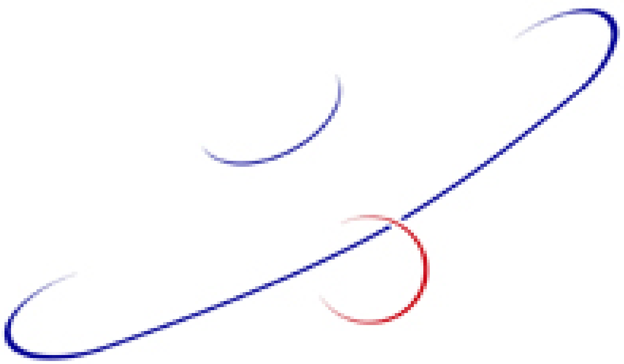
Évolution de **circuits neuronaux** pour le **contrôle** de **robots volants** basé sur la **vision**



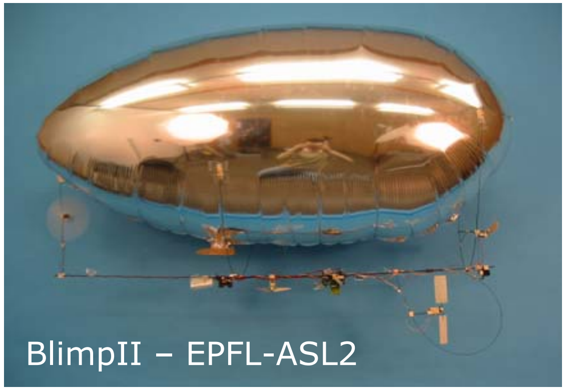
EPFL - Laboratoire de Systèmes Autonomes – prof. Dario Floreano

Journées Micro-Drones – 01.10.03 - J.C. Zufferey

http: / / asl.epfl.ch
Autonomous Systems Lab

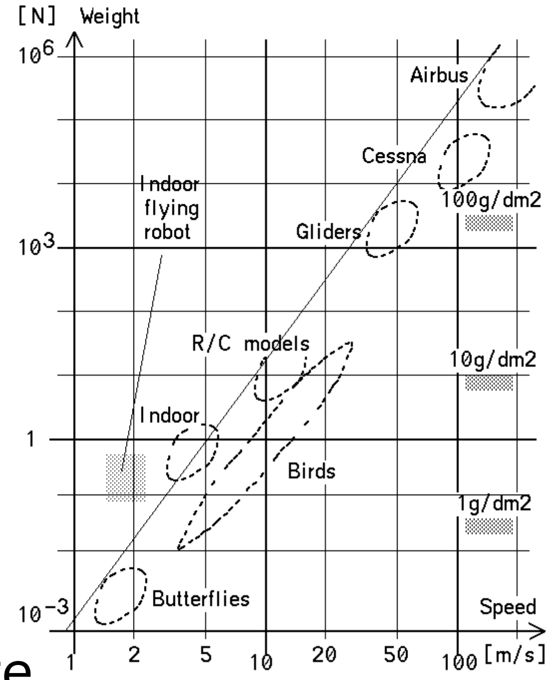
Autonomie de navigation pour

- Systèmes (indoor) à vol lent => légèreté

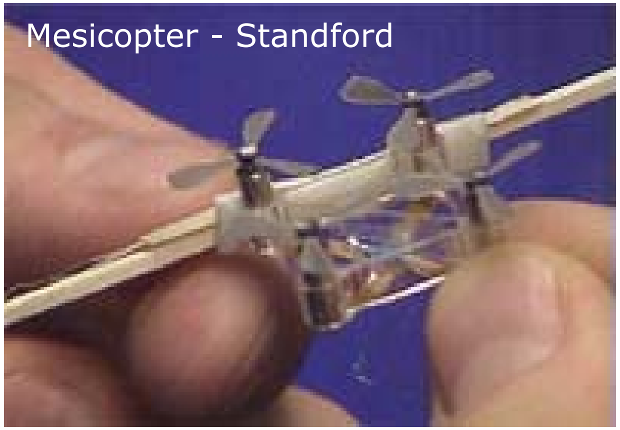


BlimpII – EPFL-ASL2

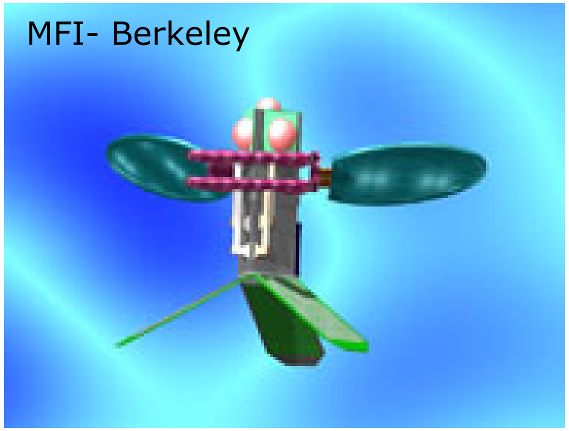
Celine – DIDEL & EPFL-ASL2



- Microsystèmes aériens => taille très réduite



Mesicopter - Standford



MFI- Berkeley

Contraintes spécifiques

Contraintes de poids / taille et capacité énergétique

Exemple : 1-10 g et 10-100 mAh

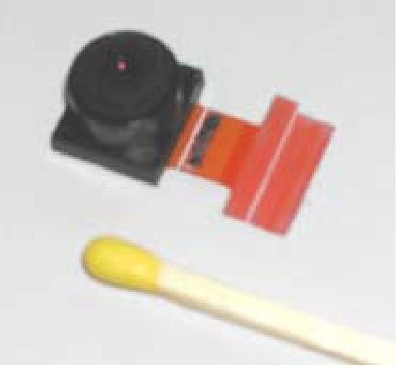
⇒ limitation au niveau de la puissance de calcul

- pentium IV @ 1.5GHz (60W)
- microcontrôleur 8-bit @ 20MHz (30mW)

⇒ limitation au niveau des capteurs

- radar, capteurs de distance
- GPS
- capteurs inertiels (MEMS)
- capteurs de vision (CMOS)

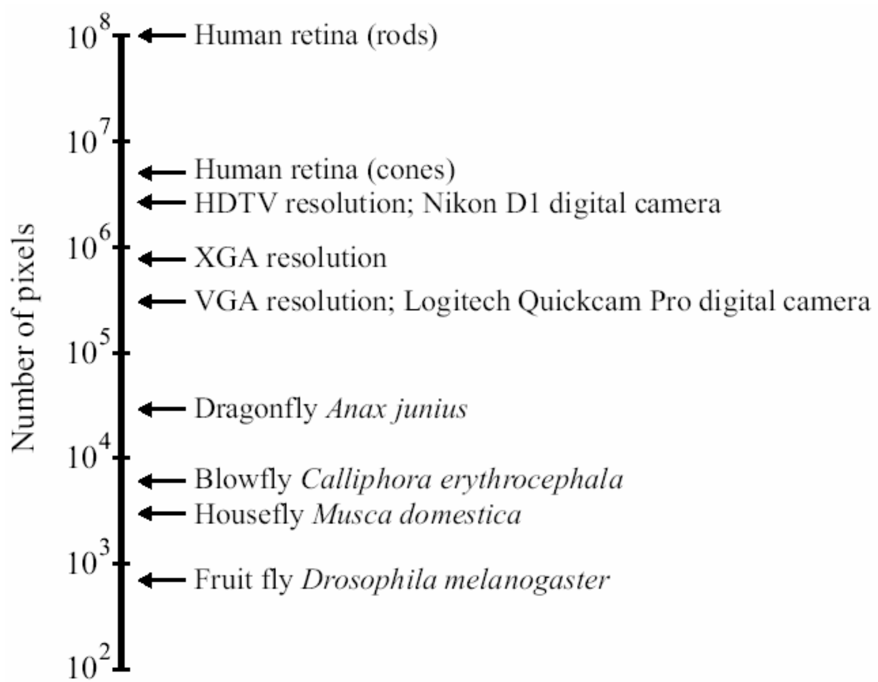
Rate gyro (0.4g)



CMOS VGA camera (0.7g)

Bio-inspiration

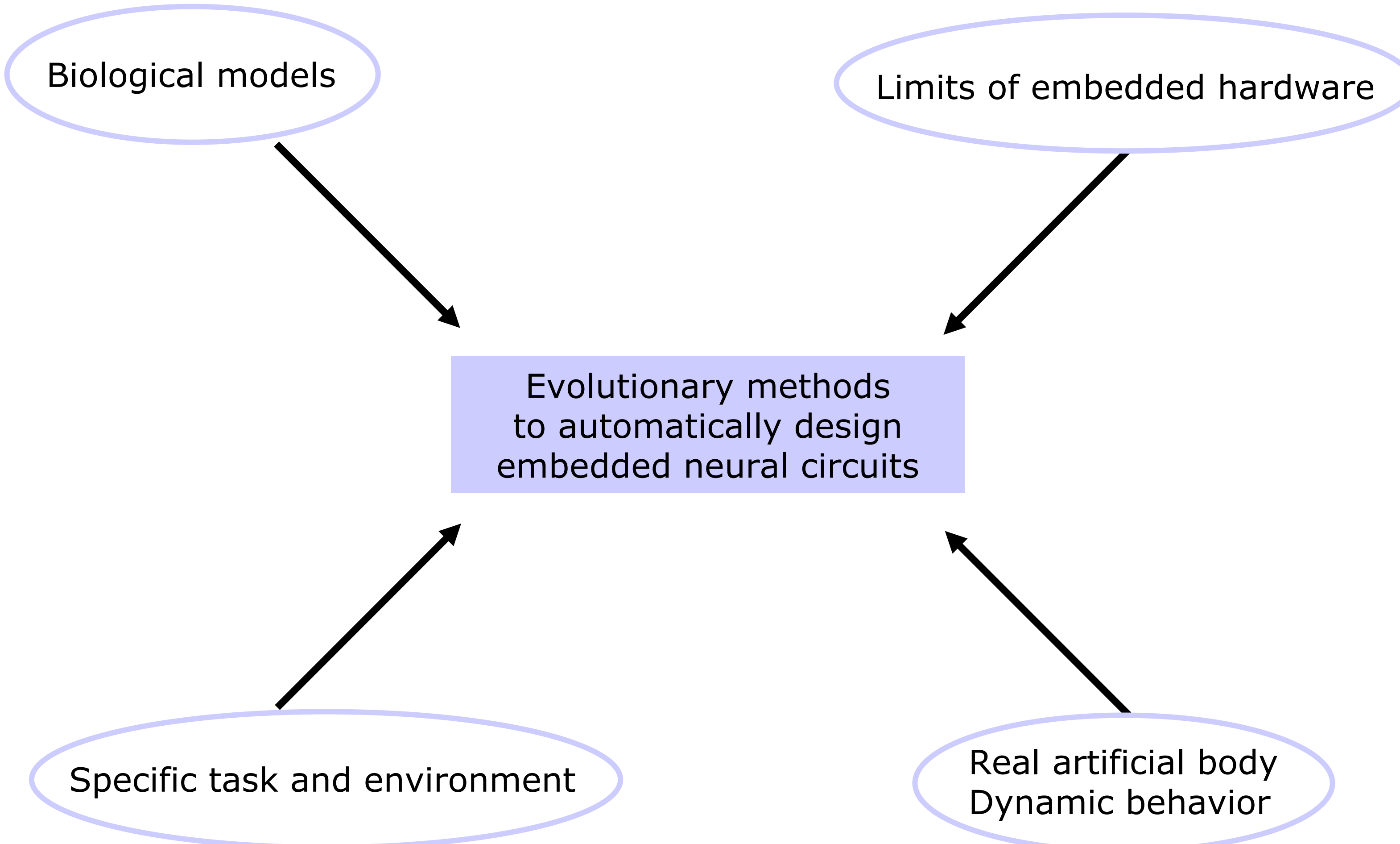
The fly…
…one of the most fascinating autonomous agent…
…one of the best studied insect (especially the visual system).



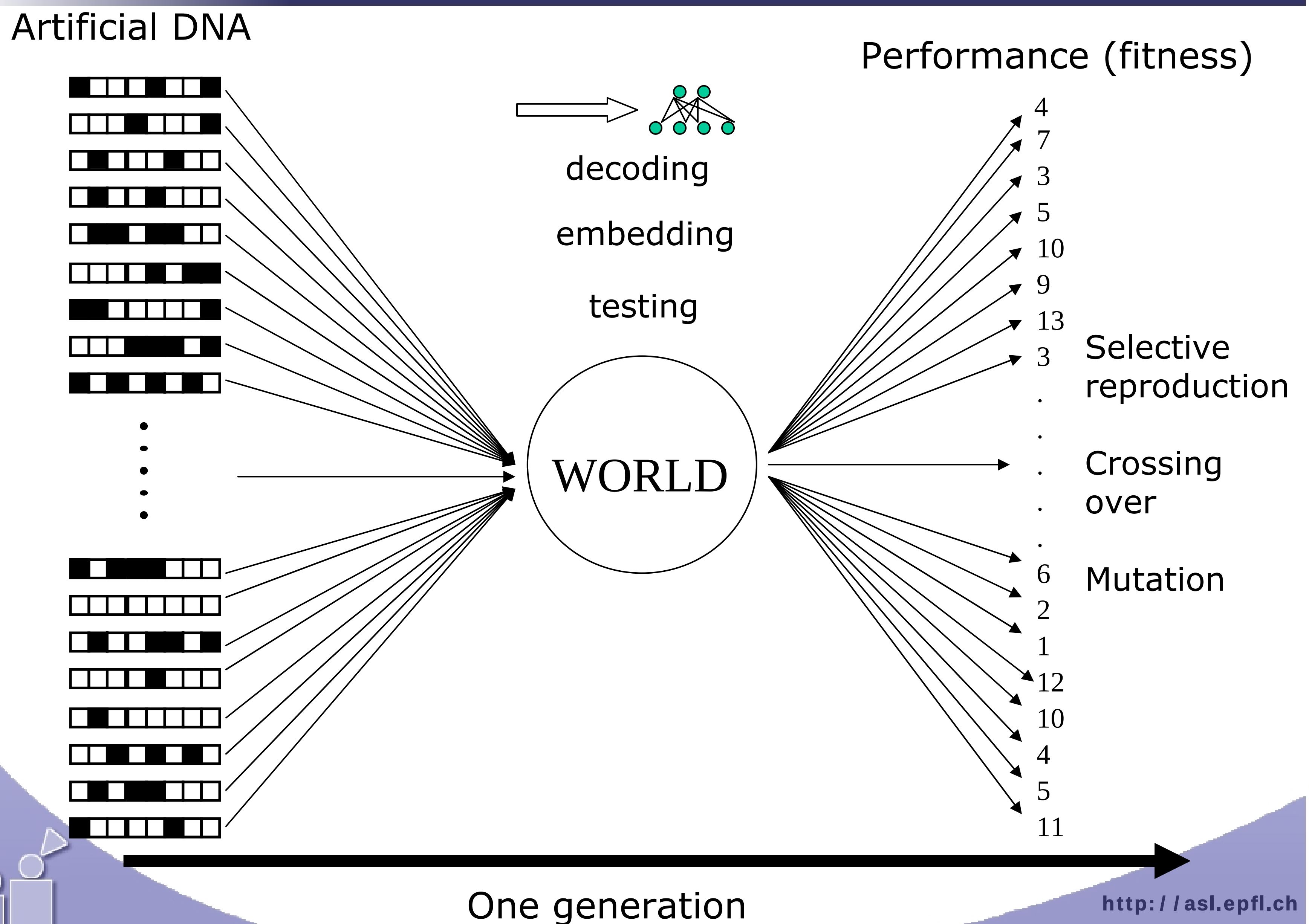
The compound eye:

- Between 1400 (Drosophila) and 25’000 ommatidia
- Roughly 37x37 pixels => quite low resolution
- Best resolving power of 1°, average of 5°
- By comparison humans resolve 1’
- Very large field of view (almost 360°)

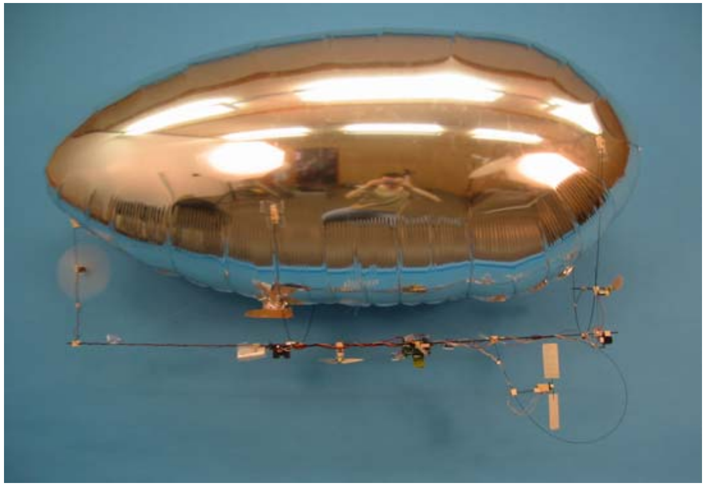
En résumé...

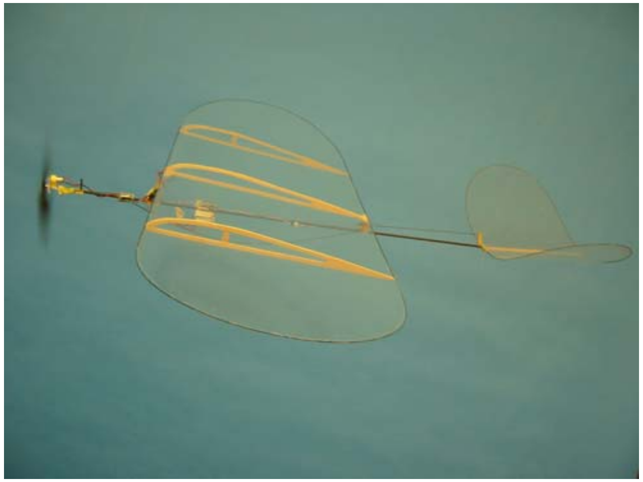

Biological models
Limits of embedded hardware
Evolutionary methods
to automatically design
embedded neural circuits
Specific task and environment
Real artificial body
Dynamic behavior

Robotique évolutionniste



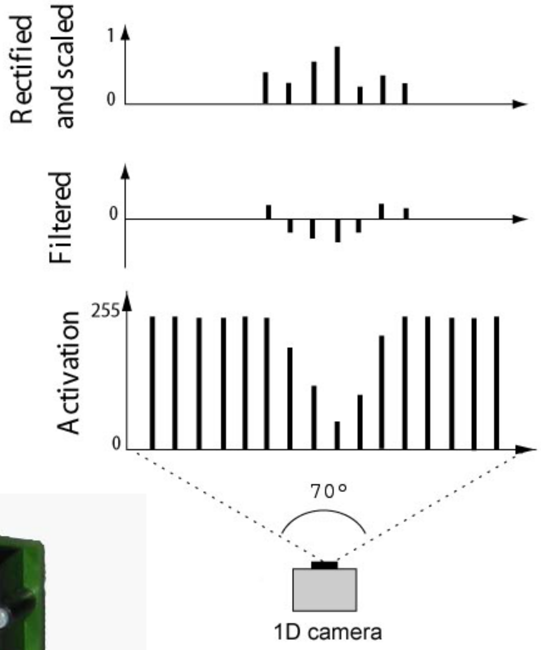
Approche incrémentale

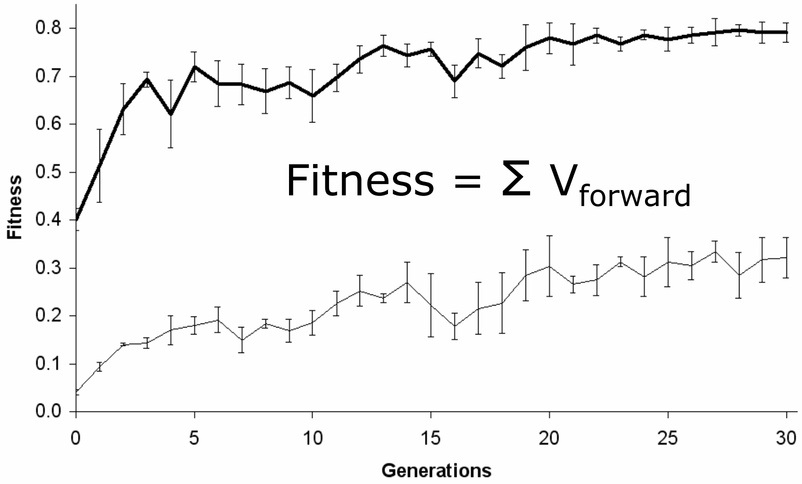


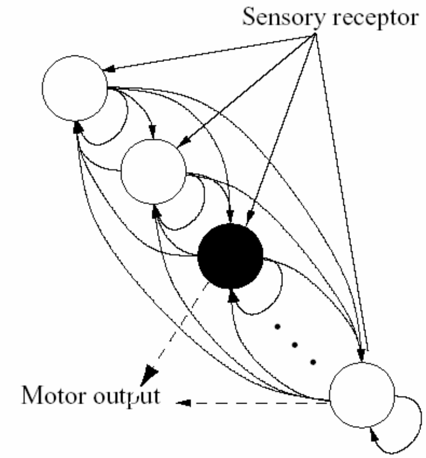


	Khepera	Blimp 2D limited	Blimp	Plane
DOF	3	3	4	6
Attitude control	-	-	-	required
Obstacle avoidance	required	required	required	required
Course stabilization	-	required	required	required
Altitude control	-	-	required	required

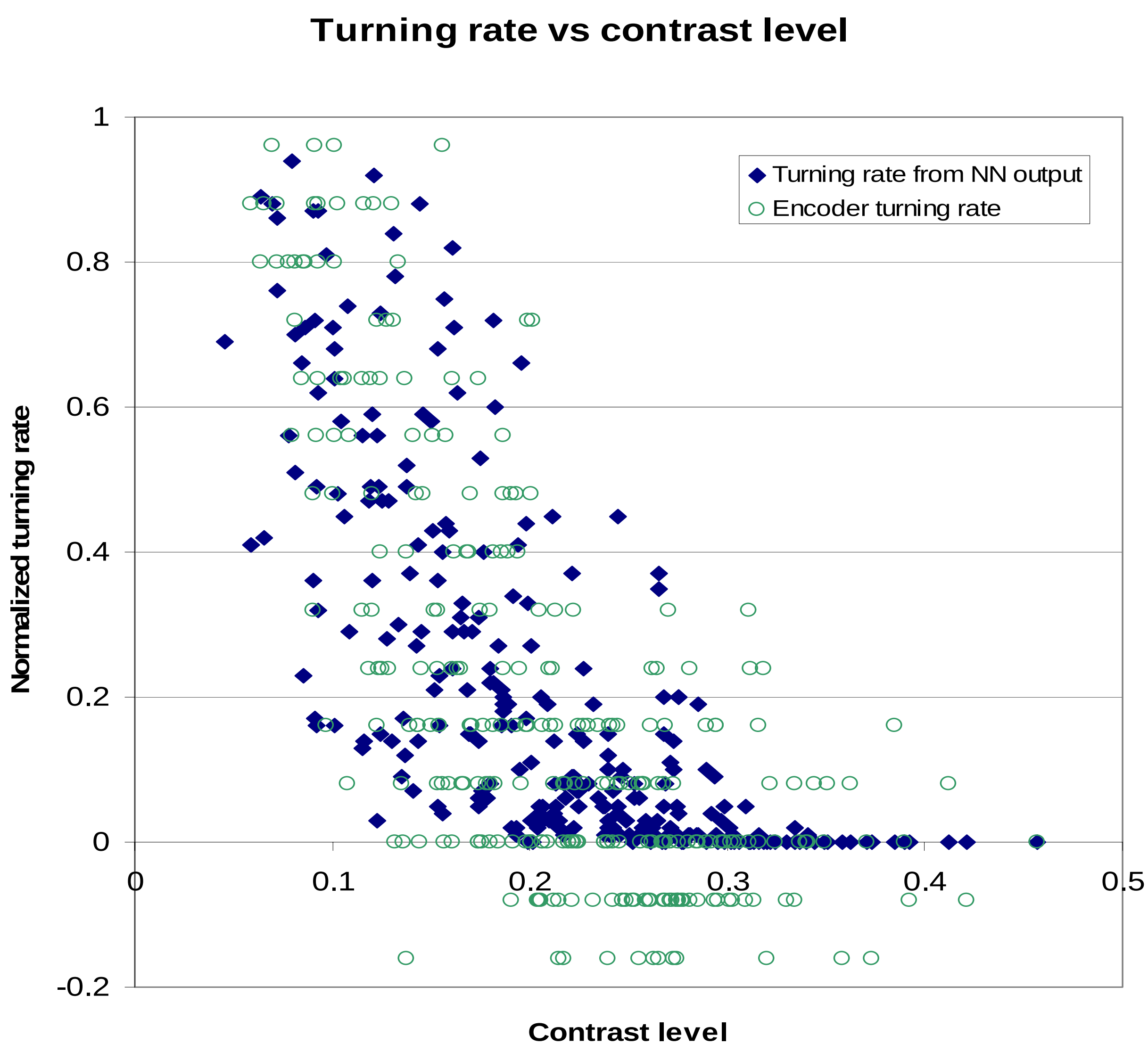
Khepera


Rectified and scaled
1
0
Filtered
0
Activation
255
0
70°
1D camera

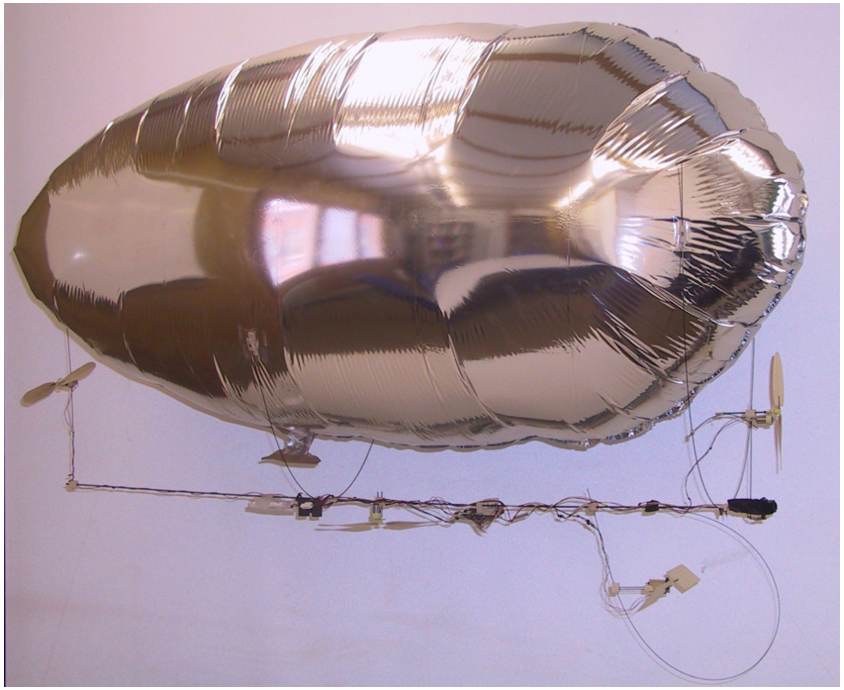

Fitness = $\Sigma V_{forward}$
Fitness
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
5
10
15
20
25
30
Generations


Sensory receptor
Motor output

Comment ça marche ?



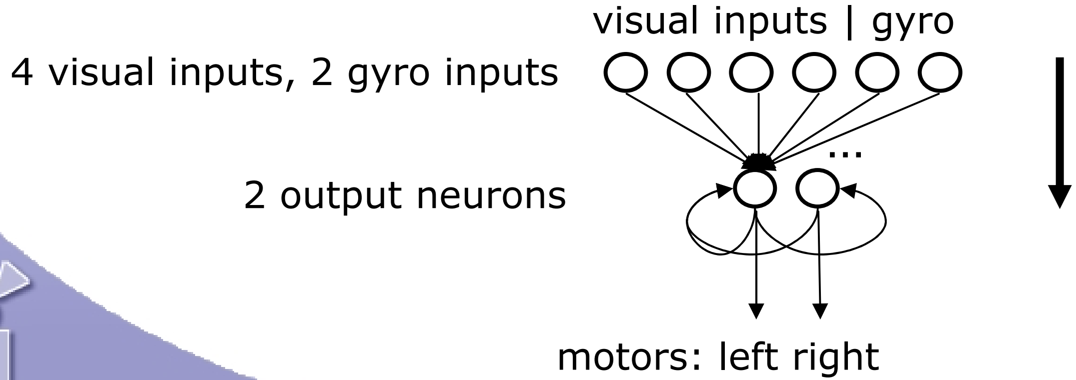
BlimpII



Fitness = $\Sigma V_{forward}$

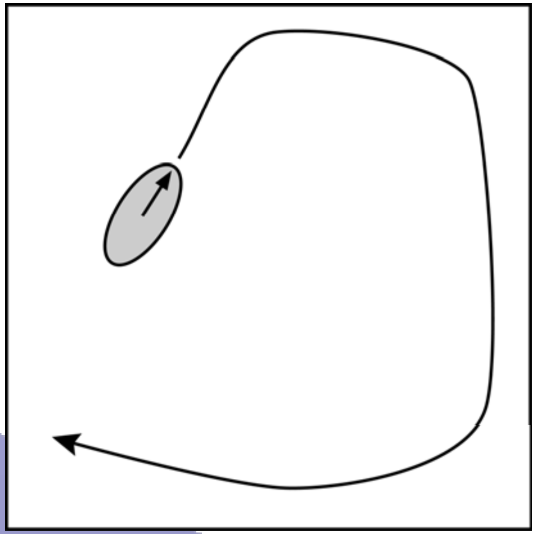
- V is given by the anemometer
- The testing room is 5x5m
- The trajectory is not predefined
- Gyro & contrast level

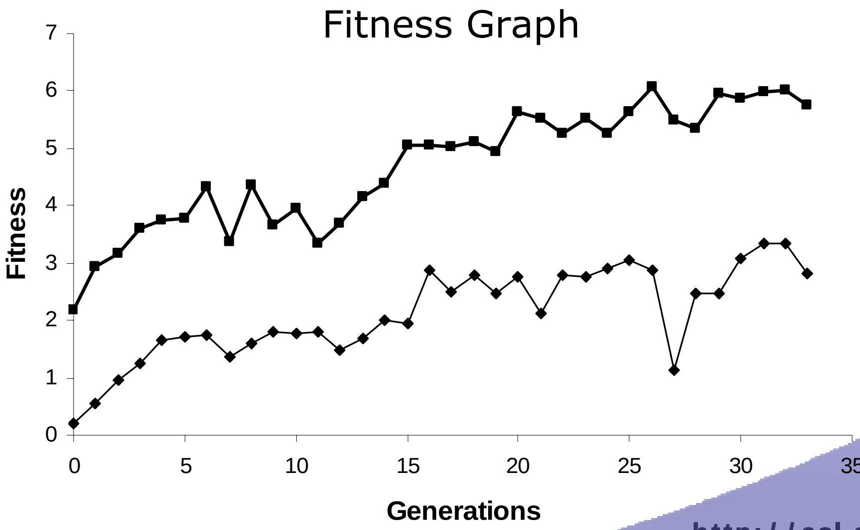
Simple Sigmoid Neural Network



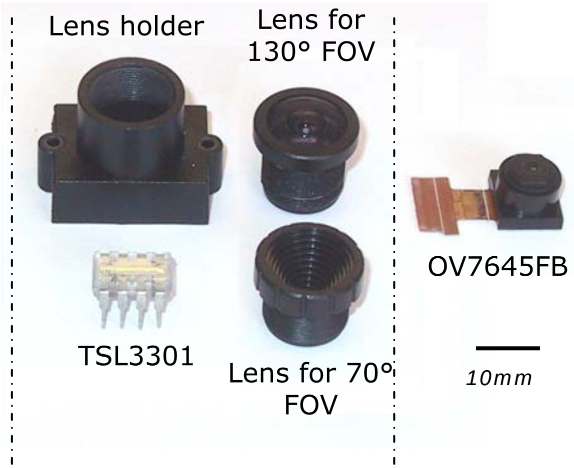
BlimpII – résultats

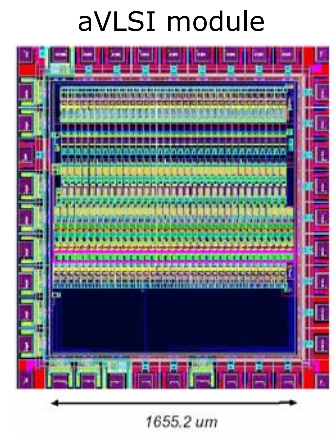
- Chaque individu (réseau neuronal) est testé durant 1.5 minute dans une salle carrée de 5m de côté avec des textures contrastées sur les murs.
- Le robot est connecté à un ordinateur par un système radio Bluetooth.
- Une expérience d'évolution dure environ une semaine (~30 générations).
- Les meilleures individus sont capables de piloter le Blimp dans la salle avec une importante vitesse vers l'avant tout en évitant les collisions avec les murs.

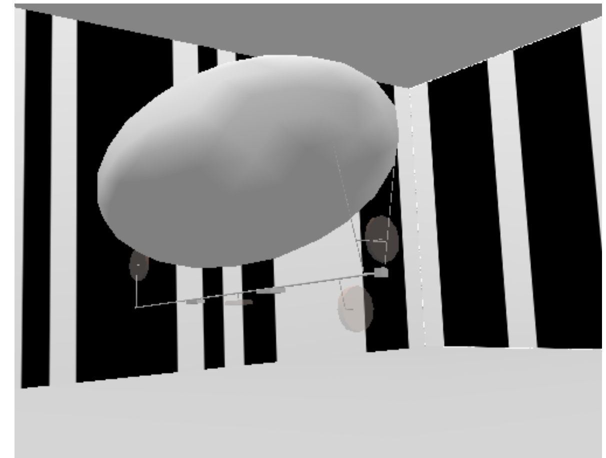




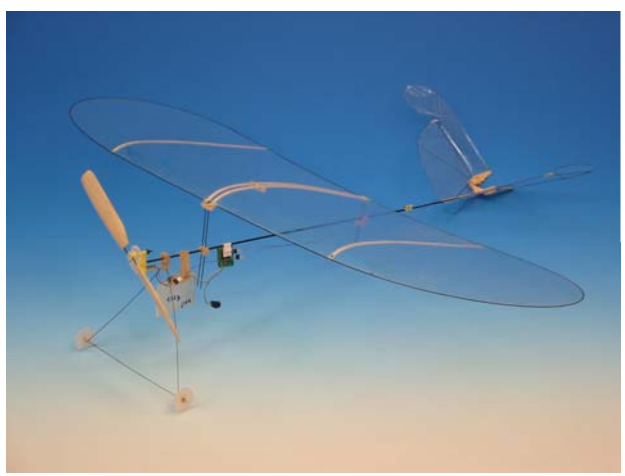
Travaux futurs







- Utilisation de flux optique
- Evolution en simulation avec des systèmes à ailes
- Passage simulation -> réalité



Le celine de chez DIDEL:

•Avion d'intérieur à vol lent
•Poids : 10 g
•Vitesse : 1 m/s
•Espace de vol typique : 5x5 m

Références

- Zufferey, J.C., Beyeler, A. and Floreano, D. (2003) **Vision-based Navigation from Wheels to Wings**. In Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems. To appear.

- Zufferey, J.C., Floreano, D., van Leeuwen, M. and Merenda, T. (2002) **Evolving Vision-based Flying Robots**. Bülthoff, Lee, Poggio, Wallraven (Eds.), Proceedings of the 2nd International Workshop on Biologically Motivated Computer Vision, LNCS 2525, pp. 592-600, Berlin, Springer-Verlag.

- Nicoud, J.D. and Zufferey, J.C. (2002) **Toward Indoor Flying Robots**. In Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems, pp. 787-792.

http://phd.zuff.info