RoboCupJunior Rescue Simulation - Rules 2022 Final

The RoboCupJunior Rescue Simulation rules are developed and reviewed by the RoboCupJunior Rescue Committee 2022. The simulation platform is developed and maintained by the Platform development team.

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Official Resources

RoboCupJunior Official Website	RoboCupJunior Official Forum	RCJ Rescue Community Website
https://junior.robocup.org	https://junior.forum.robocup.org	https://rescue.rcj.cloud

Corrections and clarifications to the rules may be posted on the Forum in advance of updating this rule file. It is the responsibility of the teams to review the forum to have a complete vision of these rules.

Before you read the rules

Please read through the RoboCupJunior General Rules before proceeding on with these rules, as they are the premise for all rules. The English rules published by the RoboCupJunior Rescue Committee are the only official rules for RoboCupJunior Rescue Simulation 2022. The translated versions that can be published by each regional committee are only reference information for non-English speakers to better understand the rules. It is the responsibility of the teams to have read and understood the official rules.
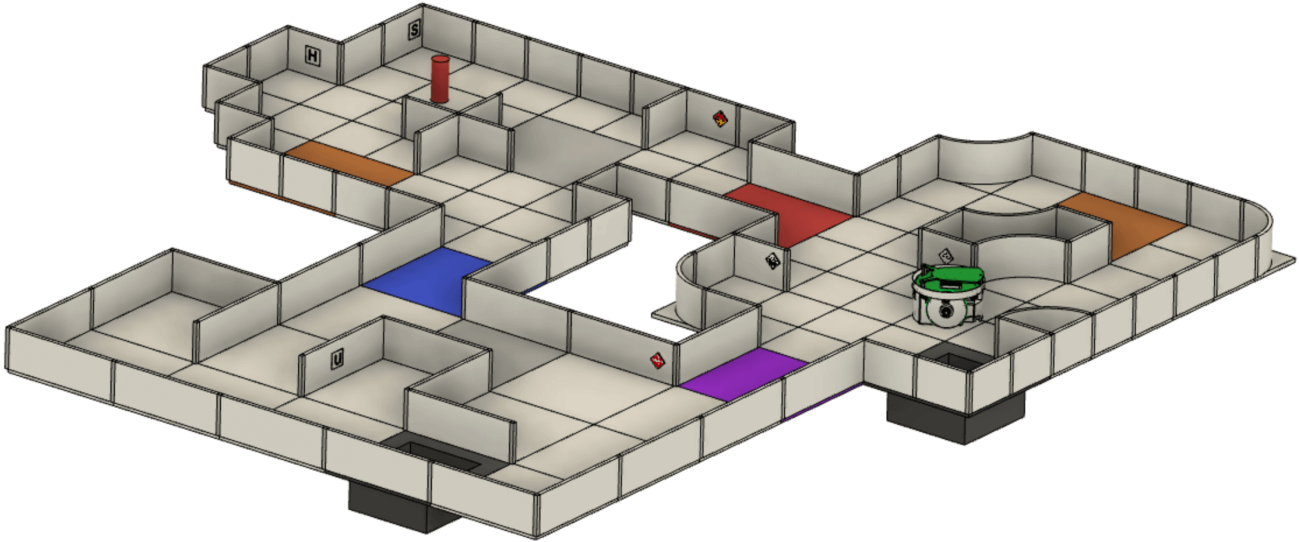
Due to the prolonged effects of the pandemic, there are remaining uncertainty on how the 2022 competition will be organised. Sections of the rules that apply specifically for in-person competitions and online competitions will be marked with a " * ". These sections are highly likely to be affected in the future. '''

The "robot" refers "virtual robot" in these rules.

Scenario

For navigation of hard to dangerous or hard to access environments, robots can be used for search and rescue operations to minimize the risk to humans. In this challenge the autonomous controller for a robot must be developed to search and identify victims in a simulated hazardous rescue scenario. The robot must navigate through challenging terrains without getting stuck, must search for victims and signal the victims' locations alongside the map of the maze environment to human search teams.

Summary

The robot needs to search through a maze for victims. The robot should not find the fastest path through the maze, instead it should explore as much of the maze as possible. The maze will be split into three distinct areas with different types of walls. The robot will be awarded 5 to 30 points depending on each victim detected. Points obtained in each area will be multiplied by a factor unique to each area.

If the robot is stuck in the maze, it can be restarted at the last visited checkpoint. Silver tiles in the field represent checkpoints so the robot can save the position to a map (if it uses a map) in a non-volatile medium and restore it in case of a restart.

Contents

1. Code of Conduct

1.1. Spirit

1. It is expected that all participants (students and mentors alike) respect the aims and ideals of RoboCupJunior as set out in our mission statement.

2. The volunteers, referees and officials will act within the spirit of the event to ensure the competition is competitive, fair and, most importantly, fun.

3. **It is not whether you win or lose, but how much you learn that counts!**

1.2. Fair Play

1. Robots that cause deliberate or repeated damage to the field will be disqualified.

2. Humans that cause deliberate interference with the Rescue Simulation runs including simulation engine, server, and/or computers, will be disqualified.

3. It is expected that the aim of all teams is to participate fairly.

1.3. Behavior

1. Each team is responsible for verifying the latest version of the rules on the RoboCupJunior Official website, and additional clarifications/corrections on the official forum made by the RoboCupJunior Rescue Committee prior to the competition.

2. * Participants should be mindful of other people and their robots when moving around the tournament venue.

3. * Participants are not allowed to enter setup areas of other leagues or other teams, unless explicitly invited to do so by team members.

4. Teams will be responsible for checking updated information (schedules, meetings, announcements, etc.) during the event. Updated information will be provided on notice boards in the venue and (if possible) on the local competition website and/or the RoboCup or RoboCupJunior websites.

5. Participants and the companions who misbehave may be asked to leave the venue and risk being disqualified from the tournament.

6. These rules will be enforced equally to all participants at the discretion of the referees, officials, tournament organizers and local law enforcement authorities.

7. * Teams are expected to be present at the venue early on the setup day as important activities will occur. These activities include, but are not limited to: registration, participation raffle, interviews, captains and mentor's meetings.

1.4. Mentors

1. * Adults are not allowed in the student work area.

2. Mentors are not permitted to be directly involved in the programming before and during the competition.

3. Mentor interference with robots or referee decisions will result in a warning in the first instance. If this behavior recurs, the team could face a possible elimination from the tournament.

4. Robots have to be mainly student's own work. Any robot that appears to be identical to another robot may be prompted for re-inspection.

1.5. Ethics and Integrity

1. Fraud and misconduct are not condoned. Fraudulent acts may include the following:

   a. Mentors working on the software or hardware of student's robot(s) during the competition.

   b. More experienced/advanced groups of students may provide advice but should not do the work for other groups. Otherwise, the team risks being disqualified.

2. RoboCupJunior reserves the right to revoke an award if fraudulent behavior can be proven after the award ceremony takes place.

3. If it is evident that a mentor intentionally violates the code of conduct, and repeatedly modifies and works on the student's robot(s) during the competition, the mentor will be banned from future participation in RoboCupJunior competitions.

4. Teams that violate the code of conduct can be disqualified from the tournament. It is also possible to disqualify a single team member from further participation in the tournament.

5. In less severe cases of violations of the code of conduct, a team will be given a warning. In severe or repeated cases of violations of the code of conduct, a team can be disqualified immediately without warning.

1.6. Sharing

1. The spirit of world RoboCup competitions is that any technological and curricular developments should be shared with other participants after the tournament. This furthers the mission of RoboCupJunior as an educational initiative.

2. Any developments may be published on the RoboCupJunior website after the event.

3. Participants are strongly encouraged to ask questions to their fellow competitors to foster a culture of curiosity and exploration in the fields of science and technology.

4. The RoboCupJunior Forum should be used for general queries and discussions whereas the platform specific Discord server should be used for technical questions regarding the platform.

2. Field

2.1. Simulation platforms

1. We will be running games on a platform called Webots. For the setup guide: Platform wiki page.

2. Teams are required to create programs to solve maze tasks.

3. * The organizers will run the games on a server-client model and will prepare one RJ-45 socket for teams to connect to the game server. Teams must prepare a computer and an ethernet cable to run the prepared programs.

4. * The organizers will collect all of the teams' simulation software before the competition in advance to be recorded. The recordings will be used as competition runs and will be showcased during the competition.

5. Teams are encouraged to develop their own worlds, and upload these to the Forum to encourage sharing.
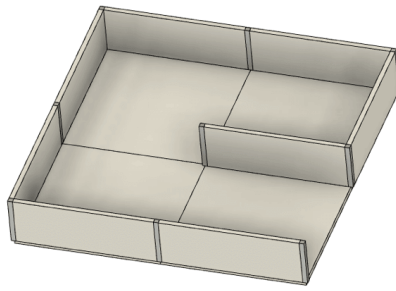
2.2. Description

1. The field layout will consist of a collection of tiles with a horizontal floor, a perimeter wall, and walls within the field.

2. The field may be divided in up to three distinct areas with different types of walls for the robot to navigate around.

3. All areas are connected to each other by a passage one standard tile in width. The floor of this passage will be marked by a colour.
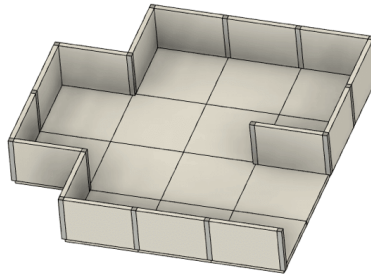
2.3. Checkpoints

1. Silver tiles in the field represent checkpoints.

2. Silver tiles will be placed randomly at the start of each game.

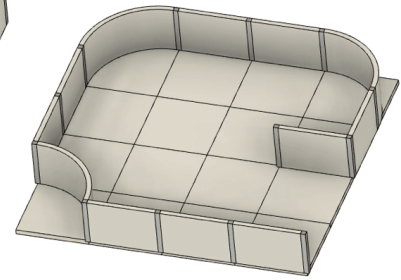## 2.4. Tiles, Areas, and Walls

1. The field is divided into tiles that are 12cm by 12cm in dimension. The tiles are not physical structures but rather a concept of how the field is generated. For areas 2 and 3, quarter-tiles are considered where each tile is subdivided into four 6cm by 6cm squares.

2. Walls will have a thickness of 1cm and a height of 6cm.

3. Pathways for the robot are intended to be of the width of the tile and may open into foyers wider than the pathways.

   ◦ Area 1: Walls are placed on the edges of each tile.

   ◦ Area 2: Walls can be placed on the edges of each quarter-tile.

   ◦ Area 3: Walls can be placed on the edges of each quarter tile. A 90-degree corner can be rounded into a quarter circle.
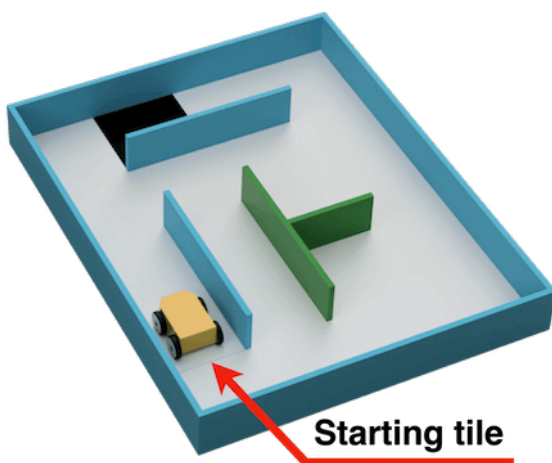
Area 1

Area 2

Area 3

4. For areas 2 and 3, regions where the robot cannot physically traverse (i.e.: openings that are half tile length) will not contain victims and hazmat signs. Such regions must be fully viewable from the opening.

5. Connection tiles between each area must have two sides surrounded by a wall, such that the tile has an unambiguous entrance and exit edge to the two areas.

6. The colours of the connection tiles are as such:

    ◦ Between Area 1 and 2: Blue

    ◦ Between Area 1 and 3: Purple

    ◦ Between Area 2 and 3: Red

7. One of the outermost tiles in Area1 is the starting tile, where a robot should start the run.

8. Walls may or may not lead to the starting tile by following the left/right most wall consistently. Walls that lead to the starting tile are called 'linear walls'. The walls that do NOT lead to the starting tile are called 'floating walls'. Black tiles will affect the determination of wall type (linear or floating), since they can be considered as virtual walls.

Starting tile

Linear walls

Floating walls

※The colour and walls configuration are for illustration only.

2.5. Swamps, Obstacles, and Holes

1. Swamps:

    a. The colour is brown.

    b. Affects the straight-drivability and speed of the robot.
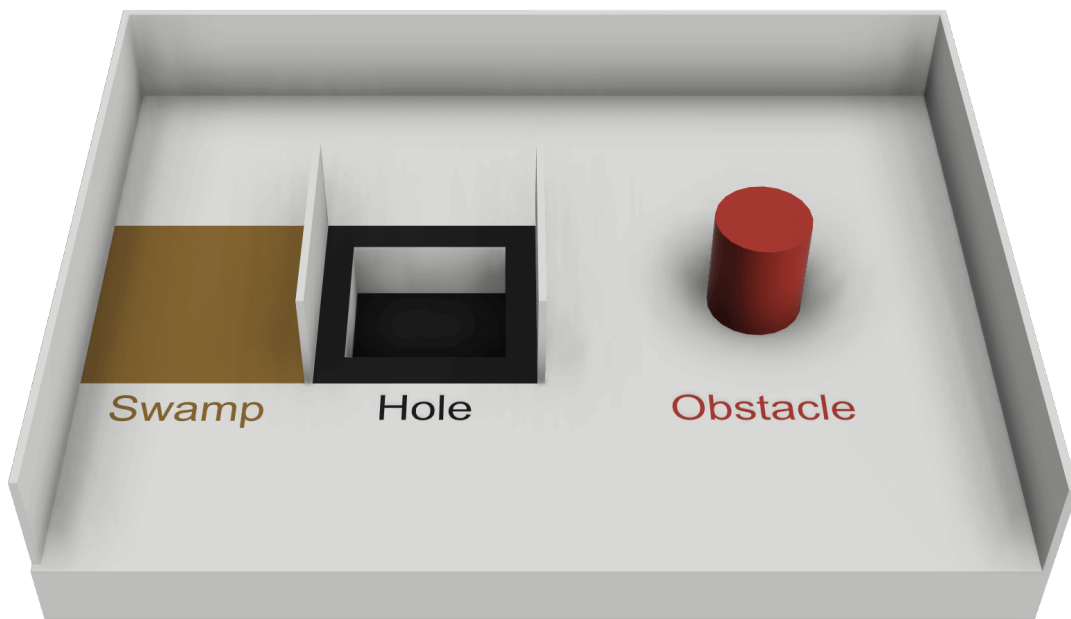
2. Obstacles:

   a. May be fixed to the floor.

   b. May be any shape including rectangular, pyramidal, spherical or cylindrical.

   c. The colour of the obstacle is not specified.

   d. It must be at least 8cm away from every wall.

3. Holes:

   a. The edge of the holes is coloured black and will be 1.5cm from neighbouring tiles.

   b. The robot has to avoid the hole.

2.6. Victims and Hazmat Signs

1. Victims and hazmat signs are represented by a 2cm by 2cm image placed anywhere on walls (including curved surfaces)

2. Visual victims are uppercase letters printed on or attached to the wall. They are printed in black, using a sans serif typeface such as "Arial". The letters represent the health status of the victim.

   a. Harmed victim: H

   b. Stable victim: S

   c. Unharmed victim: U

3. Hazmat signs are taken from the RoboCup Rescue League Website, out of which four will be used:

   ◦ Flammable Gas [F]

   ◦ Poison [P]

   ◦ Corrosive [C]

   ◦ Organic Peroxide [O]

3. Robots

3.1. Construction

1. The robot model used on each platform is provided by the organizers.

2. Teams are allowed to customise their robot (sensor locations, sensor types, wheel location, etc) using the provided robot customiser tool.

3. An upper bound to the budget is introduced. Each sensor and wheel costs a certain amount which can be viewed in the Robot Customiser Tool. This upper bound is 3000. The number of sensors is also limited, which can be also viewed from the same tool.

3.2. Sensors

1. The robot has the following sensors.

   a. Location sensor to detect where the robot is in the field

   b. Colour sensor to detect floor colour

   c. Distance sensors to measure distance to surrounding walls

   d. RGB camera to search victims and hazmat signs

   e. LiDAR to measure the distance to surrounding walls

f. Add the option to use inertial measurement unit (IMU) sensors: gyroscopic sensor and accelerometer

2. The simulation world and robot will have been created with noise which is similar to real world noise levels. Teams should ensure their programs are robust to this noise. The noise levels within the simulation will not be changed for the competition.

3.3. Control

1. Robots must be controlled autonomously.

2. Robots will be started by the referee.

3. Robots may utilize various maze navigation algorithms. Any pre-mapped type of dead reckoning (movements predefined based on known locations or placement of features in the field) is prohibited.

3.4. Team

1. Each team must have between 2 and 4 members.

2. A student can be registered on only one team across all RoboCupJunior leagues/sub-leagues.

3. A team is only allowed to participate in one league/sub-league in across all RoboCupJunior leagues/sub-leagues.

4. Each team member will need to explain their work and should have a specific technical role.

5. All team members must be the correct age as stated on the RoboCupJunior General Rules.

6. Mentors/parents are not allowed to work with or help the students during the competition. The students will have to self-govern themselves (without mentor's supervision or assistance) during the long stretch of hours at the competition.

3.5. Inspection

1. Students will be asked to explain the operation of their programs in order to verify that all are their own works.

2. Students will be asked about their preparation efforts and may be requested to answer surveys and participate in video-taped interviews for research purposes.

3. All teams must complete a web form prior to the competition to allow referees to better prepare for the interviews. Instructions on how to submit the form will be provided to the teams prior to the competition.

4. All teams must submit their source code accompanied by documentation and an engineering journal. All three documents will be shared online after the competition such that other teams can draw inspiration and learn from them.

5. The engineering journal – concise dated log shows your journey of the project. NOT meant to an after-thought document (a template will be provided)

6. The documentation - serves a summary of your project. This is an after-thought document to encapsulate your project as a whole (a template will be provided)

3.6. Violations

1. Modifications must be made within the time schedule of the tournament and teams cannot delay tournament play while making modifications.

2. No mentor assistance is allowed during the competition. (See Section 1, "Code of Conduct")

3. Any violations of the rules may be penalized by disqualification from the tournament or the round or may result in a loss of points at the discretion of the referees, officials, RoboCupJunior Rescue Committee or RoboCupJunior General Chairs.

4. Play

4.1. Pre-round Practice

1. When possible, teams will have access to practice simulation environments for calibration and testing throughout the competition.

2. Whenever there are dedicated independent simulation environments for competition and practice, it is at the organizers' discretion if testing is allowed on the competition environments.

4.2. Humans

1. * Teams should designate one of their members as "captain" and another one as "co-captain." Only these two team members will be allowed access to the competition areas where the simulation environments are located, unless otherwise directed by a referee.

2. All operations of the simulation environment in game, such as loading programs and operating LoP, are performed by the referee.

3. * No one is allowed to touch the simulation environments intentionally during a game.

4.3. Before the game

1. * When the beginning of a round is called, teams must submit their computer with the program to run saved on it. The method to collect the computers will be announced by the organizers.

2. * The time limit of submitting the computer with the program to be run in each game will be decided by the organizers.

3. * If the computer is not submitted by the time limit, the team is considered to have abandoned the game. The score of the game will be -50 points.

4. * Competition World for each round will only be revealed after the round's computers submission time expires.

5. * No changes or updates to the program after the deadline of each round are allowed.

6. * A game begins at the scheduled starting time whether or not the team is present or ready. Start times will be posted around the venue.

7. Pre-mapping the field and/or victim's location is prohibited. Pre-mapping activities will result in

immediate robot disqualification for the round.

8. * Teams must submit the source code and any other required documents before a particular day set by the OC. Details will be shared through the Official RCJ Forum.
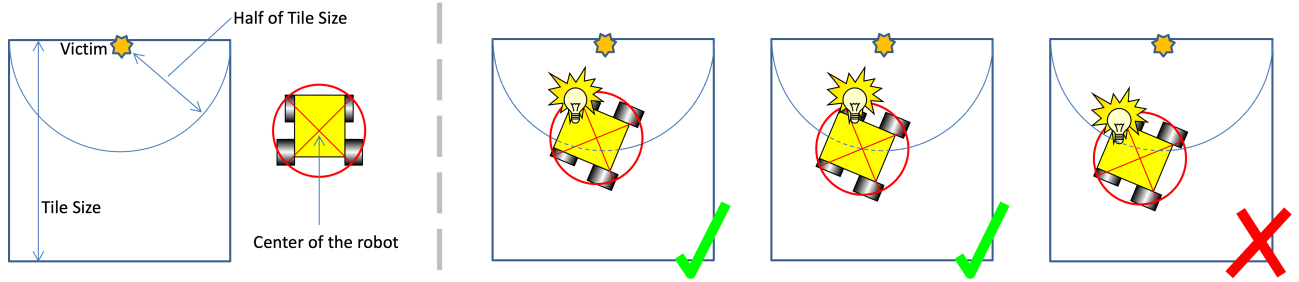
4.4. Start the game

1. * Before the start of the game, the next team should prepare the computer submitted at the beginning of the round to run the program, as a client to the game server. A maximum of 2 minutes will be given.

2. * When ready, run the program and report to the referee. The team is not allowed to touch a client computer after this in any reasons.

3. * The game will start with a referee's operation on game server.

4. Each game time will be last between 4 to 8 minutes depending on the field. The field designer will decide this duration.

5. A "visited tile" means that centre of the robot is inside. This judgement is made by the game management system.

6. * Judges will start the game with the submitted code loaded on the simulation platform.

4.5. Lack of progress

1. A Lack of Progress (LoP) occurs when:

   a. The robot has fallen into a hole.

   b. Robot being in a static location for 20 seconds or more (automatically called).

   c. The referee determines the robot is not completely static but is stuck in sequence of motion. There will be a button to allow referee to execute a manual lack of progress.

   d. The robot can call the LoP autonomously.

   e. * In any other cases, calling for LOP rests on team captain, but final decision must be made by referee.

2. In the event of a lack of progress, the robot must return to the last visited checkpoint (or the start tile if never reached a checkpoint). The robot can be installed in any direction. For the definition of the visited tile (see 4.4.5).

3. When a LOP is triggered, the engine will send a letter "L" to the robot.

4.6. Scoring

1. To identify a victim, the robot must stop by the victim for 1 second. After 1 second, it must send a command to the game manager with the type of the victim in a platform specific format.

2. For successful victim identification, the centre of robot must be equal to or less than half a tile distance from the location of the victim, when the robot indicates a victim has been identified.

3. Victim identification (VI). Points are rewarded for each Successful Victim Identification on the field.

   a. For victims and hazmat signs located on a tile adjacent to a linear wall (even diagonally), i.e. all victims at the 6 tiles around a linear wall.
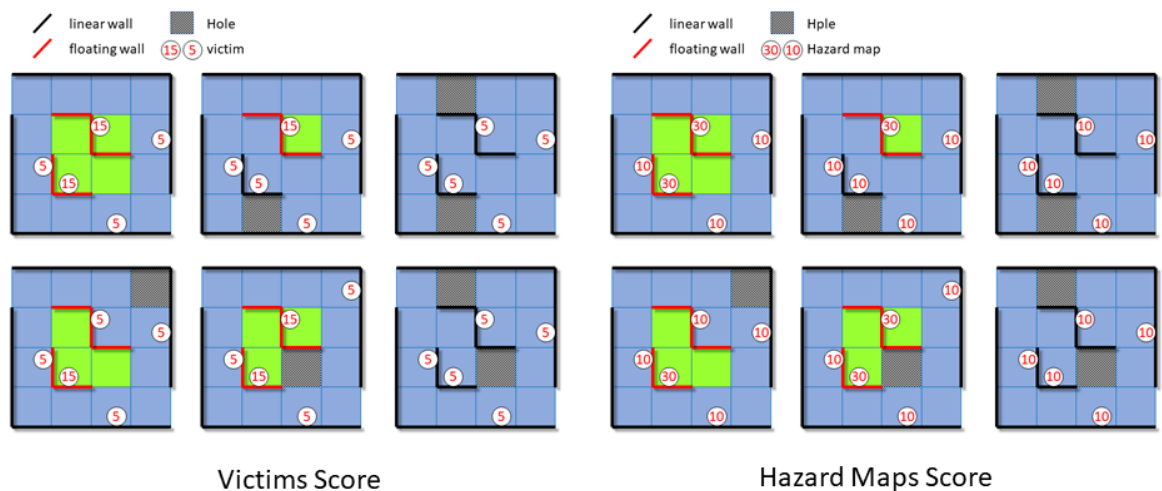
      i. Victims: 5 points

      ii. Hazmat signs: 10 points

   b. On other walls (i.e.: floating walls)

      i. Victims: 15 points

      ii. Hazmat signs: 30 points

Victims Score   Hazard Maps Score

> ℹ️ Some of the victims on the floating wall are worth 5 points. This is because these victims are placed a tile which is adjacent to a linear wall. This also applies to hazmat signs. The colours in the figure are for illustration purposes only.

4. Victim type identification (VT). Additional 10 points are rewarded if the reported type of the victim and Hazmat sign is correct.
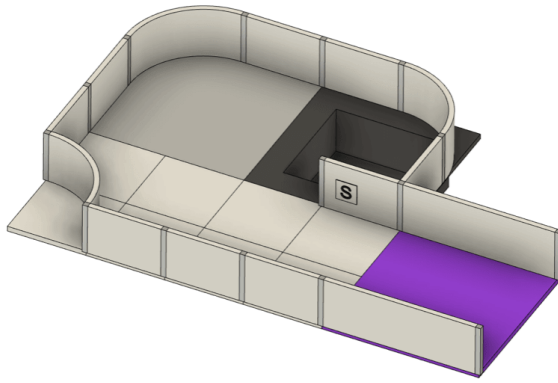
   a. Victims: 10 points

   b. Hazmat sign: 20 points

5. Victim misidentification (VMI). If a robot identifies the location of the victim to be greater than half the tile size away from the true position, it will be considered a misidentification and will cause 5 points deduction. However, the total points will never go below zero points.

6. Successful Checkpoint Negotiation (CN). A robot is awarded 10 points for each visited checkpoint. Refer to 4.4.5 for definition of visited tile.

7. Lack of progress (LoP). Each LoP will cause 5 points deduction. However, the total points will never go below zero points.

8. Area multipliers (AM). The scores for VI, VT, and CN obtained in each of the three areas will be multiplied by a unique multiplier. The multipliers are 1, 1.25, and 1.5 for areas 1, 2, and 3 respectively.

9. Successful Exit Bonus (EB). A robot will be awarded 10% of total score as an exit bonus if at least one victim has been identified, the robot returns to the starting tile, and sends an 'exit' command to the game manager to finish the game.

10. Mapping bonus (MB). When the game ends, the robot may submit a matrix with the map of the maze encoded in a particular format. The aim of the map is to encode the geometry of the environment, key elements such as holes, and victim locations. The mapping bonus is a multiplier between 1 and 2.

    a. Each quarter tile and its surrounding edges and vertices will be represented by a cell (value).

    b. Walls are marked by '1'; holes as '2'; swamps as '3'; checkpoints as '4'; starting tile as '5'; connection tiles from 1 to 2 as '6', 1 to 3 as '7', 2 to 3 as '8'; victims as the corresponding victim code, and any other tiles/edges/vertices should be zero.

    c. For curved walls in area 3, the vertex should be represented by a '0'

    d. The presence of a victim should be marked on the cell that represents the corresponding wall. If more than one victim is on a wall, the entry should be concatenated.

    e. Maps can be stored in any rotation as long as it is a multiple of 90°

    f. The correctness of a submitted map matrix will be checked against the matrix representing the real map (real map matrix).

        i. The starting tile will be used to align the two maps' matrices.

        ii. For every non-zero entry on both the real and submitted map matrices, the two values are compared.

        iii. If the two values match, the correct count is incremented. Otherwise, incorrect count is incremented.

        iv. The correctness is given by the ratio of the correct count over the sum of the correct count and incorrect count.

        v. The correctness will be calculated for each possible orientation of the submitted map matrix aligned to the real map matrix. The maximum value will be used.

    g. The mapping bonus multiplier will be the correctness + 1

    h. Ambiguous edge cases will be noted in the official documentation. For new edge cases that were are not defined, please contact the International RoboCupJunior Rescue Committee and/or the platform development team.

    i. Method of submitting a map matrix is described in the documentation and in example codes located in the platform releases.

$$\rightleftarrows \quad \begin{pmatrix} 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 4 & 0 & 4 & 0 & 2 & 0 & 2 & 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 1 & 4 & 0 & 4 & 0 & 2 & 0 & 2 & 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 1 & S & 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 8 & 0 & 8 & 0 \\ 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 8 & 0 & 8 & 0 \\ 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \end{pmatrix}$$

11. Ties in scoring will be resolved based on the time each robot took to complete the game.

12. No duplicate rewards. For example, if a robot successfully visited a checkpoint multiple times, only one successful checkpoint negotiation will be rewarded. The same result applies to all other scoring rules.

13. Scoring will be automated through the platform scoring engine.

$$\textbf{Score} = \left(\sum_{\textbf{Area}} (\textbf{VI} + \textbf{VT} + \textbf{CN}) \cdot \textbf{AM} - \textbf{VMI} - \textbf{LoP} \right) \cdot \textbf{EB} \cdot \textbf{MB}$$

4.7. End of Play

1. A team may elect to stop the round early at any time. In this case, the team captain must indicate to the referee the team's desire to terminate the game. The team will be awarded all points earned up to the call for the end of the round.

2. The round ends when:

    a. The time expires.

    b. The team captain calls end of game

    c. The robot sends an 'exit' command to the game manager.

5. Open Technical Evaluation

5.1. Description

1. Your technical innovation will be evaluated during a dedicated time frame. All teams need to prepare for an open display during this time frame.

2. Judges will circulate and interact with the teams. The Open Technical Evaluation is intended to be a casual conversation with a "question and answer" atmosphere.

3. The main objective of the Open Technical Evaluation is to emphasize the ingenuity of innovation. Being innovative may mean technical advances as compared to the existing knowledge, or an out-of-the-ordinary, simple but clever, solution to existing tasks.

5.2. Evaluation Aspects

1. A standardized rubric system will be used focusing on:
   - creativity
   - cleverness
   - simplicity
   - functionality

2. Your "work" can include (but is not limited to) one of the following aspects:
   - creation of a new software algorithm to a solution

3. Teams must provide documents that explain their work. Each invention must be supported by concise but clear documentation. The documents must show precise steps towards the creation of the invention.

4. Documents must include one poster and one engineering journal. Teams should be prepared to explain their work.

5. Engineering journals which include development process and best practices must be submitted. More details about the mechanism to be used will be announced at the RoboCupJunior forum.

6. The poster should include name of team, country, league, programming language / libraries used, detail description of the algorithm you developed, time used for development and awards won by the team in its country, etc.

5.3. Sharing

1. Teams are encouraged to review other's posters and presentations.

2. Teams awarded with certificates are required to post their documents and presentation online when asked by the RoboCupJunior Rescue Committee.

6. Conflict Resolution

6.1. Referee and Referee Assistant

1. During game play, the decisions made by the referee and/or the referee assistant are final.

2. * At conclusion of game play, the referee will ask the captain to sign the score sheet. Captains will be given a maximum of 1 minute to review the score sheet and sign it. By signing the score sheet, the captain accepts the final score on behalf of the entire team. In case of further clarification, the team captain should write their comments on the score sheet and sign it.

6.2. Rule Clarification

1. If any rule clarification is needed, please contact the International RoboCupJunior Rescue Committee through the RoboCupJunior Forum.

2. If necessary even during a tournament, a rule clarification may be made by members of the

6.3. Special Circumstances

1. If special circumstances, such as unforeseen problems or capabilities of a robot occur, rules may be modified by the RoboCupJunior Rescue Committee Chair in conjunction with available committee members, even during a tournament.

2. If any of the team captains/mentors do not show up to the team meetings to discuss the problems and the resulting rule modifications described at 6.3.1, it will be considered as an agreement.

3. In the event of unexpected issues, the OC will do its utmost to avoid any disadvantage to the team.