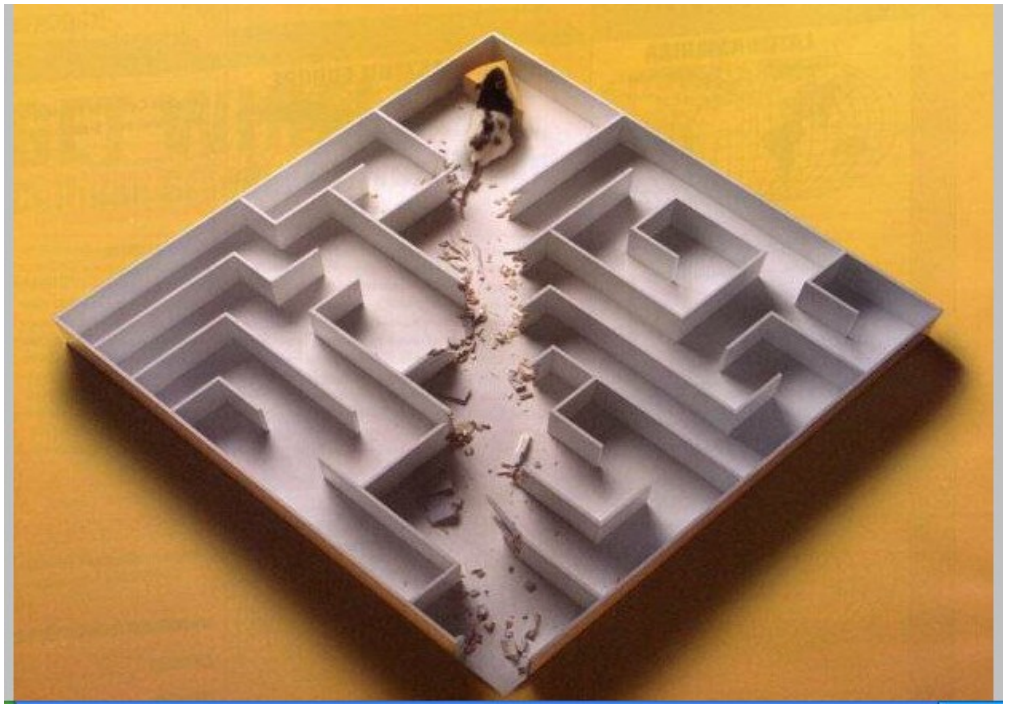
# Navigation in animats: From reflexes, to cognitive maps, and to planning; From evolution, to development, and to learning



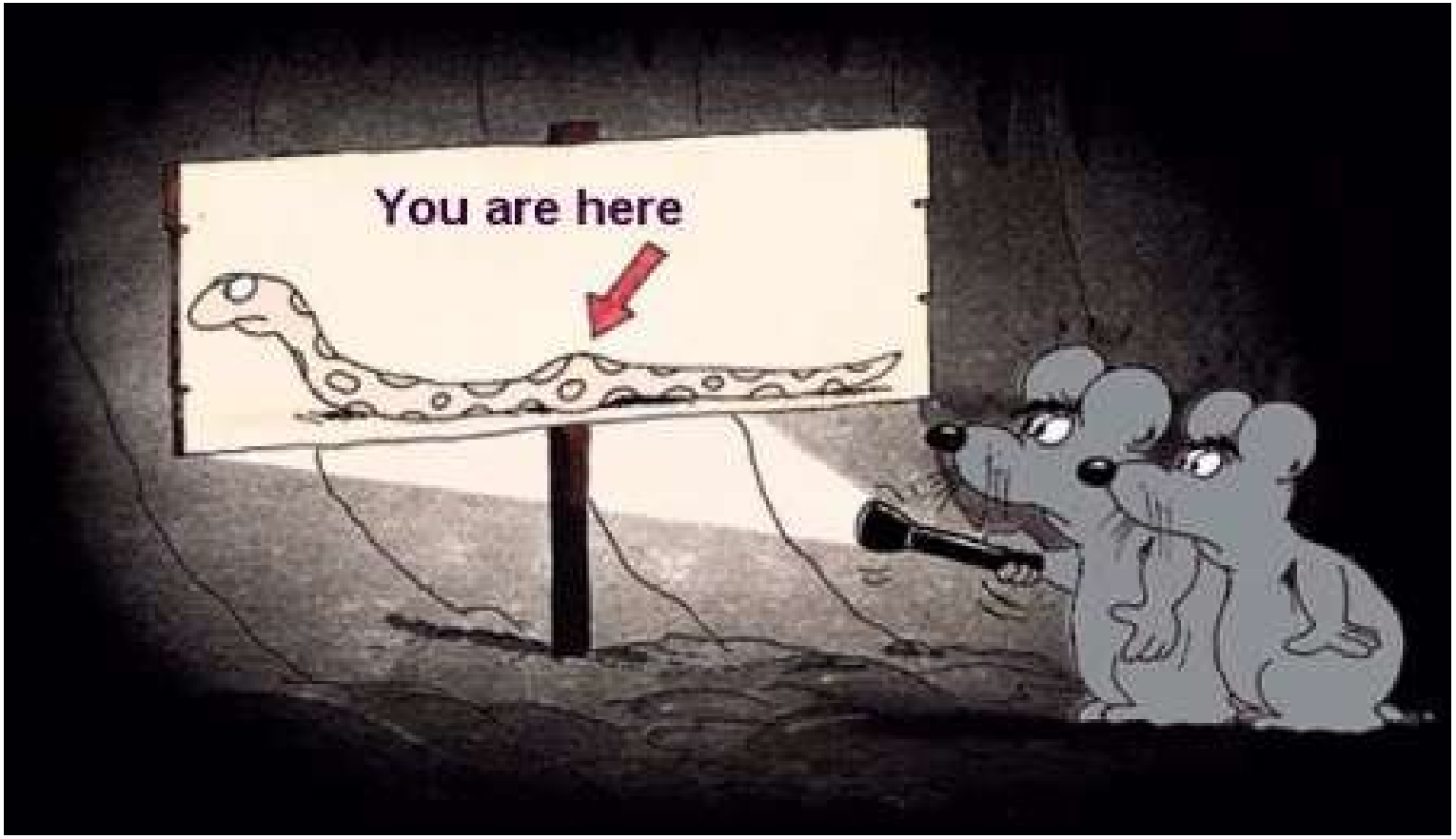
**Jean-Arcady Meyer**

**http://animatlab.lip6.fr**

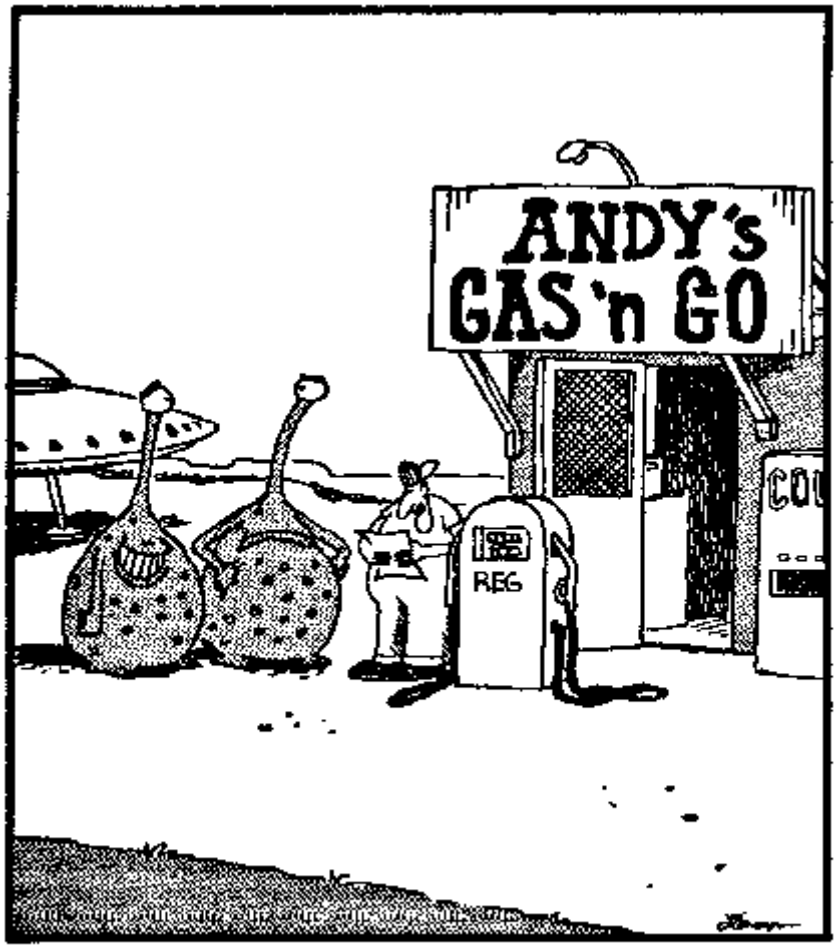
Navigation is the process of determining and maintaining a course or trajectory from one place to another (Gallistel, 1990).

# The four issues at odds

## 1. Localization

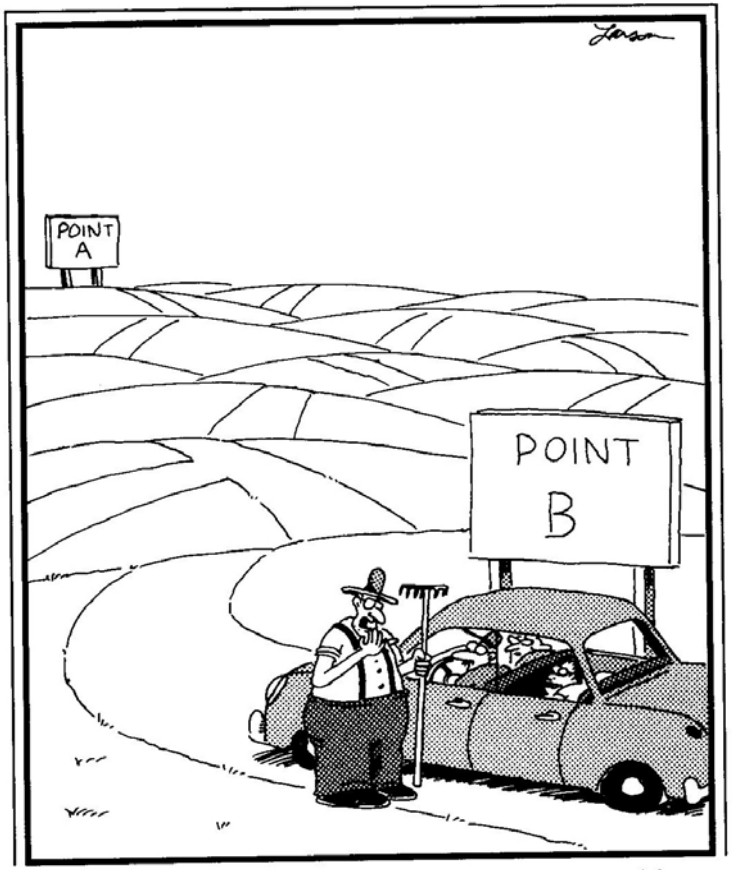


# 2. Map-building




"Shoot! You not only got the wrong planet, you got the wrong solar system. ... I mean, a wrong planet I can understand - but a whole solar system?"

# 3. Movement




"Well, lemme think. … You've stumped me, son. Most folks only wanna know how to go the other way."

# 4. Obstacle-avoidance


"Here, Fifi! C'mon!... Faster, Fifi!"

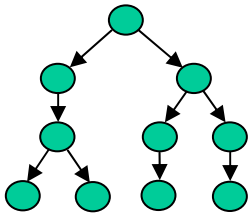
# Getting Around in the World: Does All Navigation Require Cognition?

• Definitely no: mere reflexes (present) may be enough for movements and obstacle-avoidance, but memory (past) and planning (future) may be mandatory for localization, map-building and goal-seeking.

•Implementing navigation capacities in animats may entail adaptive processes like evolution, development or learning.

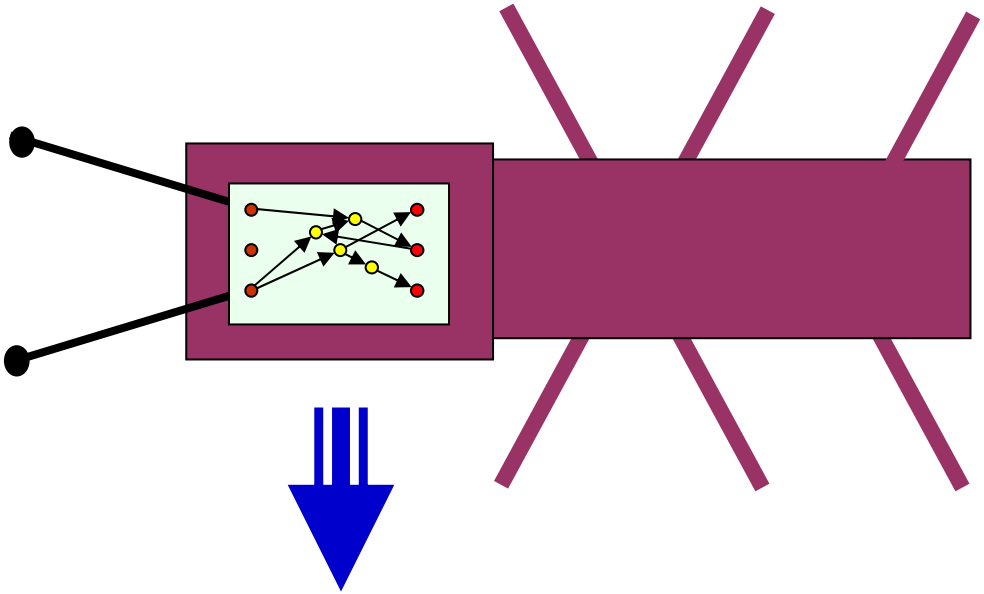
# Moving

# Development and Evolution of neural controllers for walking

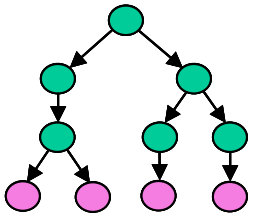


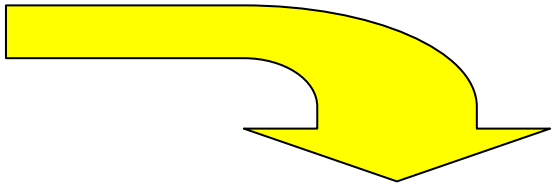
Genotype

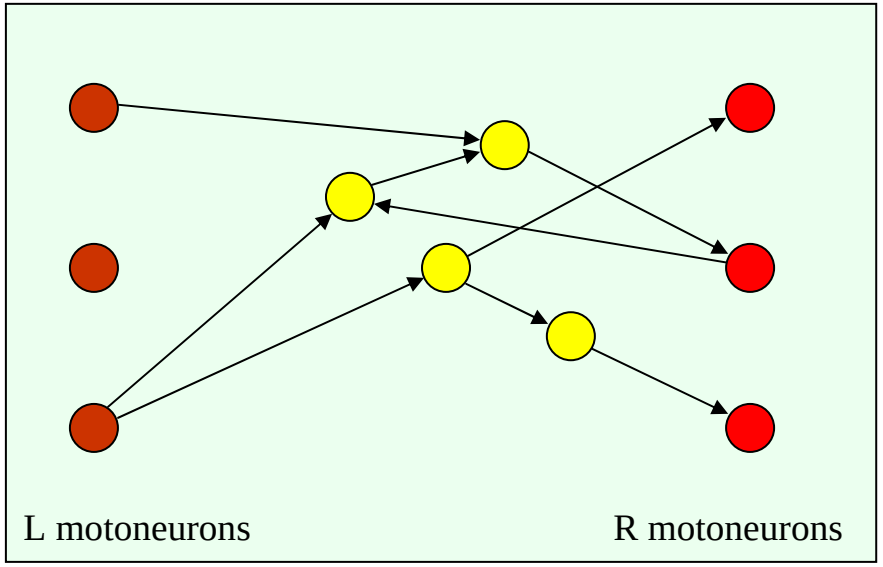
Phenotype

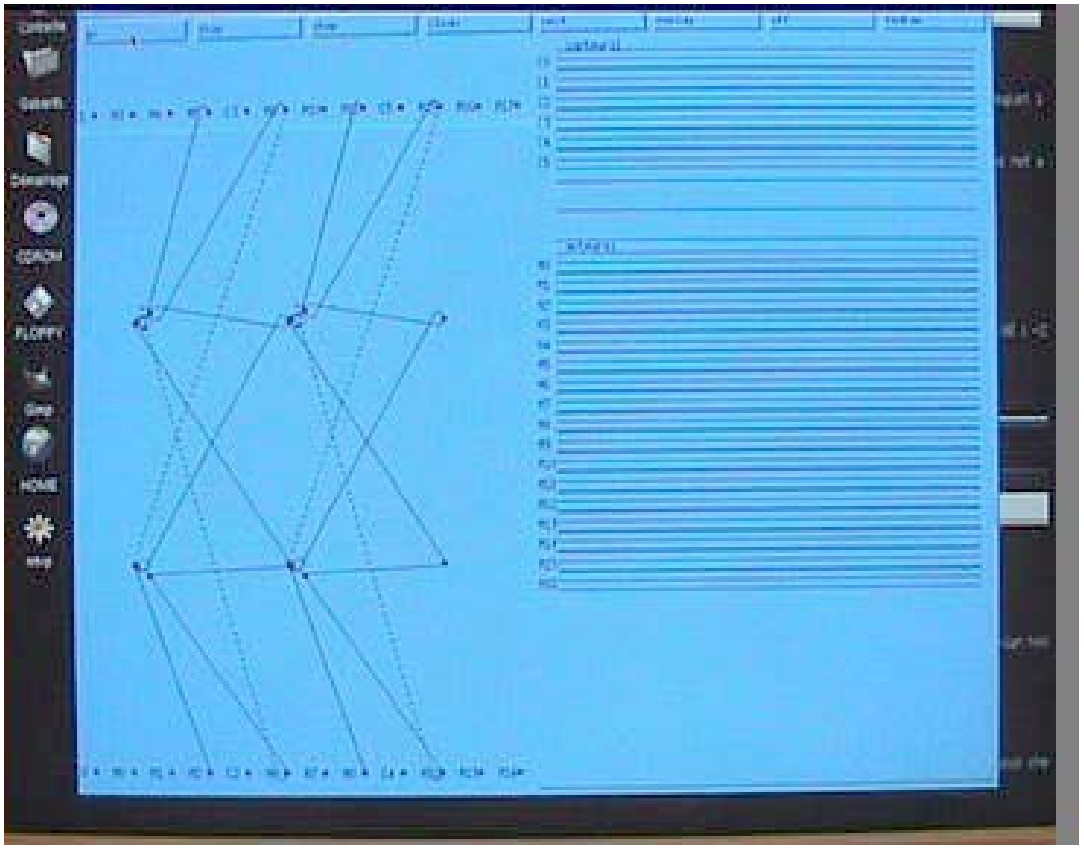


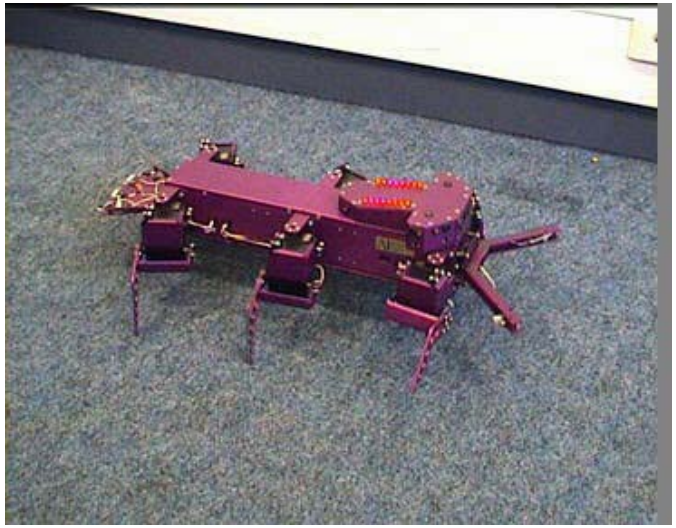
**Selection of successfull individuals**






L motoneurons
R motoneurons





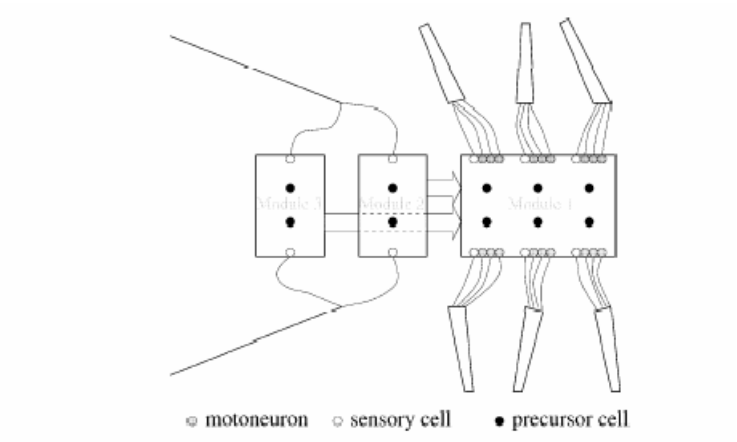
**First generations**

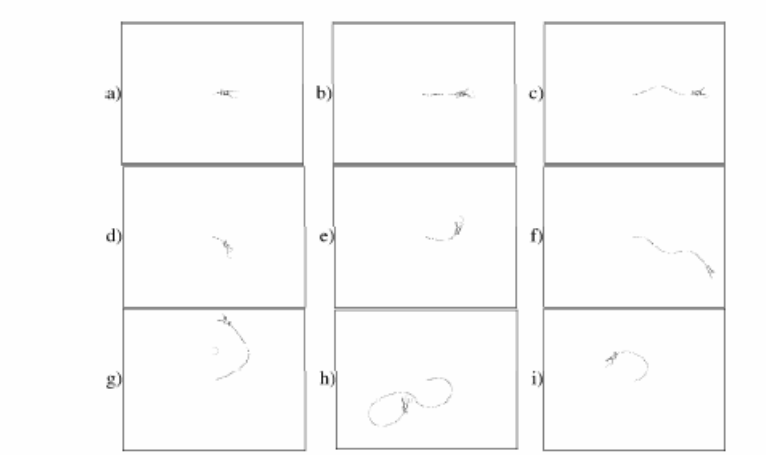
**Last generations**

Kodjabachian, Filliat - AnimatLab

# Evolution of additional behaviors

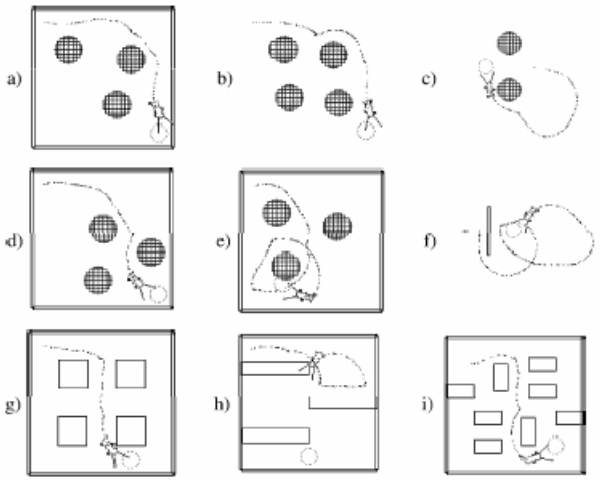
Locomotion + goal-following



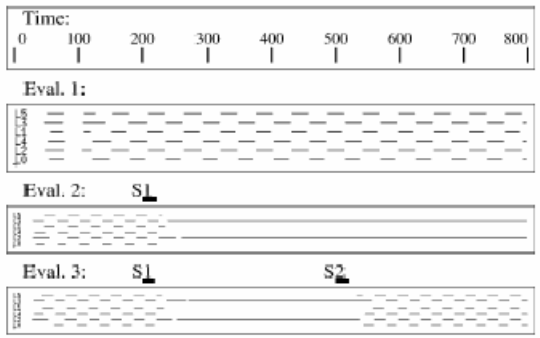




Kodjabachian - AnimatLab

Locomotion + goal-following
+ obstacle-avoidance



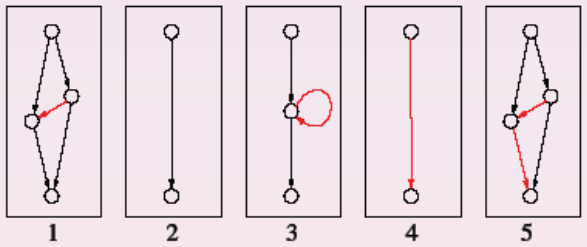

Stop-Go




Kodjabachian - AnimatLab

# Evolution of neural controllers for flying

**Model–module list**

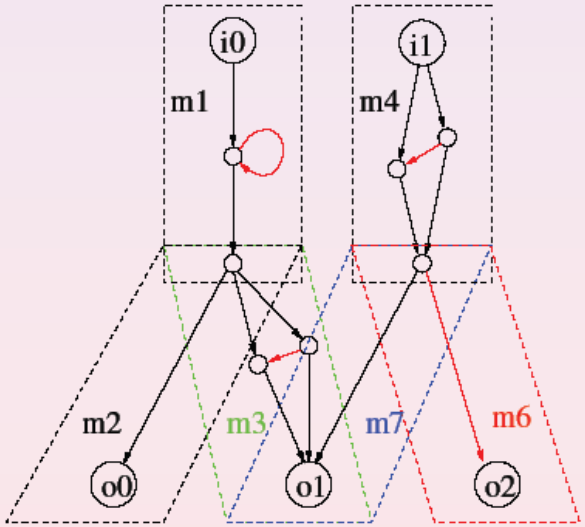


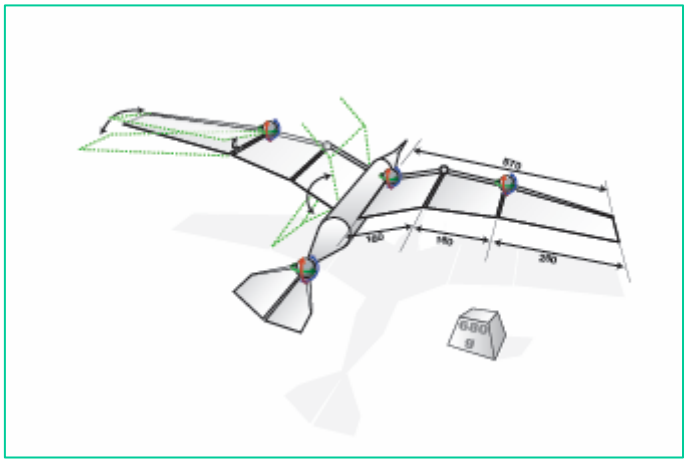

**Module list**

| m1 | m2 | m3 | m4 | m5 | m6 | m7 |
|---|---|---|---|---|---|---|
| 3 | 2 | 1 | 1 | 5 | 4 | 2 |

**Link list**

m1–>m3 m1–>m2
m2–>o0 m6–>o2
m3–>o1 m7–>o1
i1–>m4 m4–>m6
m4–>m7 i0–>m1

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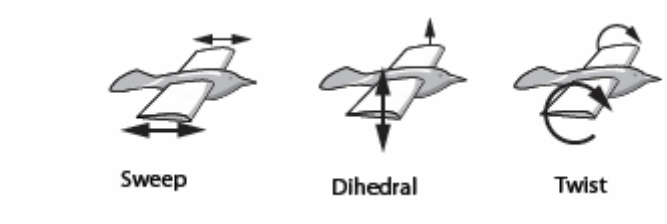
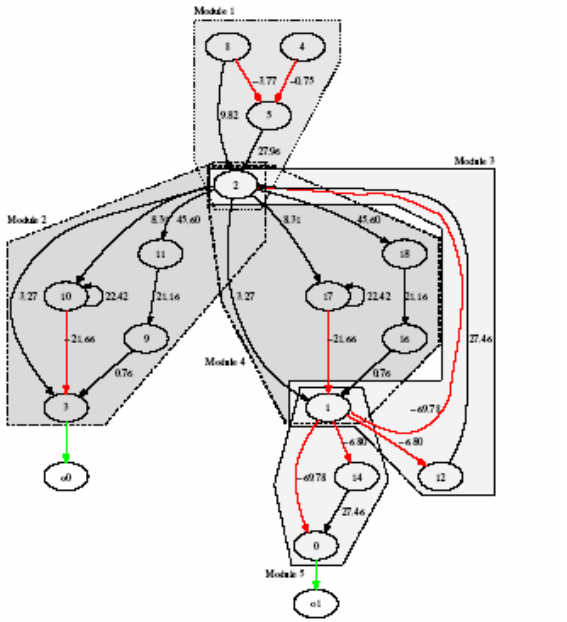
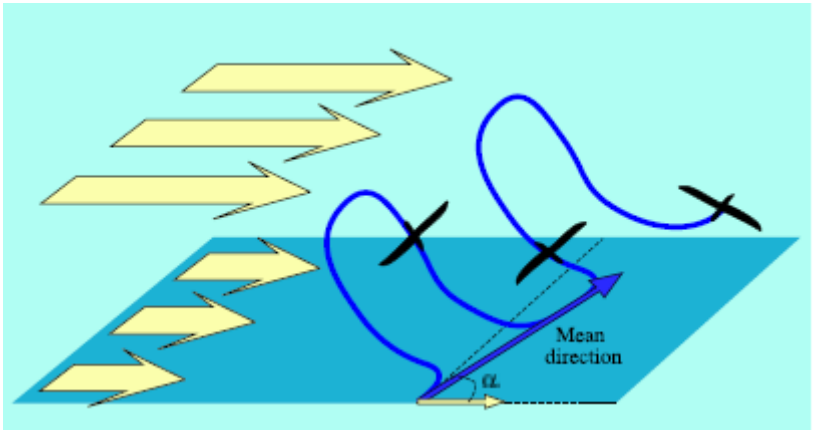
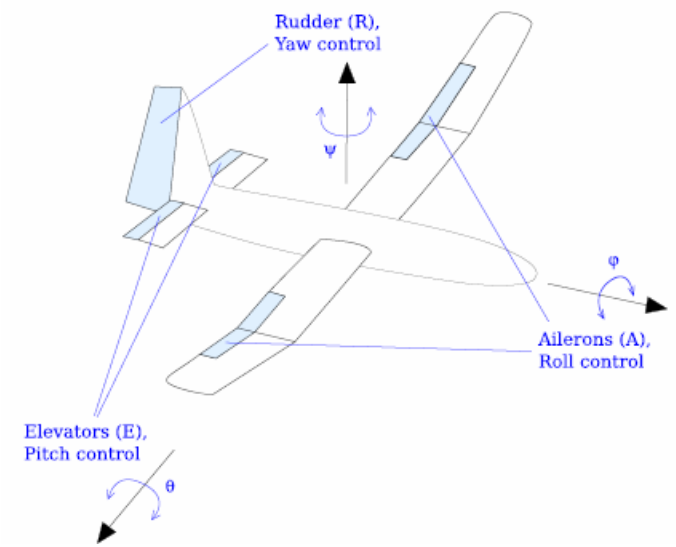
180
280
660
9


Sweep
Dihedral
Twist

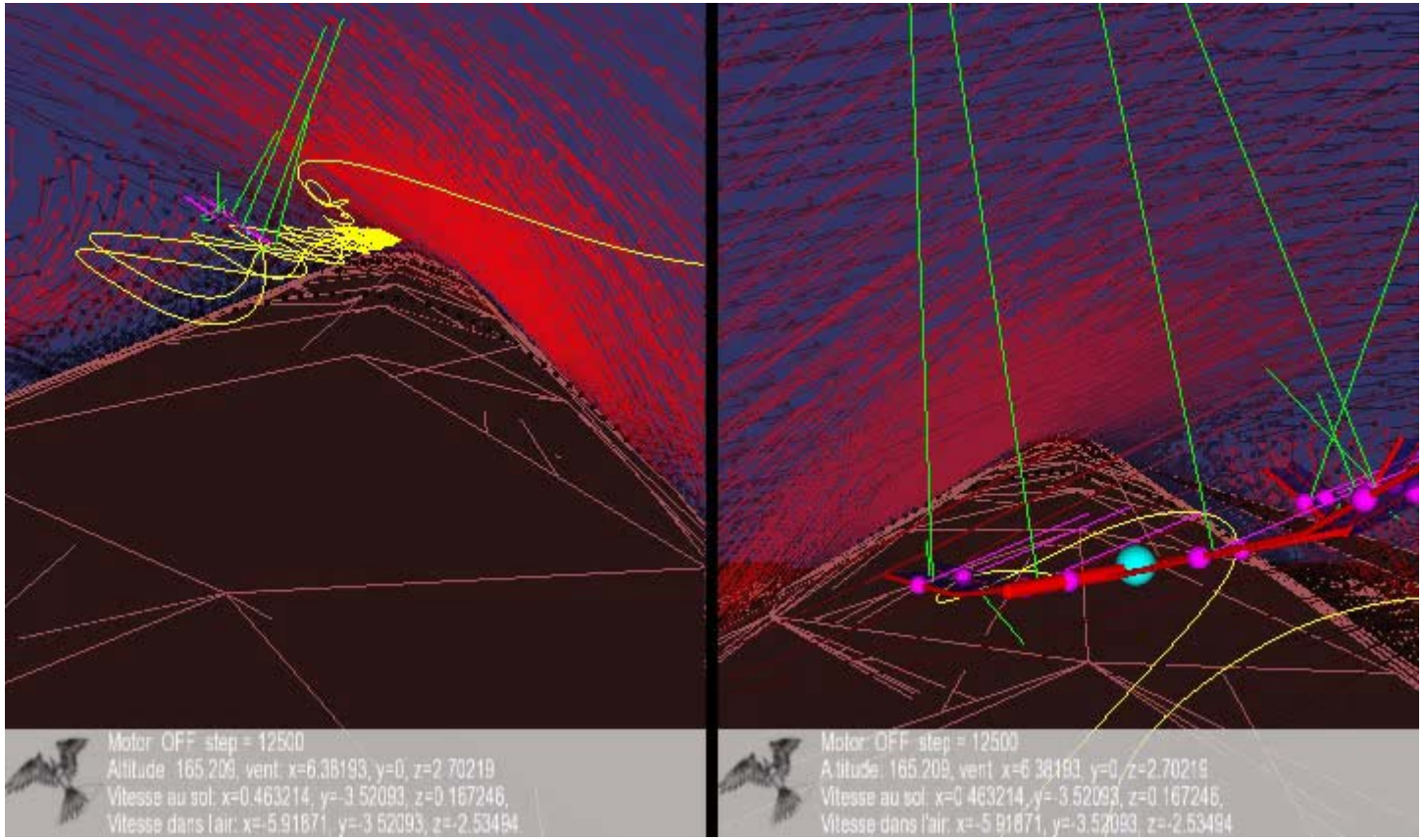

Module 1
Module 2
Module 3
Module 4
Module 5
8
4
-3.77
-4.75
9.82
5
27.96
2
8.31
45.60
11
18
1.27
10
22.42
21.16
17
9
16
-21.66
0.76
27.46
3
1
-69.78
-6.80
o0
14
12
0
o1

# Evolution of neural controllers for soaring



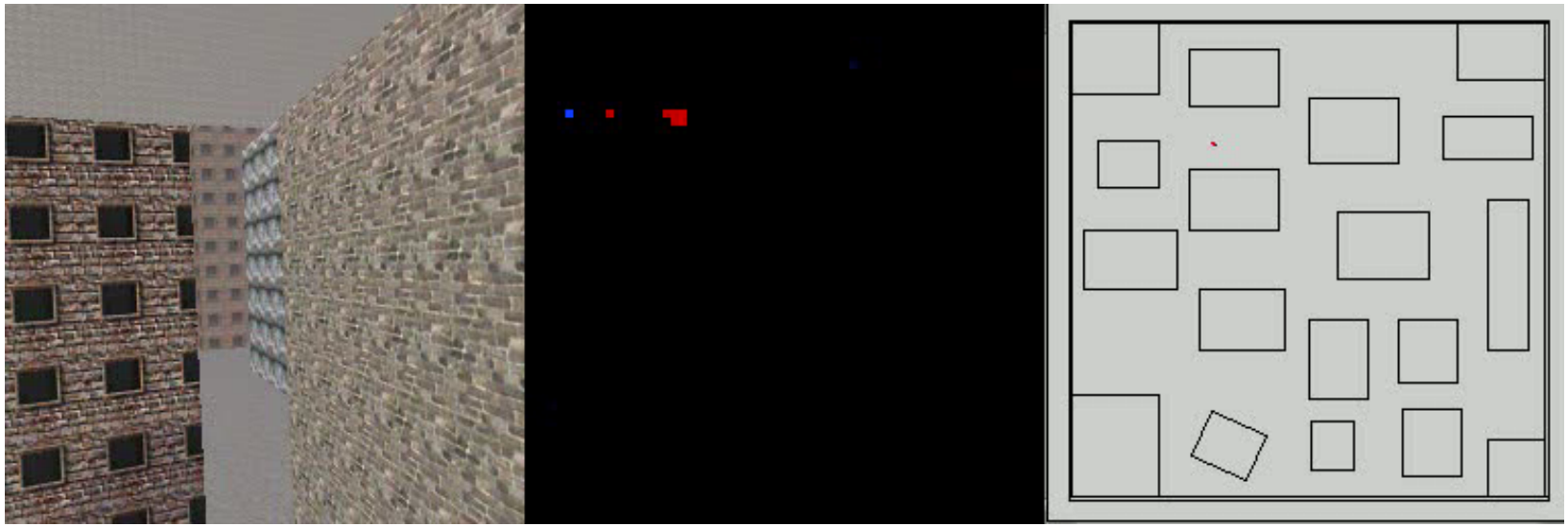

Baratte et al. - AnimatLab




Schmitt et al. - AnimatLab

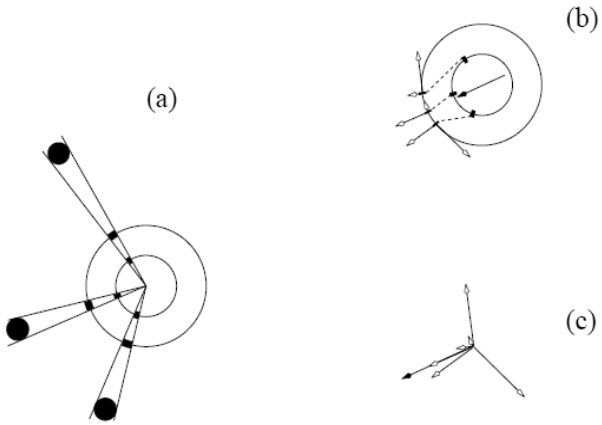
# Avoiding obstacles

# Obstacle-avoidance via optic-flow monitoring

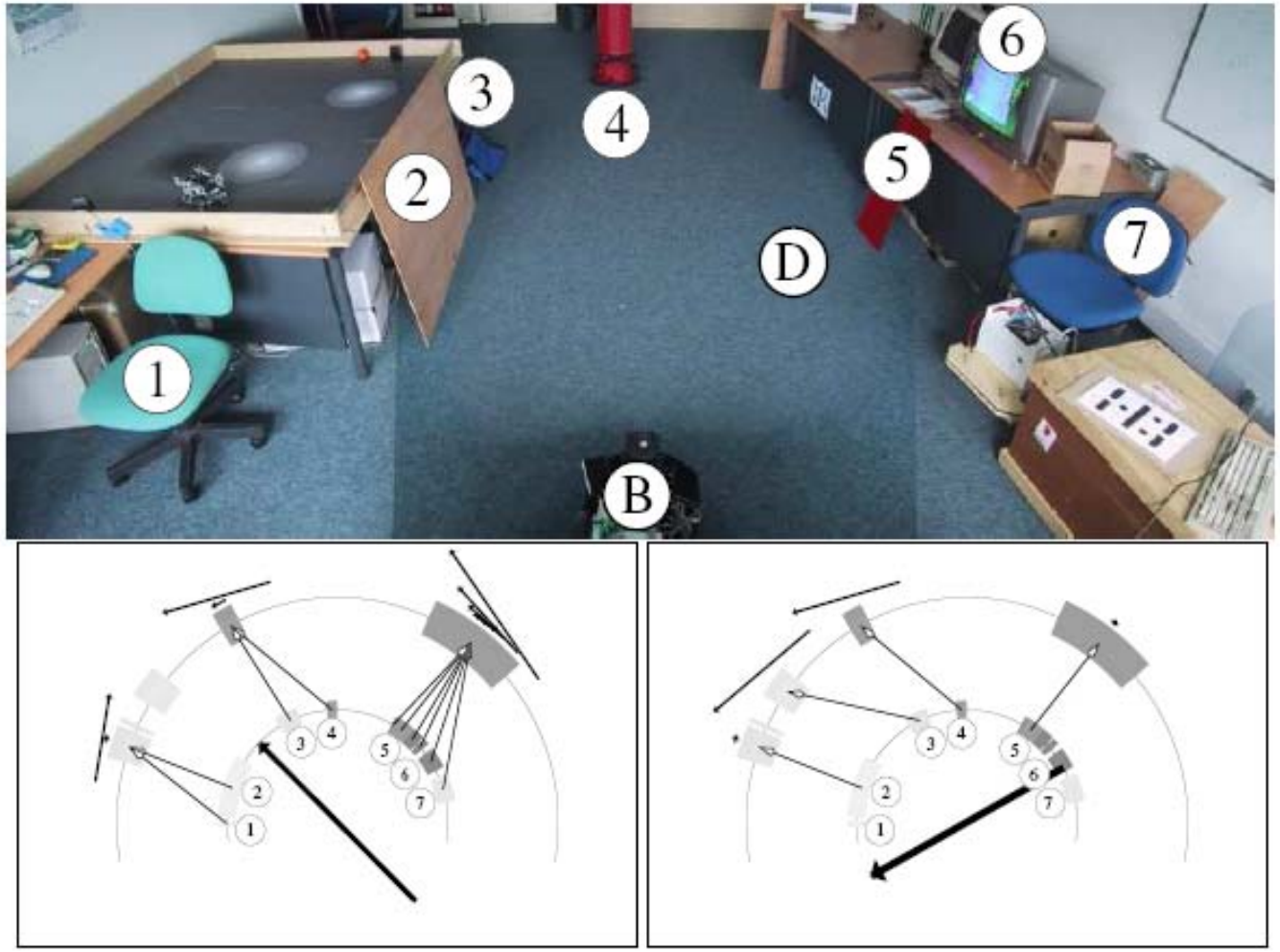


# Goal-seeking

# Snapshot-matching for homing




Gourichon - AnimatLab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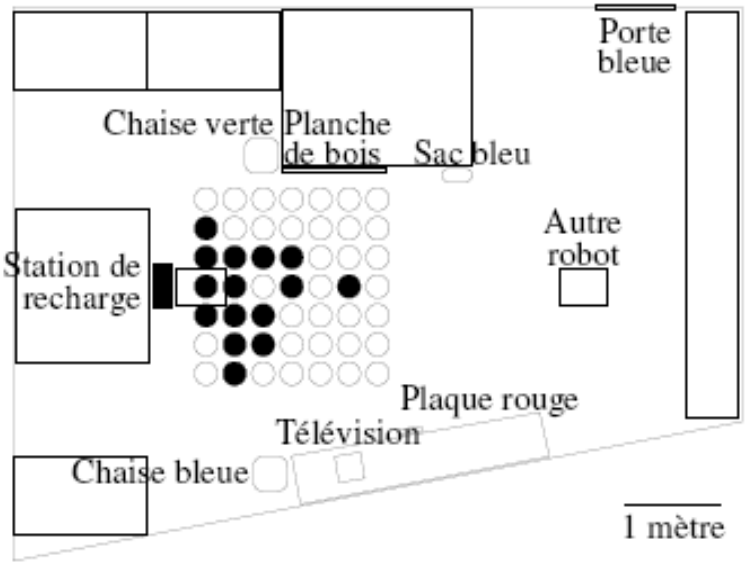
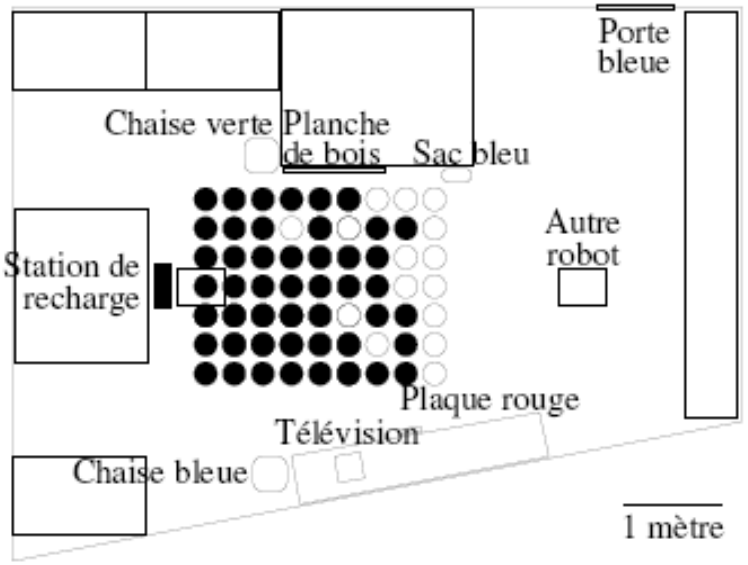
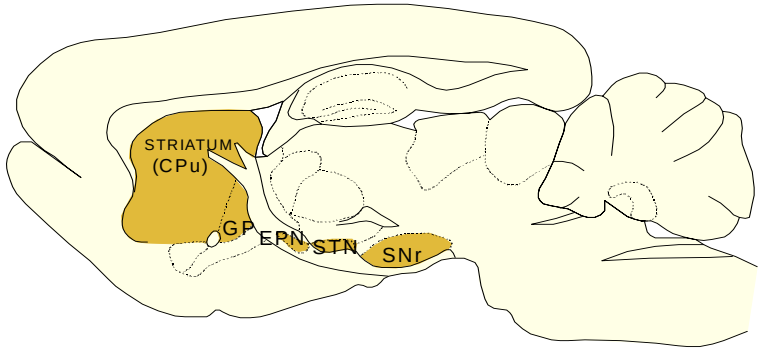
D

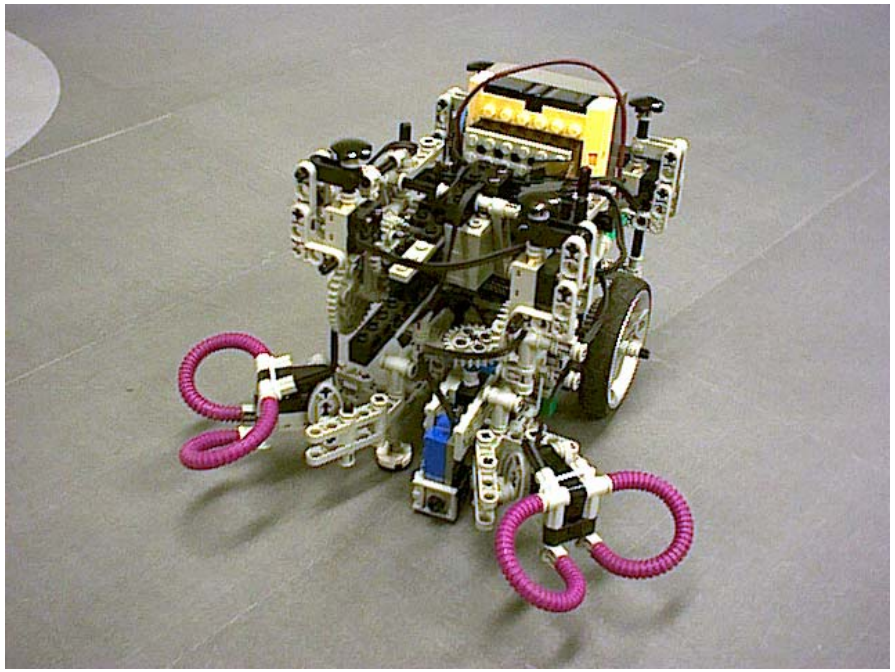

Porte
bleue
Chaise verte
Planche
de bois
Sac bleu
Station de
recharge
Autre
robot
Plaque rouge
Télévision
Chaise bleue
1 mètre


Porte
bleue
Chaise verte
Planche
de bois
Sac bleu
Station de
recharge
Autre
robot
Plaque rouge
Télévision
Chaise bleue
1 mètre

# Action selection

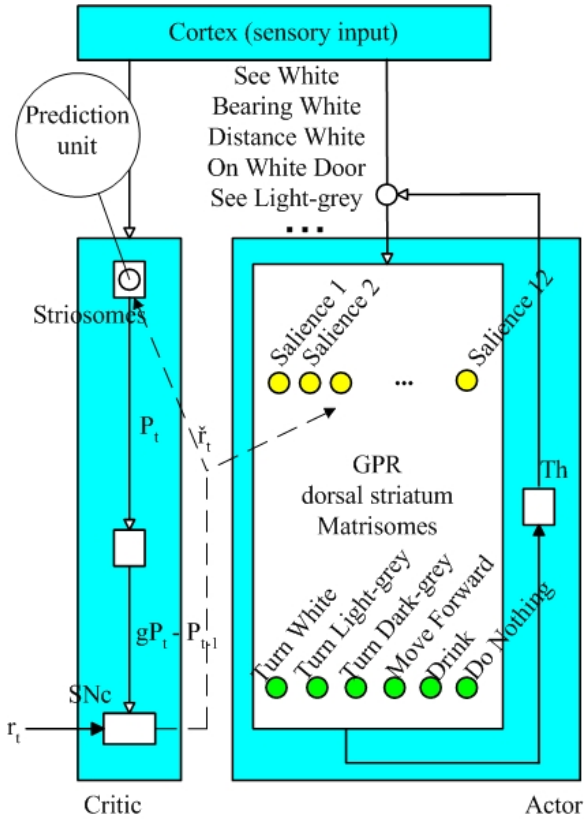


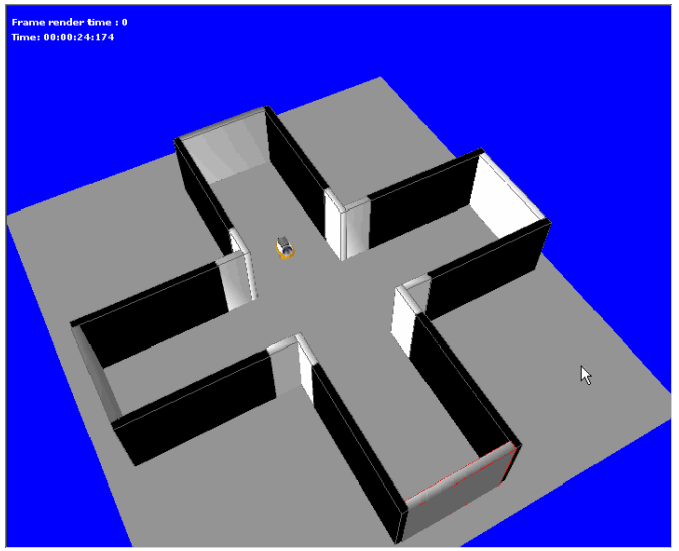

Basal ganglia



Cuzin, Girard, Guillot - AnimatLab

# Reinforcement learning



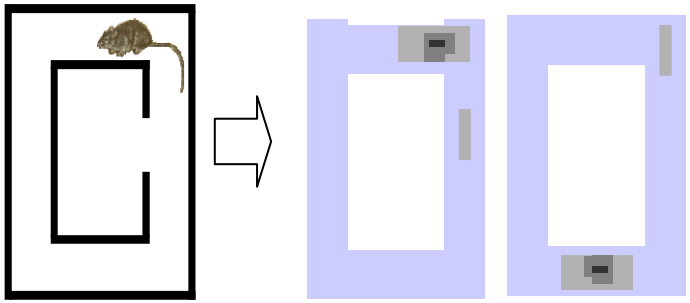




Khamassi - AnimatLab

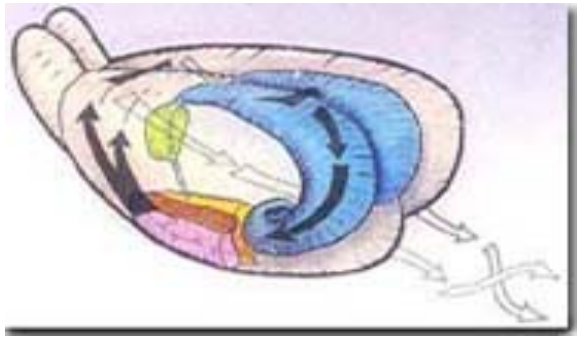
# Self-localizing

# Visual localization in UAV

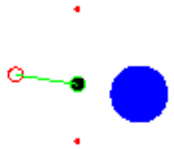

# Map-building

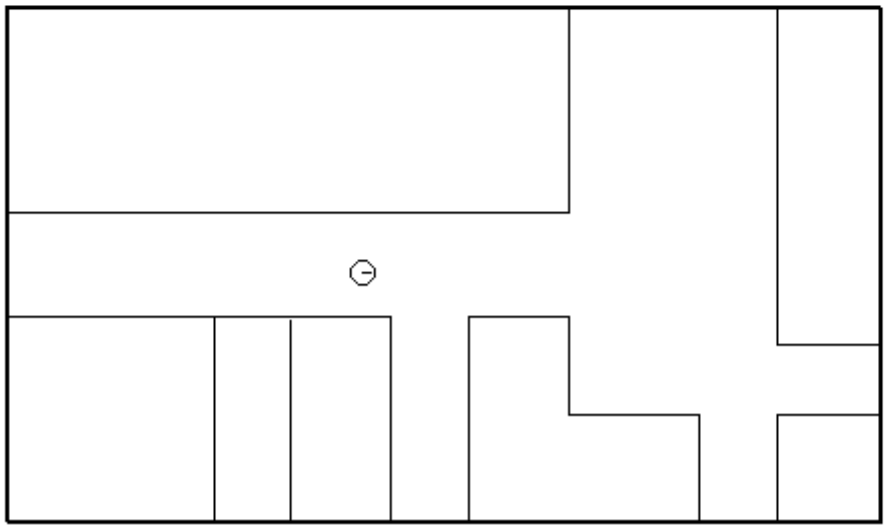


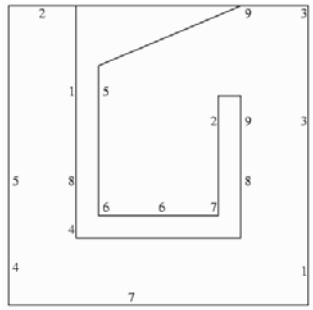

**Place cells in the hippocampus**

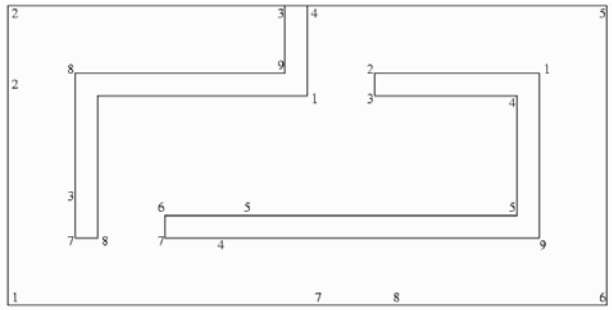


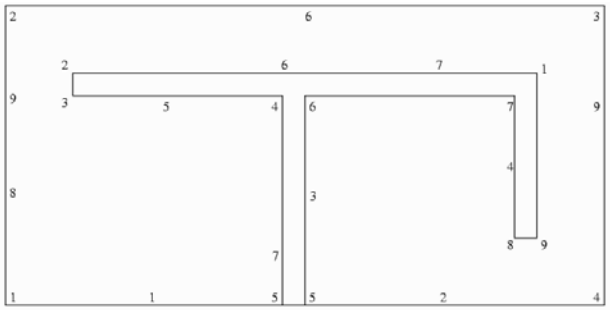
**The rat's hippocampus**

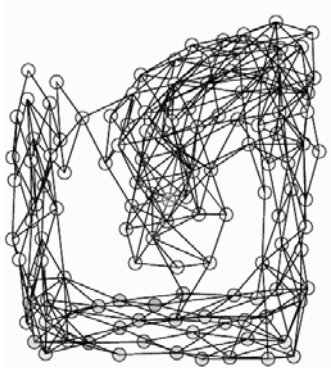


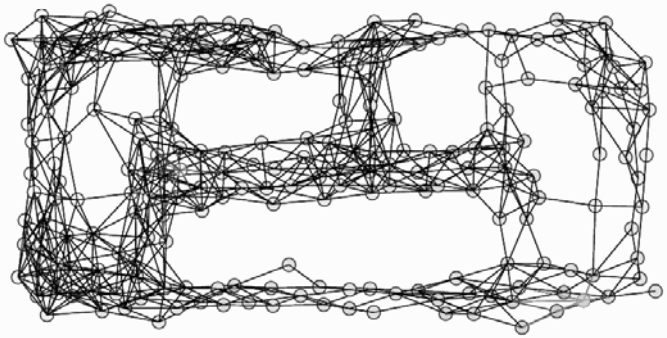


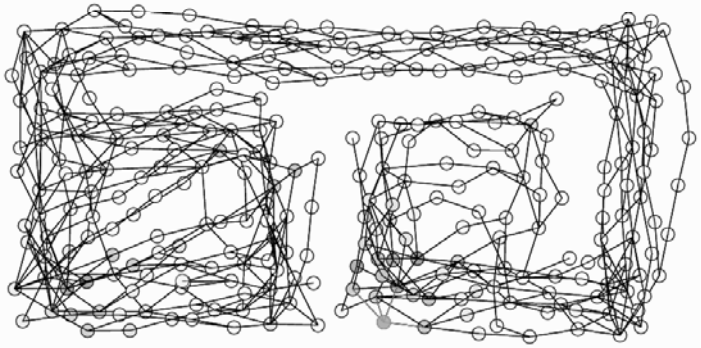


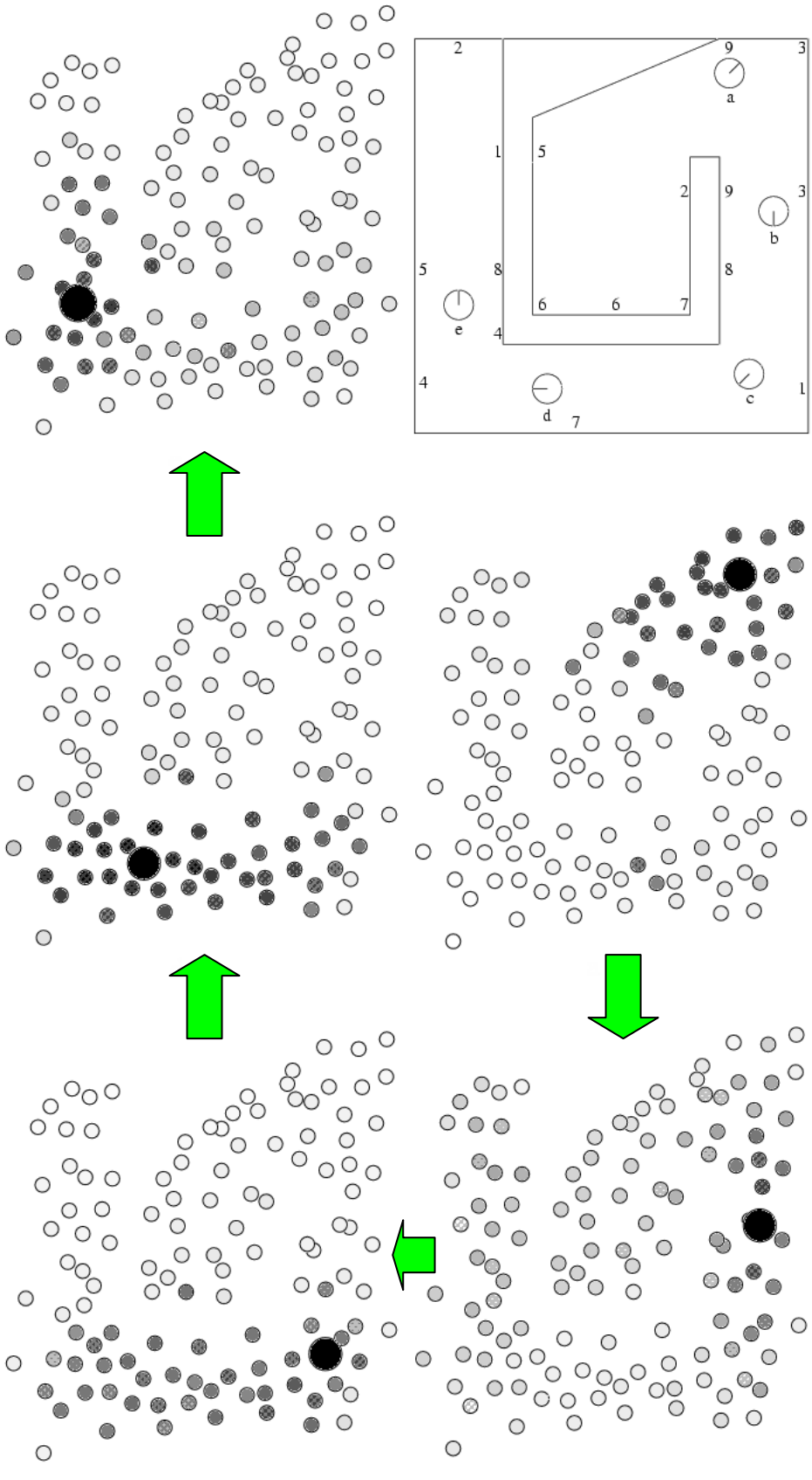








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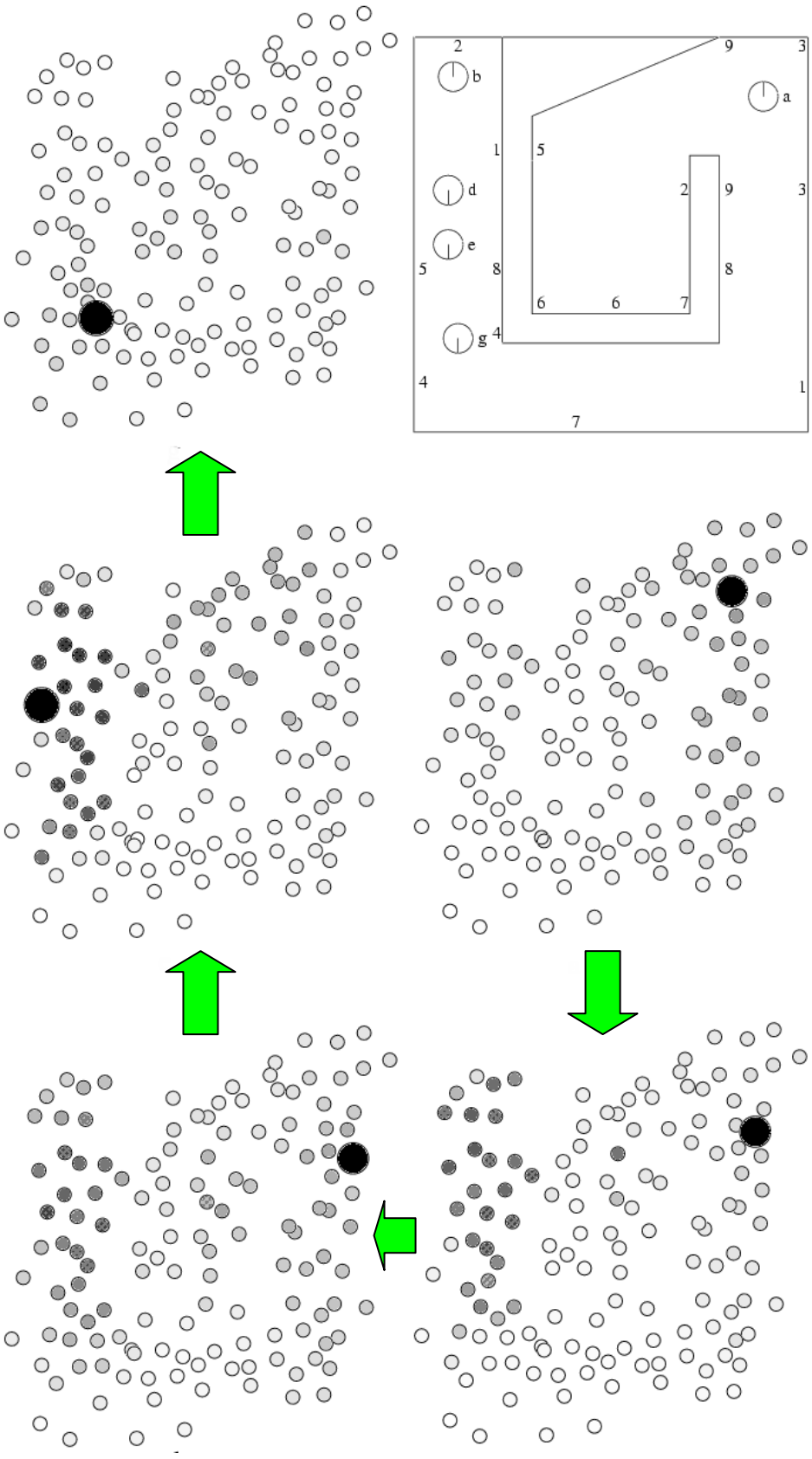
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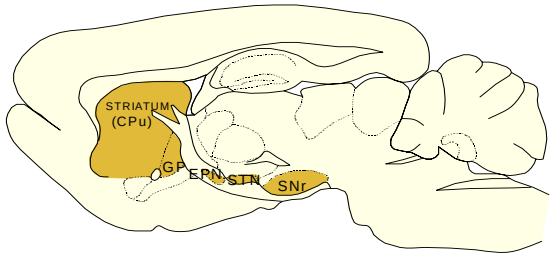
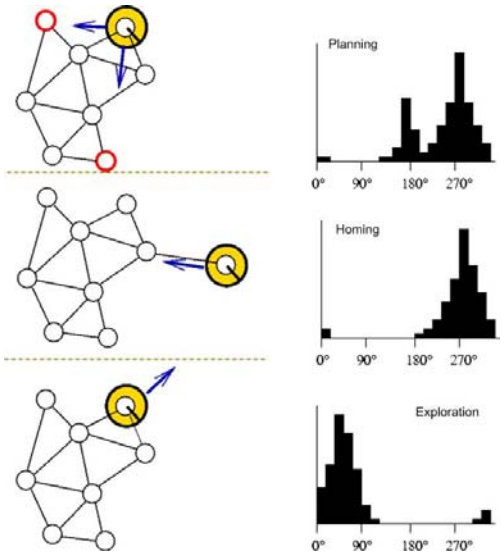
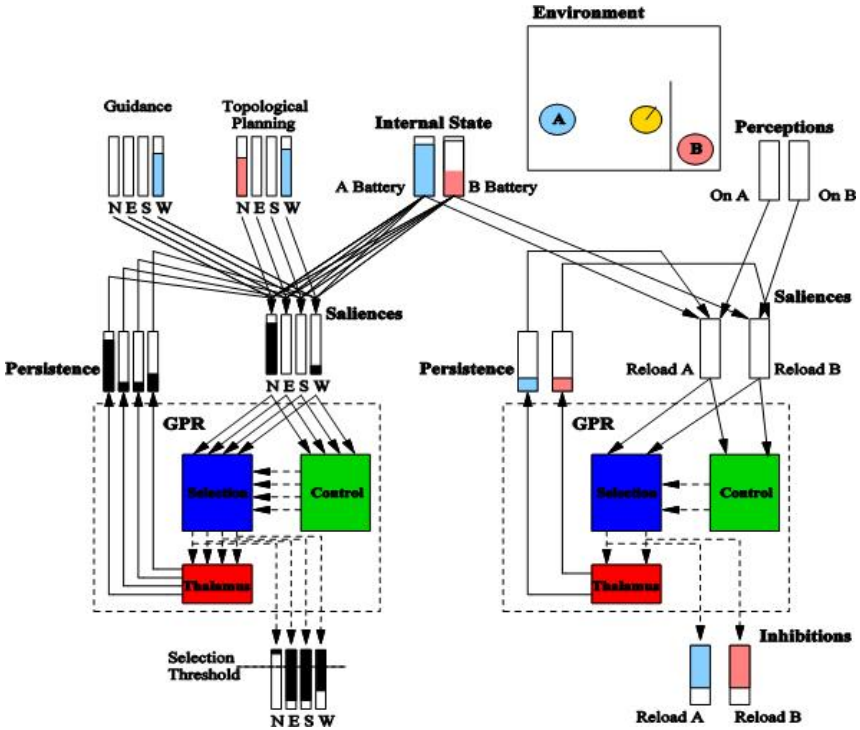
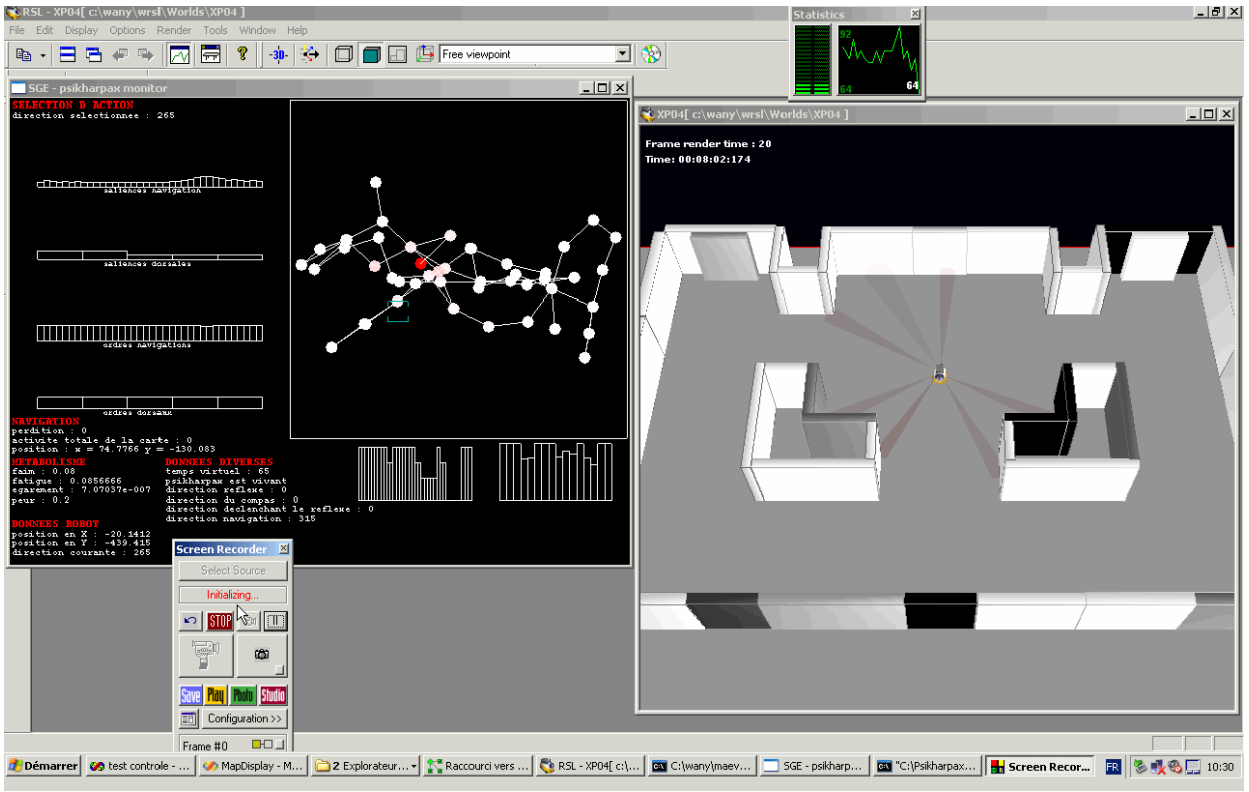
# Map-building + goal-seeking




Girard - AnimatLab


RSL - XP04[ c:\wany\wrsl\Worlds\XP04 ]
File Edit Display Options Render Tools Window Help
Free viewpoint
Statistics
SGE - psikharpax monitor
SELECTION D ACTION
direction selectionnee : 265
saillances navigation
saillances dorsales
ordres navigations
ordres dorsaux
NAVIGATION
perdition : 0
activite totale de la carte : 0
position : x = 74.7766 y = -130.083
METABOLISME
faim : 0.08
fatigue : 0.0856666
egarement : 7.07037e-007
peur : 0.2
DONNEES DIVERSES
temps virtuel : 65
psikharpax est vivant
direction reflexe : 0
direction du compas : 0
direction declenchant le reflexe : 0
direction navigation : 315
DONNEES ROBOT
position en X : -20.1412
position en Y : -439.415
direction courante : 265
Screen Recorder
Select Source
Initializing...
STOP
Save
Play
Photo
Studio
Configuration >>
Frame #0
XP04[ c:\wany\wrsl\Worlds\XP04 ]
Frame render time : 20
Time: 00:08:02:174
Démarrer
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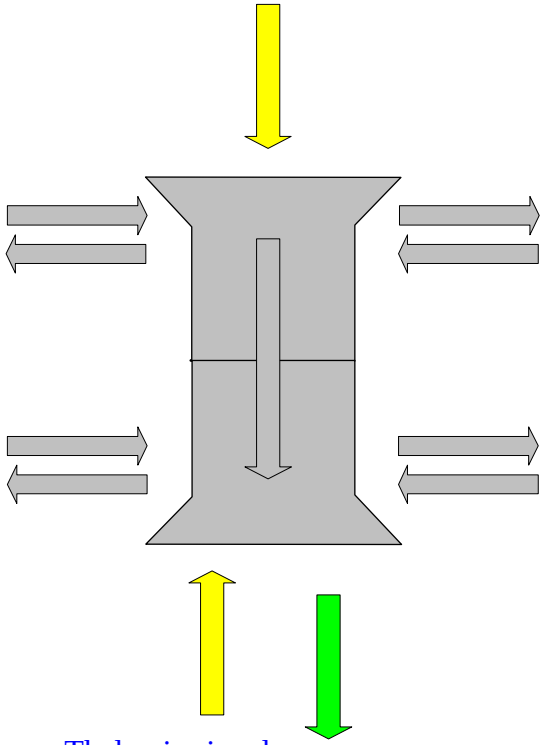
# Planning

# Cortical columns (Burnod, 1988) for planning

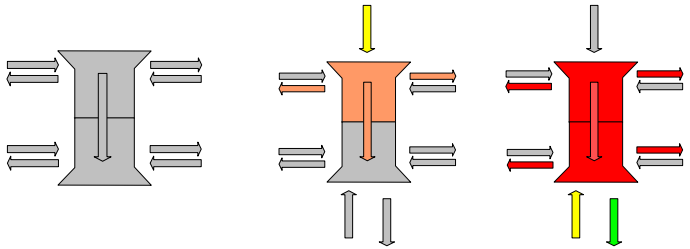
Limbic signal
(goals, desires, needs…)



Thalamic signal
(sensory inputs)

Towards basal ganglia
(motor outputs)

A column may be in 3 different states:

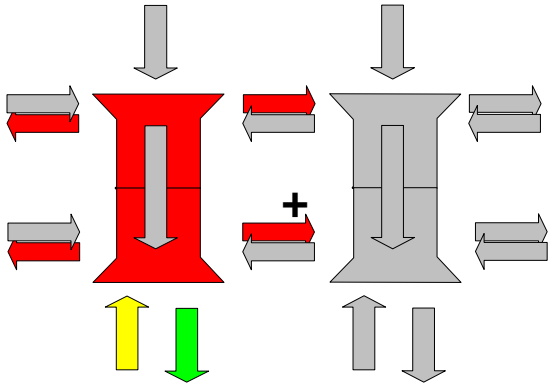


inhibited

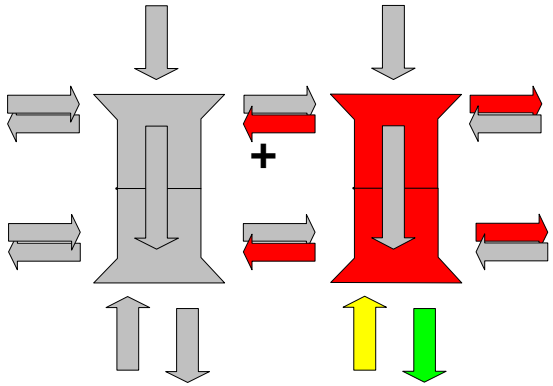
calling

excited

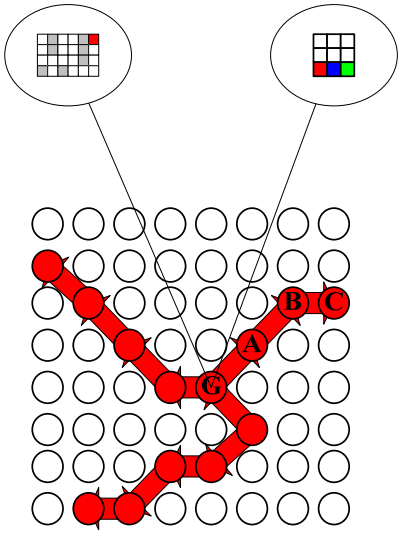
Intercolumnar links are learnt during exploration



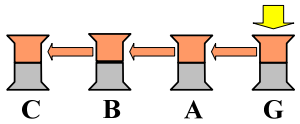

t

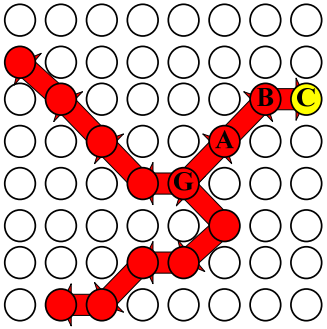



t + 1

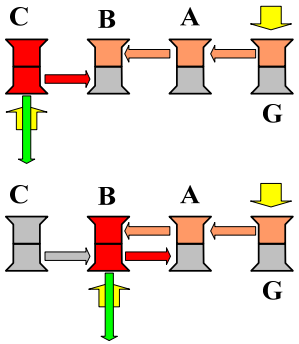



1. Planning phase

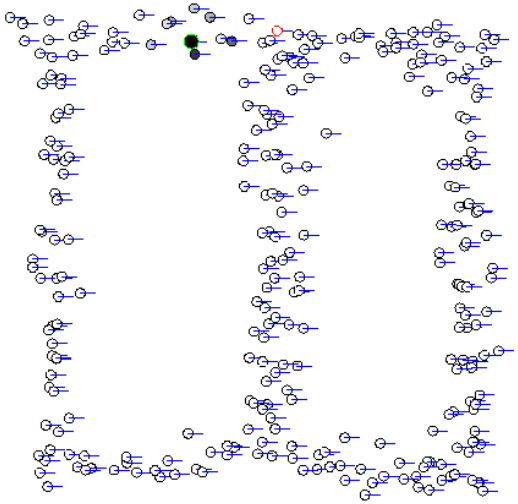


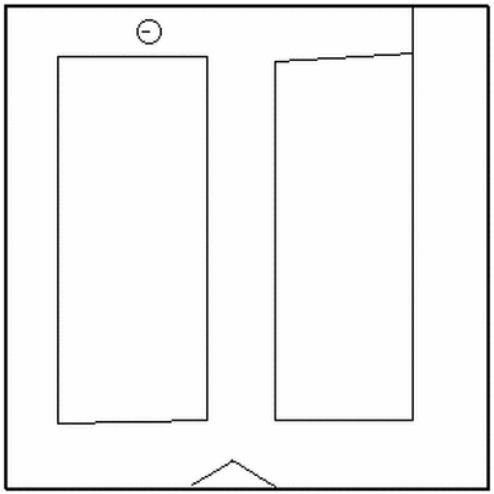




2. Execution phase



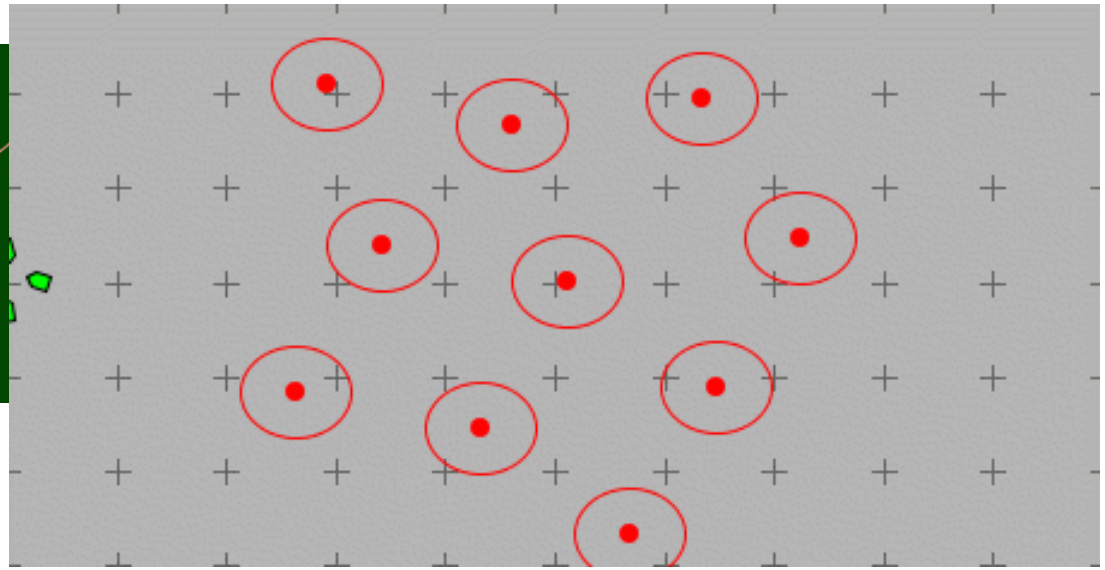
# Detour experiments



# Coordinated navigation

… to flying patrols



From dogs and sheeps…

# Reinforcement learning in video games



Robert - AnimatLab

**http://animatlab.lip6.fr**