Probabilistic Modelling to Improve Particle Swarm Optimization in Controller Design

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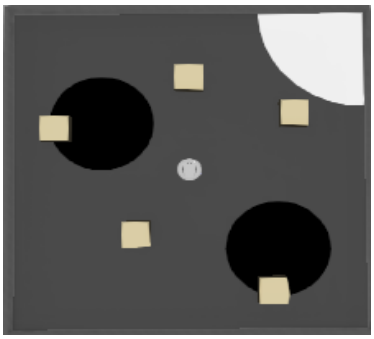
The 21st century, often referred to as the numerical, is at the heart of technological transformations. Robotics is the study of replacing human beings with machines for certain tasks including both physical execution and decision making.

The aim of the project was to compare different approaches to obtain the most cost-effective optimization using Particle Swarm Optimization and two different simulators:

- Webots, a sub-microscopic simulator with a lower level of abstraction.
- A probabilistic simulator which has a higher level of abstraction.

The scenario used to compare and test the different methods is a foraging task based on previous projects. To successfully complete the task, the robot must roam the arena until it finds a black area, corresponding to some resources. Once a black area is found, the robot must then find the white area that corresponds to its home. The task is considered completed once the robot reaches the white area.

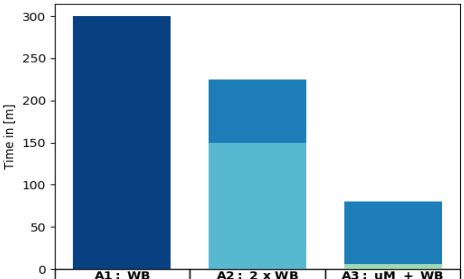


Top view of the arena in Webots simulator

The microscopic model was built using a mixture of geometric probabilities which are dependent on the characteristic of the arena and the state of the robot. The second type of probabilities are time dependent; this was done for all transition from specific states to steady states. This allows to represent the high-fidelity simulation more accurately. Moreover, to make sure that the probabilities mimic the sub-microscopic modelling it was decided to have two categories of event which would be independent:

- Collision with the obstacles and walls
- Floor color underneath the robot

For each time step of the simulation, a dice is used for each independent event to decide in what state the robot will be.



	A1 : WB	A2 : 2 x WB	A3 : uM + WB
Mixed WB	300.0	0.0	0.0
Continuous WB	0.0	75.0	75.0
Discrete WB	0.0	150.0	0.0
Discrete uM	0.0	0.0	5.6

Comparison of the wall-clock time needed per synthesizing strategy in minutes

The results show a comparison in wall-clock time for 3 different solutions to optimize the controller using PSO:

- A1: Using only Webots with mixed discrete continuous parameters
- A2: Using only Webots with separate optimization processes for discrete and continuous parameters
- A3: Using the microscopic model for the discrete parameters and Webots for the continuous ones

The mixture of Webots and the probabilistic model is the most efficient in terms of computation time with approximately 75% save of time compared to the mixed discrete model and 66% reduction compared to the 2 step Webots strategy.