

How can we design a more intelligent path-planning?

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Is AI really intelligent?

They might be more **efficient** and/or **effective** than human
but still **less intelligent**, at least so far.

What is intelligence?



Intelligence should be spontaneous, flexible, and/or unpredictable,
more or less.

“I beg your pardon?”

Intelligent people try a different explanation for an easier understanding
while
others just repeat the same expression, maybe with a louder voice.

Let's make an agent to be spontaneous!

Behaviors might differ even in a similar situations.

Goal is

to make an agent behave differently even when it encounters the same situation as before.

Path Planning as a benchmark

An agent plans a shortest path from start to goal.

Genetic Algorithm (GA)

Agent decides actions following its **chromosome**

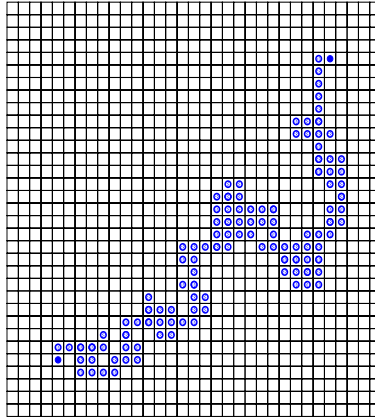
e.g., with chromosomes like

(4 1 1 2 1 3 2 3 3 4 2 1 3 4 3 2 3 3 2 1 1 3 2 1 3 ...)

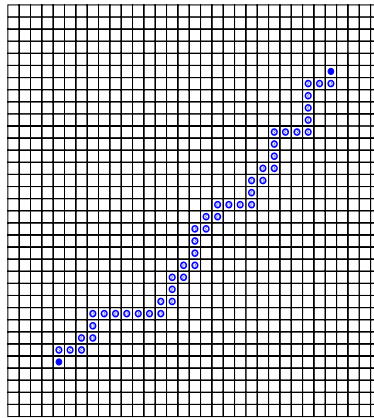
indicates the agent a route to be followed.

Random walk evolved to be minimized

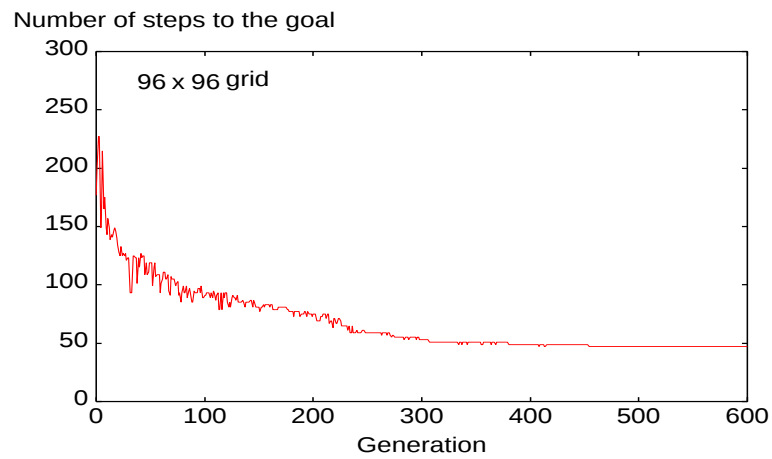
96x96 grid 178 steps



96x96 grid 48 steps



Task was easy



(An interpretation of GA from robotics point of view)

Edelman's Neural Darwinism (1978)

Assume evolution in an agent's brain in advance the action.

(e.g. 100 **random** chromosomes to be evolved)

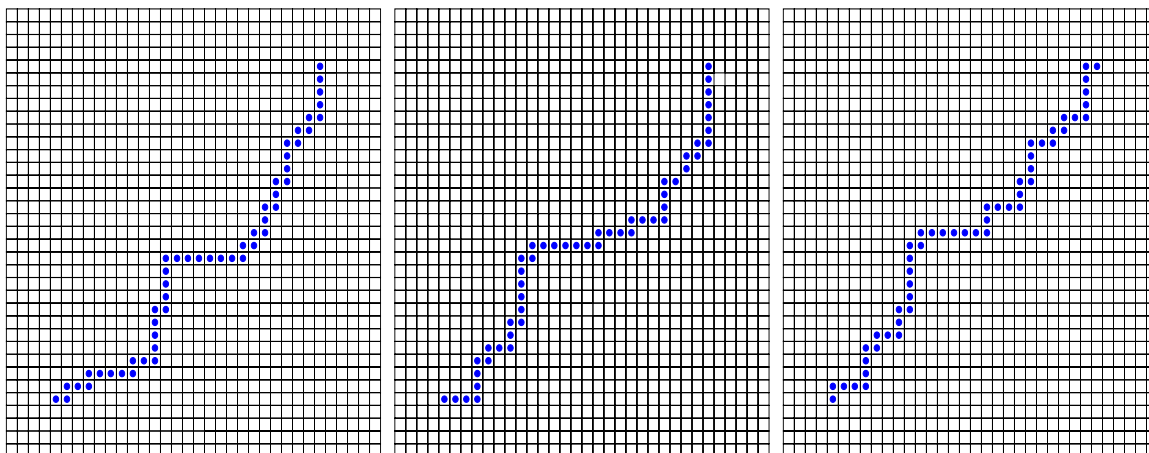


after a convergence



Agent acts following **the best** chromosome.

Route can be different from run to run, if any.



It's not so realistic, however.

No one, these days, believe this really happens.

It takes a too long time to be a reality if the task is hard.



Let's dismiss GA now.

What about NN?

With fixed weights



An identical behavior in an identical situation.

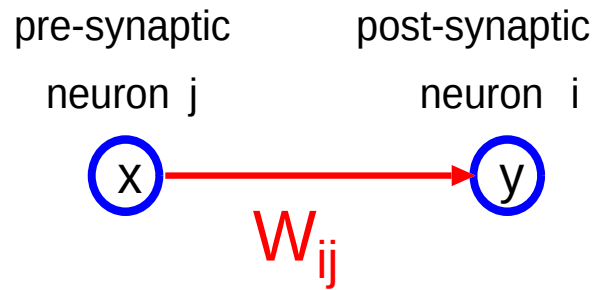
What if we modify weights during action?

(Floreano et al. 2000)

(1)

**Recurrent McCullough-Pitts Neurons
with Sigmoid**

Learning Rule



$$w_{ij}(t+1) = w_{ij}(t) + f(x_j(t), y_i(t)) \quad (x_j, y_i \in [0, 1])$$

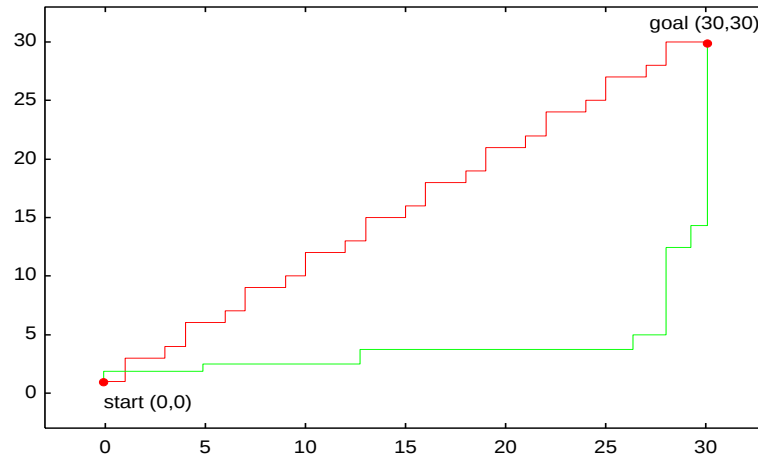
Optimum configuration of learning rules.

$$\eta_{ij}x_iy_j \quad (\text{Hebb, 1949})$$

or

$$a_{ij}x_iy_j + b_{ij}x_i + c_{ij}y_j + d \quad (\text{Durr et al. 2008})$$

Can agents take a different minimum route
every time following how it feels?



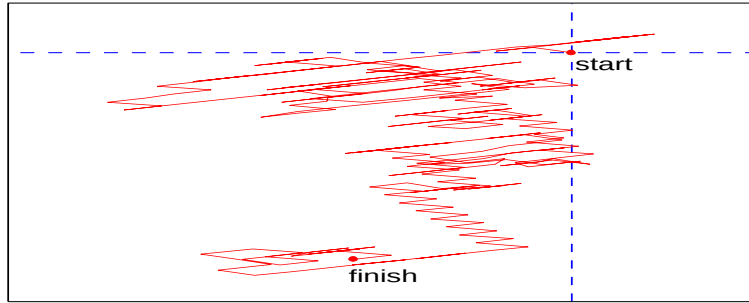
(2) Recurrent Spiking Neurons

as a more biologically plausible model.

An exploration by Integrate & Fire Model

$$u_i(t) = u_r + (u_i(t - \delta t) - u_r) \exp(-\delta t / \tau) + \sum_j w_{ij} f_j(t - \delta t)$$

Can it **learn** so that path will finish at the goal with minimum length?



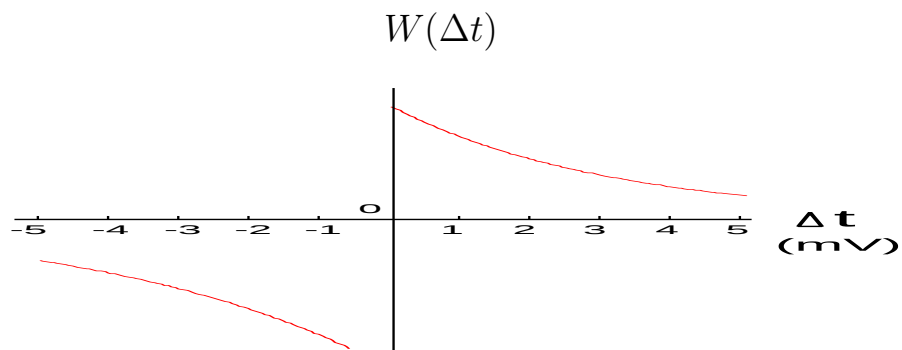
Spike timing dependent plasticity (STDP)

A counterpart of **Hebb Rule** of McCullough-Pitts Neurons
for Spiking Neurons.

What is STDP?

$$W(\Delta t) = \begin{cases} A_+ \exp(-\Delta t/\tau_+) & \text{if } \Delta t \geq 0 \\ -A_- \exp(-\Delta t/\tau_-) & \text{if } \Delta t < 0 \end{cases}$$

where $\Delta t = t_{post} - t_{pre}$



Reward-modulated STDP Learning

(Florian 2007)

$$w_{ij}(t + \delta t) = w_{ij}(t) + \gamma r(t + \delta t) \zeta_{ij}(t)$$

where

$$\zeta_{ij}(t) = P_{ij}^+(t) f_i(t) + P_{ij}^-(t) f_i(t)$$

$$P_{ij}^+(t) = P_{ij}^+(t - \delta t) \exp(-\delta t / \tau_+) + A_+ f_j(t)$$

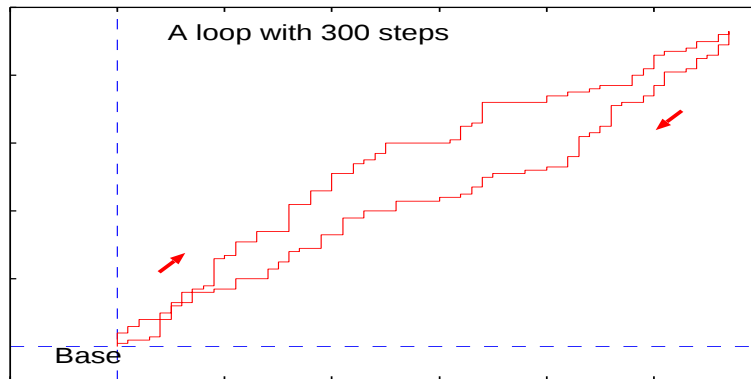
$$P_{ij}^-(t) = P_{ij}^-(t - \delta t) \exp(-\delta t / \tau_-) + A_- f_j(t)$$

Looks like a simple toy problem?

No!

More challenging benchmark

From one point to the same point **maximizing** its route with a limited fuel.



Brief Summary



We sometimes need **spontaneous** and **unpredictable** intelligence rather than **efficiency** or **effectiveness** like in case of SONY's AIBO

Robot dog vs. Real dog

When will a **robot** dog be more intelligent than **real** dogs?