Behaviour Patterns Evolution on Individual and Group Level

Stanislav Slušný,
Roman Neruda, Petra Vidnerová

Department of Theoretical Computer Science

Institute of Computer Science
Academy of Science of the Czech Republic

{slusny,roman,petra}@cs.cas.cz

CIMMACS'07, December 14, Tenerife

Outline

Introduction

Behaviour Emergence

- study ability of autonomous agents to develop desired behaviour
- learning achieved by interactions with environment

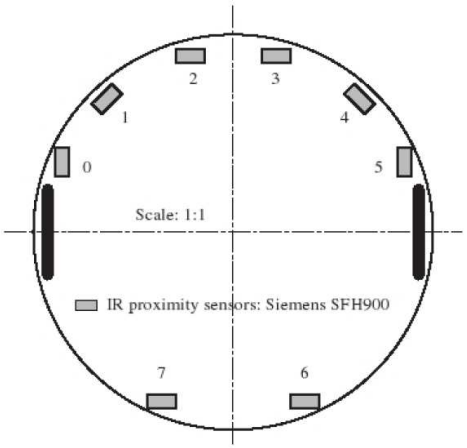
Evolutionary Robotics

- neural networks
- evolutionary algorithms, genetic algorithms
- Khepera robots

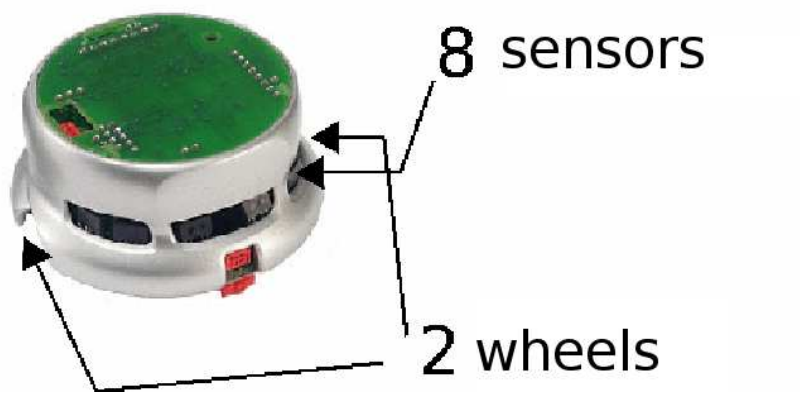
The Khepera Robot

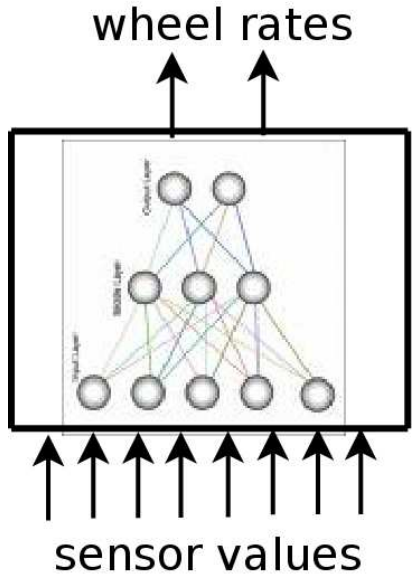
'slow small short-sighted robot'

- mobile robot, 70 mm in diameter, 80 g
- two lateral wheels (rotate in both directions)
- 8 active infrared light sensors
- Motorola 68331, 25 MHz, 512 KB RAM



Evolutionary Learning





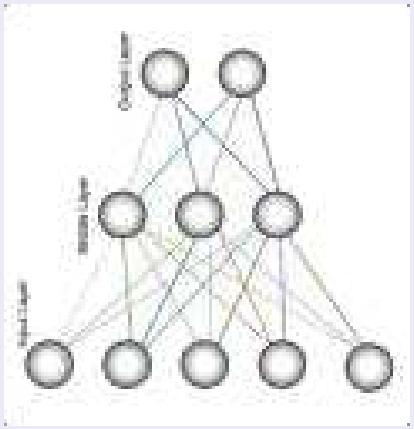
Evolutionary robotics = Neural Networks + Genetic Algorithms

- design of intelligent agent (robot) by self-organization process based on artificial evolution
- reactive agent - i.e. no memory

Neural Networks

Multilayer Perceptrons (MLP)

- feed-forward neural network
- neuron output: $y(x) = \varphi\left(\sum_{i=1}^{n} w_i x_i\right)$
- activation function: logistic sigmoid



Other Architectures

- Elman's networks (recurrent)
- RBF networks

Genetic Algorithm

Individual (genom)

- encodes weights of neural network
- real encoding

Fitness function

- quality measure of solution

Fitness Evaluation

1. initialize environment
2. place robot at random start point
3. run robot for given number of steps or until it crashes

Experiments

Goal

- evaluate feasibility of evolutionary learning for basic tasks, such as avoiding obstacles, exploration, etc.
- 2 experiments: individual exploration, collective exploration

Methodology

- YAKS (Yet Another Khepera Simulator), open source
- different environments for learning testing
- tests on real robot
- each experiments repeated 10 times

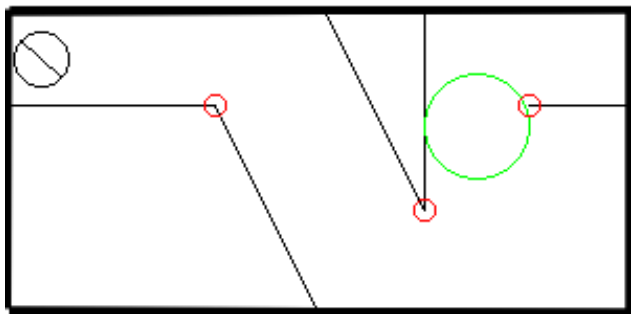
Individual maze exploration

Task

- robot is placed into maze, arena 60 $\times$ 30 cm
- its goal is to fully explore the maze

Learning

- small, quite simple maze
- fitness: 250 simulation steps, 4 trials



Individual Maze Exploration

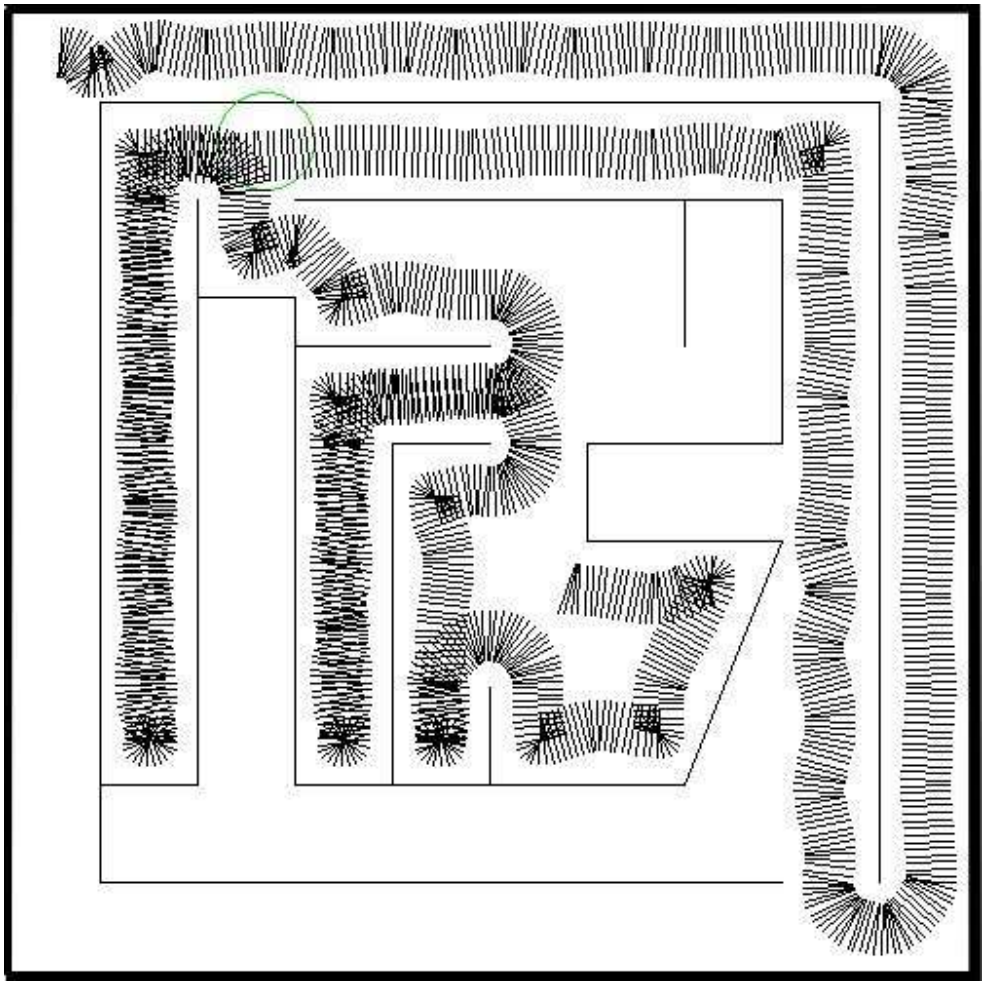
Fitness evaluation

- move and avoid obstacles: $T_{k,j} = V_{k,j}(1 - \sqrt{\Delta V_{k,j}})(1 - i_{k,j})$
- mean evaluation for one step $S_j = \sum_{k=1}^{250} \frac{T_{k,j}}{250}$
- bonus for reaching target zone $\Delta_j = 1$

$$Fitness = \sum_{j=1}^{4}(S_j + \Delta_j)$$

$V_{k,j} = |v_l| + |v_r| \in \langle 0, 1 \rangle$ sum of motor rates
$\Delta V_{k,j}$ left and right motor difference
$i_{k,j} \in \langle 0, 1 \rangle$ highest sensor value

Evolved behaviour: robot in big maze (video)



Collective exploration

Task

- team of 3 robots, one of them team leader
- their goal is to reach target arena

Setup

- leader is equipped with light bulb, others can sense light
- all robots have 8 sensors in active and passive mode, and ground sensor (17 inputs of NN)
- each trial 500 simulation steps, leader situated randomly, others not far from him

Collective exploration

Fitness evaluation

$$T_{k,j} = L_{k,j} M_{1,k,j} M_{2,k,j}$$

L leader - exploration behaviour:

$$L_{k,j} = V_{k,j}(1 - \sqrt{\Delta V_{k,j}})(1 - i_{k,j}) + Z_{k,j}$$

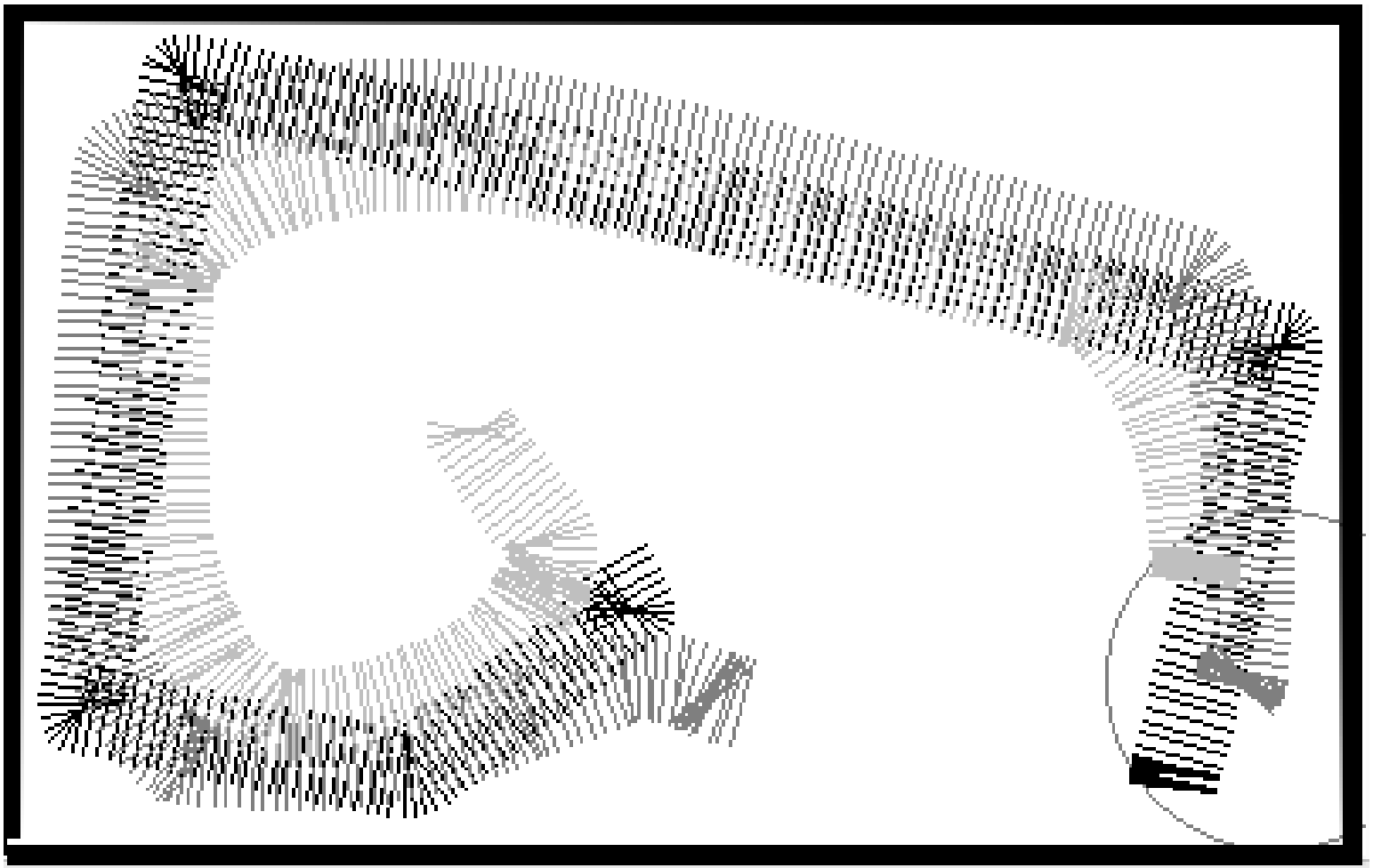
$Z_{k,j}$ - reward for target arena

M grouping behaviour:

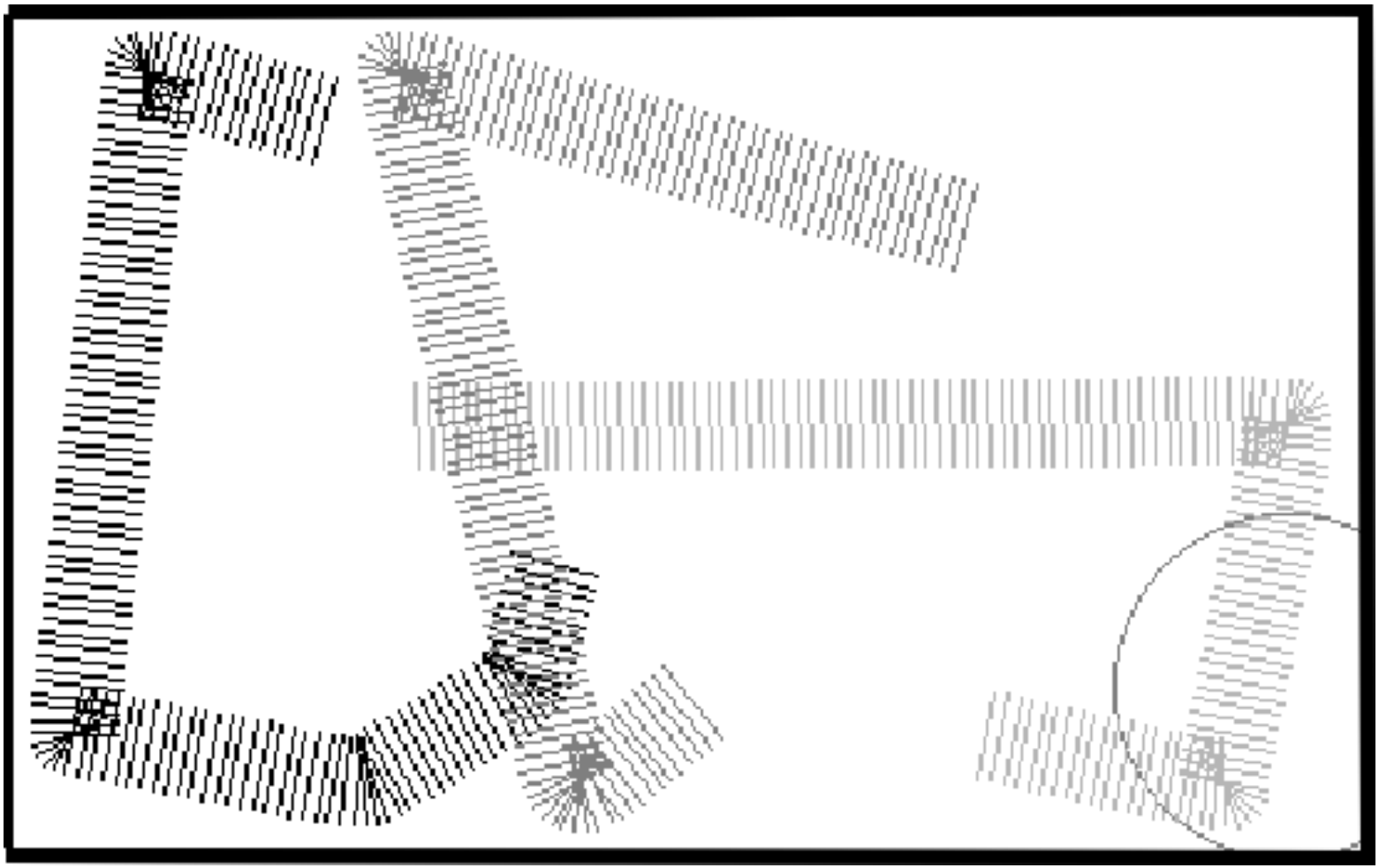
$$M_{i,k,j} = (1 - D_{k,j}(i, 0)),$$

where $D_{k,j}(i, 0)$ is distance from the leader

Evolved behaviour: collective exploration



Light down!



Conclusions and future work

Summary

- demonstrated that behavioural pattern can emerge from rather simple setup
- learning does not require large number of parameters (30,60 weights)

Future work

- more complex tasks, compound behaviours, specialization and labour division
- incremental learning, modular control systems

THANK YOU

Any questions?