Homeostasis based control of micro robots

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Overview

1) Homeostasis and its use for swarm robotics

2) Test scenario

3) Adaption by Reinforcement Learning

4) Balancing opposing objectives

5) Hormone mechanism

6) Integration via MDLe

Homostasis = Maintaining equilibrium

homoios = the same, stasis = to stand

organisms: Keep bodily functions on necessary levels (e.g.: temperature, glucose level, ...)

not: static behavior, but: adopt to dynamic environment

Stabilize set of variables

Robots: Keep set of variables in given intervals

Possible scenarios: Formation, energy level, ...

Supports other control algorithms by maintaining good working conditions

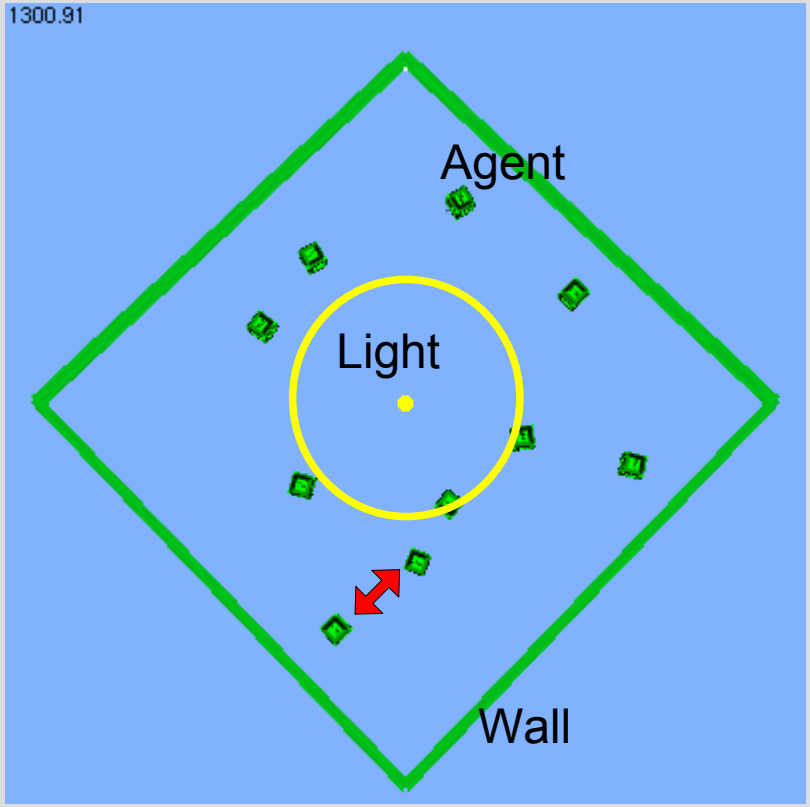
Scenario: Robots as cockroaches

Swarm of JASMINE-like robots (simulated)

Variable 1: Brightness
Variable 2: Density of robots
Variable 3: Number of collisions

We want these to be minimal

Scenario: Robots as cockroaches



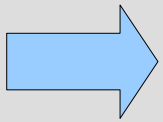
What we want...

Adaption: Need to learn how actions influence variables (unknown and changing environment!)

Balance: Need to respect every variable equally

Flexibility: Want this module to cooperate with other planning software

Learning by doing

Adaption  We need learning algorithm

Use Reinforcement (Q-)Learning, because:

Unsupervised learning allows permanent adaption during agent's life

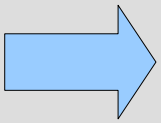
But: We don't need convergence!

Objective function = distance to optimal value

Weighted objectives

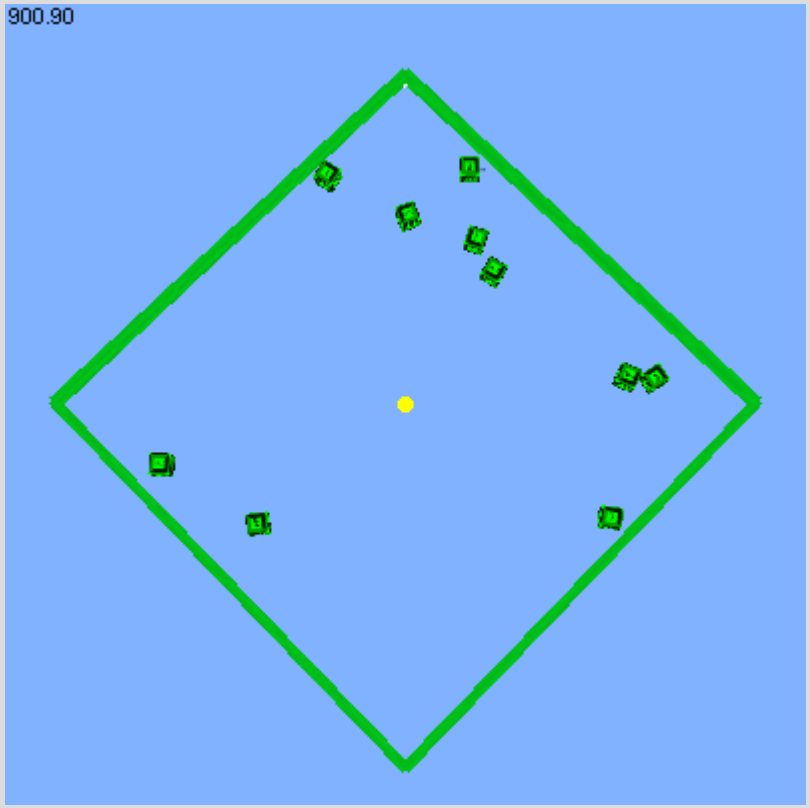
Problem: Set of variables to stabilize
Some of them are opposed to each other:

All robots trying to reach the dark spots
vs.
All robots trying to have few neighbours

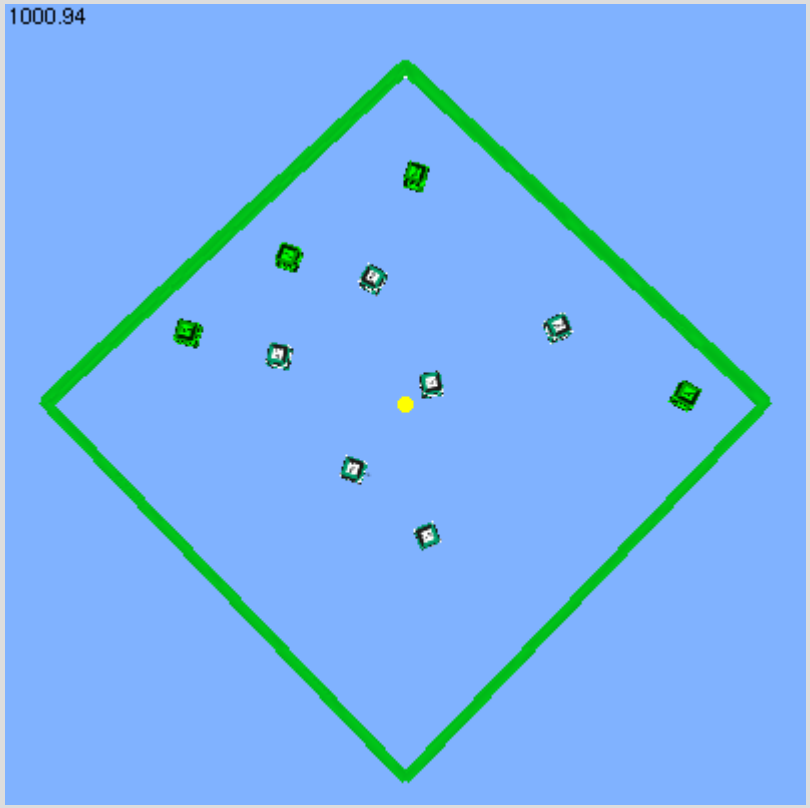


Solution: weight goals of robots!

Light aversion too strong



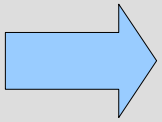
Density aversion too strong



Worst fitness has greatest influence

One learning module for every variable

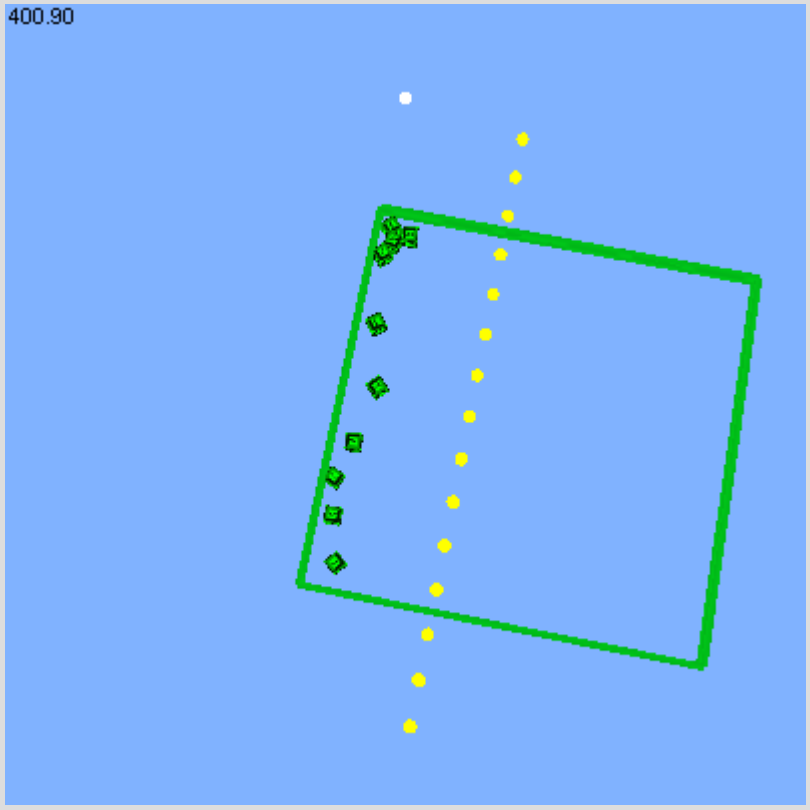
Weight modules according to corresponding fitness



Maintains equilibrium between all objectives

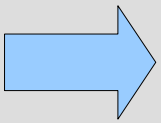
Desperate measures in critical situations

With RL only, agents cannot escape from local maximum:



We need other mechanisms!

Desperate measures in critical situations

Humans: low on oxygen  release adrenaline

Adopt this „hormone“ mechanism to our agents:

Accumulate hormone, when no improvement in sight

hormone > h_{limit}: enter stress mode!

MDLe = seamless integration

MDLe atoms and interrupts to include homeostasis control in complex framework:

```
<ATOM name="percept" ... />
```

Calls routine to update perception vector

```
<ATOM name="turn"
  interrupt="homTurn" ... />
```

= true iff action „turn“ chosen by homeostatic control

Questions?

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