Evolving an artificial “brain”

Course: Artificial intelligence

Robby and a genetic algorithm

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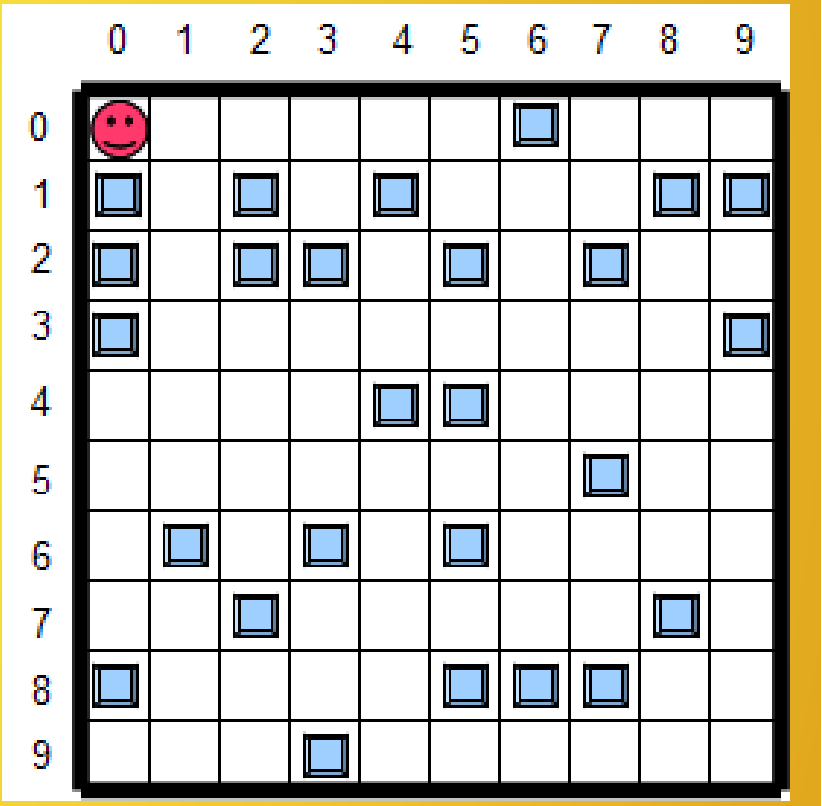
Problem description

- A robot's job is to collect thrown away bottles
- Robby operates in a grid of dimension 10x10 surrounded by walls
- The blue squares are bottles that need to be collected



Problem description

- The grid contains 100 cells
- A cell is either empty or contains a bottle to collect
- The starting position of Robby is the top left corner i.e. position(0,0)
- Robby has a limited field of vision: he sees only the cell where he currently is and adjacent cells (north, south, east, west)

Problem description

- Actions that the robot can make based on his perception are:
  - do nothing,
  - pick up the bottle from the cell you are on,
  - move to the northern adjacent cell,
  - move to the southern adjacent cell,
  - move to the eastern adjacent cell,
  - move to the western adjacent cell,
  - move in a randomly chosen direction.

Problem description

- To clean the entire grid the robot can use a maximum of 200 actions, the final position of Robby is not important
- Robby can not remember anything, the only information that is at his disposal while standing at cell (i,j) is what he sees from that cell.
- He must make a decision of what to do based on this information alone.

The problem

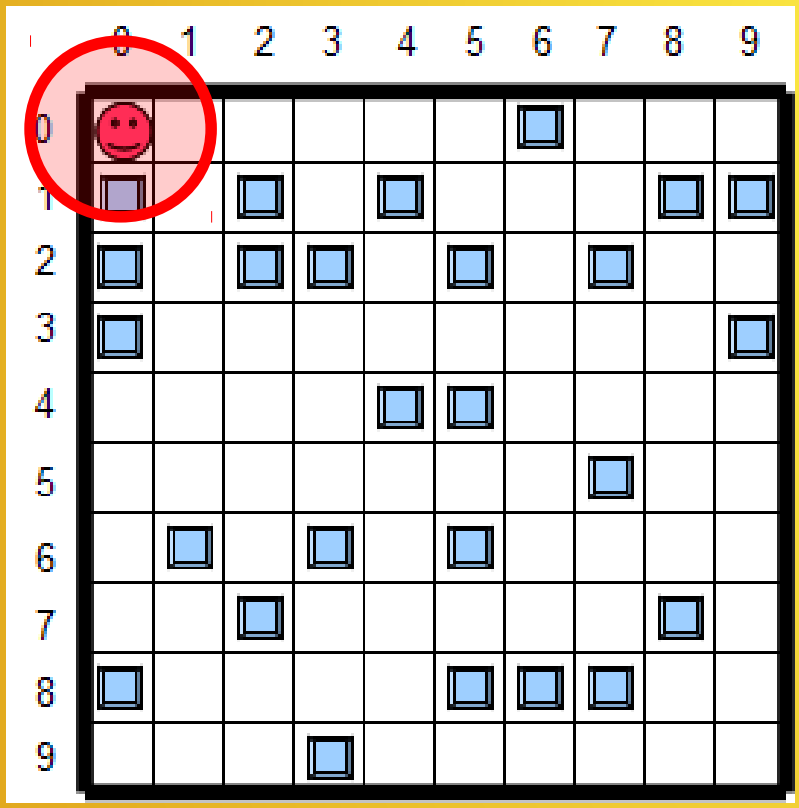
- The task of Robby is to collect as many bottles as possible within the limited number of actions
- We will use a genetic algorithm to evolve Robby's “brain”

Robot “brain” model

- How many different perceptions can Robby have?
- Let's count: a cell can contain:
  - Nothing (denoted by 0)
  - Bottle (denoted by 1)
  - Wall (denoted by 2)

Robot “brain” model

- Robby perceives 5 cells in total; these are all the possibilities:



Current	Up	Down	Right	Left
0	2	1	0	2

Current perception

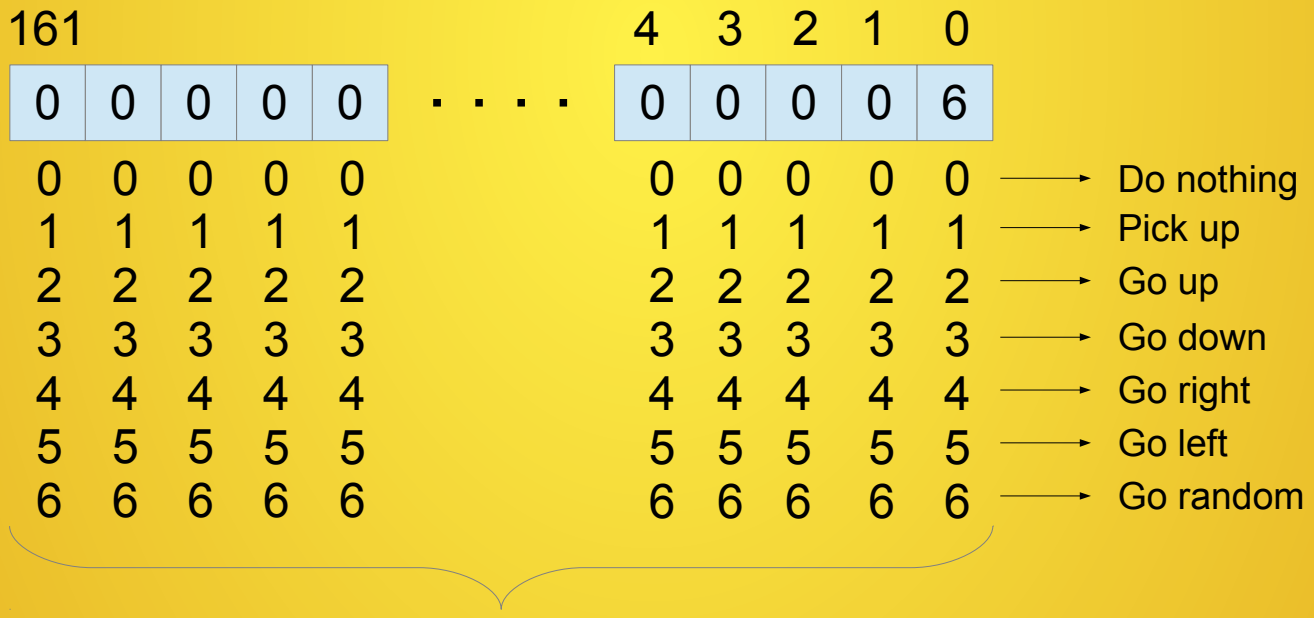
0	0	0	0	0	Nothing
1	1	1	1	1	Bottle
	2	2	2	2	Wall

Seen as a ternary number 0 to 161

$$2\cdot 3^3+1\cdot 3^2+2\cdot 3^0=65_{10}$$

Robot “brain” model

- Robby's brain can now be seen as a 162-dimensional vector: at position *j* is the action for perception *j*:



Actions for each of 162 possible perceptions

Robot “brain” model

- The number of different “brains” is:

$$\underbrace{7 \cdot 7 \cdot 7 \cdot \ldots \cdot 7}_{\text{Actions for each of 162 possible perceptions}} = 7^{162}$$

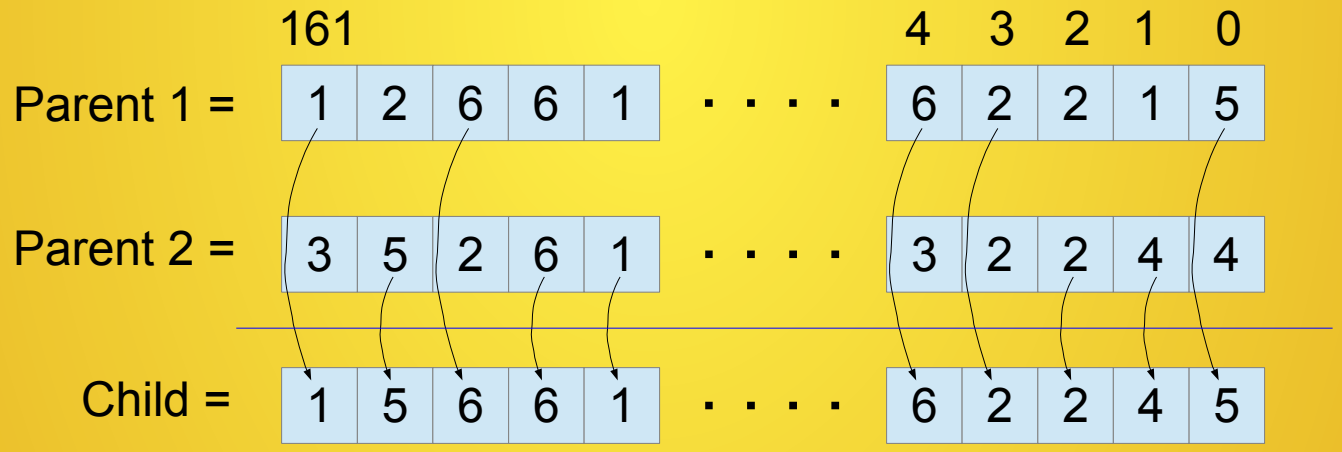
- If a single “brain” can be evaluated in 1μs, we still need 10^{123} years, i.e. 10^{113} times the age of the universe to check them all

Evolution

- We implement a three-tournament genetic algorithm (TGA)
  - Generate a random population of POP_SIZE “brains” and evaluate them
  - Repeat until finished
    - Randomly choose three individuals
    - Child = Crossover of the better two + mutation
    - Evaluate the child use it to replace the third individual

Evolution

- Crossover
  - For each perception copy the action from one of the parents (randomly choose which)



Evolution

- Mutation
  - With a given mutation probability randomly choose a new action for a perception

Evolution

- Evaluation
  - Simulate the procedure of collecting bottles in the given number of steps in N different worlds
  - The total fitness of an individual is the average of performances across worlds
- Scoring actions performed
  - Bottle picked up: +10
  - Picking up bottle on empty cell: -5
  - Crashing into the wall: -10

Evolution

- Stopping criterion
  - Given number of iterations
  - Finding a solution that is acceptably good

Evolution

(Simulation)