes
Register Stage: July 1, 2024 - July 31, 2024	Registration	Teams can login Registration Website and practice kits will be sent to successfully registered teams
Practice Stage: Aug 1, 2024 – Oct 14, 2024	Practice	Teams practice completing the challenge mission according to the Rules Manual
Competition Stage: Oct 15, 2024 – Oct 16, 2024	Competition	Participating teams are required to proceed field-test during IROS 2024

8. Awards

The award follows the criteria listed in Table 3.

Table 3. Award Settings

Prize	Ranking	Quantity	Awards
Grand price	First place	1	• Achievement certificates (for each member) • $2,000 (pre-tax)
First prize	Second place	1	• Achievement certificates (for each member) • $1,000 (pre-tax)
	Third place	1	• Achievement certificates (for each member) • $500 (pre-tax)
	Fourth place	1	• Achievement certificates (for each member)
Second prize	5-8	4	• Achievement certificates (for each member)
Third prize	9-16	8	• Achievement certificates (for each member)

9. Appeals

9.1 Appeal Materials

- **How to appeal:**

Save the edited video (contents of which to be prepared by the team) and the text files containing the appeal materials in a folder (its total size not exceeding 100MB) and send it to the arbitration staff.

- **Material format:**

No video may exceed one minute in length. The name of the video must indicate the round of the match and the time it was taken (rounded to minutes). The videos should be compatible with the latest version of Windows Media Player; the photos must be in JPG format; and the text documents must be in PDF format and not exceed 1,000 characters in length.

- **Naming of materials:**

The file name of each video and photo must be within 30 characters.

- **Text requirements:**

One text file can only correspond to one video or a photo, which must be indicated in the text.

Only the violations reflected in the corresponding materials need to be addressed in the text files.

9.2 Appeal Decision

The arbitration decisions that can be made include maintaining the original match results or ordering a rematch.

Teams may not appeal against the decision made by the Arbitration Commission.

If a rematch is required by an arbitration decision, the committee will inform the teams of the time of the rematch when announcing the decision. If the team refuses the rematch, the appeal is deemed failed and the original match results are maintained.

10. Q&A

After the start of the practice stage, the committee will set up an official chat group in which it will conduct online Q&A sessions and upload frequently asked questions in the competition onto the group's "Q&A Files."