



NATIONAL ROBOTICS COMPETITION

NRC COSPACE ROBOT CHALLENGE PRIMARY & SECONDARY CATEGORY (Rescue Challenge)

ENVIRONMENTAL SUSTAINABILITY



Version: 6 May 2024

Organised by:



SP Singapore Polytechnic

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NRC 2024 PRIMARY & SECONDARY CATEGORY

CHALLENGE BOOKLET CHANGE LOG

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1. General Information

1.1 National Robotics Competition (NRC) 2024

[National Robotics Competition \(NRC\)](#) has been an ongoing competition organised annually by Science Centre Singapore for the past 25 years with support from the Ministry of Education, various partners and sponsors. NRC has attracted more than 60,000 team members and 240,000 supporters to date. It is the only robotics competition in Singapore supported by the Ministry of Education.

NRC spurs students' interest and innovation in Science, Technology, Engineering and Mathematics (STEM). Students will be able to put their knowledge to practice and engage in hands-on STEM learning. With NRC as a stage for students to develop kinaesthetic learning and collaboration, it encourages students to develop problem-solving skills, entrepreneurial skills, creative thinking skills and team spirit among the team members. This is in line with Science Centre Singapore's mission "To promote interest, learning and creativity in science and technology, through imaginative and enjoyable experience and contribute to the nation's development of its human resource".

NRC 2024 tournaments comprise of:

- NRC Regular Category
- NRC Open Category
- NRC AI Maker Series
- NRC Preschool
 - Kubo Challenge
 - ARTEc Challenge
- NRC Smorphi
- NRC CoSpace Robot Challenge
 - Autonomous Driving Category
 - **Rescue Category**

Registration for these category challenges will be via <https://forms.gle/V8wzHjY6gfrRBys29>.
Competition registration opens from **till 1st July 2024**.

Note: Registration will be on a first come, first serve basis. If the category is full, your registration will be rejected and refunded

1.2 Theme for NRC CoSpace Robot Challenge 2024

These are the official rules for NRC CoSpace Robot Challenge (Rescue Category) 2024. This rule book is released by the RoboCup Singapore CoSpace Technical Committee. English rules have priority over any translations.

The theme for NRC CoSpace Robot Challenge (Rescue Category) 2024 is **ENVIRONMENTAL SUSTAINABILITY**.

In NRC CoSpace Robot Challenge – rescue category, teams are required to complete 3 individual tasks commonly used in smart transportation, such as

- Navigation challenge
- Recognition challenge
- Path planning challenge
- Sorting challenge...

The 3 tasks are designed to lead students on:

- How to use different type of sensors
- How to solve common problems in environmental sustainability, such as path planning and resource sorting.

There are two age groups.

- The primary age group is for students with little experience with robotics and coding. Novice teams are also welcome.
- Secondary age group is for students with foundation of robotics and coding, such as application using different sensors.

The NRC CoSpace Robot Challenge (Rescue Category) 2024 has two sub-divisions.

- Real Robot Challenges
 - If teams have the CoSpace VRBOT-C6, you can participate in the Real Robot Challenge. The real robot challenge for 2024 is optional.
- Virtual Robot Challenge
 - It is compulsory for all teams to take part in the virtual robot Challenge.
 - The NRC CoSpace Robot Challenge (Rescue Category) 2024 will also give the grand championship award to the best teams who top both the Real Robot Challenge and the Virtual Robot Challenge.

With the foundations built-up, students are able to complete the RoboCup Asia-Pacific (RCAP) CoSpace Autonomous Driving Challenge missions.

Contact us:

- Rule clarification: cospace@robocupsg.org

- Technical support: support@CoSpaceRobot.org

2. General Rules

2.1 NRC CoSpace Robot Challenge (Rescue Category) Description

In NRC CoSpace Robot Challenge – Rescue Category, teams are required to program a virtual robot to complete 3 individual tasks commonly used in environmental sustainability challenge, such as path planning and resource sorting.

2.2 Team

2.2.1 Age Division

- Primary Age Group:
 - Teams with all student members aged 8 to 12 year old can participate in primary age group. If one team member is 13 or above, the team can only take part in secondary age group.
- Secondary Age Group:
 - Teams with all student members aged 13 to 16 year old can participate in secondary age group.

2.2.2 Team Members

- A CoSpace coding team should comprise 1 to 3 members. Each participant can only register for one team.
- Each team must have a captain. The captain is responsible for communication with referees during the game.
- Every team member including team captain needs to carry out a technical role for the team (strategy planning, programming, etc.), which should be identified at registration. Each member will need to explain his/her technical role and should be prepared to answer questions regarding the technical aspects of their involvement during preparation for the CoSpace coding challenge.

2.2.3 Responsibility

The team members are responsible for:

- Verifying the latest version of the rules prior to the competition. If any rule clarification is needed, please contact the CoSpace Technical/Organizing Committee.
- Checking updated information (schedules, meetings, announcements, etc.) during the event.

- Communication with CoSpace Technical/Organizing Committee for all CoSpace coding challenge related matters.

2.3 Referees

A referee is an official who manages the CoSpace coding challenge and makes sure that the challenge rules are followed. The referee receives and uploads the teams' virtual programs, as well as running the game.

2.4 Interruption of a Game

In principle, a game will not be stopped during the challenge unless the referee needs to discuss an issue/problem with the CoSpace Technical/Organizing Committee.

2.5 Conflict Resolution

2.5.1 Referee

- During the CoSpace Robot Challenge, the referee's decisions are final.
- At the conclusion of a game, the referee will ask the captain to sign the CoSpace Robot Challenge result sheet. Captains are given a maximum of 1 minute to review the result and sign. By signing it, the captain accepts the final result on behalf of the entire team. In case of further clarification, the team captain should write their comments on the result sheet and sign it.
- A violation of the rules may result in disqualification from the tournament or the round at the discretion of the referee, officials, organizing committee and general chairs.
- In case the team refuses to sign the scoresheet after the game, they should be advised to file a complaint following the procedure in Section 2.5.4 This should not interrupt the following games. The referee should follow the instruction given by the chief judge.

2.5.2 Rule Clarification

- It is the team's responsibility to verify on the official website the latest version of the rules prior to the competition. If any rule clarification is needed, please contact the CoSpace Technical/ Organizing Committee.
- If necessary, a rule clarification may be made by members of the CoSpace Technical/ Organizing Committee, even during a tournament.

2.5.3 Special Circumstances

- 2.5.3.1 Under special circumstances, such as the occurrence of unforeseen problems or malfunctions of the robot, rules may be modified by the Organizing Committee Chair in

conjunction with available Technical Committee and Organizing Committee members, if necessary, even during a tournament.

- 2.5.3.2 If any of the team captains/members/mentors do not show up to the team meetings to discuss the problems and the resulting rule modifications described in 2.5.3.1, it will be considered as an endorsement

2.5.4 Complaint Procedure

- Rule issues are not to be discussed during the run. Referee decisions are binding for the CoSpace robot challenge. A team may protest by executing the following complaint procedure. The procedure is automatically invoked if a referee decides to abort the run for any reason.
- To initiate the complaint procedure, the team leader of the challenging team has to contact a member of the Technical Committee within 10 minutes of the end of the run. The member of the Technical Committee will then invoke a team leader conference in consultation with the Organizing Committee. The following parties will participate in this conference: the referees of the run, Organising Committee members, and the Technical Committee (counselling). The situation shall be resolved by unanimous consent or by vote of the Organising Committee members. The chief charge should inform the referee concern about the final decisions.
- All teams are reminded that while this is a competition, the league is also about cooperative research and evaluation, as such, complaints should be handled in a fair and forthcoming way.

2.6 Code of Conduct

2.6.1 Fair Play

- CoSpace coding challenge is built upon the foundation of fairness, respect, and friendship. Team members should be mindful of other people and their robots when moving around the tournament venue.
- Mentors (teachers, parents, chaperones, translators, and other adult team members) are not allowed in the student work area. They are not allowed to be involved in the programming of students' robots.

2.6.2 Behaviour

- Prior to the Challenge, team leaders and mentors are required to sign and acknowledge that they fully understand and are aware of the rules as well as Code of Conducts for the Challenge. All participants are responsible for their own actions.
- During challenge, participants are to follow the directions of the referee. Failure to do so will result in a WARNING (Yellow Card). Subsequent infractions will result in an automatic DISQUALIFICATION (Red Card) of the round. Disqualification as a result of deliberately distract the competition is FINAL and appeals will not be entertained in any form. The status of Yellow/Red Cards will be recorded.

- **WARNING (Yellow Card) procedure**
 - A WARNING can be issued at the sole discretion of the lead referee; however, assistant referee will be consulted. If no objection is raised, WARNING will be issued.
 - A WARNING will be issued for the following disruptive behaviours and activities including but not limited to:
 - a) Not following referee's instructions
 - b) Disturbing other participants and/or competition staffs (including referees).
 - c) Speaking loudly, shouting, using any kind of profanities or making sound that resembles profanity.
 - d) Sabotaging other teams' belongings or equipment.
 - e) Entering competition area when other teams are competing.
 - f) Entering other teams' area without explicit permission.
 - g) Engaging in disorderly conducts such as fighting, physical scuffles, running around competition and/or team area.
 - h) Harassing referee.
 - i) Mentor interference with referee decisions.
- **DISQUALIFICATION (Red Card) procedure**
 - A DISQUALIFICATION can be issued at the sole discretion of the lead referee; however, assistant referee will be consulted. If no objection is raised, DISQUALIFICATION will be issued.
 - An immediate DISQUALIFICATION can only be issued jointly by the lead and assistant referee. A DISQUALIFICATION will be issued for the following cases:
 - a) Teams have collected two consecutive WARNINGS during competition period. A competition period is defined as the start to end of duration of competition.
 - b) If one team copies a program from another team, both teams will be disqualified.
 - Once the RED CARD is issued, the team will be disqualified from the current run. If team receives 2 RED CARDS, it will be disqualified from the whole entire competition.
 - All immediate DISQUALIFICATION will be reviewed by the Chief Judge and the Organising Committee. Infractions that resulted in immediate DISQUALIFICATION will be reviewed and additional sanctions such as bans from future competitions will be considered.
- **Penalty**
 - The following are strictly prohibited:
 - a) During the game, using third-party software, self-written code, or any other tools to retrieve additional system information is strictly prohibited.
 - b) Any other behaviours that affect the normal operation of the RCAP CoSpace Simulator, and direct or indirect control of the behaviours of the RCAP CoSpace Simulator, such as the scaling of the simulation window is strictly prohibited.
 - A DISQUALIFICATION from the current match can be issued at the sole discretion of the CoSpace Chief Judge and CoSpace Technical Committee if teams offend the Penalty rules for the first time.

- A DISQUALIFICATION from the entire competition can be issued at the sole discretion of the CoSpace Chief Judge and CoSpace Technical Committee for repeat offenders.
- **Sharing**
 - Teams are encouraged to share their codes and strategies with members after the competition.
 - Any developments may be published on the RCAP Academy Channel (<https://www.youtube.com/RCAPAcademy/>) or CoSpaceRobot.org after the event.
 - CoSpace coding challenge sharing and presentation furthers the mission of RoboCup as an educational initiative.
- **Spirit**
 - It is expected that all participants (students and mentors alike) will respect the RoboCup mission.
 - The referees and officials will act within the spirit of the event.
 - It is not whether you win or lose, but how much you learn that counts!

3. Fields

3.1 Real World (Real Field)

REAL_WORLD Dimension

The dimensions of the REAL_WORLD are 180cm x 240cm.

The floor may be either smooth or textured and may have steps and/or gaps of up to 3mm. It can also be printed on a canvas.

The real world will be placed so that the floor is level.

REAL_WORLD Layout

The REAL_WORLD may consist of any of black guidelines, obstacles, detour markers and mysterious tasks.

Guidelines

- The guideline can be black, white or any other distinct colours.
- The guideline (width: 1.8 - 2.2cm) may be made with standard electrical insulating tape or printed onto other materials.
- The guideline forms a path to guide REAL_ROBOT in REAL_WORLD.
- Straight sections of the black guideline may have gaps with at least 5cm of straight line before each gap. The length of a gap will be no more than 20cm.



Figure 1: Sample of black

Ramps/Bridges

There could be ramps/bridges to allow the robots to “climb” up to and down from different levels. Ramps will not exceed an incline of 25 degrees from the horizontal.

Detour Markers

There are some colour markers to help robots make decisions at junctions. The marker can be of any colour.



Figure 2: Sample of detour markers

Obstacles

The obstacles can be cylinders or cubes. The size, design and colour of obstacles can be varied.

Tasks

There are 3 tasks on the REAL_WORLD. Each task has a start, end point and several waypoints.

Waypoints

The real robot must navigate through all waypoints in any order on the REAL_WORLD. The real robot may be requested to perform special actions when passing the waypoints.

Typical REAL_WORLD layout:

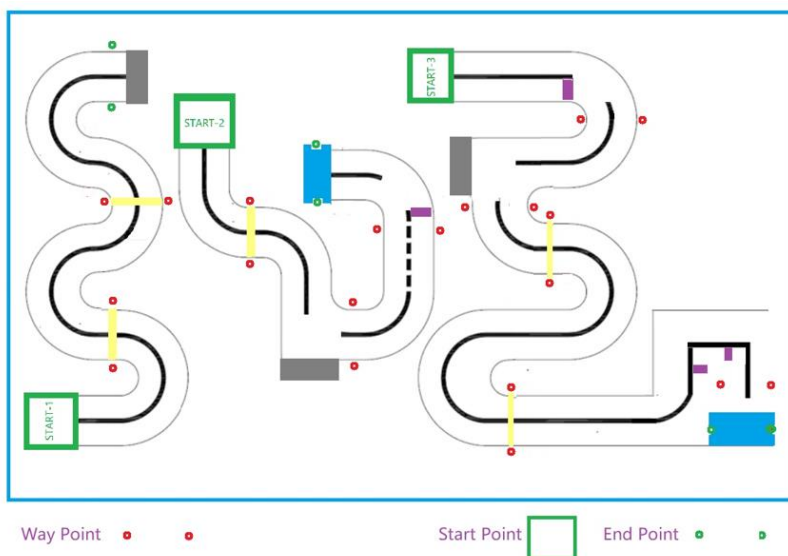


Figure 3: Real Field

3.2 Virtual Field

VIRTUAL_WORLD Layout

The dimensions of VIRTUAL_WORLD is 270cm x 360cm.

The VIRTUAL_WORLD is a 3D simulated environment. The floor is not restricted to white or light colour.

There will be no boundary for VIRTUAL_WORLD. Teams are required to keep the robot within the virtual arena based on the dimensions given. There will be an indication of the boundary for audience.



Figure 3: Typical VIRTUAL_WORLD Layout

4. Robot

4.1 Virtual Robot

ROBOT Configuration

The CoSpace Coding Challenge (Rescue Category) uses a Standard Platform. The ROBOT has the following configuration:

- 3 Ultrasonic sensors
- 1 Gyro sensor
- 2 Colour (RGB) sensors
- 2 DC motors
- 1 LED for status indication
- 1 GPS sensor (Secondary Only)

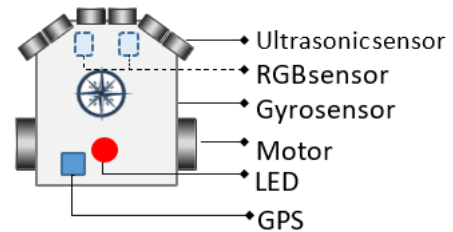


Figure 4: ROBOT configuration

Robot Control and Programming

- Teams can use GUI, Python or C to program the VIRTUAL_ROBOT to complete the task in VIRTUAL_WORLD.
- ROBOT must be controlled autonomously. The use of a remote control, manual control, or passing information (by sensors, cables, wirelessly, etc.) to the robot is not allowed.

4.2 Real Robot

Real Robot Configuration

The CoSpace Robot VRBOT-C6 will be used in REAL_ROBOT challenge. Its configuration is as follows:

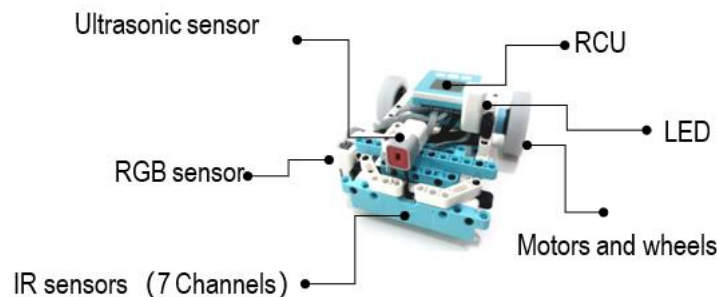


Figure 5: CoSpace Robot VRBOT-C6

- The introduction video of CoSpace VRBOT-C6 can be found at <https://youtu.be/RW2wTzgDLxE>. To find out more about VRBOT-C6 please drop a message to the friendly folks at: sales@sang-nila.com.

- Teams can use GUI or Python to complete the task in REAL_WORLD.
- It is team's responsibility to ensure the real robot is in good working condition to avoid any issues caused by the real robot during the real game. The robot should be fully charged.
- Teams are not allowed to change the motors, controllers, sensors, layout, and structures of the assembled real robot in this challenge.
- It is encouraged to make the robot carry a small flag with a team name and team ID.
- ROBOT must be controlled autonomously in both VIRTUAL and REAL challenges. The use of a remote control, manual control, or passing information to the robot (by sensors, cables, and wireless devices etc) is not allowed.

5. Challenge and Tasks

5.1 Challenge

The NRC CoSpace Robot Challenge (Rescue Category) 2024 has two sub-divisions.

- Real Robot Challenge
 - If teams have the CoSpace VRBOT-C6, you can participate in the Real Robot Challenge. The real robot challenge for 2024 is optional.
- Virtual Robot Challenge
 - It is compulsory for all teams to take part in the Virtual Robot Challenge.

NRC CoSpace Robot Challenge (Rescue Category) 2024 will also give the grand championship award to the best teams who top both the Real Robot Challenge and the Virtual Robot Challenge.

Both Virtual and Real Robot Challenge will have maximum 3 Tasks.

5.2 Tasks

Examples of Tasks for Primary Age Group

Task 1: Navigation – Ultrasonic sensors.

By utilizing the three ultrasonic sensors, participants can program the CoSpace Rescue robot effectively explore every corner of the field and identify reusable resources. This is also the foundation for solving problems like mazes.

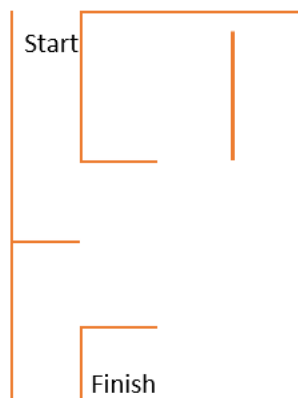


Figure 6: Task 1 example (Primary)

Task 2: Recognition – Colour Sensors (RGB)



The CoSpace Rescue robots are equipped with two colour sensors (RGB). The recognition of colours can be seen as a fundamental application of pattern recognition, and by mastering this skill, participants can program the CoSpace Rescue robot identify and utilize reusable resources and stations more efficiently.

Task 3: Open Challenges

In the primary school group competition, participants will also encounter more comprehensive problems, such as basic path planning, comprehensive application of multiple sensors, and so on. Participants need to complete the environment sustainability challenge using ultrasonic, RGB and Compass sensors.

Examples of Tasks for Secondary Age Group

Task 1: Navigation Challenge

Participants need to efficiently navigate the field by using sensors comprehensively. For example, by combining ultrasonic, colour and real-time GPS coordinate information, robots can complete maze tasks and pass through multiple specific colour stations as required.

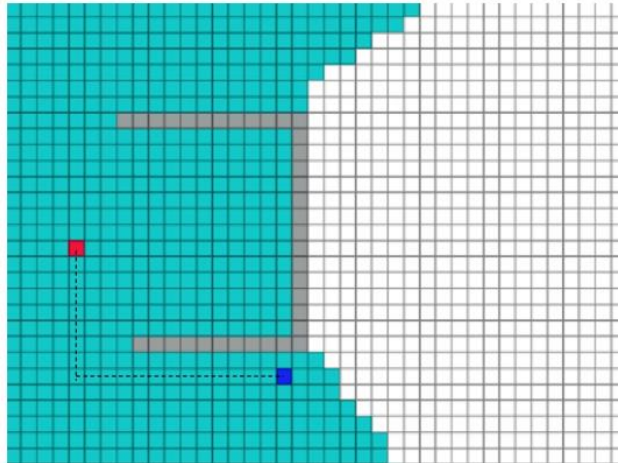


Figure 7: Task 1 example (Secondary)

Task 2: Sorting Challenges

In this task, teams are required to program an autonomous car to complete open challenges using all sensors mounted on the car.



Figure 8: Task 2 example (Secondary)

Task 3: Open Challenges

In the secondary school group competition, participants will also encounter more comprehensive problems, such as GPS usage, path planning, comprehensive application of multiple sensors, and so on. Participants need to complete the environmental sustainability missions using all sensors mounted on the robot.

SuperTeam Challenge

- SuperTeam is the combination of 2 – 3 teams from different schools.
- In SuperTeam Challenge, teams have to develop and program strategies for both real and virtual autonomous robots to navigate through the real and virtual worlds to solve the environment sustainability challenge while competing with another team's robot that is searching and collecting objects in the same real and virtual worlds.

6. Gameplay, Judging and Scoring

6.1 Gameplay

Release of Task

The organising Committee will announce the tasks in the competition hall.

AI Submission

- The chief judge will announce the time for submission of the AI in the competition hall.
- Each team must submit an AI program for all 3 tasks which is created during the programming period to the chief judge. The code file name should follow the format announced by the chief judge in the competition hall.

Virtual Run

- 5 minutes before each run, team captains must report to the referee at their respective game stations.
- The referee or the team leader (following the referee's command) reset the virtual robot and upload the virtual AI program.
- It is the team captain's responsibility to ensure that the correct program is uploaded.
- The referee or the team leader (following the referee's instruction) run the game. After clicking the play button, NO person is allowed to touch the PC until the game end.
- Team captain must be present during the virtual run.
- Referee will complete all 5 tasks. Team captain is required to acknowledge the result by signing on the scoresheet.

Real Run

- The team captain will upload the programs to the REAL_ROBOT, place the REAL_ROBOT at the "START" point of each task in REAL_WORLD as instructed by the referee.
- It is the team captain's responsibility to ensure that the correct program is uploaded.
- Team captains must be present during the full length of the real run.
- Teams will be given 2 minutes for last-minute calibration and testing of the REAL_ROBOT on the real field before the start of the real run.
- The Team captain will need to follow the referee's instruction to place the real robot at the designated "START" station.

- The team captain will manually start the REAL_ROBOT after the referee command.
- REAL_ROBOT is required to pass all way points in any order for each task.
- For each task, there will be a maximum of 3 re-starts allowed for each task. The number of the re-starts will not be considered as further penalty in any form

6.2 Judging and Scoring

Tasks and Weightages

- CoSpace Real Robot Challenge
 - Task 1: Navigation challenge – 20%
 - Task 2: Smart sensing challenge – 30%
 - Task 3: Open challenge – 50%
- CoSpace Real Robot Challenge
 - Task 1: Navigation challenge – 20%
 - Task 2: Smart sensing challenge – 30%
 - Task 3: Open challenge – 50%

Judging

The completion criteria for each task are defined as follows: "The robot must start from the designated starting point of each respective task, navigate through a series of waypoints, and finally reach the endpoint."

In the CoSpace real robot challenge, only the number of successfully completed is taken into account when computing the result of this task, regardless of the time spent during the entire duration.

The score for each task is calculated using the following formula:

$$\text{Score of each task} = \frac{\text{Number of waypoints passed}}{\text{Total waypoints} + 1} \times \text{Weightage of the task} \times 100$$

In CoSpace virtual challenge, the same formula is adopted. The result will be computed by CoSpace Server at the end of each virtual task.

Scoring

- CoSpace Real Robot Challenge
 - The score of each round of real robot challenge is determined by the accumulative scores of three tasks.
 - If the real robot challenge consists of a few rounds of games, the final core is the summation of each individual rounds.
 - In the event of a tie, the ranking of the real robot challenge is then determined by score of Task 3 followed by time taken for task 3.
- CoSpace Real Robot Challenge
 - The score of each round of virtual challenge is determined by the accumulative scores of three tasks.

- If the virtual robot challenge consists of a few rounds of games, the final core is the summation of each individual rounds.
- In the event of a tie, the ranking of the virtual robot challenge is then determined by score of Task 3 followed by time taken for task 3.
- CoSpace Robot Grand Challenge
 - The score of each round of grand challenge is determined by the accumulative scores of three real robot tasks and three virtual tasks.
 - If the grand challenge consists of a few rounds of games, the final core is the summation of each individual rounds.
 - In the event of a tie, the ranking of the grand challenge is then determined by score of virtual Task 3 followed by time taken for virtual task 3.

7. Awards and Prizes

The NRC CoSpace Robot Challenge (Rescue Category) 2024 will present awards to the top 3 teams of the following categories:

- CoSpace Real Robot Challenge
 - 1st Place: Medals for each participant
 - 2nd Place: Medals for each participant
 - 3rd Place: Medals for each participant
- CoSpace Real Robot Challenge
 - 1st Place: Medals for each participant
 - 2nd Place: Medals for each participant
 - 3rd Place: Medals for each participant
- CoSpace Robot Grand Challenge

The winner of grand challenge is evaluated based on the total score of Real Robot Challenge and Virtual Robot Challenge.

- 1st Place: \$300, Trophy for each team and Medals for each participant
- 2nd Place: Medals for each participant
- 3rd Place: Medals for each participant

All participants will also receive certificates of participation.

The organiser reserves the right to amend the prizes without prior notice.

RoboCup Singapore CoSpace Technical Committee.

CONTACT US

Rule clarification: cospace@robocupsg.org

Technical support: support@CoSpaceRobot.org