EPFL

Laboratory of Intelligent Systems

RoboGen™

RoboGen Introduction

Evolutionary Robotics Course

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Assistants:

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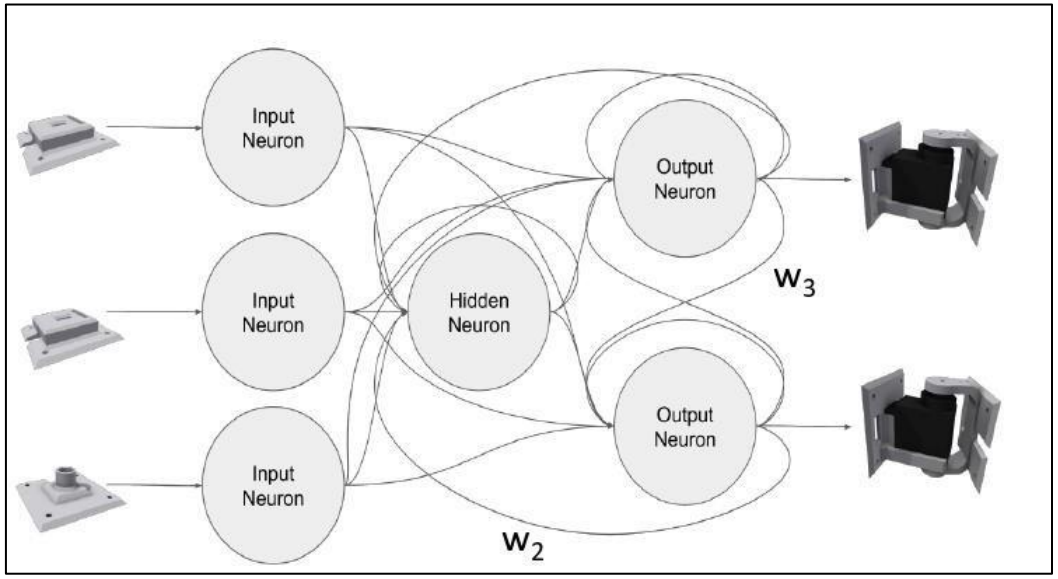
Alexander Dittrich

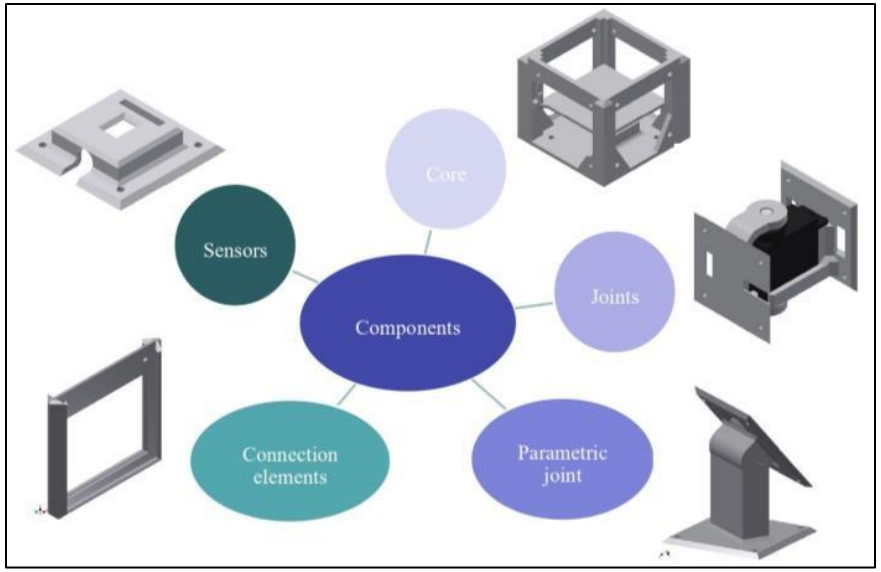
Juliette Hars

Schedule

Date	Week	Program	Lecturer
22.02.24	1	Organization of Lecture, Introduction to Evolutionary Computation, How to build an evolutionary algorithm?	Floreano
29.02.24	2	Evolutionary Strategies, Exercise Genetic Algorithm (Python), Exercise Evolutionary Strategies (Python)	Floreano, Dittrich, Hars
07.03.24	3	Multi-objective Optimization (NSGA-II), Exercise NSGA-II	Floreano, Dittrich, Hars
14.03.24	4	Foundations of Neural Networks, Unsupervised Learning	Floreano
21.03.24	5	Supervised Learning, Reinforcement Learning	Floreano
28.03.24	6	Evolution of Neural Controllers, Evolution and Learning	Floreano
04.04.24	7	*Easter Holiday*	
11.04.24	8	Introduction to Group Project, Brain Evolution for pre-defined body in RoboGen	Petrs, Dittrich, Hars
18.04.24	9	Evolution of body morphologies, Co-evolution of Brains and Bodies, Body Encoding and Evolutionary Parameters in RoboGen	Floreano, Petrs, Dittrich, Hars
25.04.24	10	Body Encoding and Evolutionary Parameters in RoboGen, Brain and Body Co-Evolution in RoboGen	Petrs, Dittrich, Hars
02.05.24	11	Cooperative Co-Evolution, Body-Brain Co-evolution in RoboGen	Floreano, Petrs, Dittrich, Hars
09.05.24	12	*Ascension Day*	
16.05.24	13	Introduction to RoboGen Hardware, Handout of Robotic Kits and Accessories	Petrs, Dittrich, Hars
23.05.24	14	Towards Self-Reproducing Robots, Group Project Coaching	Floreano, Petrs, Dittrich, Hars
30.05.24	15	Group Project Demonstrations and Final Presentation	Floreano, Petrs, Dittrich, Hars

RoboGen for morphology and control co-evolution





Software Suite

Evolution Engine

F=MG

Simulator

Software utilities for hardware

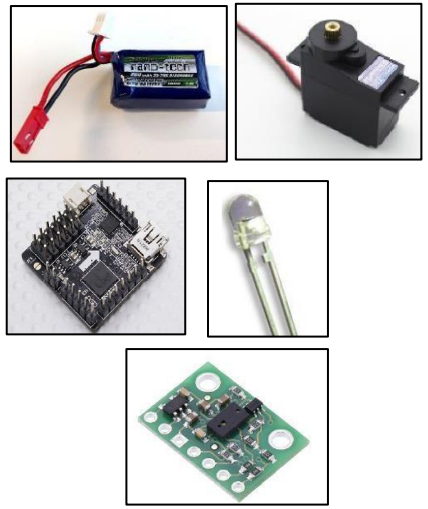
Hardware

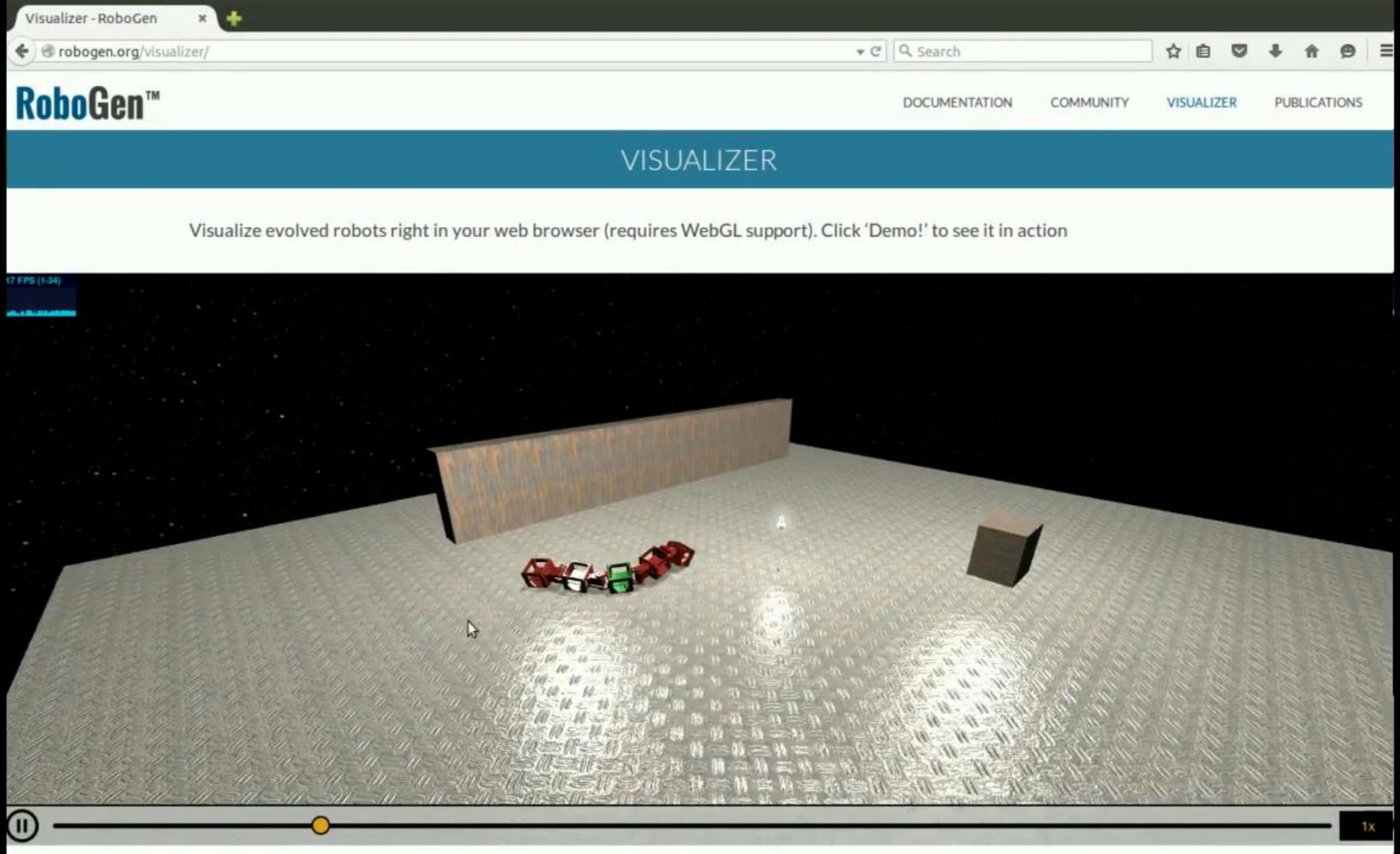
Electronics

Actuators

3D printed Components

Robogen Robots




Visualizer - RoboGen
robogen.org/visualizer/
Search
RoboGen™
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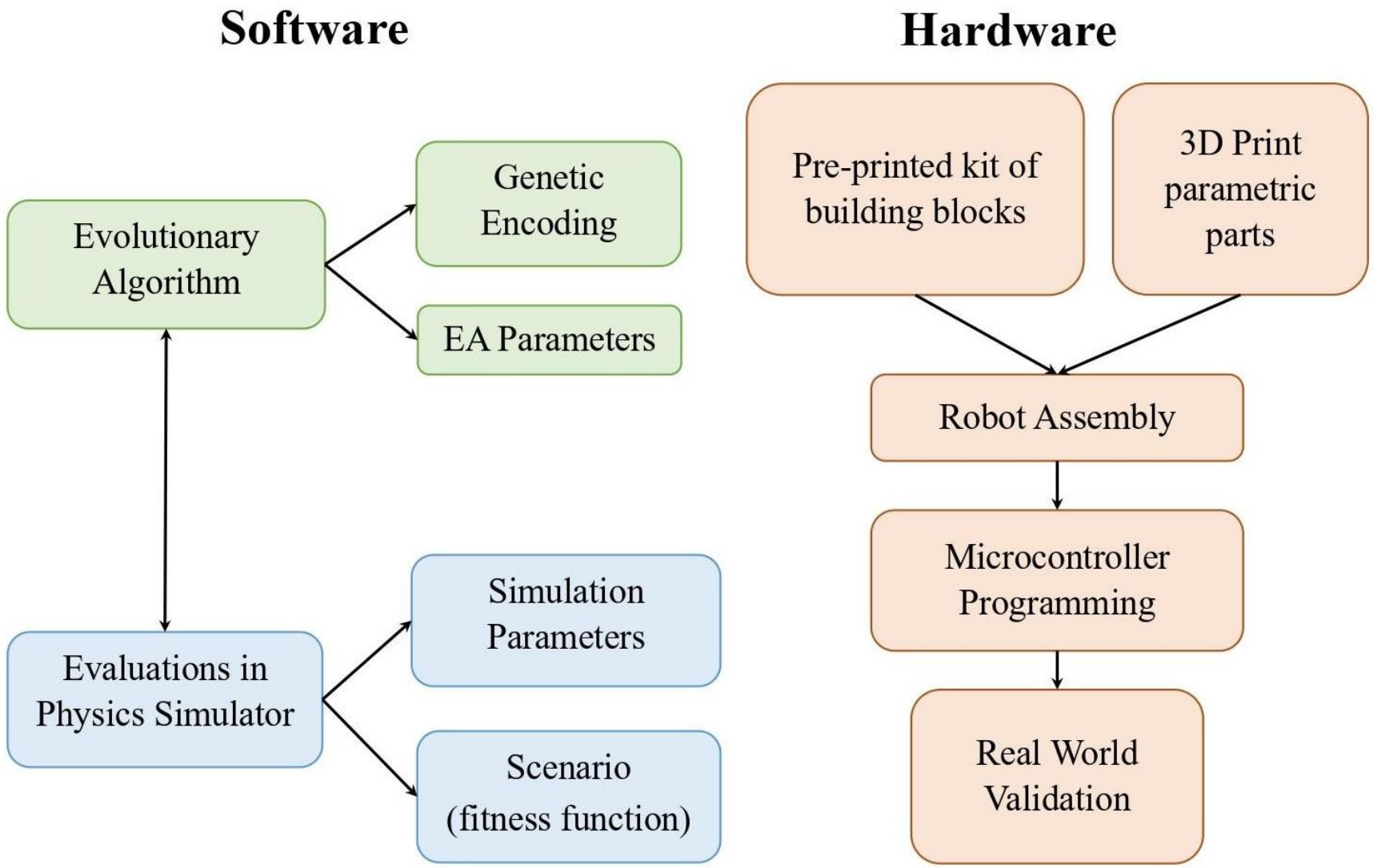
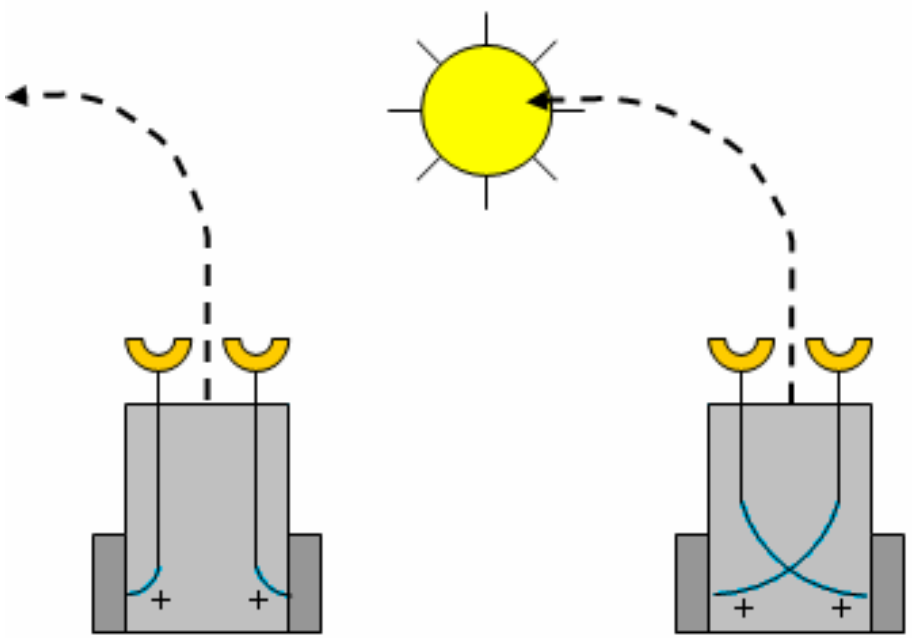
Visualize evolved robots right in your web browser (requires WebGL support). Click 'Demo!' to see it in action
1x

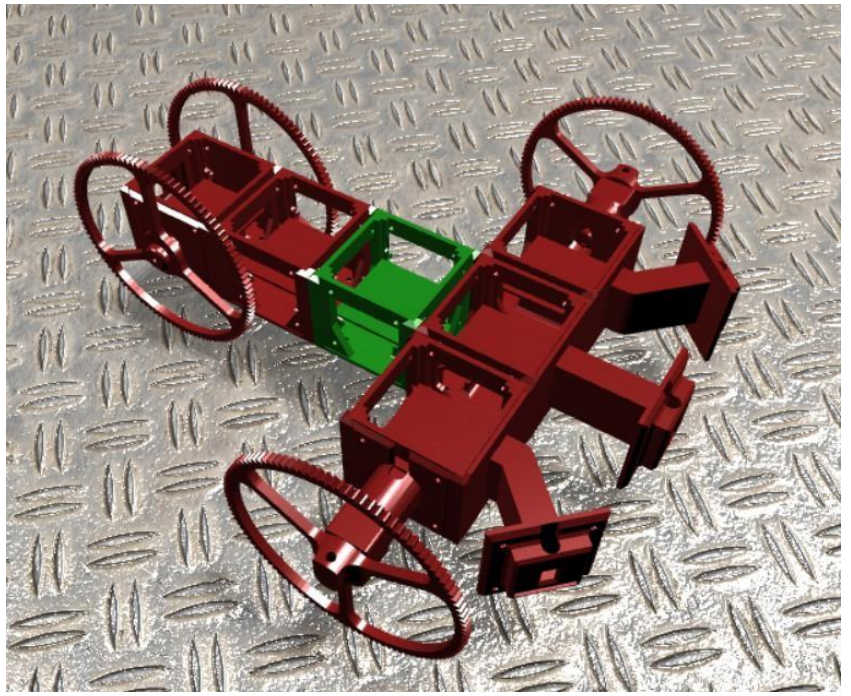
Co-evolution of robot bodies and brain



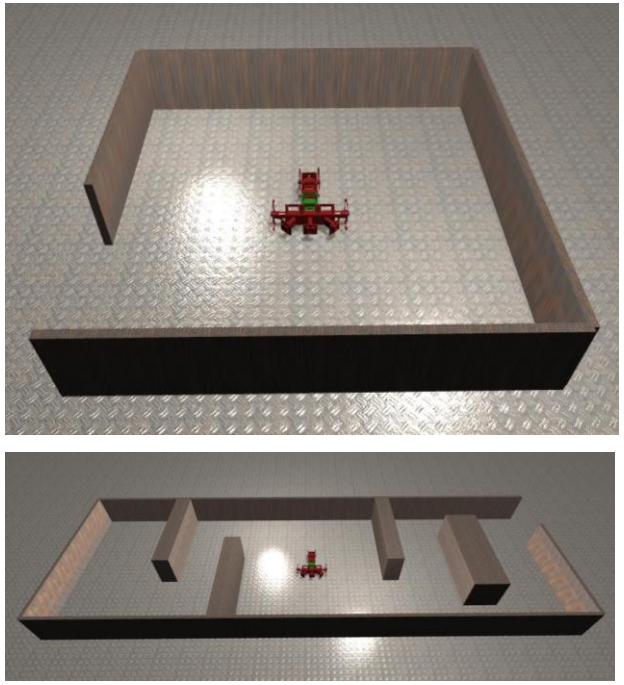
Morphological intelligence



Braitenberg vehicles + light source

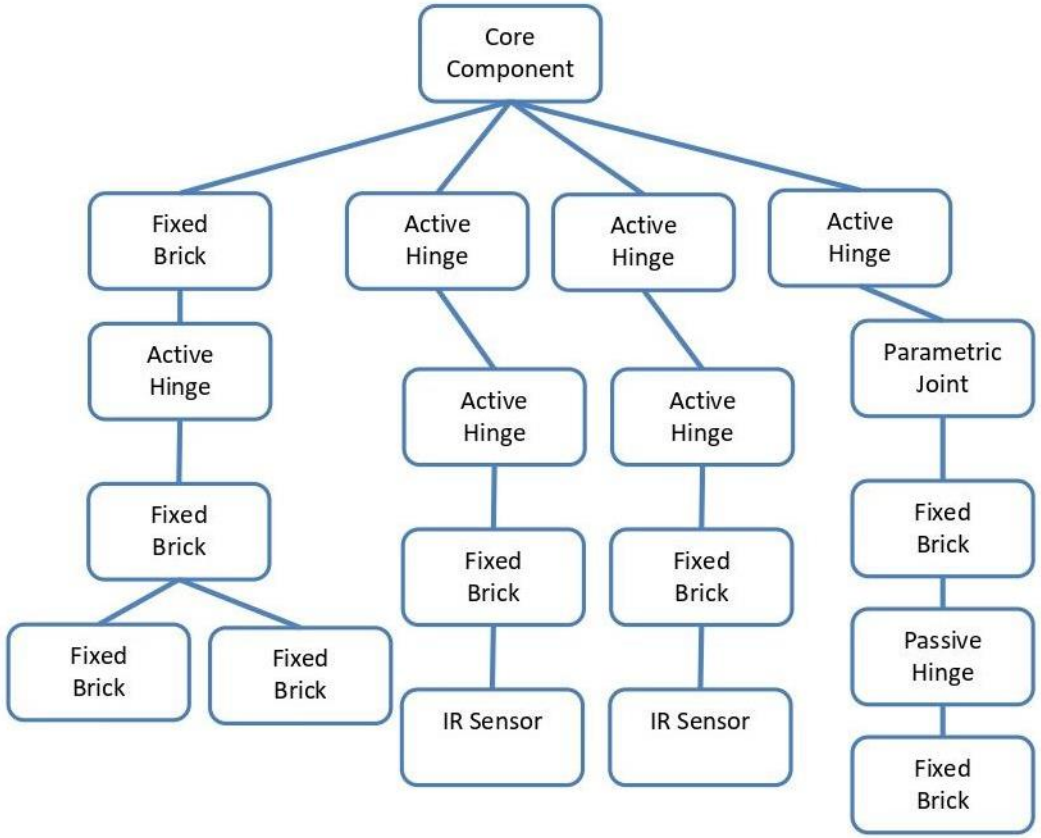


RoboGen vehicle

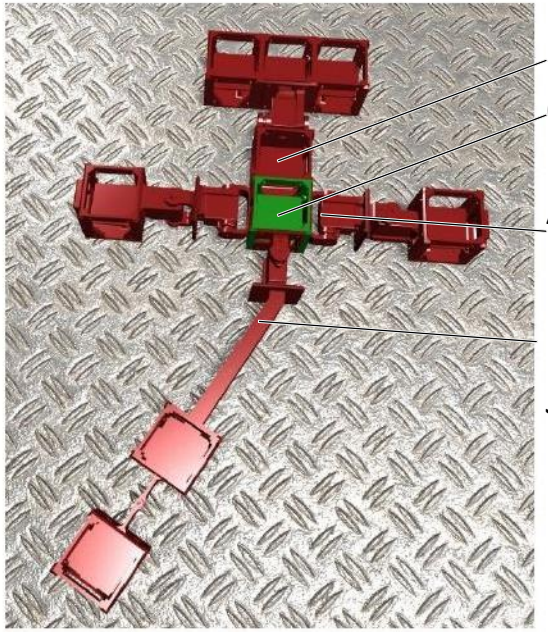


More complex environment

Software: Genetic encoding



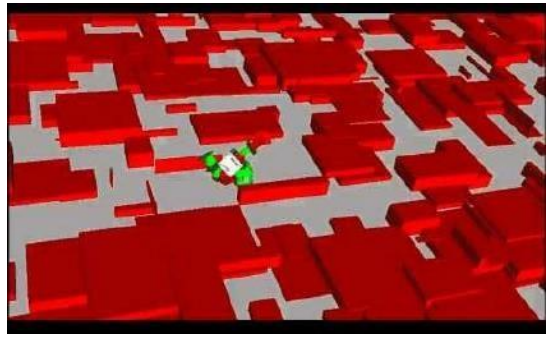
Robot Body



https://robogen.org/docs/guidelines-for-writing-a-robot-text-file/

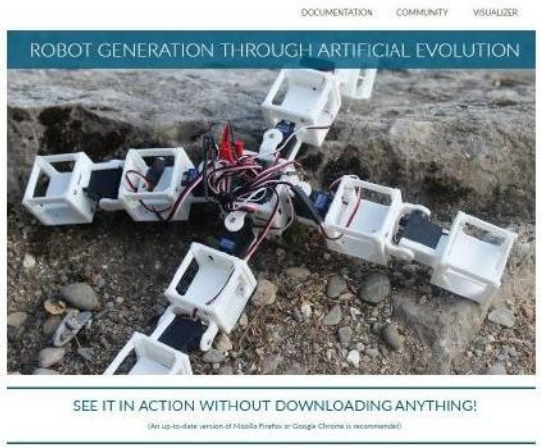
Setting up RoboGen

- **Environment:**
  - Arena: obstacles (https://robogen.org/docs/evolution-configuration/#Obstacles_configuration_file)
  - Properties: e.g. friction, etc. (https://robogen.org/docs/evolution-configuration/#Simulator_settings)



- **Fitness function:**
  - Inbuilt:
    1. Racing: https://github.com/lis-epfl/robogen/blob/8b710b93221882cdb9b970f55bf84d287dc2e4be/examples/racing_scenario.js
    2. Chasing: https://github.com/lis-epfl/robogen/blob/8b710b93221882cdb9b970f55bf84d287dc2e4be/examples/chasing_scenario.js
  - Write a custom one in JavaScript (https://robogen.org/docs/custom-scenarios/)
- **Evolutionary algorithm parameters: e.g. mutation rate, number of generations, etc.** (https://robogen.org/docs/evolution-configuration/#Evolution_client_settings)

More about RoboGen



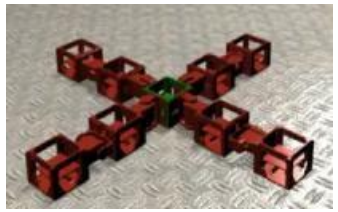
[RoboGen Website]

[YouTube Channel]

[RoboGen App]

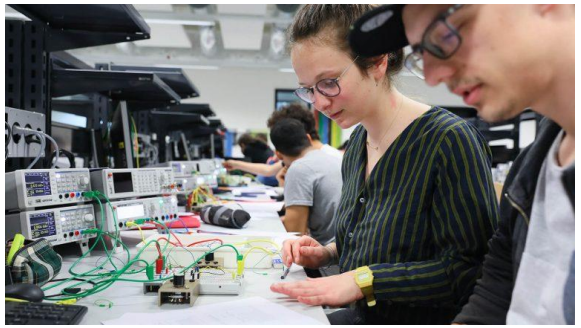
Project schedule

11th April
- Introduction to RoboGen
- Evolving the controller for a cart robot
- Project group formation



18th April
- Begin brain + body coevolution

25th April
- Information on robot fabrication
- SPOT training (will be confirmed)



2nd -23rd May
- Graded project coaching

31st May
- **Final graded presentations**

3-4 students/group

3-4 students/group

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Evaluation

- Graded presentation on the 30th of May.
- A template will be given
- The presentation will document your work, your methods, your results and your analysis.
- Hint: performing repetitions of your experiments in order to conduct a statistical analysis is strongly encouraged!

Your grade will be influenced by
- Demonstration of scientific approach
- Creativity
- The results you obtain
- Task difficulty
- Clarity
- Completeness of presentations

Project tips

You will need to evolve the body and brain of a robot for a given scenario. A (non-exhaustive) list of factors to consider during your project:

- **Fitness function**: You will need to design your own. How well you do this will be a significant factor in the success of your project.
  - See https://robogen.org/docs/custom-scenarios/ for details on writing a custom fitness function.
- **Environment** (e.g. obstacles, light source, terrain, etc.):
  - See https://robogen.org/docs/evolution-configuration/#Obstacles_configuration_file for writing a custom arena and
  - https://robogen.org/docs/evolution-configuration/#Simulator_settings for terrain, physics,
    obstacle, noise and constraint handling settings.
- **Evolutionary algorithm parameters**: A scientific approach to parameter selection should be used to find the best evolution
  - See https://robogen.org/docs/evolution-configuration for a list of evolution parameters.
- **Evaluation procedure** (length of evaluation, presence of noise, etc.): Your robot will likely perform worse when you build and test it in the real world due to the simulation to reality gap. The easiest way to get an idea of the generalisability of your solution is to first run it in the simulator using different environment parameters.

Previous examples