The Expedition Robinson Challenge: from theory to practice

BKI115a - Robotics Assignment 2016-17

A dramatic boat incident has occurred near a remote volcanic archipelago in the Pacific… Almost all robots are smashed on coral rocks. These unfortunate creatures have found their final destination. The ill-fated ones are now in the bellies of the numerous sharks that infest the waters surrounding the islands. Luckily, a few (your) robots have been washed upon the shores of several isolated islands. But they are far from safe. They really have to struggle hard for staying alive. There is not much to see on the islands: each island is covered with black lava rocks. Some islands, however, show traces of former (or current?) habitation. Forgotten paths can be detected and it has been said that some of these tracks lead to salvation…

In order to survive, robots have to perform several tasks. They have to be able to:

- Find paths
- Follow paths
- Cross bridges and seesaw
- Orient themselves by means of detecting and recognizing salient landmarks in the environment
- Escape from a difficult maze
- Pick up small blocks and move them from one island to another
- Distinguish enemies from friends, fight enemies and cuddle friends

From the first lesson on, your teachers will not only talk about the fundamental theories underlying *AI Robotics*, but also discuss these theories in terms of the tasks your robot has to perform and other practical applications of the theory. Throughout your journey along the paths of designing your robot, you should never forget the beautiful solutions that nature provides, as explored in lecture 5, about Biological Aspects. You will conceptualize the tasks to be performed using the formalisms from Chapters 1 and 2. You will further specify the behaviours in terms of these formalisms and the methods described in Chapters 3 and 4 from the MAS book. You will *design* your robot behaviours according to the architectures described in Chap 5 of the MAS book from Wooldridge. And, finally, you will implement the designed behaviours using the techniques discussed in lectures 6 and 7.

All these tasks are briefly explained below. Your robot should be able to complete them all successfully on both rehearsal day and demo day. We have set up these tasks in the form of four challenges. You are welcome to provide feedback or ask questions to your teachers and student assistants at any time: by email, visit us, or in class (preferably in class, we like questions and interaction). So please contact us with feedback and questions that may come up when you discuss these challenges with your group, when you obtain your first experiences with using your robots and the robot material, or even later on, when your robot becomes more mature. We will incorporate your feedback in a final version of this document, which should become available mid-May.

During the rehearsal day and roboday, you will follow a competition schedule that specifies at which time your team and your robot have to be present at one of the four islands.

In the design of this Expedition Robinson Challenge, we had to obey the following constraints:

- All challenges should fit in the available space
- The organization should cater for a large group of students
- Reduce the chance factor as much as possible (e.g. balls can accidently roll in any direction, rectangular blocks can not)
- Increase the required smartness (e.g. by reducing the time factor)
- Maintain a level of difficulty which is comparable to previous assignments

We believe that we have succeeded in our efforts. The next pages contain a more detailed description of these four challenges:

1. Explore your island (inspired by the vacuum cleaner task from the book) **25 points**
2. Run for your life! (will use a racetrack including bridge and seesaw) **15 points**
3. Friend or foe? (distinguish pillars and act accordingly) **20 points**
4. Search and rescue (travel a small path, find/retrieve food) **25+10 points**

There will be no penalties. In stead, **if you ask the judges and the judges agree** you can: pick up the robot, repair it, reset it, or whatever. Don't take too long, because time will not be stopped! Once you're done you must re-position your robot at the last "check point" visited. In the figures below, checkpoints are marked yellow.

Some final general rules and guidelines:

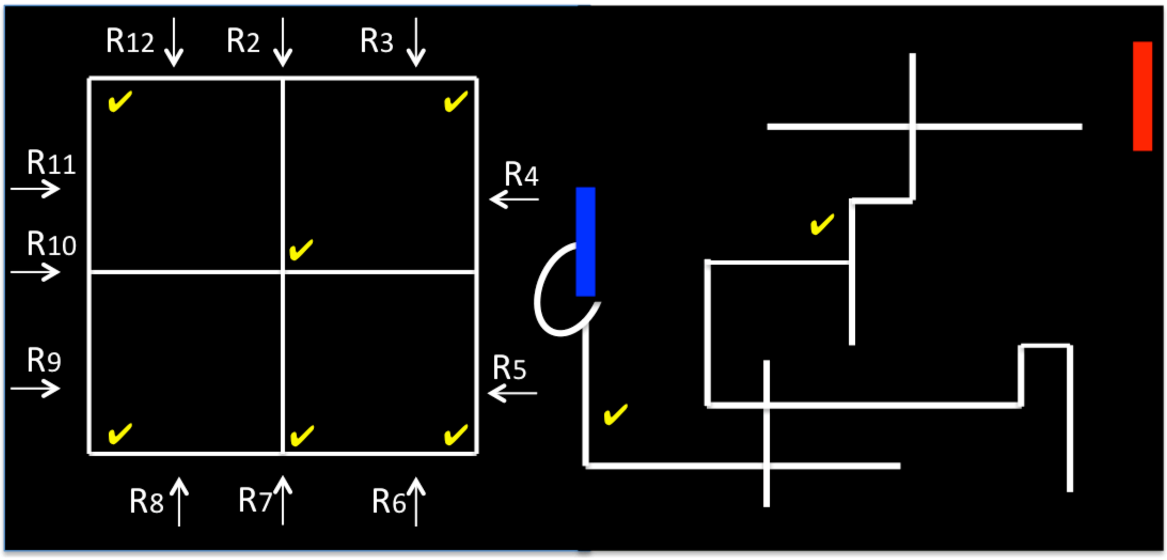
- You are allowed to start a dedicated program for each of the four challenges.
- You are **not** allowed to switch programs during the challenges, e.g. to switch from the grid task to the maze task during performance of challenge 1.
- You can earn points by displaying certain behaviors. In all cases your judges will rule and – as with any sports game – fair play includes **not** messing with the judges.

Read this assignment careful and with much attention.

Challenge 1: Explore your island and find your way out

It is important to visit every place on the island. Maybe you can find food sources, housing material, weapons or wood for making a fire. It would be a shame if you would miss these valuable resources…

This challenge is inspired by the **vacuum cleaner** task from the MAS-book and combines this task with a **maze** problem. As all other challenges, the background of your island is black (volcanic lava rock). A grid of light-coloured paths, easily distinguishable from the background, will provide your robot with clues. Your task is to first explore the island (through following a grid) and subsequently find the escape route (by following a maze). Salient landmarks are available to help you out with these tasks, like depicted in the picture below.



1a) Grid task: Your robot will be positioned at some random position, outside of the grid, and facing grid-inwards. So, in advance you will know three things: (i) the task to be performed, (ii) the environment and (iii) that if you move forward, you will find a path. The environment consists of a black background, and a white 3x3 grid. Visible at certain points in the grid is a salient landmark: a blue pole. Grid size is about 1.5 x 1.5 meters. Your task is to visit each of the nine grid points at least once and then continue with task 1b) The maze.

Expected behaviour: Starting from one of the initial positions R2-R12 (to be decided by rolling two dices). The robot should move towards the grid and once it has detected the grid (white path), it should visit all nine grid points. The robot should be reactive (i.e. detect that is on/off the path and act accordingly). In addition, the robot may try to map the environment (SLAM) and remember where corners or the blue pillar are. Once all grid points have been visited at least once, the robot should search for the blue pillar to continue with the maze task.

1b) Maze task: Searching for the blue pillar does not require that your robot stays on the path, although you may find the fact that your robot stays on the grid useful. Upon detecting the blue pillar, your robot should move towards it, find the maze entry (a not-completely-closed oval surrounding the blue pillar); solve the maze and stop when detecting the red pillar. Note that the layout of the maze will most probably differ from the depicted track, but that the complexity will be approximately the same. Once the blue pillar has been detected, it is allowed to remove it from the environment.

Expected behaviour: The robot should indicate (play sound/beep/…) that is has found the maze. It should follow the maze according to a heuristic that does not require solving so-called 'islands'. When it has reached the red pillar, the robot should show some happy behaviour and stop.

You can earn 25 points for this assignment:

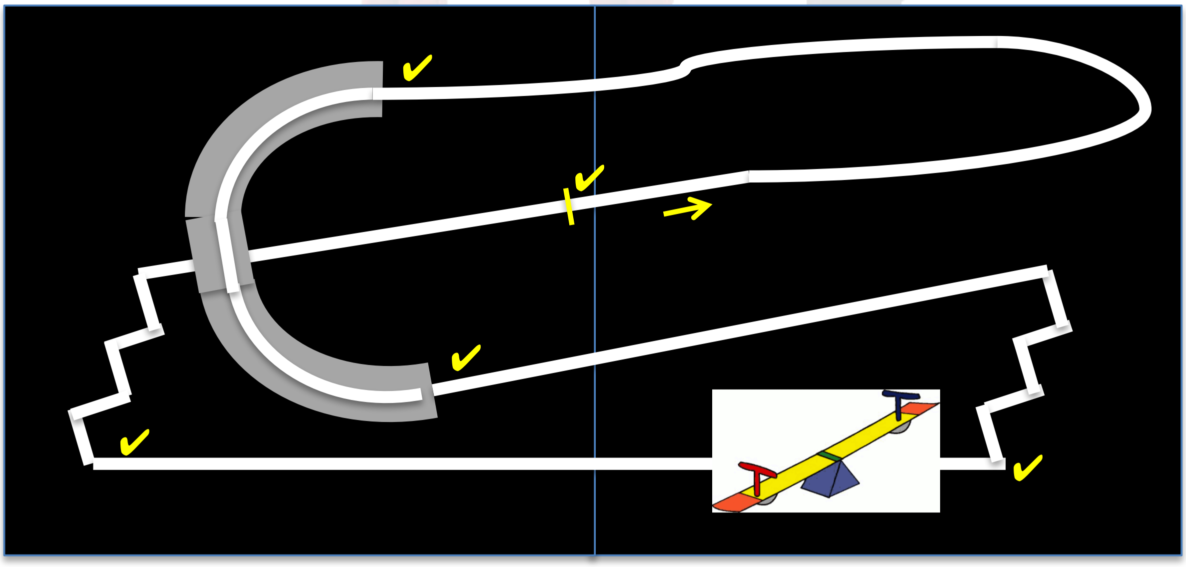
- 1 point for each grid point visited (each grid point counts once, 9pts max)
- 4 points per landmark recognized, during which your robot should play a sound (unique for each event) or show some other distinctive behaviour, so the audience and your judges can judge that your robot indeed knows where it is (8pts max).
- 4 points for each of the two maze checkpoint (8pts max). Your judges will indicate the position of the checkpoints.

In cases of failure (repair, losing the path, …), your robot will be re-positioned at the last checkpoint. The last grid point correctly passed is the checkpoint for re-positioning your robot after failure. This challenge ends when your robot has found the red pillar (and subsequently stops), or after 10 minutes have passed.

Challenge 2: Run for your life!

During your explorations you encountered some disturbing evidence of the presence of a large predator on the island. The creature has spotted you and you are in the middle of a deadly chase…

For this challenge, we will use a racetrack including bridge and seesaw. Your robot will be positioned on the start/finish line and "just" have to complete two rounds. The layout of the track will be something like depicted in the figure below. The size of the island may become something like 2x4 or 2.5x5 meters.



Maximum 15 points can be earned as follows:

- cross seesaw: 2 points
- cross bridge: 2 points
- proper path following: 4 points
- time factor:
  - fastest top-5 7 points
  - top-10 5 points
  - top-15 3 points
  - position 16-… 1 point

You should be able to complete two rounds within 10 minutes.

Tips and tricks:
Smooth and fast path-following does the trick here. Also consider the positioning of your light/color sensor: some constructions will prohibit the robot from climbing the seesaw or the bridge. The short, curvy side of the bridge is used to climb the bridge, the longer side of the bridge for descent. Test your path perception algorithm in various conditions: although at all positions the path is lighter than the background, light intensities may vary along the track. Think about making perception more robust, e.g. by using running-average or median filters. Please note that experience has shown that the fastest robots employ some sort of control algorithm.

Challenge 3: Friend or foe?

You should carefully explore this island. Some inhabitants may be friendly, others are hostile… Embrace your friends and kill your enemies. How you cuddle your friends and how your enemies will be destroyed is up to you!

This island has no paths, but it is surrounded by a (white) beach. So, when you recognize the beach, you know that you are at the edge of the island. Your robot starts at a random position, indicated by your judges. The island contains **three** red and **three** blue pillars. They will be positioned at random positions. Be creative in implementing the destructive behaviour (killing the red pillars) and your courtship behaviour (embracing the blue ones).

Points to be earned: 20

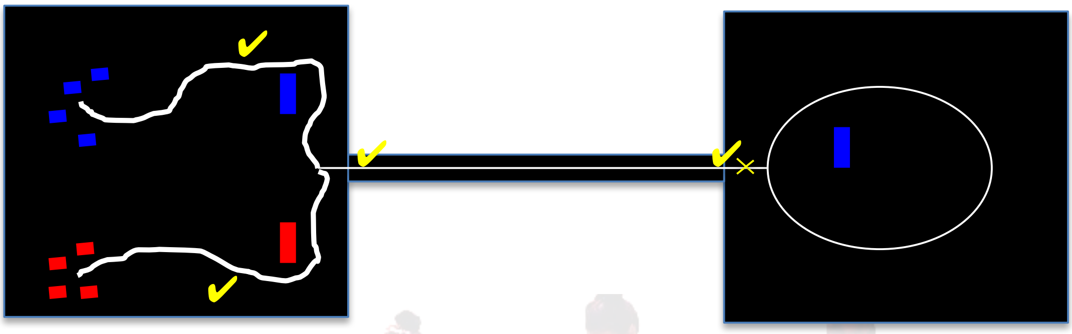
- 2 point per pillar correctly recognized (max 12 points)
- 4 points for decent kill behaviour (red pillars)
- 4 points for romantic behaviour (blue pillars)

The island will be approximately 2x2 meters. The challenge ends after 10 minutes. Checkpoint is the point at which you picked up your robot (if needed for repair) or where your robot jumped off the beach into the sea.

Expected behaviour: Your robot should explore/wander the island, scanning for pillars. Once a pillar is detected, your robot should identify it (either red or blue). Pillars will stand on a small round circle, with red/blue colour corresponding to the pillar. After identification, the corresponding actions (kill/courtship) should be performed. It is essential that one of your group members explains the behaviour of the robot during its performance to judges and audience.

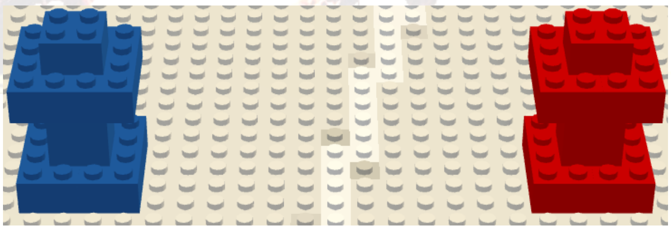
Challenge 4: Search&rescue

Your robot has heard about food and poisonous plants on a neighbouring island. That island can only be accessed at low tide (revealing a sandbank) via a narrow passage. Discovering salient landmarks can provide directions to the edible food… Once food has been found, it has to be retrieved to your island!



Is is well-known that finding sufficient resources is the most difficult task when surviving an accident like your robot has gone through. Through this complex challenge you can earn 25+**10** points. It is inspired by many previous challenges and Robinson's well-known balance beam.

- Your robot will be positioned on the path towards the island containing food (at the yellow cross, facing the "food" island).
- It has to cross the narrow passage and decide which way to take (it will be unknown in advance whether food is on the left or right path). **Note that** the passage is 30cm wide and that your robot can fall from it!
- Food will be laying on black blocks of varying heights (0cm, 5cm, 10cm, 15cm, 20cm). You can opt for either of these heights.
- The robot has to find food, pick it up and bring it back to the island.
- It can determine whether it has reached "home" through a salient landmark
- It should drop the food in the "home" circle



This picture depicts the Lego blocks to be detected and retrieved by your robot.
Great graphics design by JaspervD.

Points to be earned:

- Passing the narrow passage: 5 points
- Detecting and distinguishing landmarks: 5 points
- Detecting food: 5 points
- Picking up food: 5 points
- Bringing back food "home": 5 points
- Bringing back additional food "home": 10 points **bonus**

Each island will be approx. 2x2 meters, the narrow passage will be 150 cm long and 30 cm long. The challenge ends after 10 minutes.

Expected behaviour: Your robot starts with passing the narrow passage. You are allowed to catch/rescue it if you expect it to fall off the passage. As with all challenges, the robot should start at the last checkpoint in case of such events. Once it arrives at the other island, the robot should look for pillars. The red pillar marks the wrong direction. If it detects the blue pillar, it should follow that direction. At the end of the path, your robot will find blue food. You are free to determine your preferred height at which the food can be picked up. Food is positioned on black-colored pillars with height of your choice (either 0,5,10,15,20 cm heigh). Your robot should have a mechanism with which it can pick up the food and carry it. Food should be returned to the home island. It helps if your robot knows it way back. Returning food is successful if it is dropped in the "home" circle. Once you have retrieved one piece of food, you can earn ten bonus points.

Frequently asked questions from the past

Many of the questions and answers of this FAQ can only be fully comprehended if you really build the ecological niches and compare them to the examples given in the assignment.... as your robot (tries to) perform the tasks, you will learn if your design(s) are succesful in the real world - or not.

So:
*** get the material out of the robotlab;
*** build all challenges;
*** learn from this;
*** and return all material back to the robotlab

Here an unsorted list of questions and answers, see also Course Info on BB:

Practicals…

After the exam, on most Thursday mornings we'll have lab sessions in TvA 6

Rehearsals in week 26; report on Sunday July 3

In week 26, we have rehearsals. During the rehearsals you should collect empirical data and observations that you can use to finalize your report.
Each group will (try to) finish all four challenges. Goals of the rehearsals are (i) to really understand and agree on how all challenges should be run; (ii) obtain the **very** necessary experiences with how your robots behave and perform in the different situations; (iii) collect data and observations that you will describe in your report which is due on **Sunday July 2 23:59:59**.

Report, and the demo days... what if ...

- Report is due on **Sunday July 2 23:59:59**
- Many groups will have a robot that is not fully equipped to perform well in all challenges: it will need some final improvements. Obviously, this has consequences for how you write about your robot in your report. Furthermore, it will provide you with lots of insight about how you should improve your robot. In your report, you could use this info, for example, as follows. (i) you have designed your robot to complete all tasks successfully; (ii) you have observed that your robot failed in particular situations; (iii) as it is good practice to run pilot tests (like rehearsal day) to search for possible points for improvement, you consider the flaws that you observed as next steps to solve; and (iv) on demo day, your robot will win the competition.
- Please add your code listing (the code as it is on July 2) as an appendix to your report.

On demo day, it will be very busy and we'll have a tight schedule...how to manage that?
We will provide you with a precise schedule, containing times at which your group has to be present to perform at a certain challenge.

The robot should be able to complete four different tasks... can we build four different robots and develop four different programs, each tailored for a particular task?
Yes, you can. Obviously, it is up to you how to ensure that you can swiftly change the physical design of your robot so you can meet the deadlines from the tight schedule.

The picture <x> from the assignment depicts a situation that is hard to build using the material from the robotlab. How should we deal with this?

Well, the assignment contains *sketches* of how the world may look like. You will have to build the world and fill in the details together with the student assistants and teachers. Your initiative for exploring and building the challenges is prime. While doing so, your feedback and input is highly appreciated. For example, we have white tape (2-5cm wide) to make the paths that your robot should follow. You may state that 2cm is not wide enough. Or, complain that some corners require a little more space. Or tell that certain pieces of the path are too wrinkled. Or, maybe, that certain material seems to be missing. The latter is very important to report immediately, so we can buy new material asap. While setting up the paths, rest assured about the following:

- Paths will be glued to the floor, so wrinkles will be minimized
- We will use the rubber yellow/pink paths as well as white tape to generate paths
- If you encounter impossible corners (like the serrate straight corners in challenge 4), please report this asap and we can discuss about changing them a little bit

The rule is that you can use only material that is contained in the boxes… can we use <x> or <y>?

This rule holds. However, there are 2 exemptions on this rule, where you can use material beyond the stuff from your boxes:

- You can use elastic rubber, e.g. to strengthen certain connections, or to increase friction on the wheels/caterpillar tracks.
- You can use any decorative material to cheer up your robots

How will the "food" from task 4 look like. How does the layout of task 4 look like?

Food is shaped as depicted in the assignment:

- One 2x2 block on top;
- Two 2x4 blocks below that, forming the “roof”;
- Two 2x2 blocks on top of each other between roof and bottom
- Two 2x4 blocks on the bottom

Food is standing on top of small pieces of wood (black). You are allowed to select the pieces of your choice. So, any height between 0,5,10,15,20cm is allowed.

There are quite some lego parts available to build food and test your food-picking mechanisms. A sketch of the layout of the task is depicted in the assignment as well. There will be two large areas (about 2x2 meter each), one containing the food and the other containing a marked area where your robot has to store. Shape/size of the areas will be as sketched in the assignment. There will be an elevated small “bridge” which connects the two islands.

Can we work on our robot challenges beyond the scheduled lab sessions?

Yes! Some groups have already done this by requesting the student assistants for access to the robotlab. Don’t forget to also arrange that you return your robot to the lab. We are working on specific “opening hours” to get/return your robot. Opening hours are communicated through BB and really are non-negotiable: opening fully depends on the availability of student assistants.

We noticed that some groups have different material inside their boxes then we have: this is not fair!
Well... from day1 on, we have instructed you to check the content from your boxes. If anything is missing or superfluous, you should (have) contacted your student assistants immediately. This is still the case. So, when sensors or even motors appear to be missing: ring the alarm bell!

We heard ambiguous information about the poles/pillars: will they stand on a flat round piece of rubber with same color as the pillars, or not?
Yes. These rubber shapes have been available for testing all semester long.

We heard that we have to be careful with the material.
Yes, be careful with the material. Do not leave material behind after the practical sessions, do not damage material or lose material. We have no spare material.

As an example: a possible and very preliminary time schedule of one of the previous RoboDays (2014)

July 2 2014 in Spinoza AK54-AK55 and surrounding corridors

The day before: set up and final rehearsals;
From 09.00-10.00 final preparations (load batteries!)

time	**1:Explore**	**2:Run**	**3:Friend/Foe**	**4:Search/Rescue**
10.00	team01	team02	team03	team04
10.15	team05	team06	team07	team08
10.30	team09	team10	team11	team12
10.45	team13	team14	team15	team16
11.00	team17	team18	team19	team20
11.15	team21	team22	team01	team02
11.30	team03	team04	team05	team06
break from 11.45-12.00				
12.00	team07	team08	team09	team10
12.15	team11	team12	team13	team14
12.30	team15	team16	team17	team18
12.45	team19	team20	team21	team22
break from 13.00-13.30				
13.30	team22	team01	team02	team03
13.45	team04	team05	team06	team07
14.00	team08	team09	team10	team11
14.15	team12	team13	team14	team15
14.30	team16	team17	team18	team19
14.45	team20	team21	team22	team01
15.00	team02	team03	team04	team05
break from 15.00-15.15				
15.15	team06	team07	team08	team09
15.30	team10	team11	team12	team13
15.45	team14	team15	team16	team17
16.00	team18	team19	team20	team21

break from 16.15-16.30 (voting for public's favourite)
somewhere between 16.30-17.00 presentation of results

During the afternoon break and after 16.00, we will have drinks available for you and the audience. From around 18.00 on, we will slowly start putting the robots back into their boxes and we will start cleaning TvA6. After cleaning is done, we can continue the party until (probably) 19.30.

Overall winners

There will be one winner for each challenge and an overall winner. **Rules for deciding who is the overall winner will be published.**