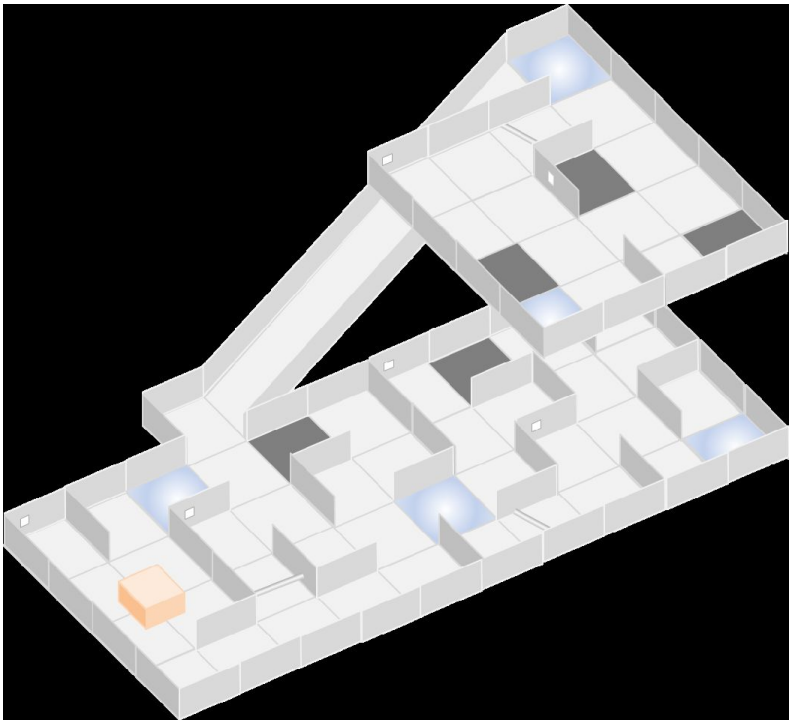
# TU Graz Robotics Challenge

## Rules Version 1_1 [1] 2018

## Overview

- open to students of all Bachelor's Degree Programmes of Graz University of Technology (TU Graz)
- a team comprises 2 – 5 students
- free choice of robotics platform
- LEGO Mindstorms NXT 2.0 will be provided by TU Graz for free (standard LEGO sensors are included)
- the development of own sensors is permitted

The task is to build and program a rescue robot which autonomously explores a maze and searches for simulated victims. A simulated victim is heated and color-coded. The robot should not find the fastest path through the maze, instead it should explore as much as possible of the maze. The robot will get points for each victim found. The robot should avoid areas with black floor. If the robot is stuck in the maze it can be restarted at the last visited checkpoint. The checkpoints are indicated with reflective floor so the robot can save its map (if it uses a map) to a non-volatile medium and restore it in case of a restart. If the robot can find its way back to the beginning after exploring the whole maze it will receive an exit bonus. The robot will also earn a reliability bonus (based on number of required restarts). There are also some obstacles where the robot can earn additional points.



Sample maze arena [http://rcj.robocup.org/rescue.html]

[1] based on RoboCupJunior Rescue Maze rules 2016 (http://rcj.robocup.org/rescue.html); rules are still subject to change, check website and version number for current rules;

# Content

# 1. Arena

## 1.1 Description

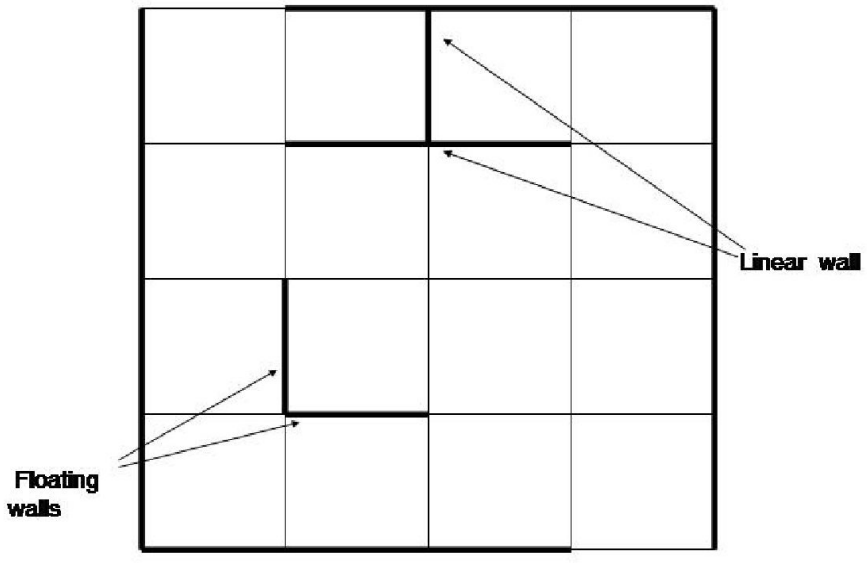
1.1.1 The maze may consist of multiple distinct areas. Areas will have a horizontal floor and a perimeter wall.
1.1.2 Areas may be joined together by doorways or ramps.
1.1.3 Walls that make up the maze are at least 15 cm high.
1.1.4 Doorways are at least 30 cm wide.
1.1.5 Ramps will be at least 30 cm wide and have an incline with a maximum of 25 degrees from horizontal surface. The ramp is always straight.

## 1.2 Floor

1.2.1 Floors may be either smooth or textured (like linoleum or carpet), and may have steps of up to 3 mm height at joints. There may be holes in the floor (about 5 mm diameter), for fastening walls.
1.2.2 Through the arena, there may exist black tiles that represent “no go” spaces. Black tiles will be placed randomly at the start of each round. Black tiles may not be completely fixed on the floor.
1.2.3 There may also exist silver tiles that represent checkpoints (see 3.6.2). Silver tiles may not be completely fixed on the floor.
1.2.4 A tile is defined as a 30x30 cm space, which is aligned to the grid made up by the walls.

## 1.3 Path

1.3.1 Walls may or may not lead to the entrance/exit. Walls that lead to the entrance/exit are called linear walls. The walls that do NOT lead to the entrance/exit are called "Floating Walls".
1.3.2 Paths will be approximately 30 cm wide but may open into foyers wider than the path.
1.3.3 One of the outermost tiles is the starting tile, where a robot should start and exit the run.
1.3.4 The starting tile is  checkpoint for reset. BUT: the starting tile does not provide points.



### 1.4 Debris, Speed Bumps and Obstacles

1.4.1 Speed bumps are fixed to the floor, and have a maximum height of 2cm.
1.4.2 Debris will not be fixed on the floor, and have a maximum height of 1cm.
1.4.3 Debris may be spread towards or adjacent to walls.
1.4.4 Obstacles may consist of any large, heavy items and its shape can be anything from rectangular, pyramidal, spherical to cylindrical.
1.4.5 Obstacles have minimum height of 15 cm.
1.4.6 Obstacle must not prevent a robot from discovering routes in the maze. An obstacle may be placed in any location where at least 20 cm is left between the obstacle and any walls.
1.4.7 Obstacles that are moved or knocked over will remain where they are moved to/fall and will not be reset during the run.

### 1.5 Victims

1.5.1 Victims are **heated and color marked (red)** sources located near the floor of the arena (centered approximately 10-15 cm above the floor).
1.5.2 Each victim has a surface area greater than 16 $cm^2$.
1.5.3 The organizers will try to keep enough difference (minimum of 10 degrees Celsius) between victims' temperatures and the indoor temperature. The temperature of the victim simulates human body temperature between 28°C to 40°C.
1.5.4 The minimum number of active victims is defined in relation to the size of maze arena.
The minimum number of victims is equal to the number of tiles in the maze, divided by 10 and rounded to the next integer.
As an example a maze of size 8x4 has 32 tiles. The minimum number of victims is 32/10 = 3.2 = 3.
There will be a minimum of three (3) **active** victims in any round in this example arena.
1.5.4.1 A victim is defined as **active** if it is a) **heated** and b) **marked with red color**
1.5.5 There may be objects that resemble victims in appearance, but are not active (= false victims). Such objects are not to be identified as victims by robots (minus 5 points for each falsely identified victim).
1.5.6 Victims will never be located on black tiles or on tiles with obstacles.

### 1.6 Environmental Conditions

1.6.1 Teams should expect the environmental conditions at a tournament to be different from the conditions at preparation.
1.6.2 Teams must come prepared to adjust their robots to the conditions at the venue.
1.6.3 Lighting and magnetic conditions may vary along the course in the rescue arena.
1.6.4 The arena may be affected by magnetic fields (e.g. generated by under floor wiring and metallic objects).
1.6.5 Teams should prepare their robots to handle unexpected lightning interference. While the organizers and referees will try their best to minimize external lighting interference, it is not possible for them to foresee all unexpected interferences such as camera flash from spectators.
1.6.6 The organizers will try their best to fasten the walls onto the field floor so that the impact from regular robot's contact should not affect the robot. (Refer to 6.1)
1.6.7. All measurements in the rules have a tolerance of 5%.
1.6.8. Objects to be detected by the robot will be distinguishable from the environment by their color or heat signature.

## 2. Robots

### 2.1 Control

2.1.1 Robots must be controlled autonomously. The use of a remote control or manual control, or passing information (by sensors, cables, wirelessly, etc.) to the robot is not allowed.
2.1.2 Robots must be started manually by the team captain.
2.1.3 Robots may utilize various maze navigation algorithms. Pre-mapped type of dead reckoning (movements predefined based on known locations before game play) is prohibited.
2.1.4 A robot must not damage any part of the arena in any way.
2.1.5 Robots should include a stop/pause button so they may be easily stopped/paused by humans to avert any potentially damaging or illegal robot actions.

## 2.2 Construction

2.2.1 The height of a robot must not exceed 30 cm.
2.2.2 Robots may not have any sensors or devices that enable it to 'see' over the walls.
2.2.2.1 Free choice of robotics platform (at each team's own charge; e.g. Arduino, Raspberry Pi, etc.). TU Graz provides 1 thermal sensor per team for free. The development of own sensors is permitted. Teams applying for the Competition 2018 have to describe their choice of robotics platform in the application/motivation letter (see 2.3.6).
2.2.3 If requested teams will be provided a standard LEGO Mindstorms NXT 2.0 robotics set for free, including 3 motors and following 4 sensors: 1x ultrasonic sensor, 1x thermal sensor, 1x color sensor, 1x light sensor. The development of own sensors using I2C communication is permitted.
2.2.4 The use of any sensor- or motor-multiplexers is permitted (at team's own charge)..
2.2.5. The use of further standard LEGO building material (in addition to which is included in the standard set) is permitted. Using non-standard LEGO building material is permitted (in case of doubt consult TU Graz).
2.2.5.1 Any commercially produced sensors that are specifically marketed to complete any single major task of *TU Graz Robotics Challenge* are prohibited. If there is any doubt, teams should consult the organizers.
2.2.6 Any programming language (e.g. NXC, RobotC, Arduino, Python...) is permitted.

## 2.3 Team

2.3.1 Each team must have only one robot.
2.3.2 Each team must have a minimum of 2 members and a maximum of 5 members.
2.3.3 The competition is open to students of **all Bachelor's Degree Programmes** of Graz University of Technology
2.3.4 Students of Master's Degree Programmes, students of other universities as well as pre-university students are not allowed to participate.
2.3.5 Every team member can be registered in only one team.
2.3.6 There is a maximum number of teams allowed for the 2018 competition. Each team has to apply for one of those available slots by sending a letter of motivation (1 page, Arial 12pt) to mkandlho@ist.tugraz.at with the subject: [robotics challenge] (deadline: 27.03.2018). The selection of teams will be based on this letter of motivation.

## 2.4 Inspection

2.4.1 The robots will be examined by a panel of referees before the start of the tournament and at other times during the competition to ensure that they meet the constraints described.
2.4.2 It is highly unlikely that a team will be able to legally use a robot identical to another team's robot from previous or the current year, or use a robot that is identical to another team's robot.
2.4.3 It is the responsibility of teams to have their robots re-inspected, if their robots are modified at any time during the tournament.
2.4.4 Students will be asked to explain the operation of their robots, in order to verify that construction and programming of the robot is their own work.
2.4.5 Students may be asked about their preparation efforts.

## 2.5 Violations

2.5.1 Any violations of the inspection rules will prevent the offending robot from competing until modifications are applied.
2.5.2 However, modifications must be made within the time schedule of the tournament and teams must not delay tournament play while making modifications.
2.5.3 If a robot fails to meet all specifications (even with modification), it will be disqualified from that round (but not from the tournament).

# 3. Play

## 3.1 Pre-round Practice

3.1.1 Where possible, teams will have access to practice arenas for calibration, testing and tuning throughout the competition.
3.1.2 During open lab days (starting 6.4.2018, every second Friday afternoon) teams can use the infrastructure of the robotics-lab and prepare for the competition.

## 3.2 Humans

3.2.1 Teams should designate one of its own team members as 'captain' and another one as 'co-captain'. Only the captain will be allowed to interact with the robot during a scoring run.
3.2.2 The captain can move the robot only when s/he is told to do so by the referee.
3.2.3 Other team members (and any spectators) within the vicinity of the rescue arena have to stand at least 150 cm away from the arena while their robot is active, unless otherwise directed by the referee.
3.2.4 No one is allowed to touch the arenas intentionally during a scoring run.

## 3.3 Start of Play

3.3.1 A run begins at the scheduled starting time whether or not the team is present/ready. Start times will be posted prominently around the venue.
3.3.2 Once the scoring run has begun, the playing robot is not permitted to leave the competition area for any reason. Each run lasts a maximum of 8 minutes.
3.3.3 Calibration is defined as the taking of sensor readings and modifying a robot's program to accommodate such sensor readings. Once the clock has started, a team may calibrate their robot at as many locations as desired on the arena, but the clock will continue to count down. A robot is not permitted to move using its own power while calibrating.
3.3.4 Calibration time is not for pre-mapping the arena and/or victims' location. Pre-mapping activities will result in immediate robot disqualification for the round.
3.3.5 Before a scoring run begins, a dice will be rolled to determine the location of the black and silver tiles. The position of the black tiles will NOT be revealed to the team until when they are ready to start a scoring run (see 3.3.6). Referees will ensure the combination of black tile placements in a maze is 'solvable' before a robot begins a scoring run.
3.3.6 Once the robot is started, a referee will place the black and silver tiles (determined by roll of dice as per 3.3.5).
3.3.7 Once a scoring run has begun, no more calibration is permitted (this includes changing of code/code selection).
3.3.8 On the day of the competition each team will have 3 scoring runs (best two runs will be scored).

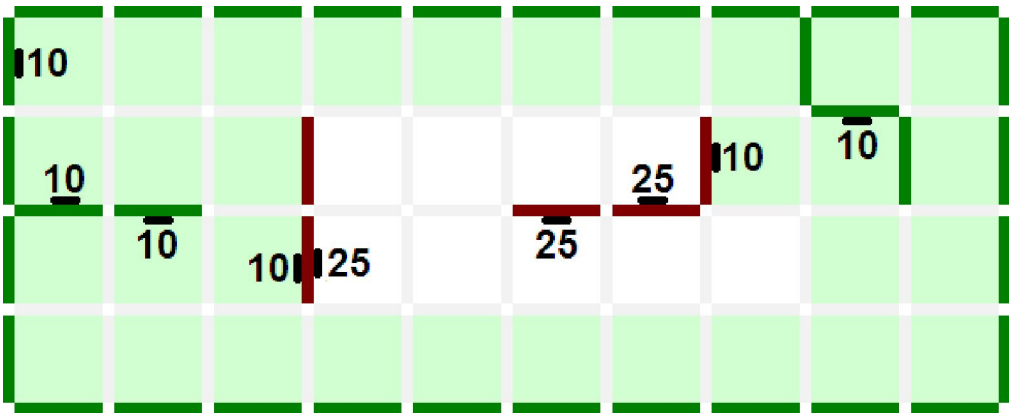
## 3.4 Game play

3.4.1 Modifying a robot during a run is prohibited; which includes remounting parts that has fallen off.
3.4.2 All parts that the robot is losing intentionally or unintentionally will be left in the arena until the run is over. Neither the team nor the judge are allowed to remove parts from the arena during a run.
3.4.3 Teams are not allowed to give a robot any advance information about the field. The robot is supposed to recognize the field by itself.
3.4.4 A "visited tile" means that more than half of the robot is inside the tile when looking down from above.

## 3.5 Scoring

3.5.1 Successful victim identification: Robots are rewarded points for each successful victim identification (heat + color; see Section 1.5) in the arena:

a) 10 points per "victim" located at a tile adjacent to a linear wall (even diagonally), i.e. all victims at the 6 tiles around a linear wall.
b) 25 points per "victim" at other walls.




[http://rcj.robocup.org/rescue.html]

In the above diagram, red lines mean floating walls while the green ones represent linear walls. Note that some of the victims on the floating walls are worth 10p, this is because the 10p victims are located in a tile near a linear wall. The colors on the diagram are just for illustrative purposes.

3.5.2 To identify a victim, a robot must stop within 15 cm of the victim while playing a clearly audible, distinct tone for at least **five** (5) seconds. When a robot completes this, it counts as one successful victim identification

3.5.2.1 Minus 5 points for each falsely identified victim (see 1.5.5.).

3.5.3 Reliability Bonus = [the number of 'successful victim identification' x 10] minus [the number of 'Lack of Progress' x 10].
However, Reliability Bonus score can only be reduced down to the minimum of 0 points.

3.5.4 Successful Speed Bump Crossing. For each tile with speed bumps passed, a robot is awarded 5 points.
3.5.5 Successful Up Ramp Negotiation. A robot is awarded 10 points for a successful climb of the ramp. To successfully climb up the ramp, a robot needs to move from the bottom horizontal tile before the ramp to the top horizontal tile after the ramp.
3.5.6 Successful Down Ramp Negotiation. A robot is awarded 5 points for successfully landing at the bottom of the ramp. A robot needs to move from the top horizontal tile of the ramp to the bottom horizontal tile of the ramp. A successful landing means that the robot can leave the tile without assistance.
3.5.7 Successful Checkpoint Negotiation. A robot is awarded 10 points for each visited checkpoint. Refer to 3.4.4 for definition of visited tile.
3.5.8 Successful Exit Bonus. A successful exit bonus is awarded when a robot successfully finishes a round on the start tile. It needs to stay there at least 10 seconds (this is to simulate the retrieval of a robot from the disaster zone). The points awarded will be 10 points per victim successfully identified.
3.5.9 Ties at the end. Ties in scoring will be resolved on the basis of the time each robot took to complete the run.
3.5.10 No duplicate rewards. For example, if a robot successfully crosses a tile with speed bumps multiple times, only one Successful Speed Bump Crossing will be rewarded per tile. Same result applies to all other scoring rules.
3.5.11 Lack of Progress Penalty. For each Lack of Progress a penalty of -5 points will be deducted from the team's total.

## 3.6 Lack of Progress

3.6.1 A Lack of Progress occurs when

a) The team captain declares a Lack of Progress.
b) A robot fails to retreat from 'visited' black tile. For a successful retreat it needs to back up without turning inside the black tile (it has to move straight backwards inside of a black tile). See definition of visited tile on rule 3.4.4.

c) A robot or a team member damages the arena.
d) A team member touches the arena or their robot without permission from a referee.

3.6.2 If a Lack of Progress occurs, the robot must be returned to the last visited checkpoint. The robot can be placed in any direction. Refer to 3.4.4 for definition of visited tile.
3.6.3 After a Lack of Progress, the team captain may reset the power supply (turn the robot off and on) and because of this the program is restarted. He is not allowed to change the program or give any information about the maze to the robot.
3.6.4 Minus 5 pts. for each Lack of Progress

### 3.7 End of Play

3.7.1 The team captain may declare an "end of round" if the team wants to stop the round early. The team will be awarded all points achieved up to the call for end of round.
3.7.2 The round ends when:

a) The time expires (8 minutes).
b) The team captain calls end of round.
c) The robot returns to the start tile and gets the exit bonus.

## 4. Team Responsibilities

4.1 Teams have to document their work.
4.2 All teams are obliged to share the results of their work (source code, construction plans, documentation, ...) with TU Graz.
4.3 All equipment (robots, sensors, further provided material) provided by TU Graz has to be returned to TU Graz after the competition in complete order and perfect condition.

## 5. Conflict Resolution

### 5.1 Referee and Referee Assistant

5.1.1 All decisions during game play are made by the referee or the referee assistant who are in charge of the arena, persons and objects surrounding them.
5.1.2 During game play, the decisions made by the referee and/or the referee assistant are final.
5.1.3 At conclusion of game play, the referee will ask the captain to sign the score sheet. The captain should be given maximum 1 minute to review the score sheet and sign it. By signing it, the captain accepts the final score on behalf of the entire team; in case of further clarification, the team captain should write their comments in the score sheet and sign it.

### 5.2 Rule Clarification

5.2.1 If any rule clarification is needed, please contact the organizers (TU Graz).
5.2.2 If necessary even during a tournament, a rule clarification may be made by the organizers (TU Graz).

### 5.3 Special Circumstances

5.3.1 If special circumstances, such as unforeseen problems or capabilities of a robot occur, rules may be modified by the organizers (TU Graz), if necessary even during a tournament. In such cases all team captains will be informed (either by email before the competition or by a team meeting during the competition).
5.3.2 If any of the team captains do not show up to the team meetings to discuss the problems and the resulting rule modifications described at 5.3.1, it will be considered as an agreement.

# 6. Code of Conduct

6.1 Robots that cause deliberate or repeated damage to the arena will be disqualified.
6.2 Humans that cause deliberate interference with robots or damage to the arena will be disqualified.
6.3 It is expected that the aim of all teams is to participate fairly.
6.4 Teams will be responsible for checking update information (schedules, meetings, announcements, etc.) during and before the competition. Update information will be provided on notice boards in the venue and (if possible) on the local competition website and/or via email.