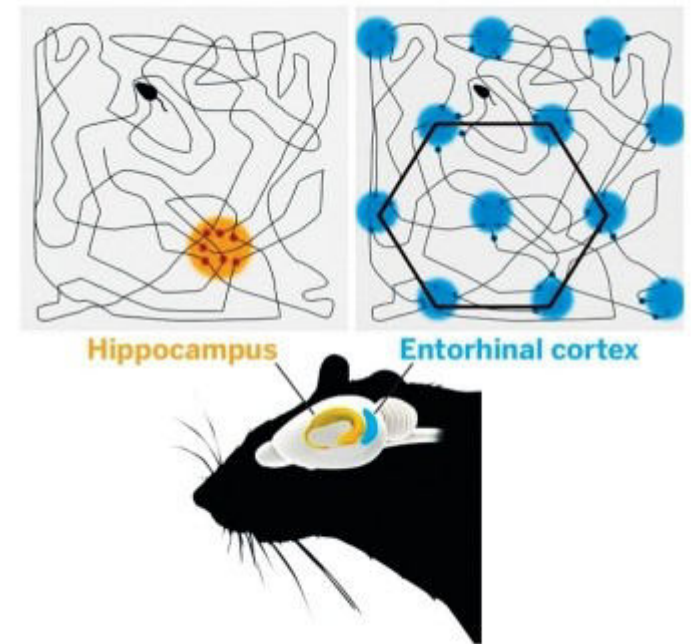
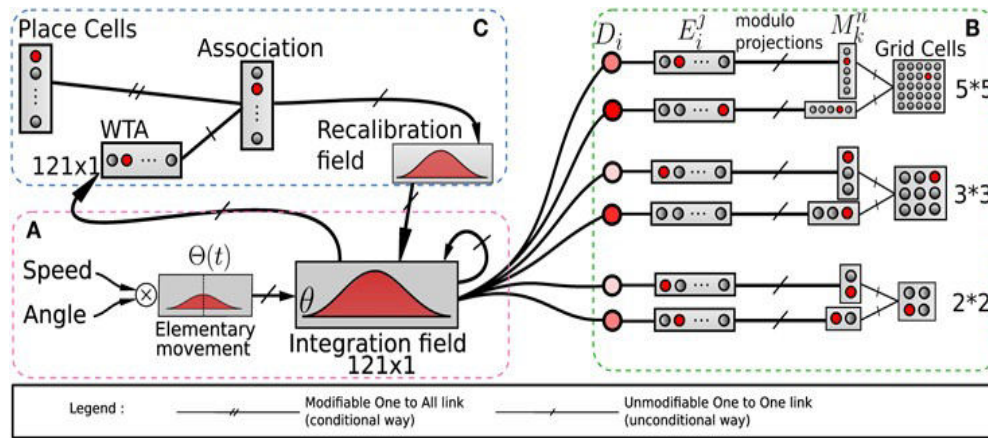
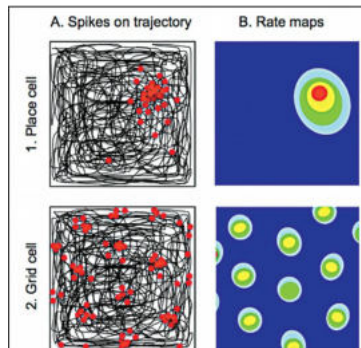


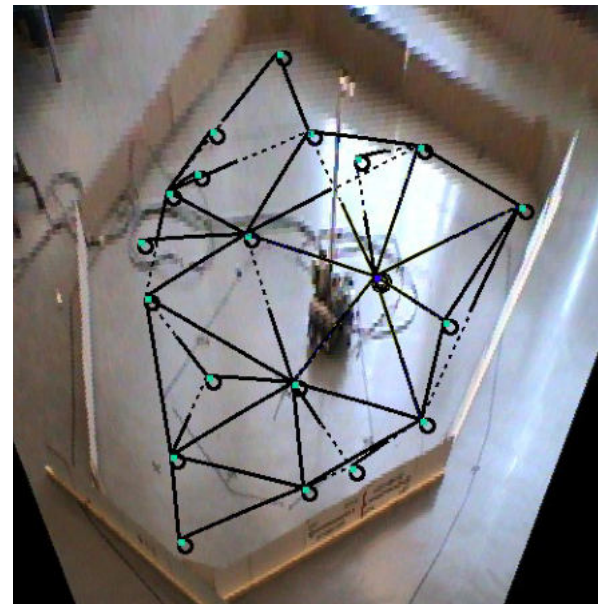
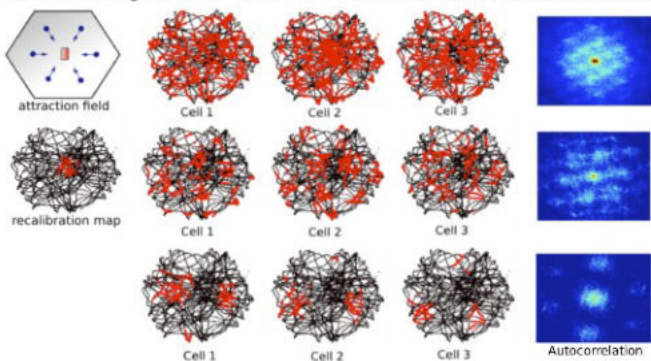
Hippocampus model



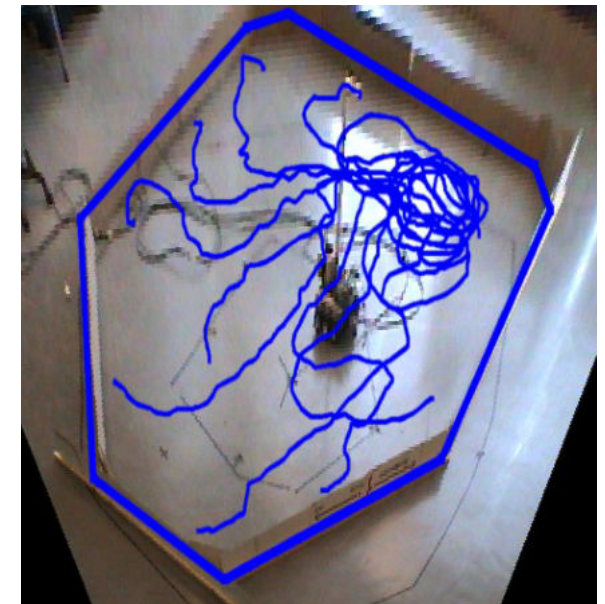
A - Grid cells recorded in rodent's dMEC



C - Artificial grid cells recorded on robot with centered recalibrations



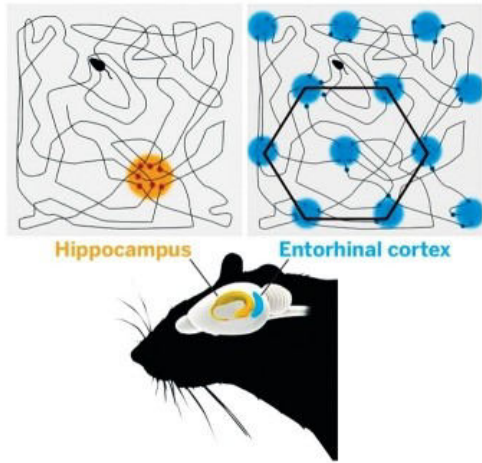
Place cells mapping



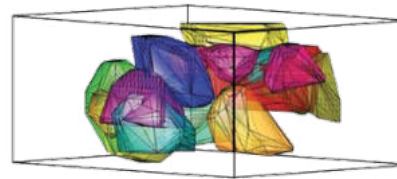
Goal-oriented behavior

Grid cells [Hafting, 2006, Gaussier 2008~2013]

2D & 3D Bio-inspired navigation control



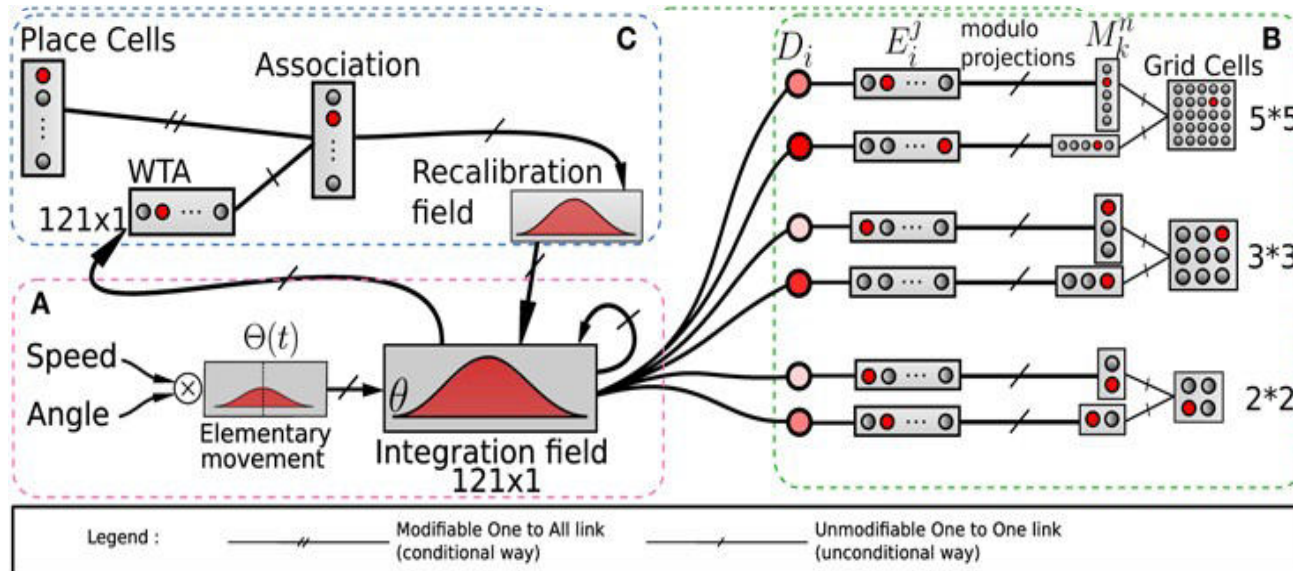
3D navigation



Autonomous vehicles



Drones



Autonomous robot, hippocampus model



**A real robot performing robust path following
by the learning of multimodal sensorimotor associations**

Adrien Jauffret

Nicolas Cuperlier

Philippe Gaussier

Nuit des chercheurs

Ecole polytechnique de Palaiseau

ETIS Laboratory, CNRS UMR 8051
Cergy-Pontoise University

Berenson : Robot Art Connaisseur

Human Robot Interaction



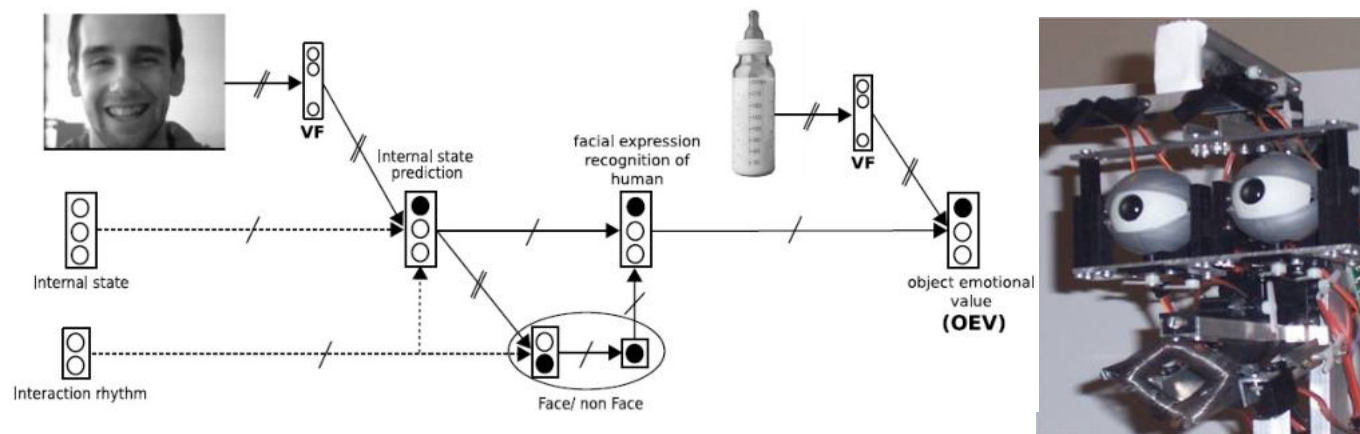
Musée du Quai Branly (Paris) 2012, 2015



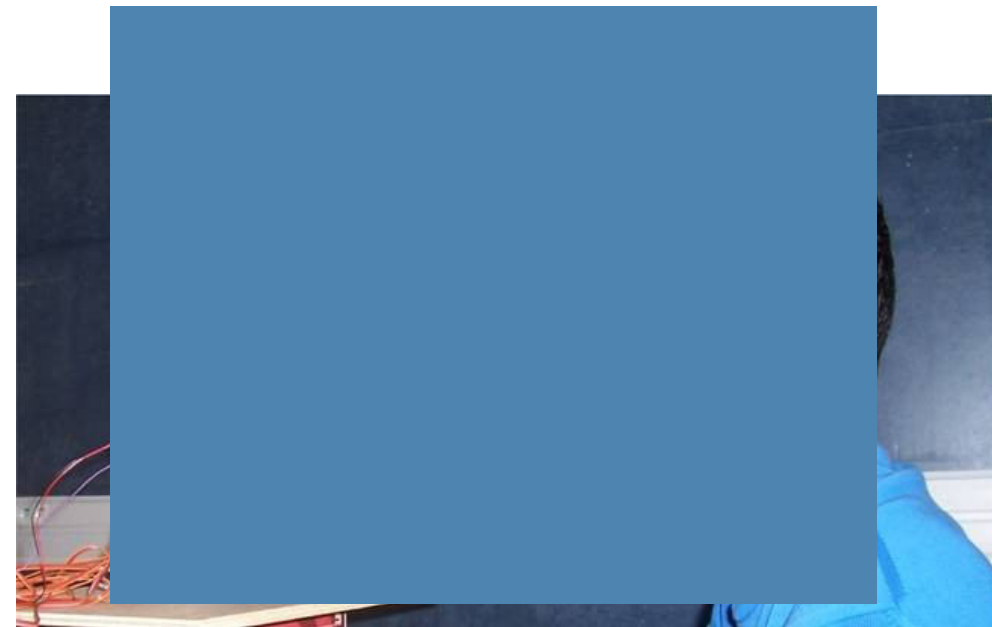
[Karaouzene *et al* 2012~]

Facial and emotional recognition and social interaction

Reinforcement learning for Emotion Generation



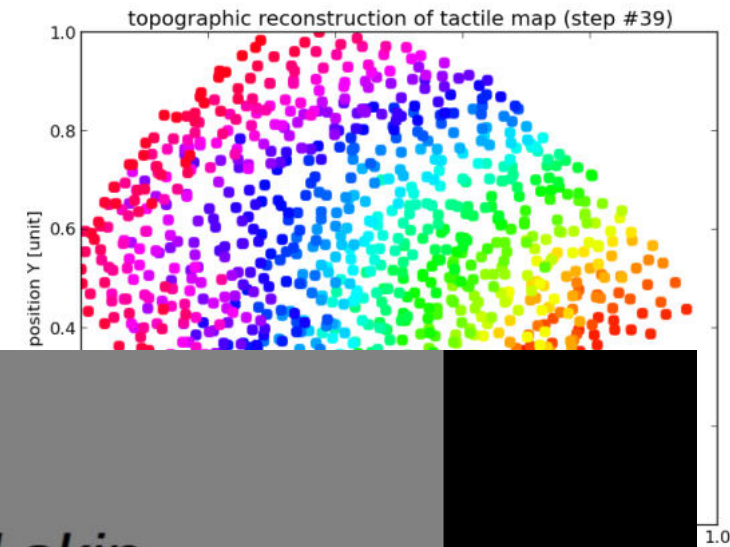
Emotion recognition



Neonate imitation

Conception of an artificial skin for robots

Output layer of NN



Conception of an artificial skin

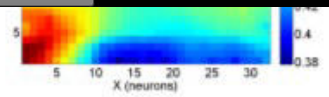
Neural learning of topographic information

*Ganna Pugach, Artem Melnyk, Alex Pitti,
Philippe Gaussier*

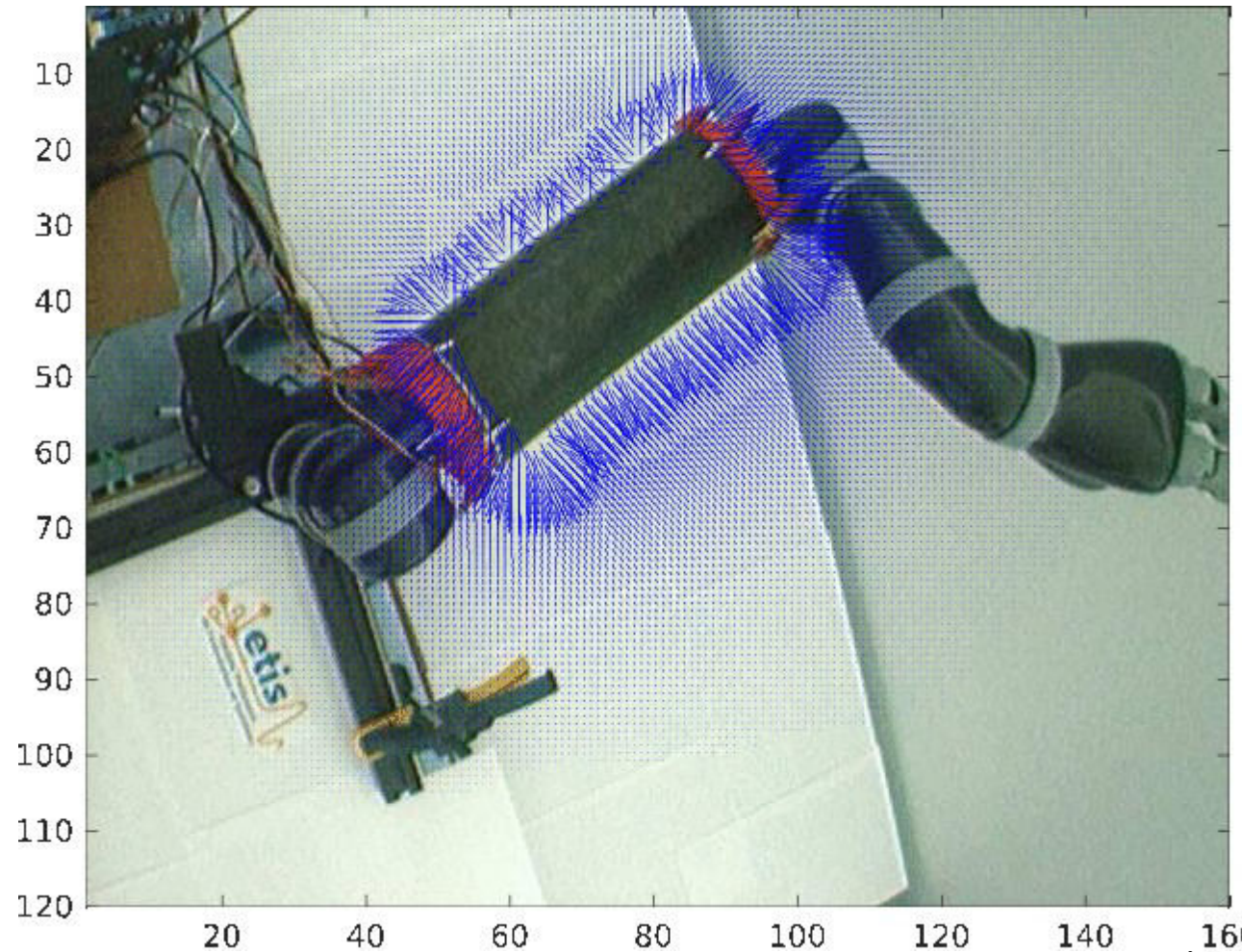
ETIS Laboratory
CNRS, ENSEA,
Cergy-Pontoise University



[Pugach, 2012~]

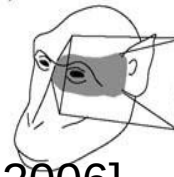


Proximal neurons, Body schema representation

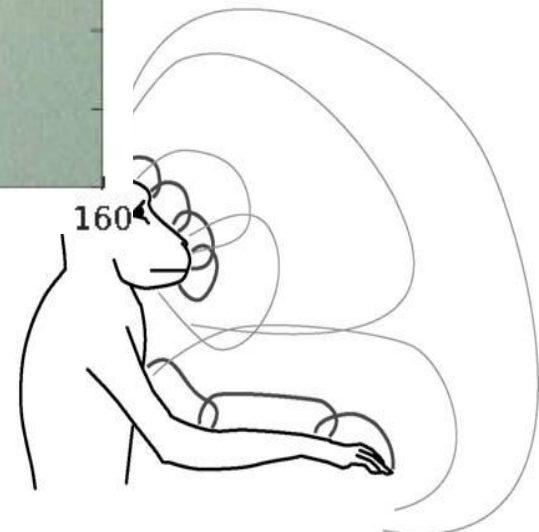
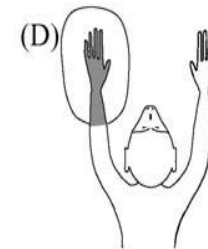


[Pugach, 2019]

(C)



(D)

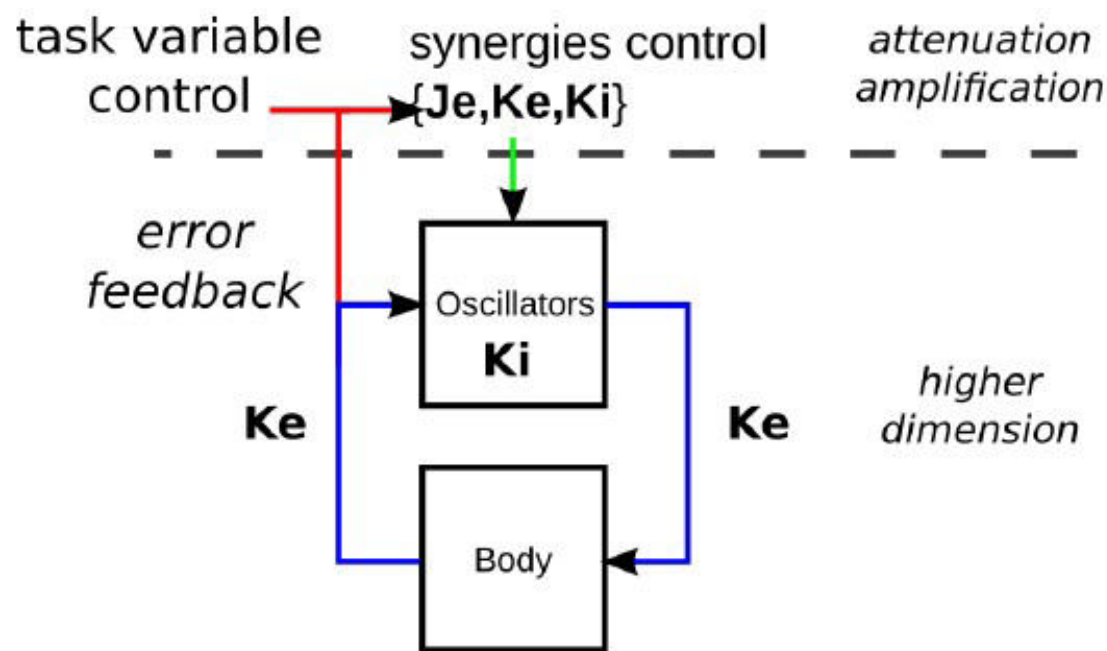


[Graziano, 2006]

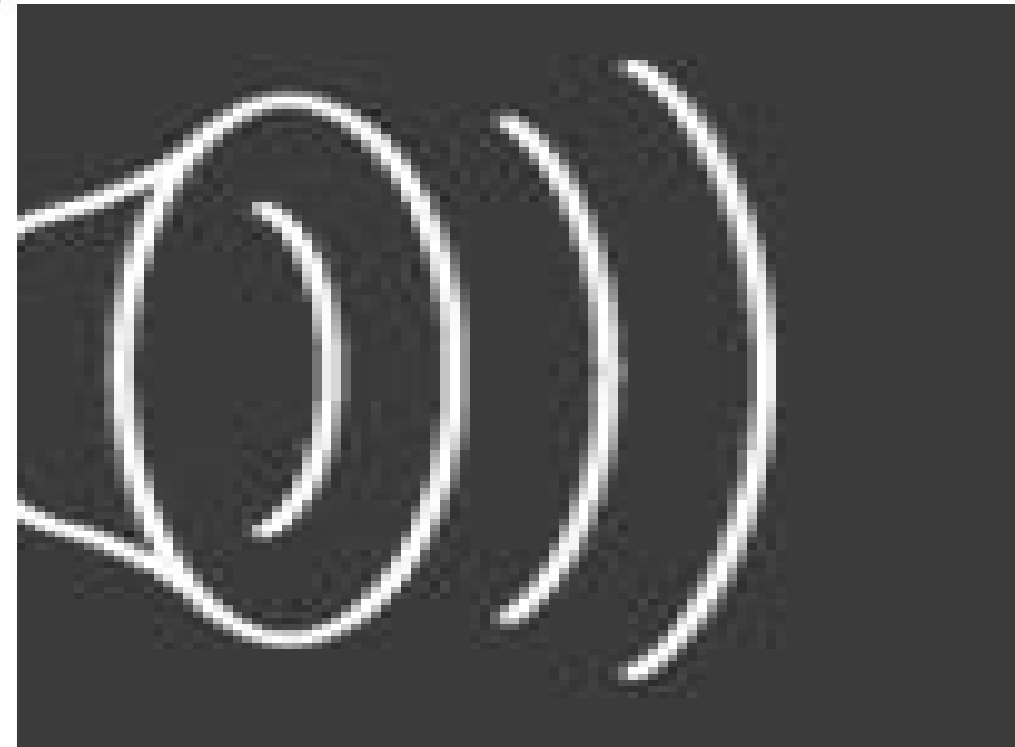
Postural control with perturbation

PD Control on **JE** based on Y vertical

$$u_i = \mathbf{JE} \sin(\vartheta_i)$$

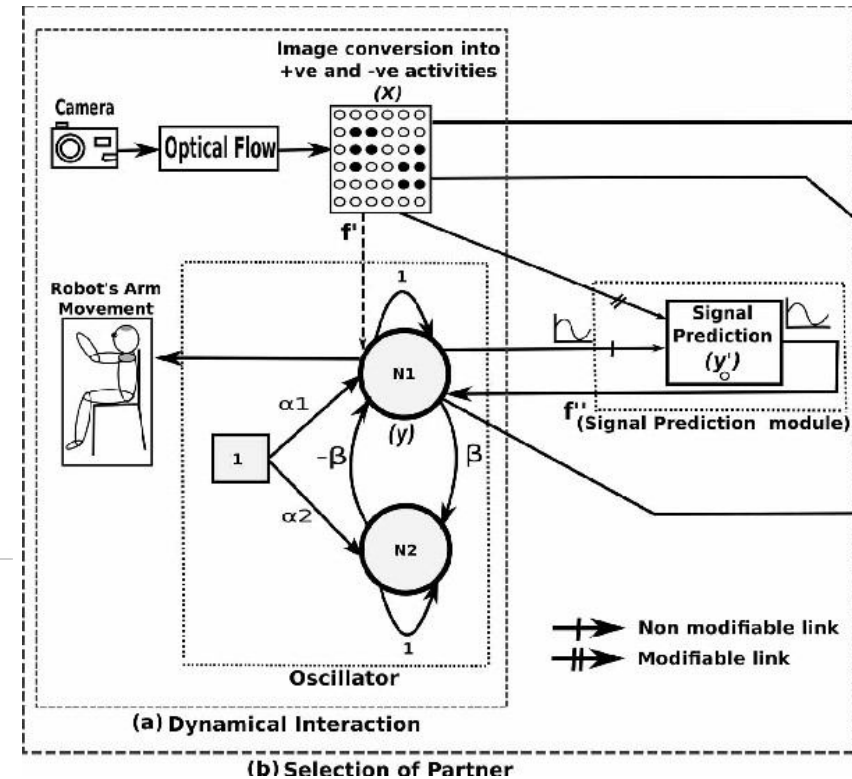
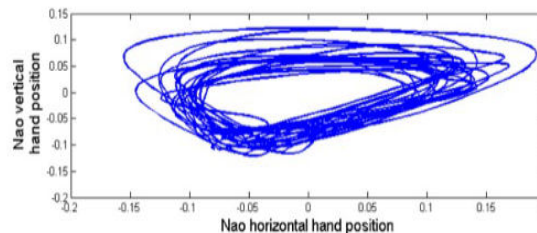
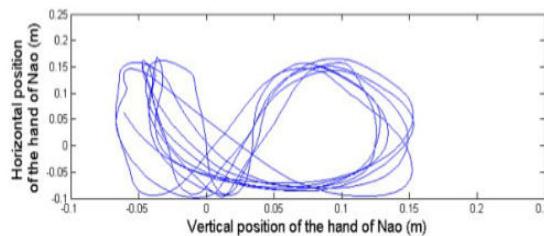
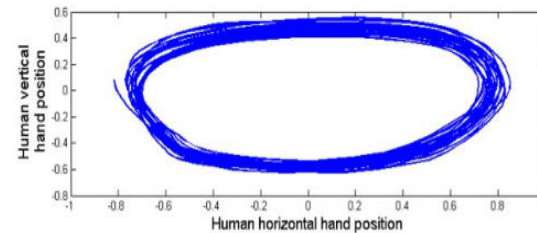
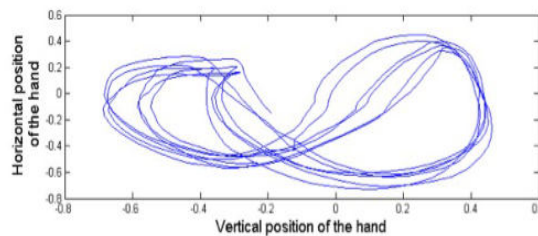


Kuramoto oscillators =
Central Patterns Generators



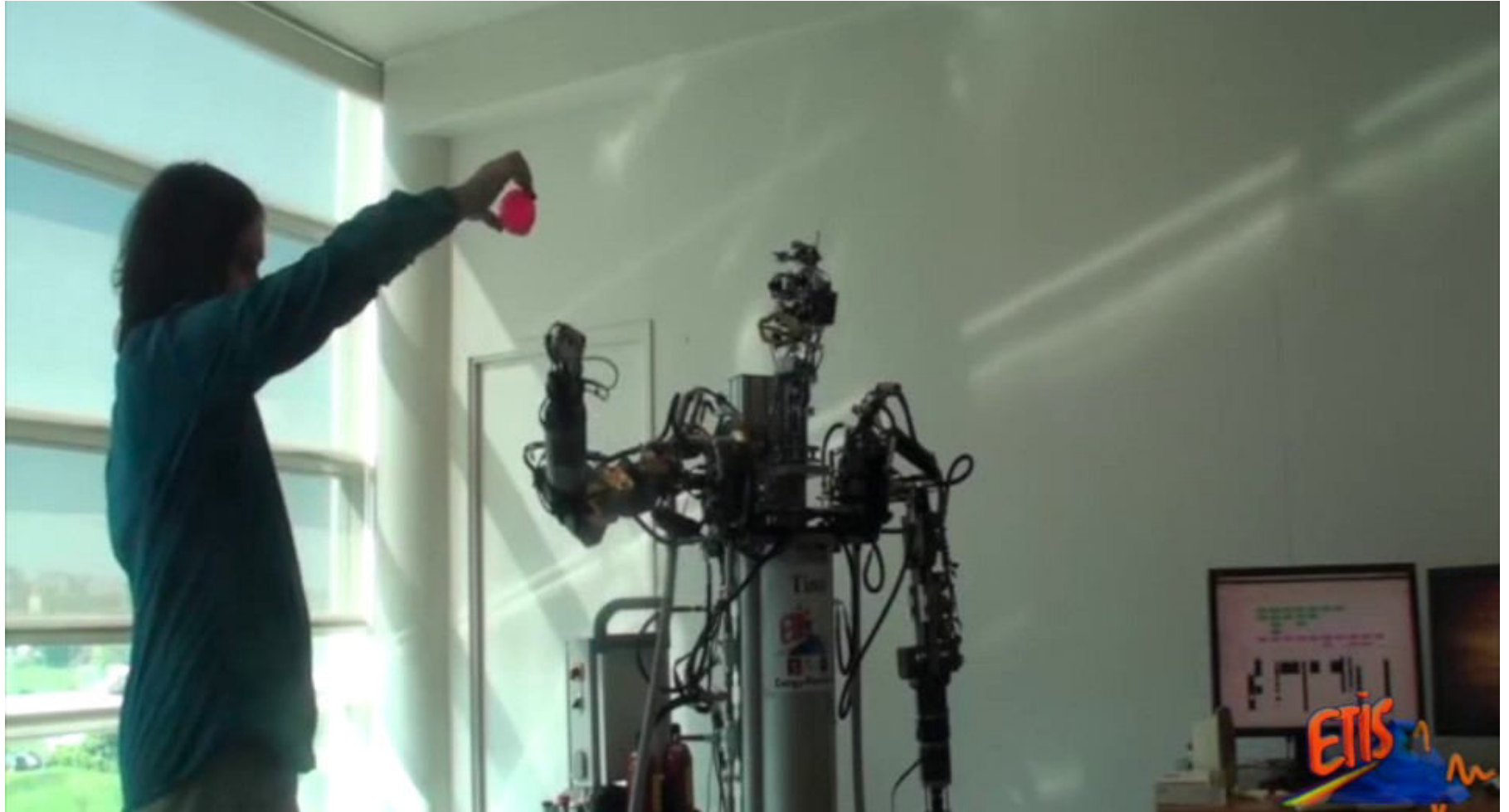
Rythmical entrainment in HRI

- Imitative movement generation and coupling

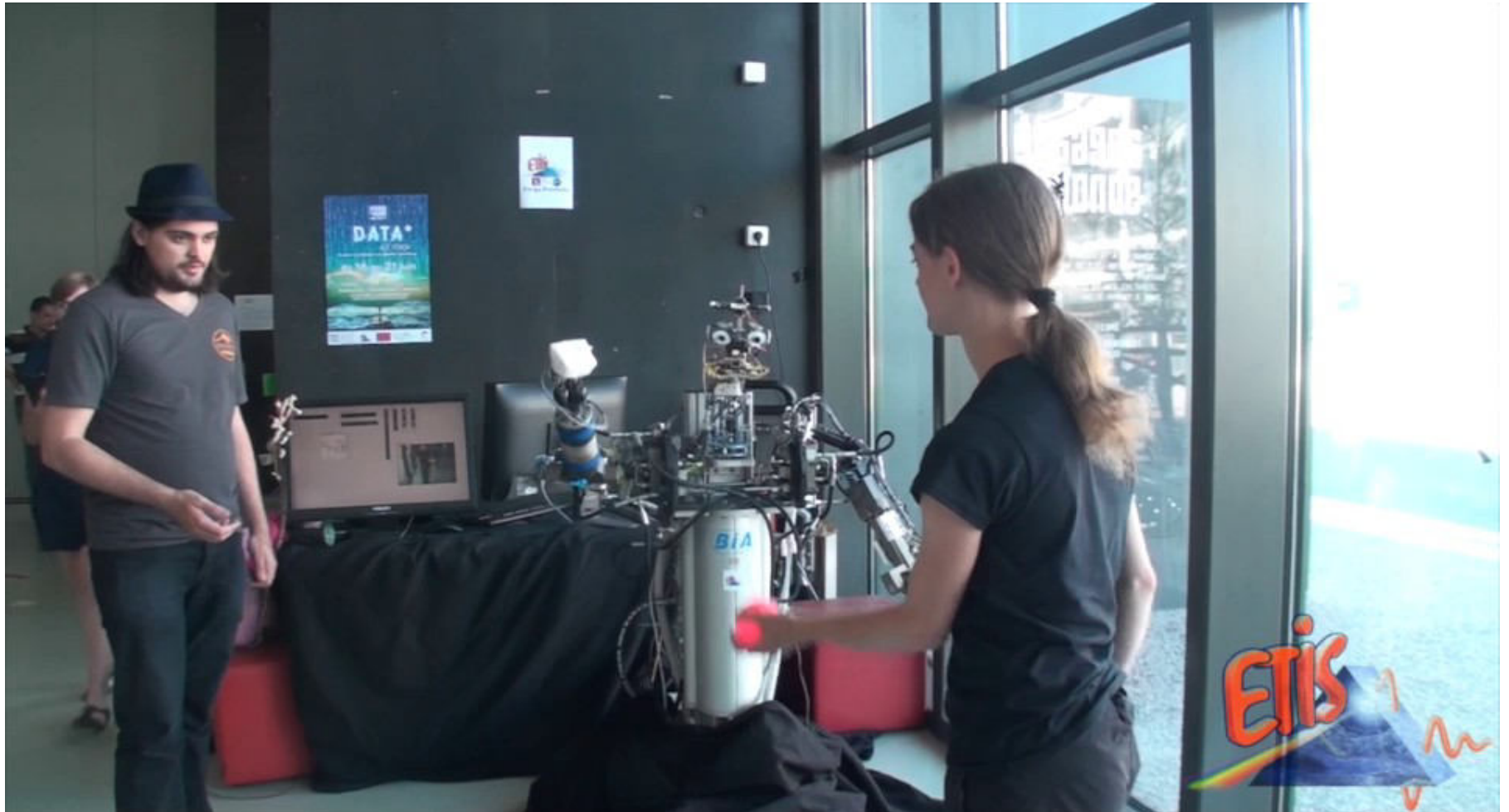


[Ansermin et al., SAB, 2016].

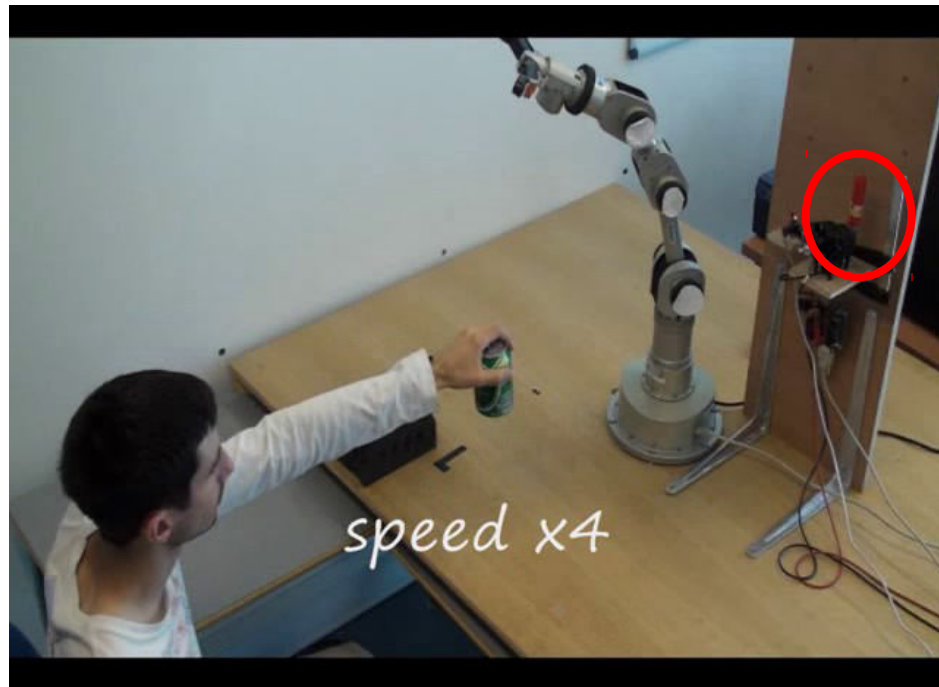
Oscillator coupling and reinforcement



TINO



Infant-like robot imitation



speed x4

Immediate imitation

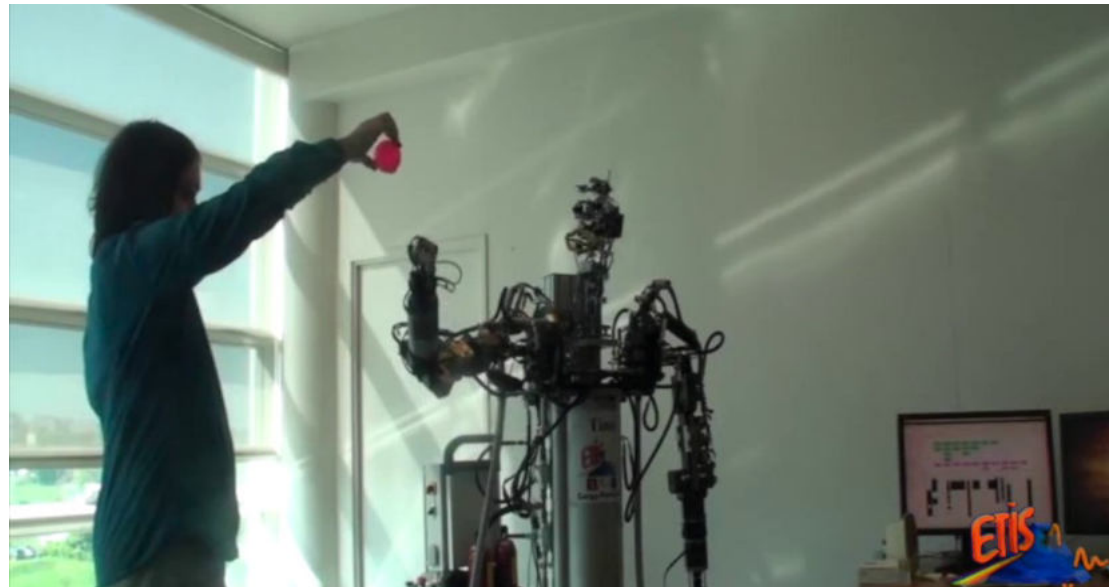
Sensori-motor learning (robot alone)

Minimal mechanisms:

- Ambiguity of perception
- Homeostatic control

emergence of immediate imitation

[Andry et al 2002 & 2004]



Visual Reaching using gain-fi

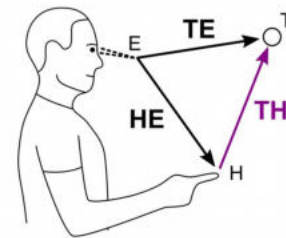
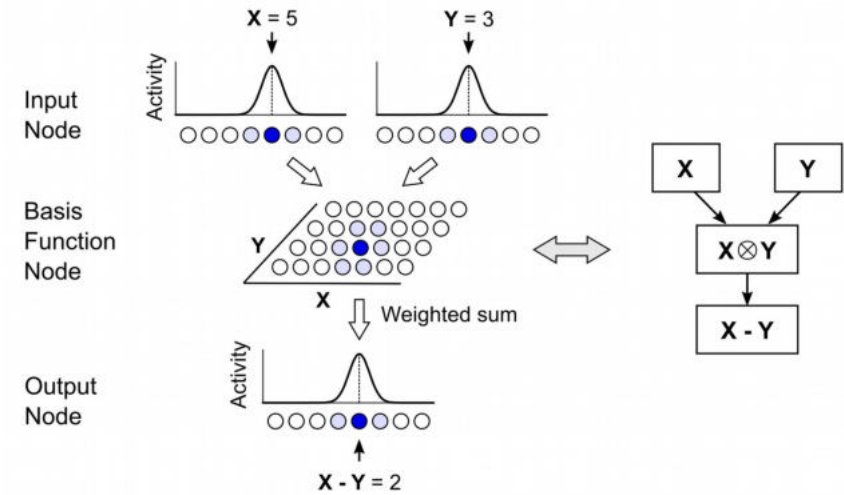
Anterior Intraparietal Area (AIP)

Area 5d Parietal P

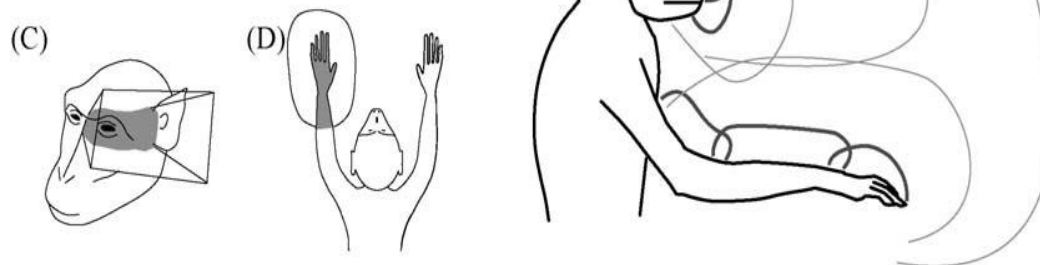
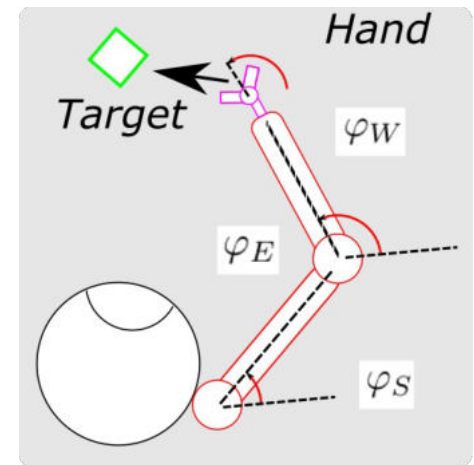
trajectory decoding

Lateral Intraparietal Area (LIP)

body (hand-) centered coordinates



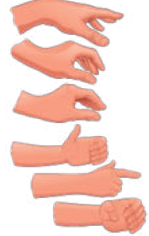
[Ustun, 2015]



[Graziano, 2006]

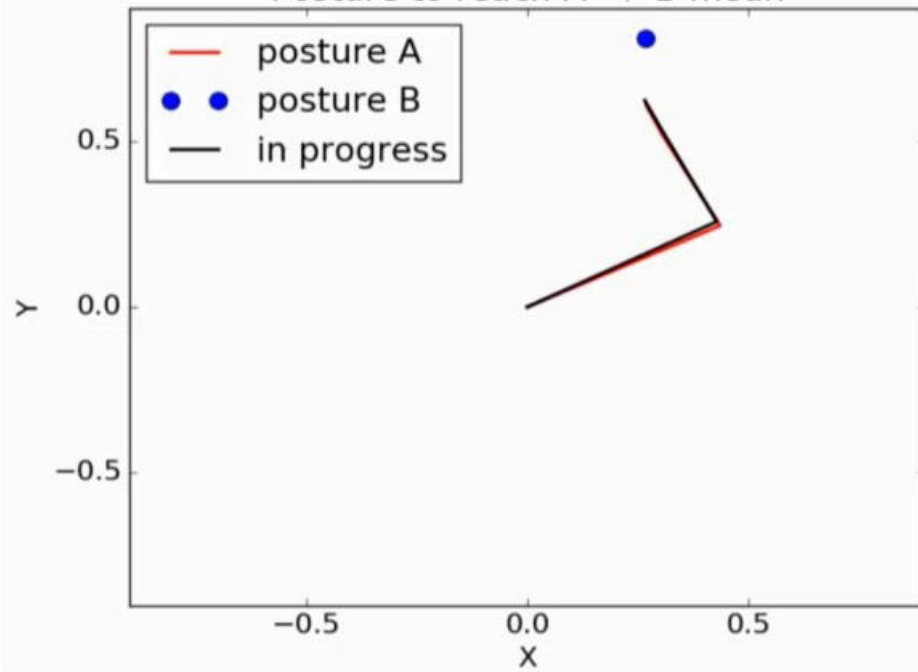
[Mahé et al, 2015]
 [Braud et al 2018]
 [Abrossimoff, et al 2018]
 [Pugach, et al 2019]
 [Aoun-Durand to be submitted]

grasp decoding

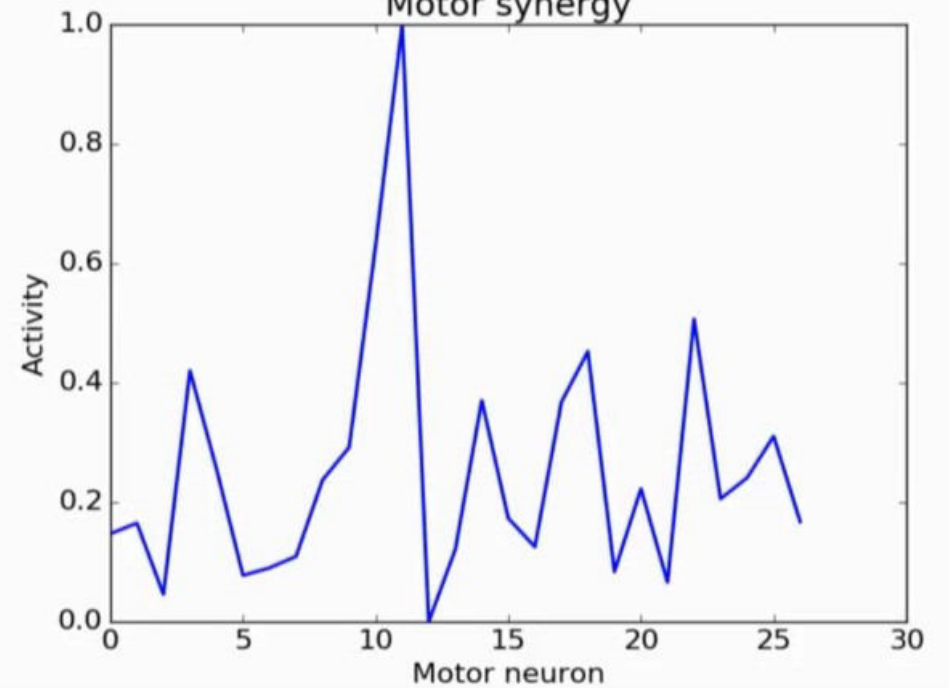


[Chivukula, 2019]

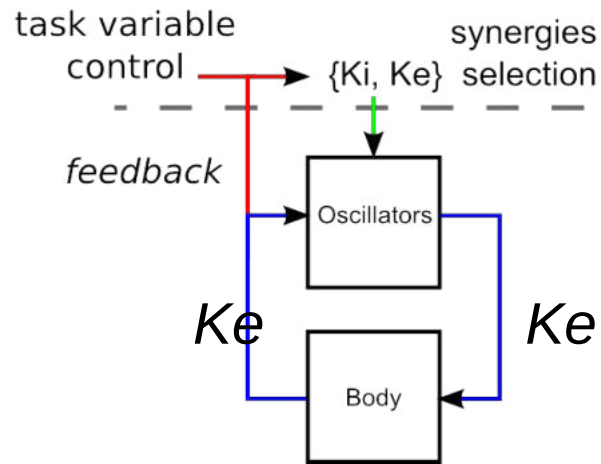
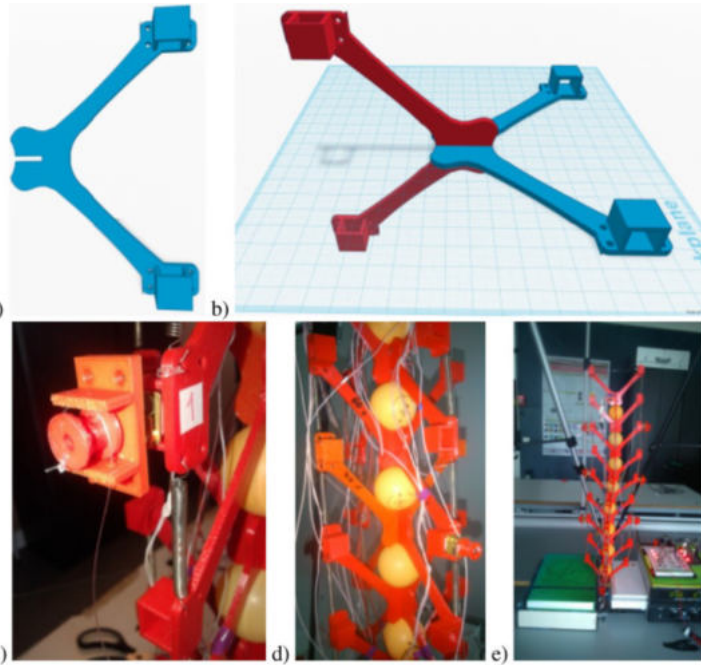
Posture to reach A $\rightarrow$ B mean



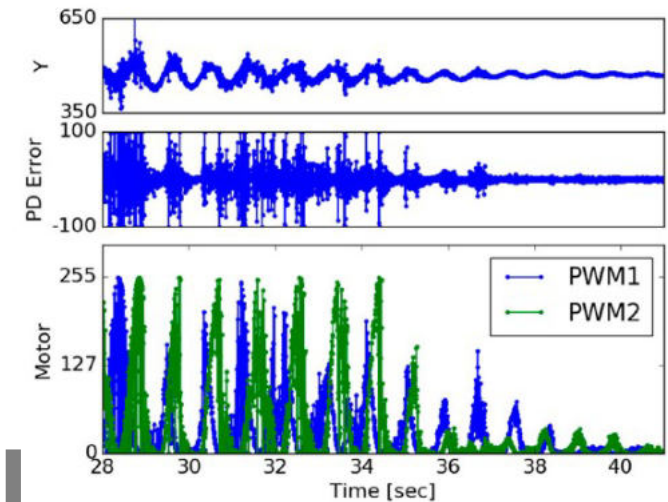
Motor synergy



Soft Robotics



Kuramoto oscillators =
Central Patterns Generators



$t = 0s$

$t = 2.4s$

$t = 2.8s$

$t = 3.2s$

$t = 3.6s$

$t = 4.4s$

