Towards the Light with Evolution

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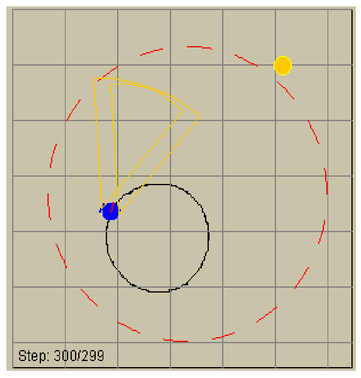
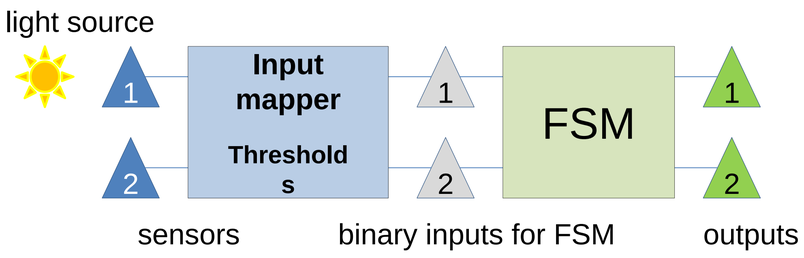
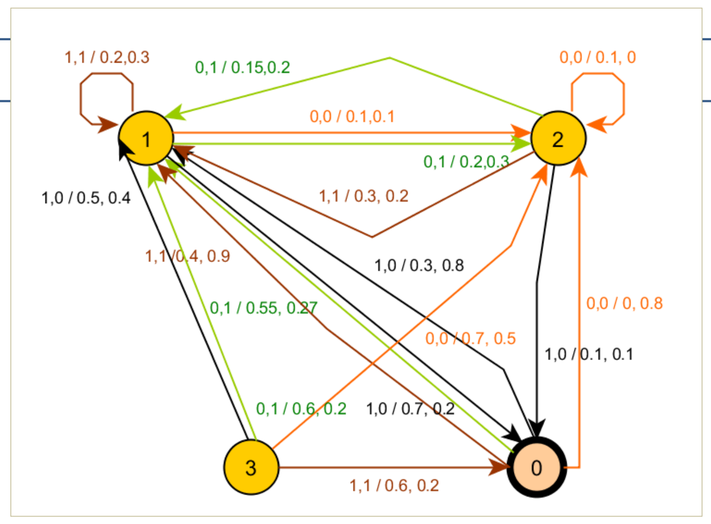
Problem



The robot aims to find the light source, which is placed in a rectangular area outside its closed neighborhood.
The robot has two light sensors and can only sense the light if it is close enough to it. The robot acts based on the output of the controller.
The controllers are evolved with a genetic algorithm.

Model (FSM)





FREVO
Framework for evolutionary design

Evolutionary algorithm:
- Elitist strategy (15% of best kept)
- Keep some random individuals for higher diversity (5%)
- Mutate 30%
- New offspring with crossover (1-point, uniform) (40%)
- Add new individuals (10%)

Fitness functions:
- (F1) time and distance
- (F2) time, distance and grid cells visited
- (F3) time, distance and weighted grid cells (favor moves in spiral)

Mutations for Mealy machine:
- Modify transition (output, next state)
- Change init state
- Replace transition
- Modify threshold for input

Mutations for NN:
- Modify bias
- Modify weight

Comparing Mealy machines:
- Hamming distance
- Using max equal prefix

Comparing NN:
Difference of sums of weights and biases

Generation of Mealy machines:
- Random
- "Simao" based on [4] – making sure all states are reachable

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References

[1] V. Braitenberg. Vehicles: Experiments in Synthetic Psychology.Bradford Books. MIT Press, 1986.

[2] M. Spichakova. "Genetic Inference of Finite State Machines", Master thesis, Tallin University of Technology, 2007

[3] N. I. Polikarpova, V. N. Tochilin, and a. a. Shalyto. Method of reduced tables for generation of automata with a large number of input variables based on genetic programming. Journal of Computer and Systems Sciences , 49(2), pp.265-282, May 2010

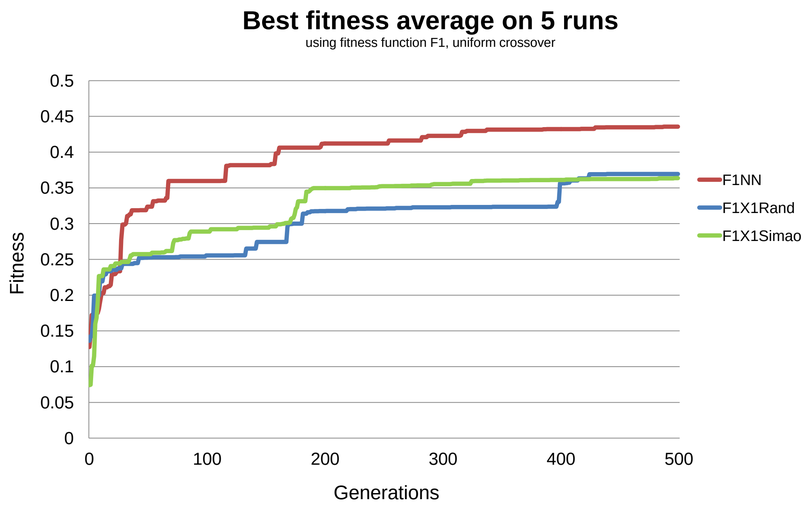
[4] Simao, A., Petrenko, A. and Maldonado, J. C.: Comparing finite state machine test coverage criteria, IET Software, 3 (2) April 2009, pp.91-105.

Encoding of Mealy machine

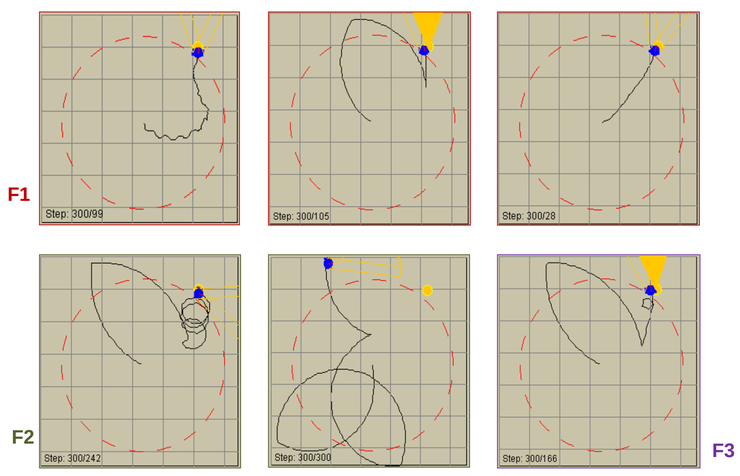
	input: 0,0				input: 0,1				input: 1,0				input: 1,1			
states	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
next states	1	2	2	2	1	2	1	1	1	0	0	1	1	1	1	0
outputs	0, 0.8	0.1, 0.1	0.1, 0	0.7, 0.5	0.55, 0.27	0.2, 0.3	0.15, 0.2	0.6, 0.2	0.3, 0.8	0.7, 0.2	0.1, 0.1	0.5, 0.4	0.4, 0.9	0.2, 0.3	0.3, 0.2	0.6, 0.2

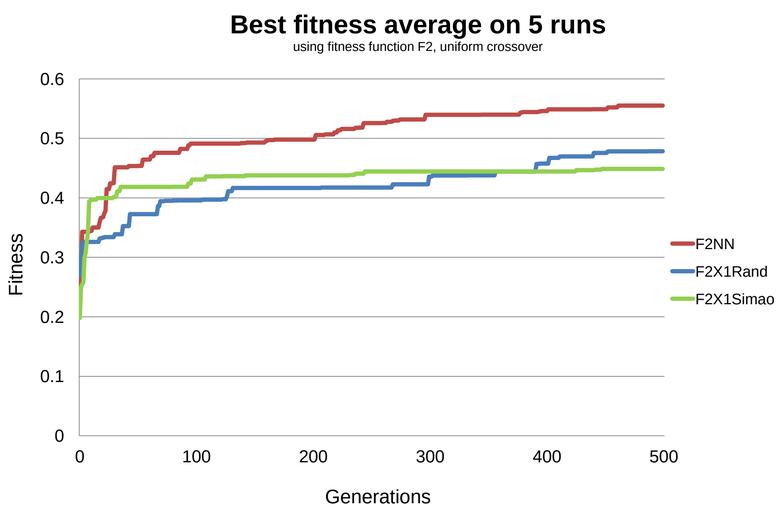
In the representation we also encode the initial state and the thresholds used for input mapping.

Experiments and Results

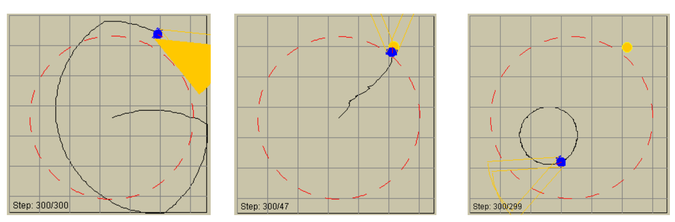


Some evolved behaviors for NN

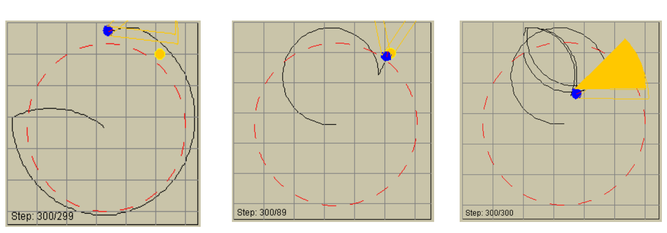




Some evolved behaviors for Mealy

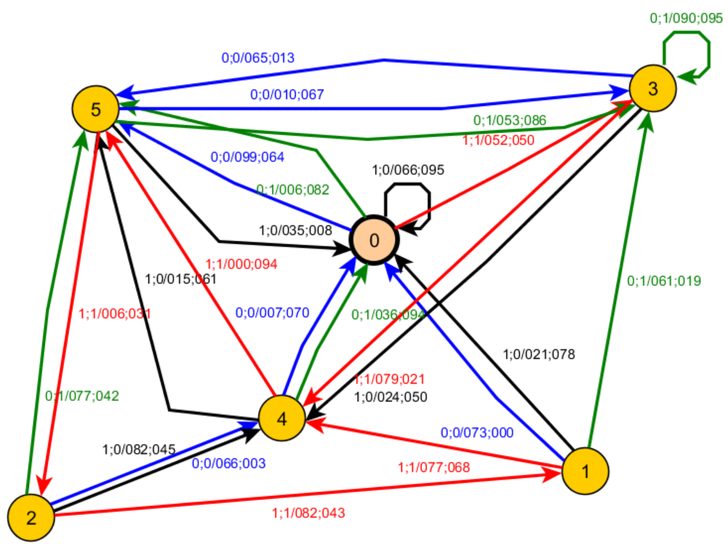


F1,2,3Rand — F1,2,3Rand, Simao



F2Rand — F1Simao — sometimes not enough sensitive - F1Simao

Best evolved Mealy machine



Evolved with F1, Simao generation, using uniform crossover (thresholds: 1, 60)

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