Evolutionary Robotics
Prof. Dario Floreano

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# The goal of the grand challenge is to evolve a robot for the next Mars exploration rover

The evolved robot must be wheelless and should be capable of locomoting as quick as possible on rough terrain while avoiding obstacles. Additionally, the robot must stabilize its core components as much as possible while locomoting as it could be used to carry delicate scientific equipment in the future.

**Submission and grading:**

- Submission deadline: **Tuesday, 31-May-2023 23:59**
- Every team should **submit the following files in a zip file on Moodle**:
    1. Their best robot (.txt file)
    2. All evolution files (scenario.js, configuration files, arenas, etc)
    3. Their presentation (PDF and pptx)
- **The performances of the robot will not be graded.** However, you need to give a presentation, which will be graded, on the procedure used to evolve the final robot. A template of the presentation will be provided on Moodle.
- The presentations will be on **Thursday, 1-June-2023**.
- The presentation will be graded on the scientific approach, clarity and completeness.

**Additional key information**:

1. Discuss the project with your group members and ask the TAs questions at the lab session on the 4th of May.
2. You will need access to the DLL prototyping facilities to build the robot you evolve. You will need to complete the online training before you use DLL:
    - General safety: go.epfl.ch/moodle-training (only the DLL Prototyping part)
    - Rules for using a prototyping space (you will need to choose the name of the course): go.epfl.ch/prototyping-training (choose: CREDITED-MICRO-515)

- To receive access to the 3D prints, you must register and attend the course. Registration are on this link: https://doodle.com/meeting/participate/id/dRlDJRwa/vote

Please complete this before you use DLL and by **the 11th of May at the latest**.

3. Start planning and evolving your robot on RoboGen as soon as possible as **you will need to leave enough time to build your robot** before the project deadline on 31st May at 23:59.
4. Each group will be provided with hardware, including electronics and 3D printed parts, which you will use to assemble and test your robot. You will need to do some electronics, 3D print extra parts, then assemble and test your evolved robot. You will likely need to use the DLL facilities in your own time. **NOTE:** You should attend all DLL labs even if you have not finished evolving your robot. You will still be able to learn to setup the electronics before you have a robot with our help.
5. There will be an introduction to DLL on the 4th of May. We will leave from room **BS160** at 11:20am.
6. Future lab sessions will be split between room BS160 and DLL. The TAs will be at the following locations:
    a. 4th May:
        i. **BS160** (10:30am – 11:30am) – RoboGen questions
        ii. **DLL** (11:30am – midday) – DLL introduction
    b. 11th May:
        i. **BS160** (9:15am – 11am) – RoboGen evolution
        ii. **DLL** (11:15am – midday) – hardware + RoboGen
    c. 25th May: **DLL** (10:15am – midday) – hardware + RoboGen
    d. 1st June: **BS160** (9:15am – midday) – final graded presentations

**Hardware**

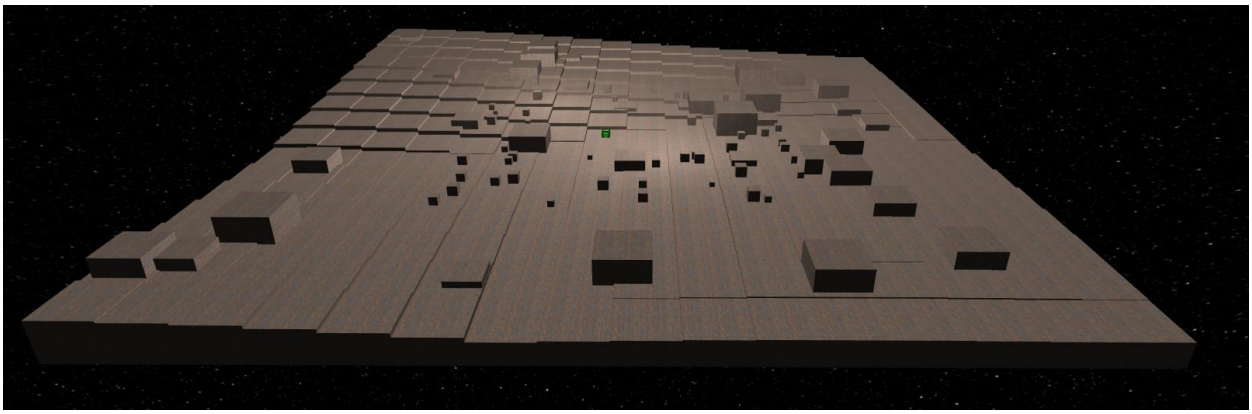
- All teams will receive a kit of components so that they can build their robot and access to the DLL building where they use the facilities such as 3D prints and soldering irons.
- To use DLL, you must first complete the 2-step online safety training:
    1. General safety: go.epfl.ch/moodle-training
    2. Rules for using a prototyping space (you will need to choose the name of the course): go.epfl.ch/prototyping-training

**Rules**

- Evolve a morphology with no more than **8 servos**.
- Teams evolving their robot with initial morphologies must justify the reason in the presentation.
- We will upload an arena (pictured below) to Moodle. However, designing your own arena is highly recommended as you can design it to fit your specific needs.
- Your robot will be built so you should use **earth's gravity**. However, as a fun task, you could check how your robot will behave on mars (gravity of mars = 3.711 $m/s^2$).
- Avoid jittery behaviours by uncommenting the option in the simulation config file.

- Allow **25 components** max in your body morphology (option in simulation config file).
- Use only IMU and IR sensors (do **not** light sensors).
- **Add noise to the servos and sensors** not higher than 0.1 and not lower than 0.02

The arena:



**Reminders and tips**

- Remember that you can split your evolution into several steps that each evolve for one distinct behaviour, e.g. first locomotion, then obstacle avoidance and finally stabilization.
- You should be scientific in your approach so make sure you only change a few parameters in each evolution and justify your choices.
- Some IMU values should be minimized in the fitness function to stabilize the core of the robot (modify your scenario file appropriately).
- Try to not run too many evolutions/visualizations of the robots (better if only one). This can lead to a crash of your web browser and therefore the end of your evolution.
- Sometime the RoboGen app seem to have a problem saving the files of the evolution. You can always try to refresh the page before you start an evolution.

You may see the fitness plateau after a certain number of generations. If this happens, try the following:

- Keep the evolution running for more generations. Big improvements can sometimes happen after 50-100 generations, even after the fitness seems to have plateaued already.
- Explore more the fitness landscape, i.e. increase the population size, mutation rate, crossover rate, or make the tournament size smaller.
- Improve the fitness function. For instance, modify the equation by changing some of the terms or give weights to different terms in the existing fitness function to change their relative importance.

**Timeline**

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|---|---|
| 04-May-2023 | Start of Grand Challenge |
| 31-May-2023 | Deadline for final robot submission |

01-June-2023 Presentations

Write to your teaching assistants if you have any questions or issues!

Good luck with your evolution!