

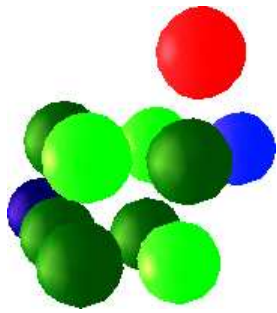
Robots behind the bush

Sean Collins

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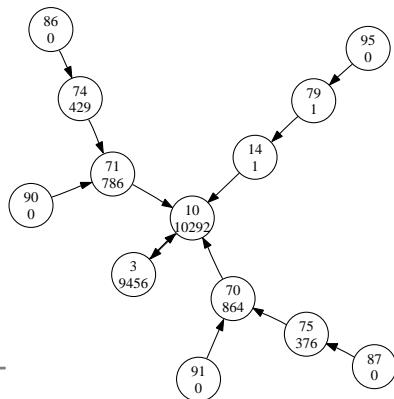
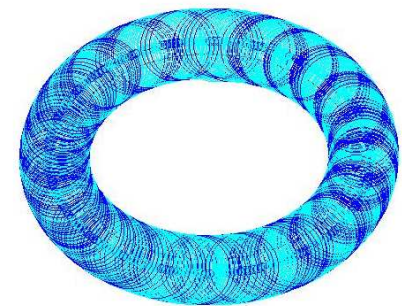
- InCA, a robot controller
 - A box of lights
 - Growing InCA solutions
- Evolution
 - Plant and animal husbandry
 - Robot Husbandry

InCA - Interactive Cellular Automata

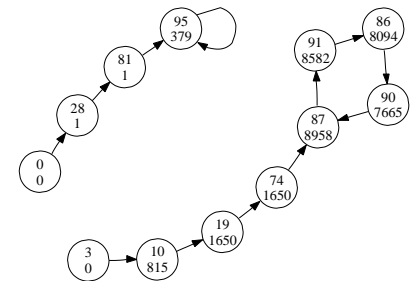


InCA are 3-D lattices of winking lights (green). The lights wink on and off depending on the states of their near neighbours. The red light is an input connection, the blue lights are outputs.

The thesis used a genetic algorithm to discover solutions to an elliptical racetrack problem. This robot is tracking the edge of the race track well.



InCA are FSMs. Separating the graphs of their state trajectories allows their behaviour to be analysed.

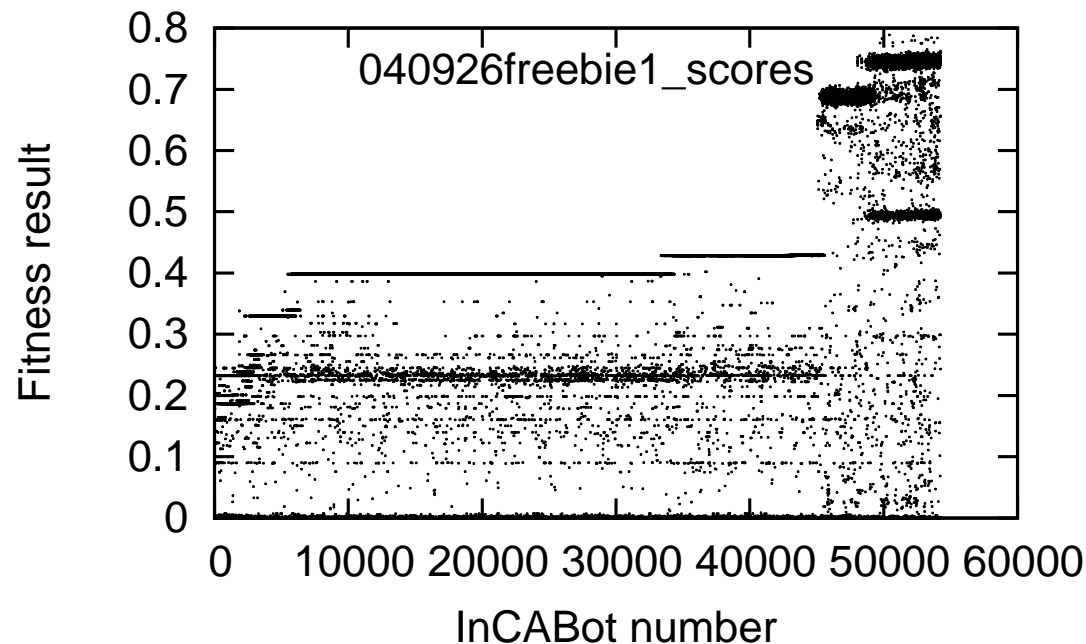


Evolving transition rules

The InCA cells update according to a *transition rule*, which can be specified by a 128-bit string for each cell (2 shown here).

```
1100000 001000000 00000000 00000000  
0000000 000000000 00000000 00000000  
0000000 000000000 00000000 00000000  
0000000 000000000 00000000 00000000
```

```
00000000 00000000 00000000 00000000  
00000000 00000000 00000000 00000000  
10000000 00000000 11000000 00000000  
00000000 00000000 00000000 00000000
```



To avoid designing the rules directly, a genetic algorithm operates on a population of potential solutions.

Using artificial evolution

The InCA evolution system used a fairly typical GA

- Autogenesis (random guesses)
- Reproduction (cloning, 2-parent sex)
- Variation (random bit flipping)
- Selection (fitness tests)

This is a very limited form of evolution compared to biological evolution!

- Single population \approx 100 members
- Single species
- Single niche
- Short 'runtime'

Minsky's dream

was to escape from programming by using a process “...like evolving an animal.”

A typical use of artificial evolution is

- Run a search
- Analyse results
- Adjust GA parameters
- Adjust Fitness test
- Adjust structure of problem
- Start again, and again, and again

Biological evolution isn't like this... or is it?

Evolution

Biological evolution has been going on (so they say) for a few billion years.

- Only one run (aside from some mass extinctions)
- Lots of populations
- Lots of fitness tests (niches)
- Lots of good results (eg, us!)

But that's a whole planet, and a few billennia.

Humans use evolution - we call it husbandry.

Husbandry

Practice of interfering or directing evolution.

- Evidence dating back several thousand years
- Plant husbandry used to improve crops and ornamentals
 - Manual pollination
 - Vegetative reproduction
- Animal husbandry used to improve farm and domestic animals
 - Interference in reproduction

Great results - more and (with exceptions) better food and flowers.

Back to the problem

Husbandry is a huge business. The owner of a prize plant or animal can expect large sums of money in exchange for the donation of genetic stock.

Robot evolution in the lab works well - for toy problems.
How about robot husbandry?
(why would anybody want to evolve robots?)

- Ornament
- Companionship
- Fun
- For money



Robot husbandry issues

Breeders clearly 'own' their stock, but:

- Animals harder to 'copy' than digital media
 - How to breed? (Virtual bush)
- Breeders' shows give independent assessments of fitness - what options for robots?
 - Behavioural fitness independent of physical appearance?
- Where to keep stock
 - Virtual farmyard
 - Lots of robots
 - Personality disorder robot



Summary

Robot evolution

- Seems to work fairly well in the lab
- For toy problems
- Usually single species (application)

Robot husbandry

- Has some technical issues (stock ownership)
- May support greater diversity
- Needs humans to get involved!

Thanks for your time, and in advance, for your suggestions!