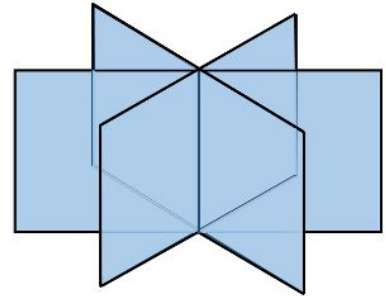




Modelling Neural Development with Braitenberg Vehicles

Stefan Dvoretzkii
EI workshop 2021



Embodied cognition with “brain”

- Braitenberg vehicles - concept from 1970s
- Many Robotics papers, incl. simulations
- Neural networks area developed in parallel
- However, there was no efficient effort to cross the two in developmental context

Robot based on an “extended Braitenberg” architecture

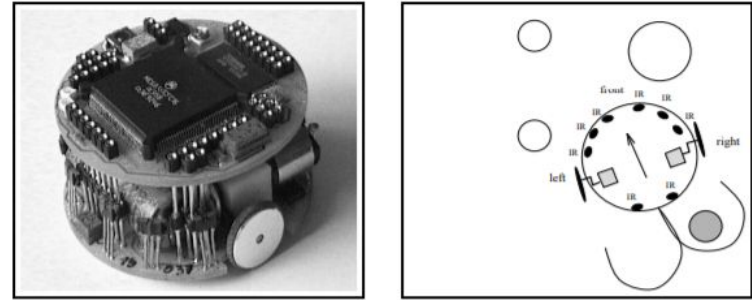
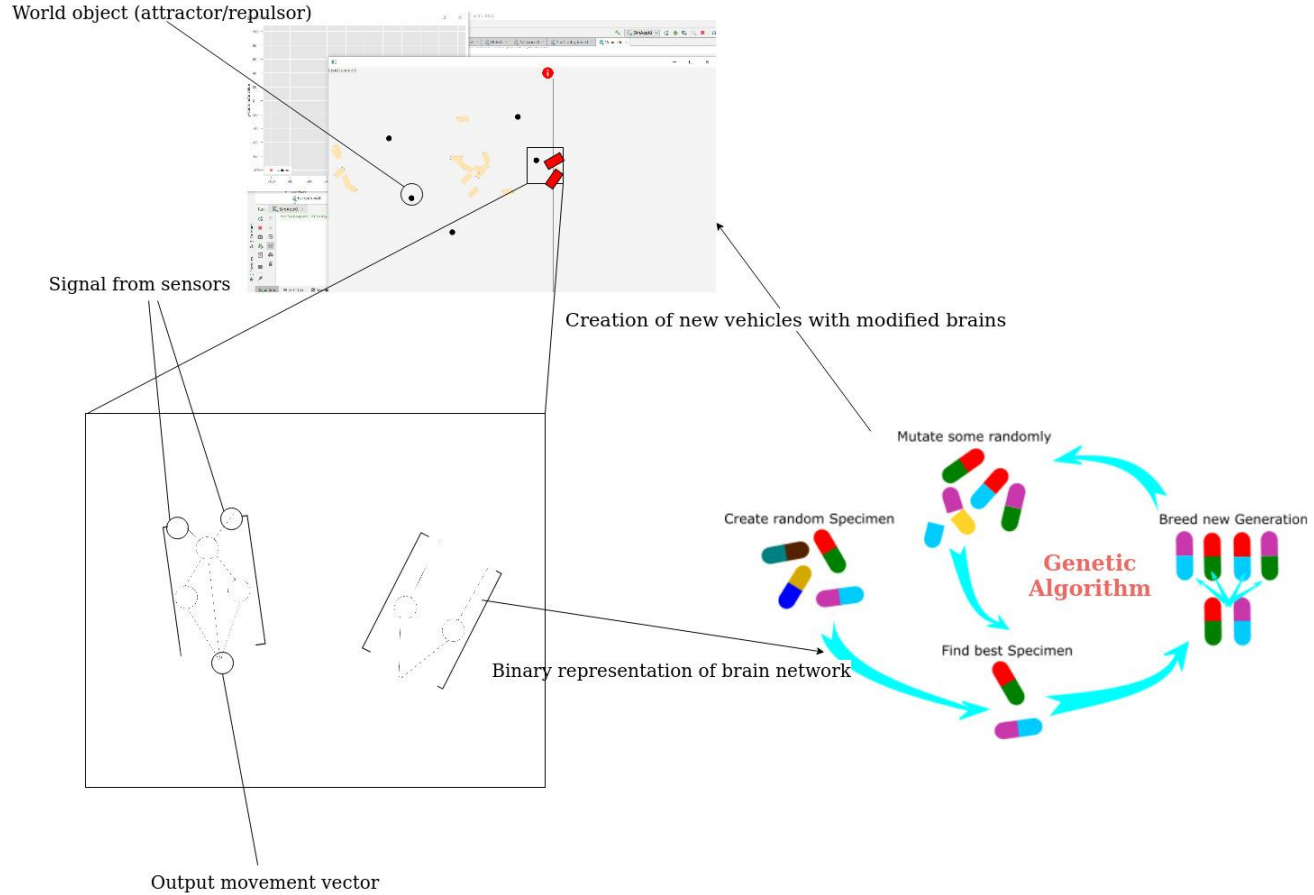


Figure 1: The robot and its environment. The pegs are graspable, i.e., they fit into the wire loop at the rear of the robot.

Source: Lambrinos 1995

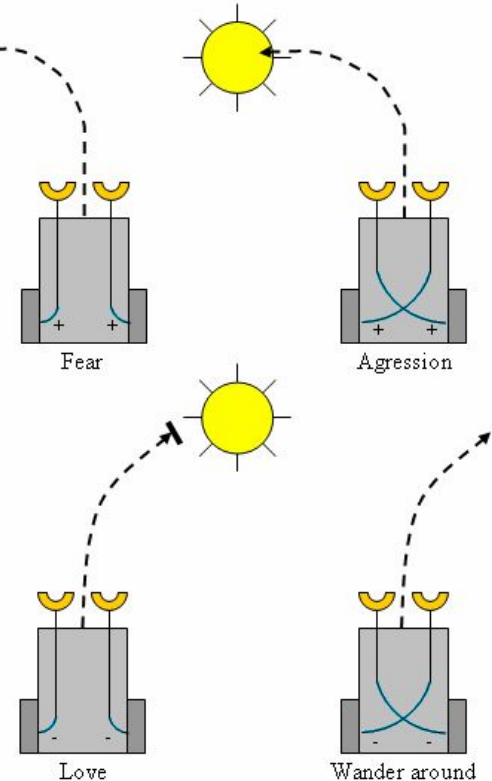
BraGenBrain algorithm



Vehicles have a body and obstacles in 2D space

- Body is comprised of sensors, motors and outer shape
 - Brain is between sensors and motors
- World contains objects that influence vehicle
- World is limited, vehicle “portals” through walls

Book example of object/vehicle relationship in space



Source image:

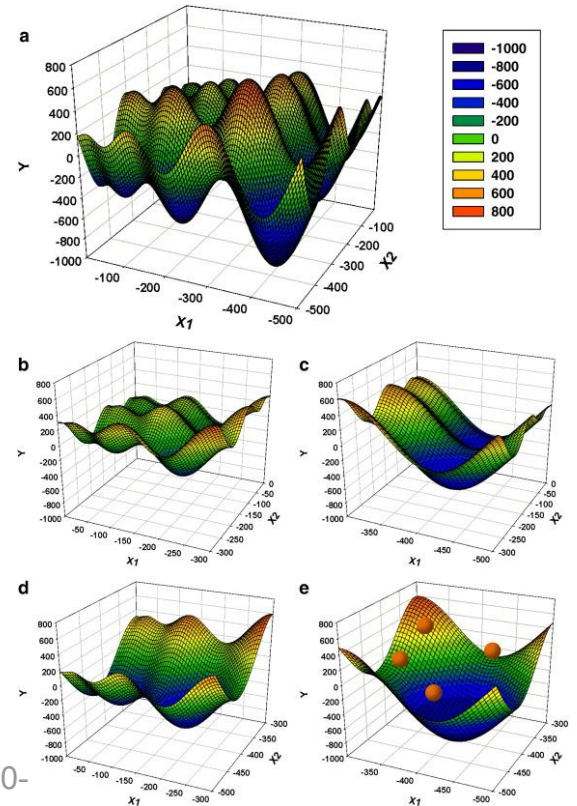
https://www.researchgate.net/profile/Evren_Daglarli/publication/318542601/figure/fig4/AS:518462306623489@1500622454876/Braitenberg-Vehicles.png

Genetic algorithms simulate brain development

- Try to simulate “real” evolution
- Fitness function
 - E.g. “motility” and “complexity of the movement pattern” criteria
- Prediction calling: partial good solutions may *not* comprise the final one

Source:

<https://ars.els-cdn.com/content/image/1-s2.0-S0169743913001627-gr1.jpg>

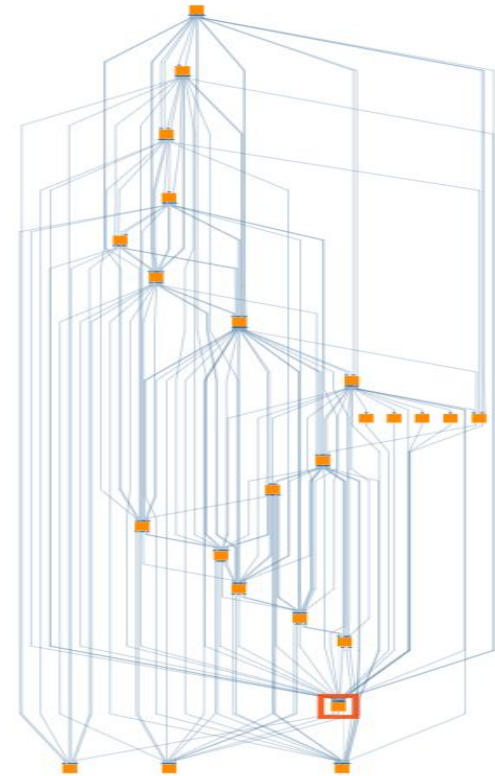


Examples of GA search space

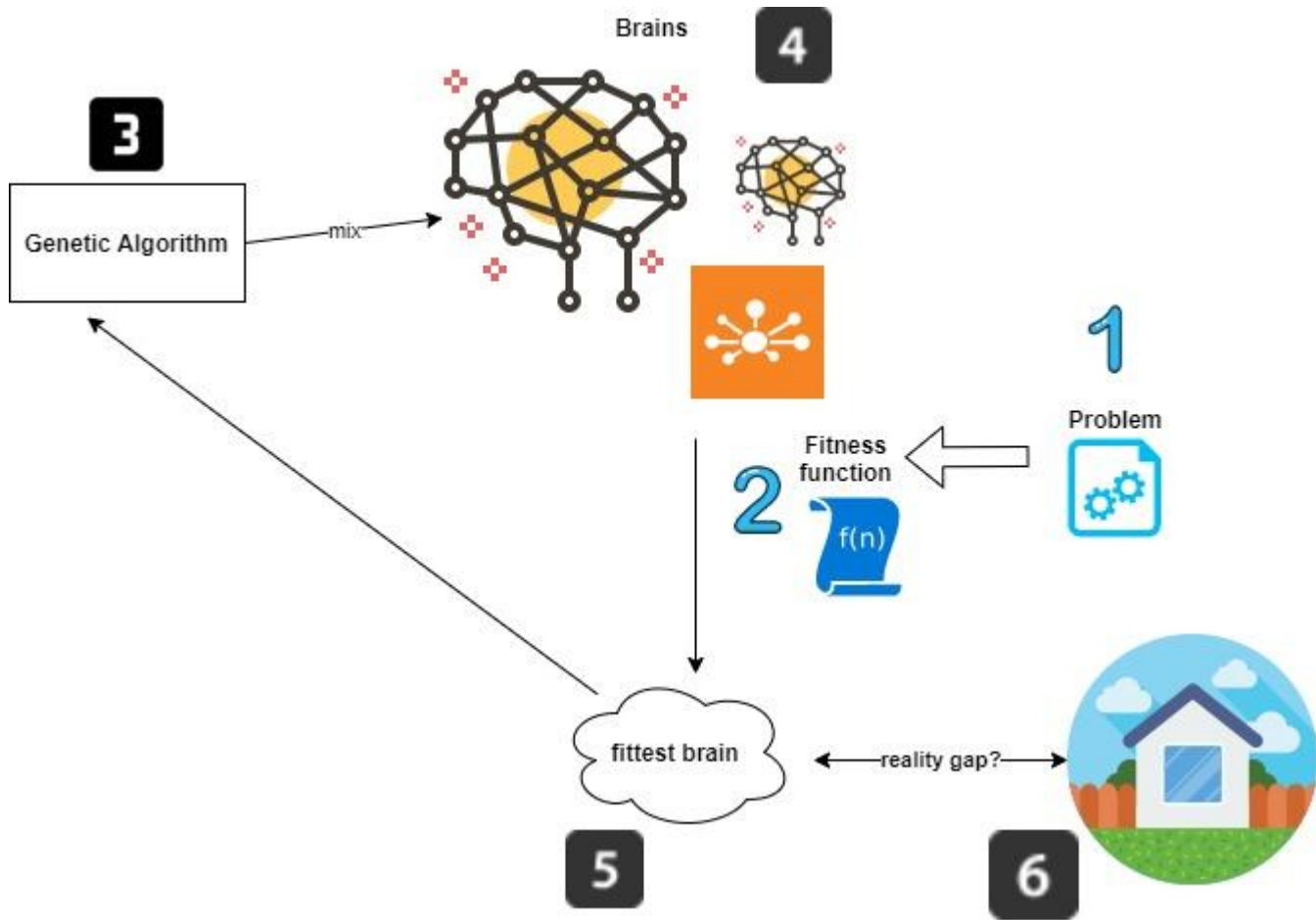
Can we develop conserved functional brain motifs?

- Simulate biological development of “brain” as neural network between motors and sensors
- Development happens and depends on environment and “lifestyle” of an agent
- Extension - select naturally occurring **connectome** patterns
 - Compare against animal connectome databases (subgraph search)

An area of rhesus monkey brain connectome

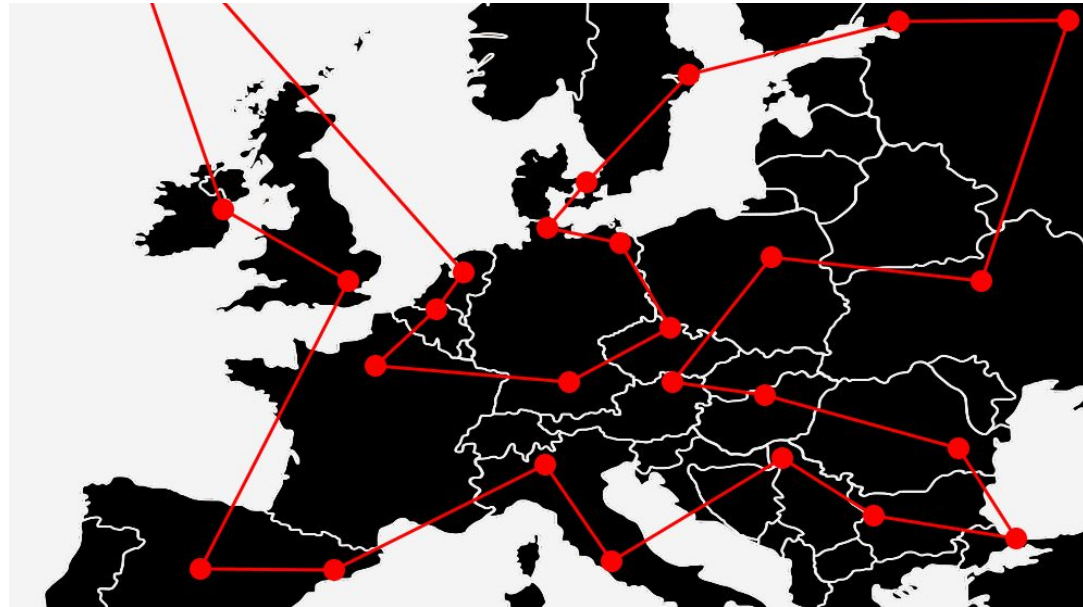


Source: data: <https://neurodata.io/project/connectomes/>,
viz: <https://www.yworks.com/yed-live/>



What could we run simulations on?

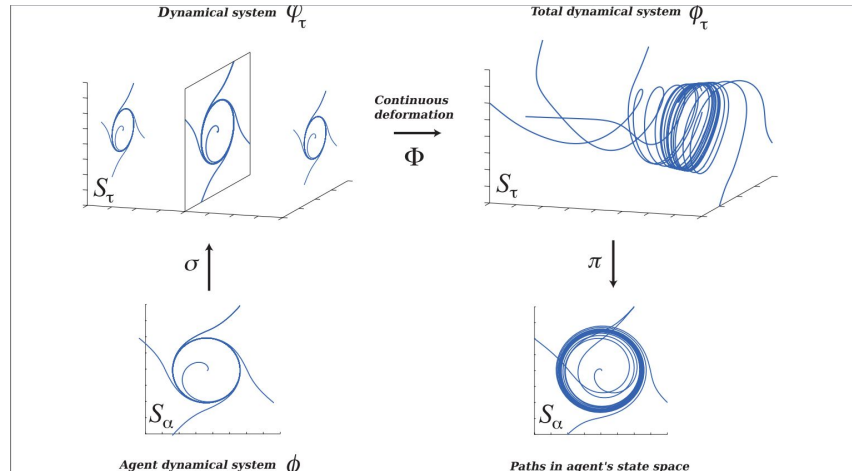
- Travelling salesman revisited: TSP visualized on Europe map
preserve vehicles providing the best route. What will their brains look like?
- What is the problem/setup you would like to see the neural development of the agent in? What would be the fitness criteria, what you would like to see the developing neural networks through?



Source:

https://miro.medium.com/max/992/1*3Ct_bqplsDVnMEJh6R29Hw.png

Dynamical system view - how can the simulation be extended?



- What are the interesting metrics to look at?
- What constraints could be changed and how to make the “world” more appropriate/more interesting to look at?
- How is this system related to e.g. cellular automata, Conway’s “Game of Life”? How patterns developed here are the same/different?

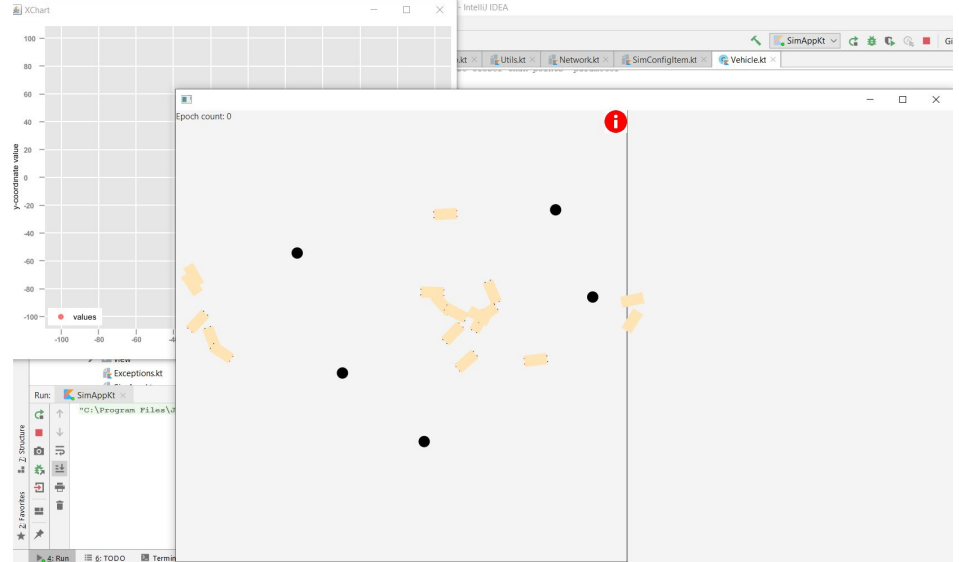
State of the project

Have:

- Prototype with “visual feedback” and initial pipeline

Want to have:

- Brain of variable nodes
- Parallel computation
- Intra-agent relations
- Stochasticity
- Variability of applications & “parameter” values



Main simulation window

Links

- Gist describing the project:
<https://gist.github.com/stefanches7/88639248e8260784a7f7c3dfa1d2d6c2>
- Main repository: <https://github.com/stefanches7/Braitenberg-Vehicles>
- Ortogonal Research Lab Mirror:
<https://github.com/Orthogonal-Research-Lab/GSoC-Braitenberg-Vehicles>
- OSF soon!

References

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Thanks!

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