SEMESTER PROJECT:
ONLINE OPTIMIZATION OF LOCOMOTION CONTROLLER FOR ROOMBOTS

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Mid-term Presentation

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Outline

- Motivation
- Introduction
- Accomplishment
- Future work
- References

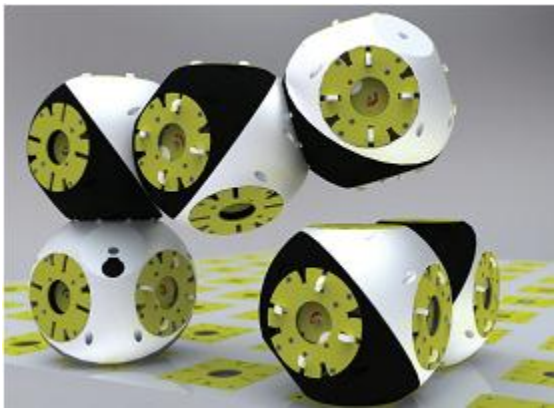
Motivation

- Roombots provide diverse types of morphologies
- The motivation is to make Roombots learn automatically **optimal gaits** for arbitrary structures with many degrees of freedom using **online optimization**.

Source: Work by S. Pouya and J.v.d. Kieboom

Roombots

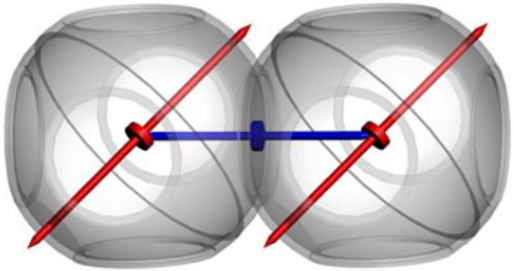
- Modular self-reconfigurable robots
- Many useful applications
  - Adaptive furniture
  - Adaptive architecture
  - New LEGO generation



Source: pictures created by A.Spröwitz

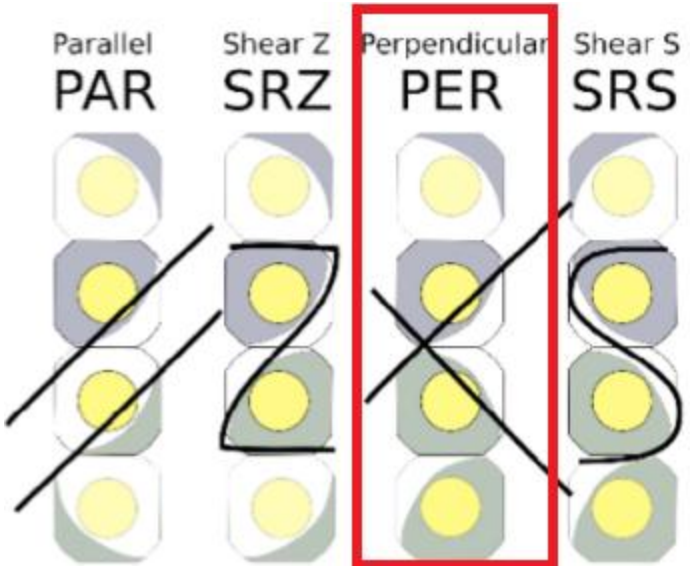
Roombots

- Module:
  - 3 degrees of freedom (DOF)
  - produce oscillatory and rotation movements



Source: A.Spröwitz

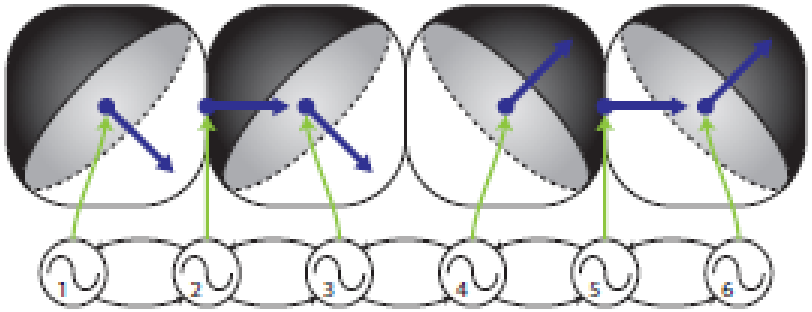
- Meta-module:
  - Two modules connected
  - 6 degrees of freedom (DOF)
  - Four connection types
    - Only PER used in this project



Source: Michka Melo

Locomotion Model

- Controlled by **Central Pattern Generator (CPG)**
  - Network of coupled phase oscillators
  - One oscillator per degree of freedom
- A meta-module with 6 DOF



Source: W.Fédéric

- One oscillator can generate:
  - Oscillator
  - Rotation
  - Locked

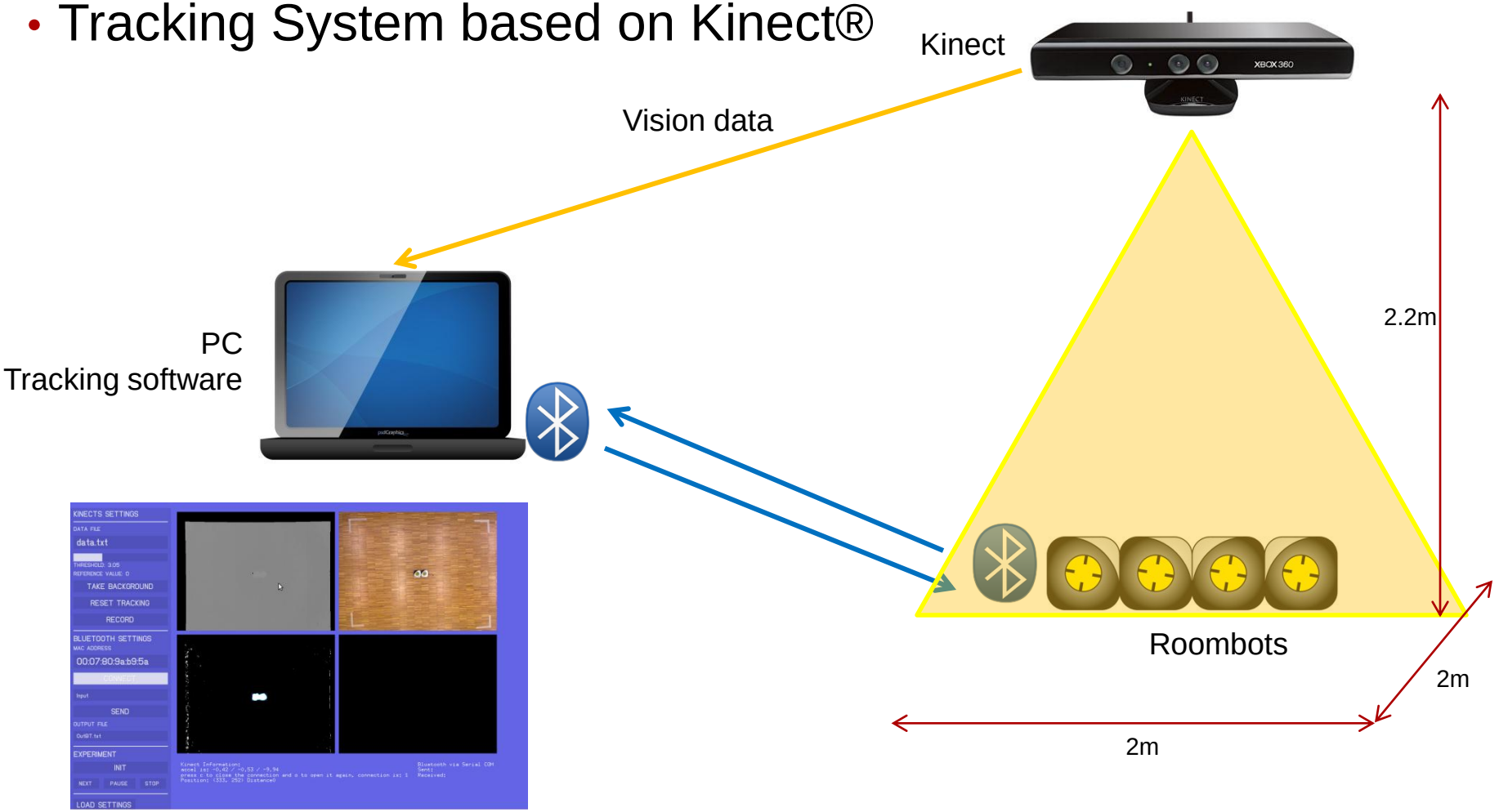
Optimization algorithm (PSO)

- Particle Swarm Optimization (PSO)
- Stochastic, population-based optimization method based on collaboration
- The velocity influenced by
  - The **local best known** position of the particle
  - The **global best know** position of all particles
- Characteristic:

Advantages	**Disadvantages**
+ Robust against local minima	+ Relatively slow + Many parameters

Experiment Setup

- Tracking System based on Kinect®



Software

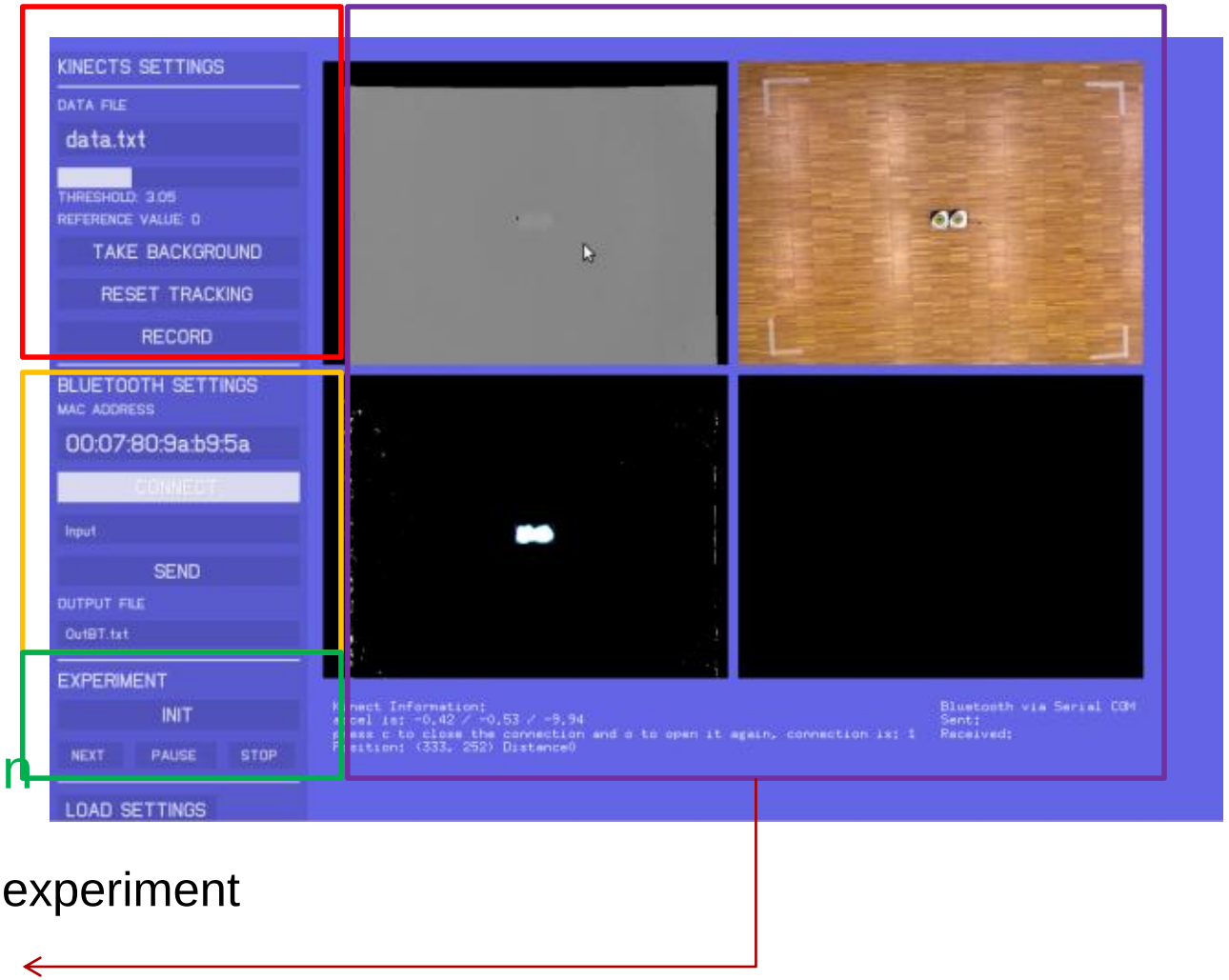
- 2 main components:

Kinect Tracking position	Bluetooth Robot Communication
Input: Depth Image from Kinect® **Output:** - Location of the robots after a certain time -> velocity -> fitness val - Save the position data to a specified file - Visual output for monitoring	- Connect using input MAC address - Send commands to Robots - Receive reply, data from Robots

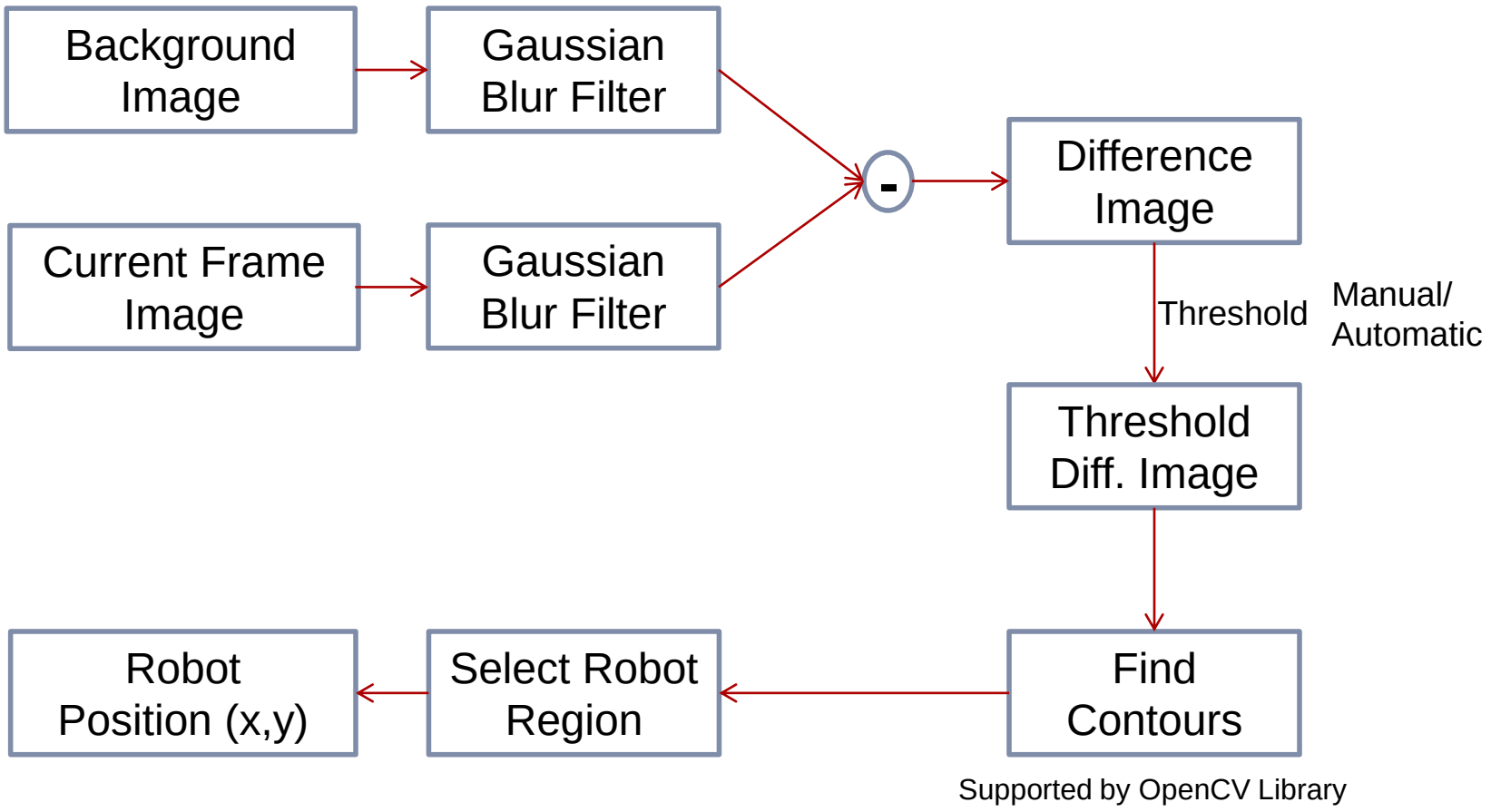
- Fast tracking speed: ~40ms per time ~24Hz
- Ease the experiment process
  - Convenient GUI
  - Full configuration

GUI

- Kinect section
  - Position data file
  - Threshold change
  - Take background
  - Record
- Bluetooth section
  - MAC of robot
  - Connect button
  - Input text box
  - Send
  - Output file
- Experiment section
  - Initialization
  - Next, pause, stop experiment
- Visual monitor

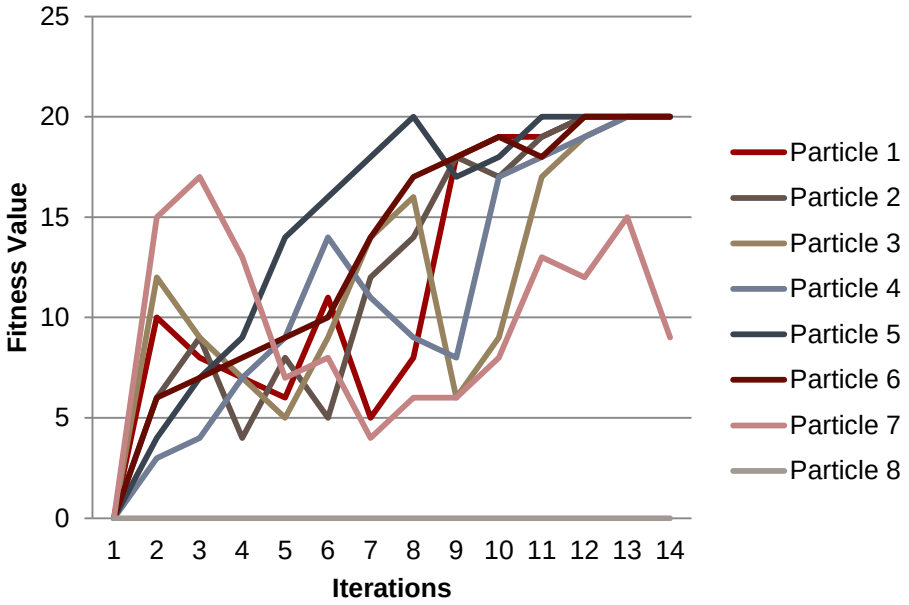


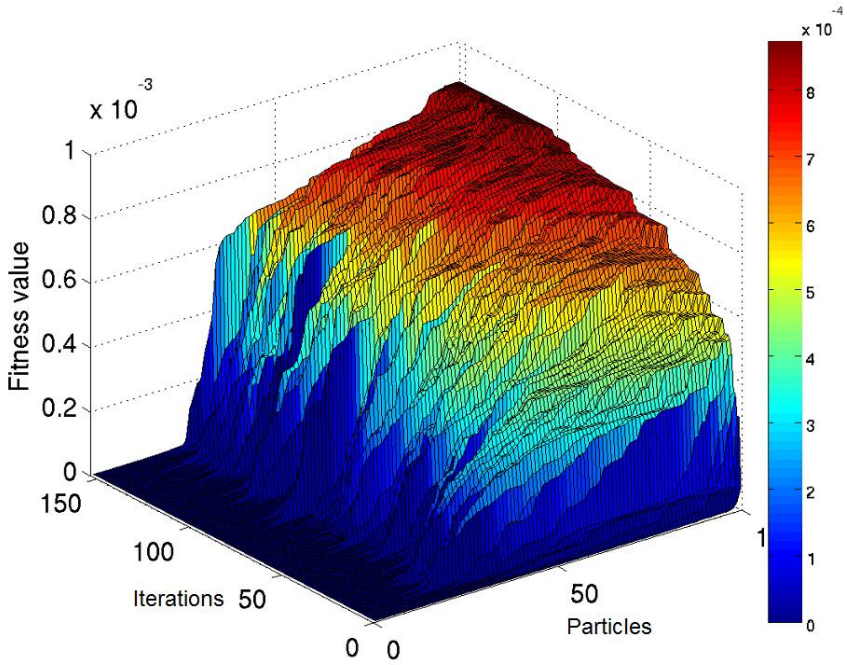
Location detection algorithm



Experiments in the future

- Expected Results
- Obtain the best gait after a number of iterations





Source: 3D graph created by Ebru Aydn

Future work

- Now
  - Main work focused on Software of tracking system
  - System setup is ready to conduct more experiments with Roombots
- Future
  - April - May:
    - Conduct experiments to explore process of obtaining optimal gaits
    - Evaluate the system and fixing problems of the system
    - Improve the system both HW and SW
    - Improve code, make user guide or manual
  - June:
    - Finalize works
    - Prepare final report and presentation

QUESTIONS???

References

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2. A. Sproewitz, R. Moeckel, J. Maye, and A. J. Ijspeert, "Learning to move in modular robots using central pattern generators and online optimization," The International Journal of Robotics Research, vol. 27, no. 3-4, pp. 423–443, 2008.
3. R. Moeckel, C. Jaquier, K. Drapel, E. Dittrich, A. Upegui, and A. Ijspeert, "Yamor and bluemove - an autonomous modular robot with bluetooth interface for exploring adaptive locomotion," Proceedings of International Conference on Climbing and Walking Robots and the Support Technologies for Mobile Machines (CLAWAR'2005), pp. 685– 692, 2005
4. A. Sproewitz, A. Billard, P. Dillenbourg, and A. J. Ijspeert, "Roombots-mechanical design of self-reconfiguring modular robots for adaptive furniture," in 2009 IEEE International Conference on Robotics and Automation, Kobe, Japan, 2009, pp. 4259–4264.
5. A.J. Ijspeert, "Central pattern generators for locomotion control in animals and robots: A review," Neural Networks 21 (4) (2008) 642–653.
6. J. Kennedy and R. Eberhart, "Particle swarm optimization." Proc. IEEE International Conf. on Neural Networks (Perth, Australia), IEEE Service Center, Piscataway, NJ, 1995 (in press).
7. Other students final reports, especially from Wilhelm Frédéric

Experiment Procedure

- Initialization
  - Psoinit: generate random particles
  - Load saved particles
- In the implementation, the cpgsimulation executed automatically after psonext*f*
- The state of particles are saved in case we run out the battery and want to continue in the future