Evolutionary Robotics
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Evolutionary Robotics Laboratory

Exercise Sheet 3: Body-Brain Co-evolution

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Goal

To further familiarize yourself with the RoboGen by performing a body-brain evolution. The body of the robot will be evolved from scratch to locomote as fast as possible.

The exercises in this sheet are directly related to the tasks in the Robogen Grand Challenge, the graded part of these laboratory sessions, so you should first read the Robogen Grand Challenge description pdf and think about how you will tackle that project as you go through this exercise sheet.

Learning objectives

By the end of this laboratory, you should have:

- Gained experience co-evolving controllers and morphologies.
- Learnt about some of the evolution options in RoboGen.
- Learnt how simple changes of the simulated environment (e.g. friction) can affect robot evolution.
- How to collect data and graphs of an evolution.

Assignments

- Go through the provided PDF instruction file during the laboratory class.
- Every team will submit the best robot (in .txt file) found with evolution on moodle by the 21st April at 23:59.

Getting Started

To get started, visit http://robogen.org/app and upload the files provided in moodle into Robogen2022/es3.

Important:

- Remember, all data is being saved to a virtual filesystem within your web browser. If you want to save anything for later use, download it to your home directory!
- As mentioned last week, this year (including the Robogen Grand Challenge) you will not be allowed to use wheels. For this year's class, the available parts are ***CoreComponent, FixedBrick, ParametricJoint, PassiveHinge, ActiveHinge, LightSensor****, and* ***IrSensor*** (if you specify addBodyPart=All when evolving morphologies, these will be the parts that your robots will be composed of).

Exercise 1

Today, you will explore the basics of evolving morphologies:

Look at the **es3/myEvolConfFull.txt**, this shows an example evolutionary configuration for evolving brains + bodies (note the line *evolutionMode*=full). Your population will start from a random collection of morphologies using the allowed parts.

- *numInitialParts*=MIN:MAX defines the possible sizes of these initial morphologies.
- The *addBodyPart* command in your evolutionary configuration file defines what body parts can be included.
  - In the example *addBodyPart*=All, but why do you think including all body parts may not always be the best idea?
  - Change this to specify just particular body parts (on separate lines), this can take either the Character Code, or name of the Body Part. For example:
    - *addBodyPart=FixedBrick*
    - *addBodyPart=ActiveHinge*
    - *addBodyPart=PassiveHinge*
- Try evolving some basic morphologies with the **myEvolConfFull.txt** file! We recommend starting with a small number of initial components (say 4 or 5), and only allowing a small subset of components at first.
- Familiarize yourself with the other parameters controlling the mutation operators for morphological evolution.
  - http://robogen.org/docs/evolution-configuration/#Evolution_client_settings
  - For example, try adjusting the probabilities of adding body parts, swapping subtrees, modifying parameters, etc.

Note: getting good results with full evolution may take some time.

- You may need to use **larger population sizes**, experiment with the replacement strategy and tournament-size and run for many generations. **You may not see good results just by running the evolver in the limited time you have during this lab. You should perform other evolutions during the week.**

Exercise 2

The evolution of a robot will be strongly affected by the simulated environment. Therefore, if some parameters in the simulator configuration file are changed, the results can be quite different. You should experiment with different ground friction coefficients to see how they influence the evolution of a robot.

Note: The full documentation for defining simulator configuration file is available http://robogen.org/docs/evolution-configuration/#Simulator_settings

terrainFriction – this specifies the coefficient of friction between the robot and the terrain.

Try setting the value of terrainFriction to 10 (this setting could represent operating in a very muddy field) and run a simulation using es3/simpleRobot.txt as the Robot description file and myConf.txt as the Configuration file. Do you notice differences in the robot's behaviour?

Now you can try evolving a robot that moves as fast as possible (with the racing scenario) in a terrain with friction coefficient of 10. Analyse the performance of the evolution (using the plot_results.py file provided in Exercise 1) and try to evolve a robot that does well in this terrain.

Exercise 3 (optional)

If your robot can locomote quickly on flat ground with a friction coefficient of 10, try evolving a robot with the same friction coefficient but with obstacles added to the environment.

Exercise 4:

Now let's consider that the robot you evolve will be used to explore Antarctica. Evolve a robot that can move as far (not as fast) as possible on flat ground when the friction coefficient is **0.04**. The performance metric is how far the robot moves in 30 seconds.

Submit a txt file of your best solution on moodle. To do this, you will first need to use the json_converter.py file (also provided in Exercise 1) to convert the json file to a txt file. Additionally, you should use the plot_results.py file to analyse your evolution.

Good luck!