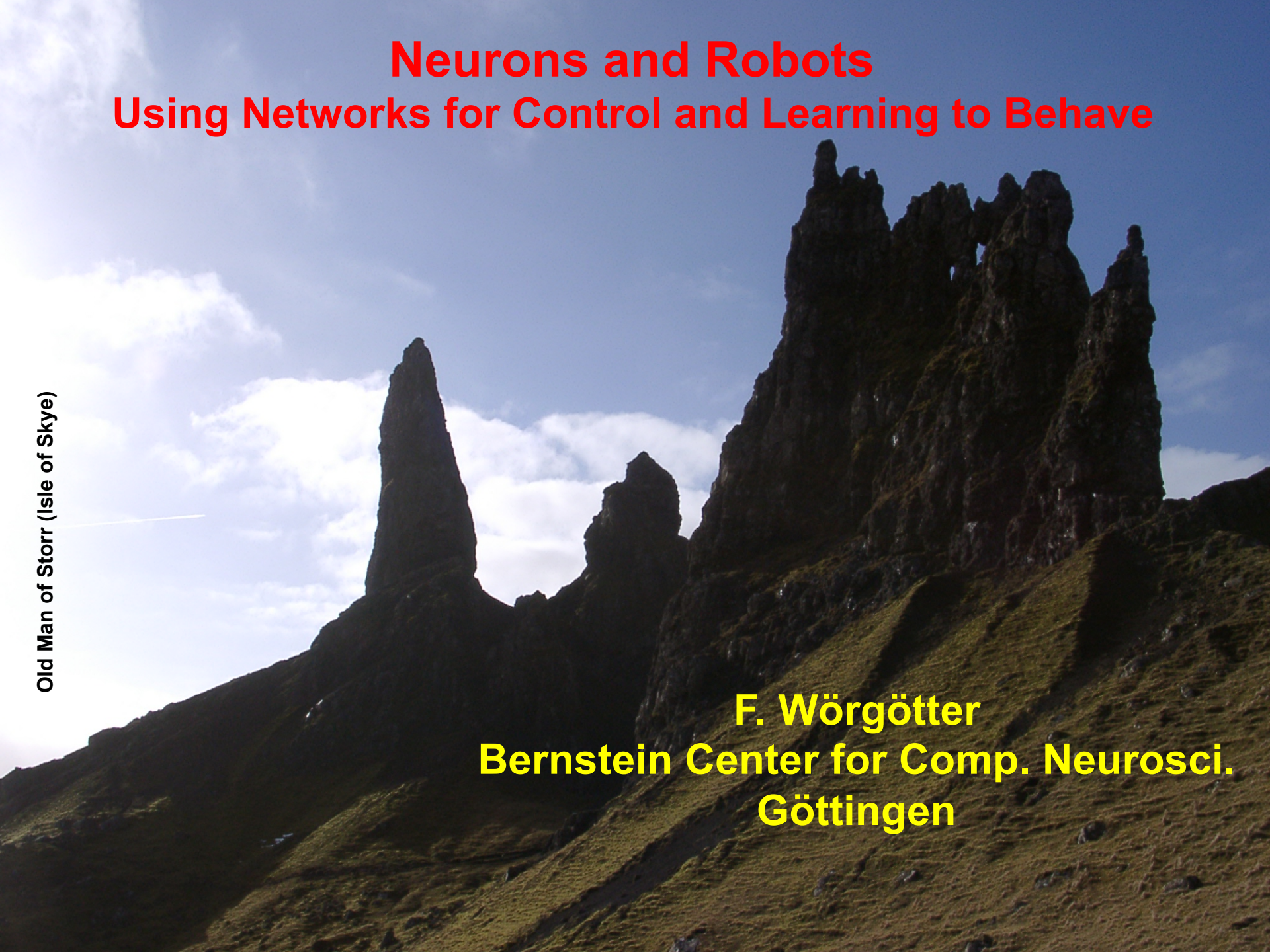
Neurons and Robots

Using Networks for Control and Learning to Behave



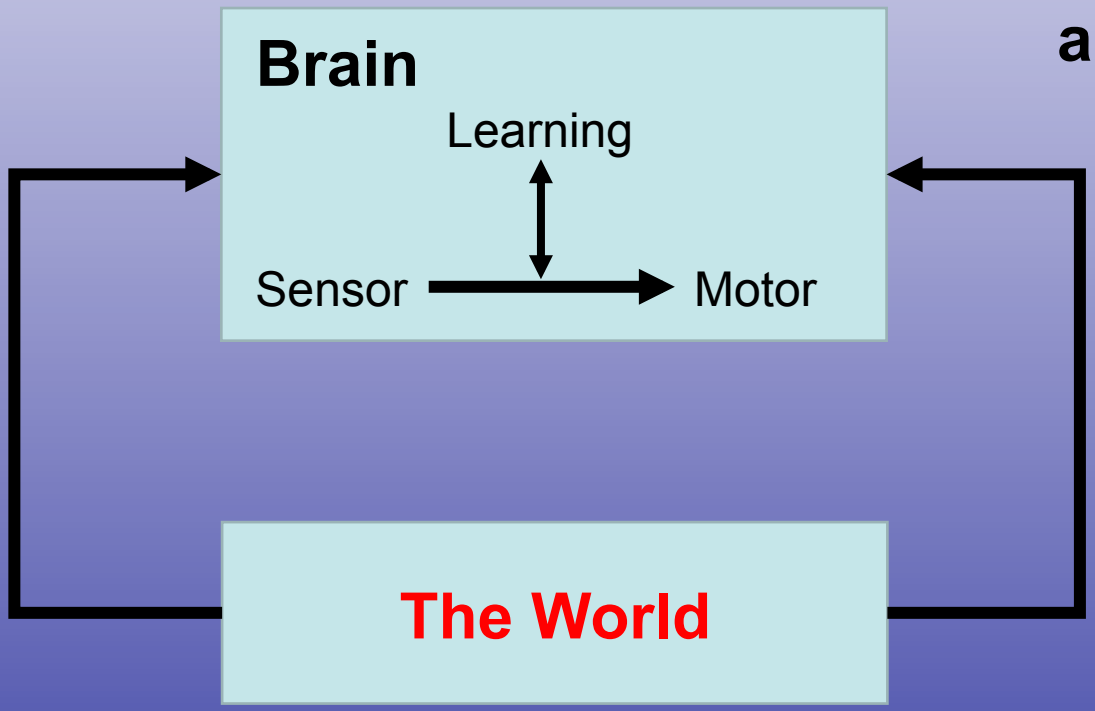
Old Man of Storr (Isle of Skye)

F. Wörgötter
Bernstein Center for Comp. Neurosci.
Göttingen

The great divide:

„Neural“ Networks are (still) no neural networks.

Real Networks are adaptive controllers

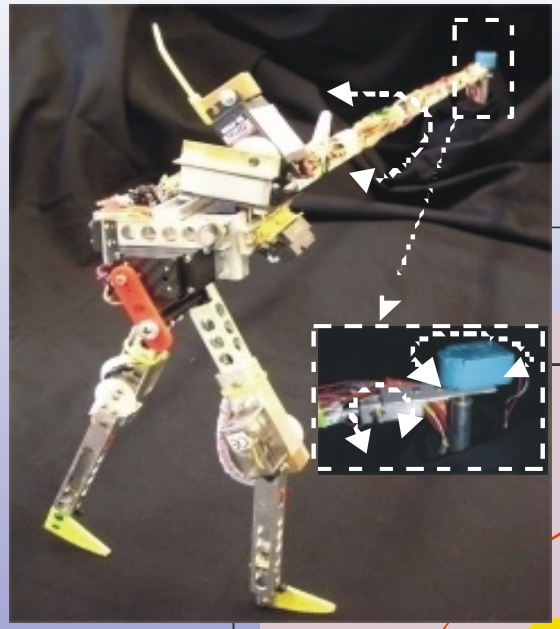


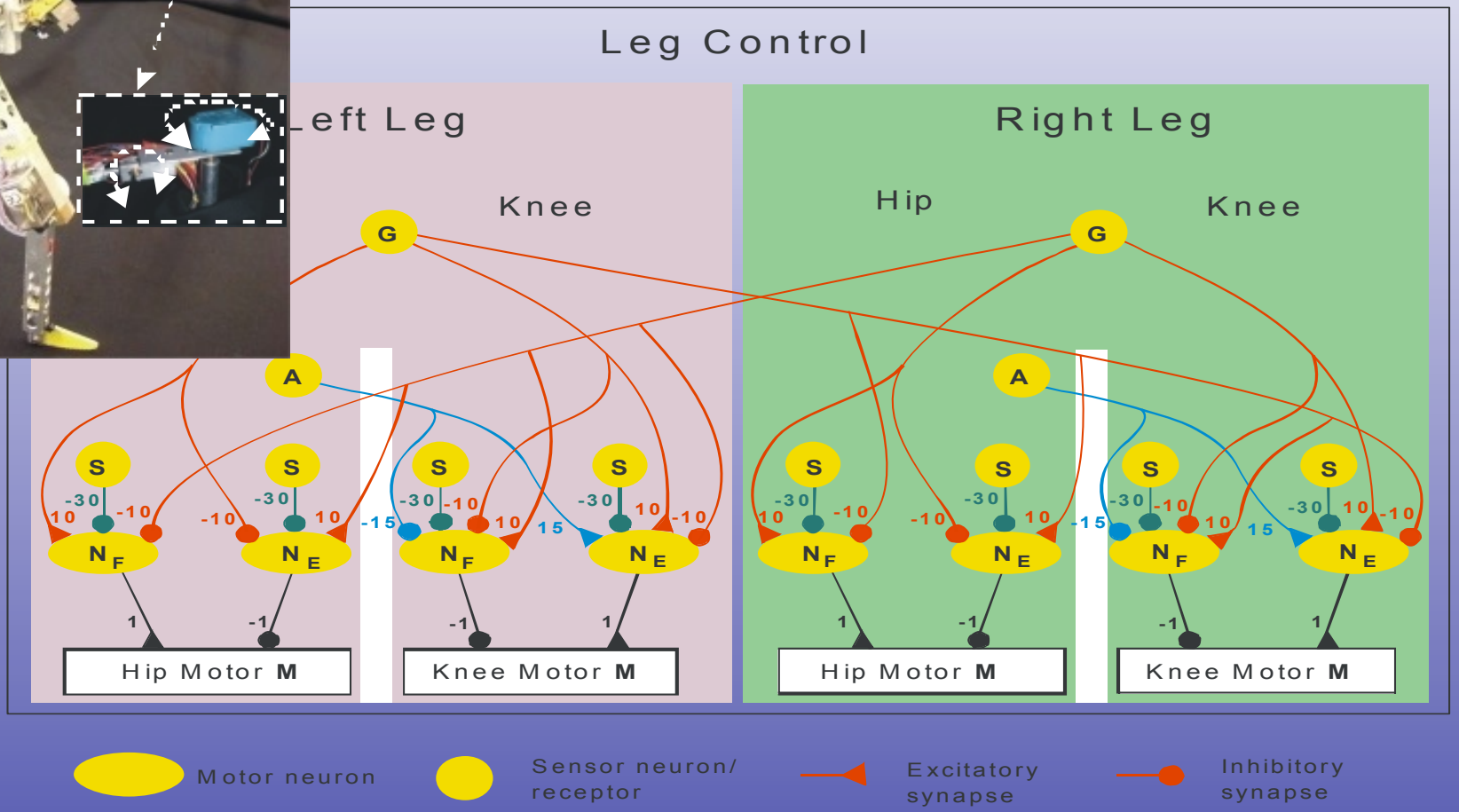
Networks and Control

- Reflex based neural control – RunBot (2007)
  - Learning to avoid a reflex
- AMOS W6, a six-legged robot (2010)
  - Deterministic Chaos and its control
  - Demonstration of a large behavioral repertoire
- Learning Goal directed manipulation actions (2015)
  - Memory in behaving networks

RunBot, the Reflex Machine

PLoS CB, 2007

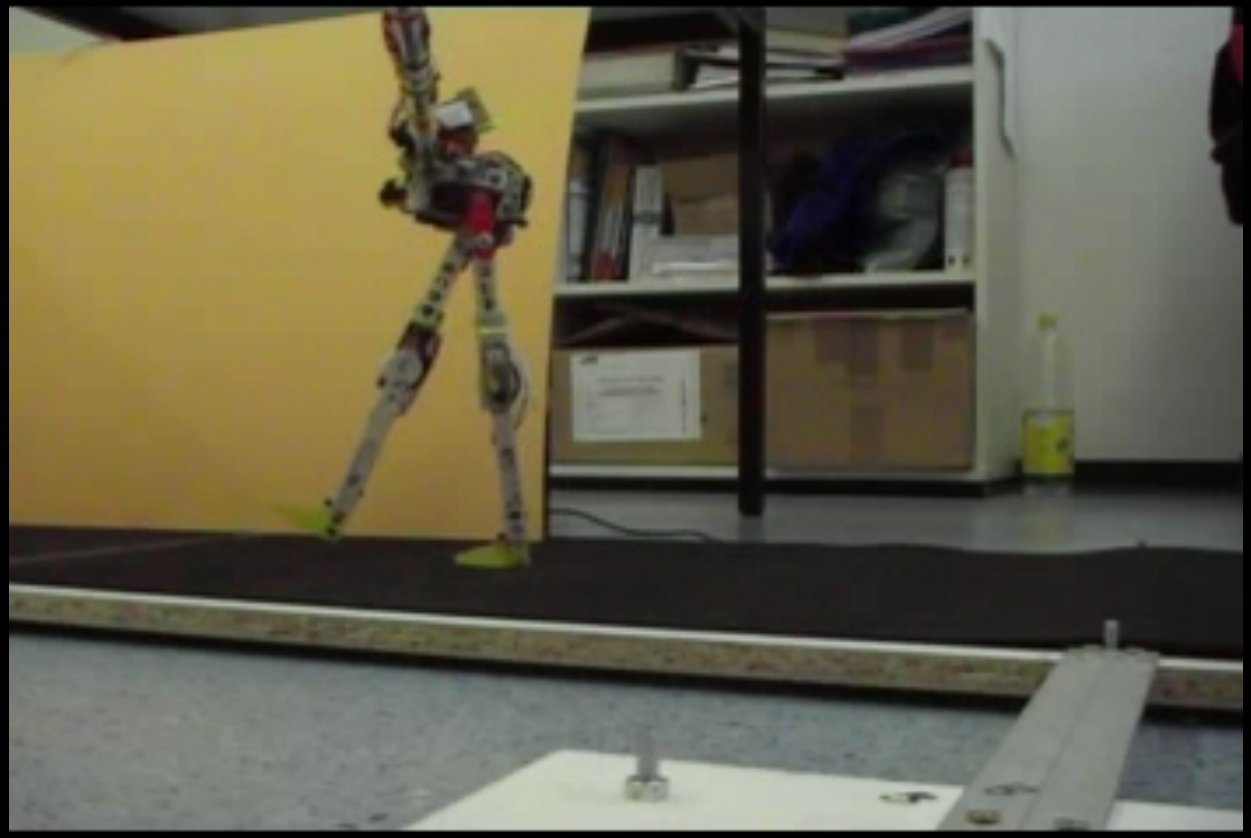




15 Sensors, 5 DOF (constrained), 19 neurons

PLoS CB, 2007

RunBot: Learning to walk up a slope



BBC, July 07
Mumbai Mirror July 07
New York Times July 07
AAAS Sci Update July 07

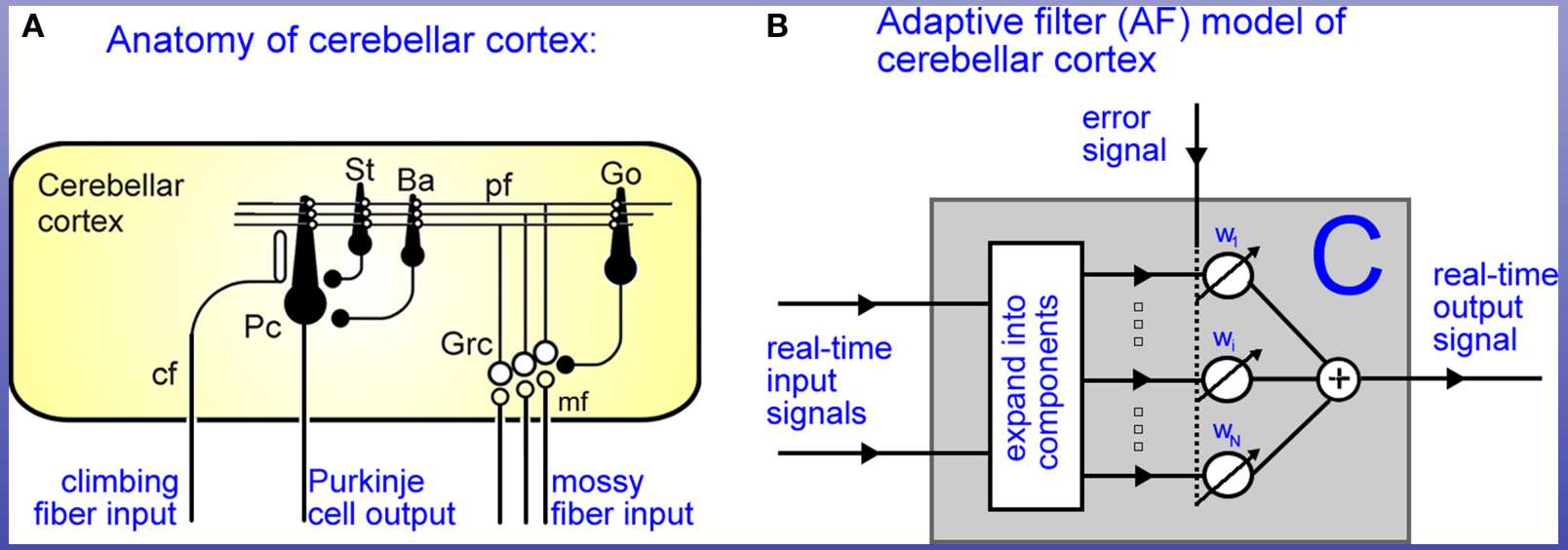
What happens here?

Cerebellar Reflex Avoidance Learning (abstracted)

Look→ Move

instead of

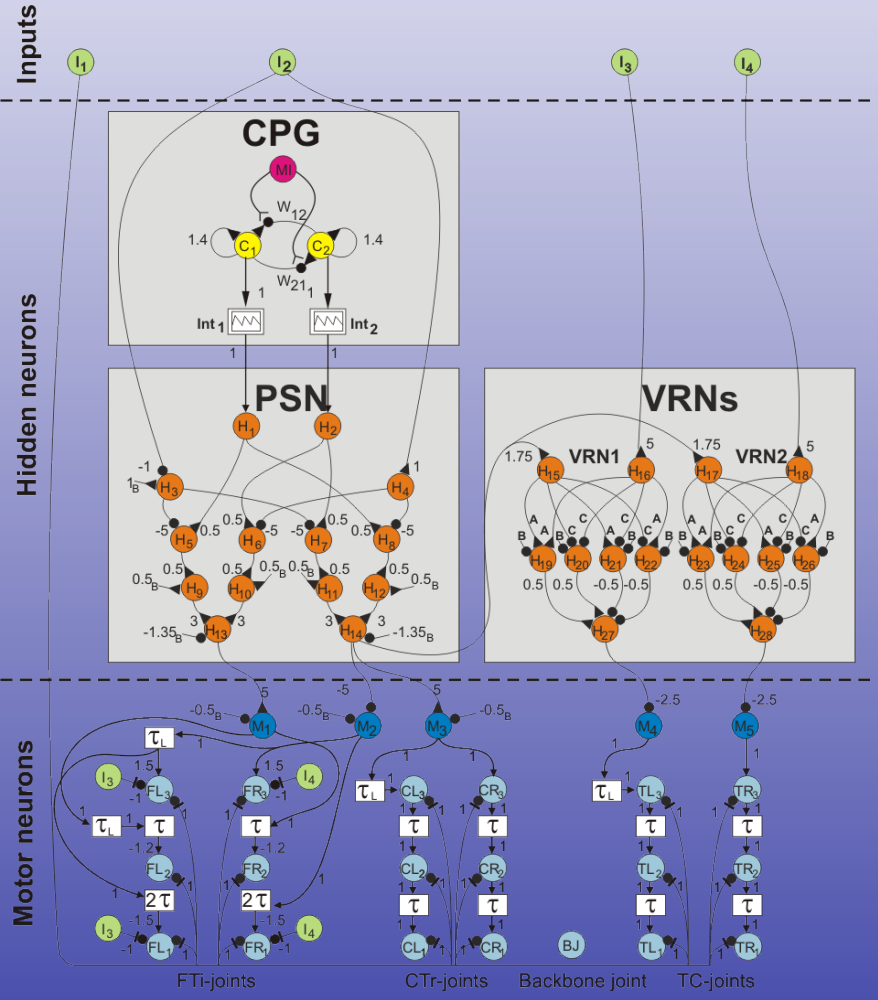
Ouch→Move

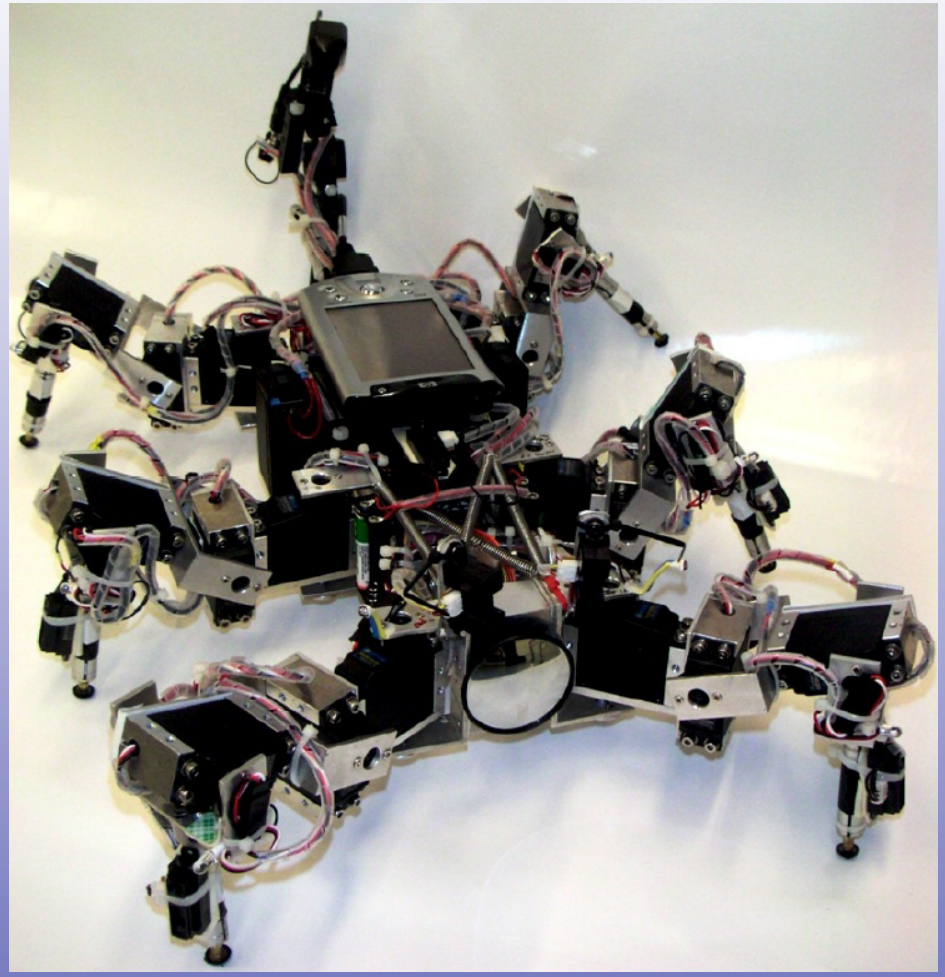


AMOS-WD06

Nature Physics 2010

How to control Chaos in networks

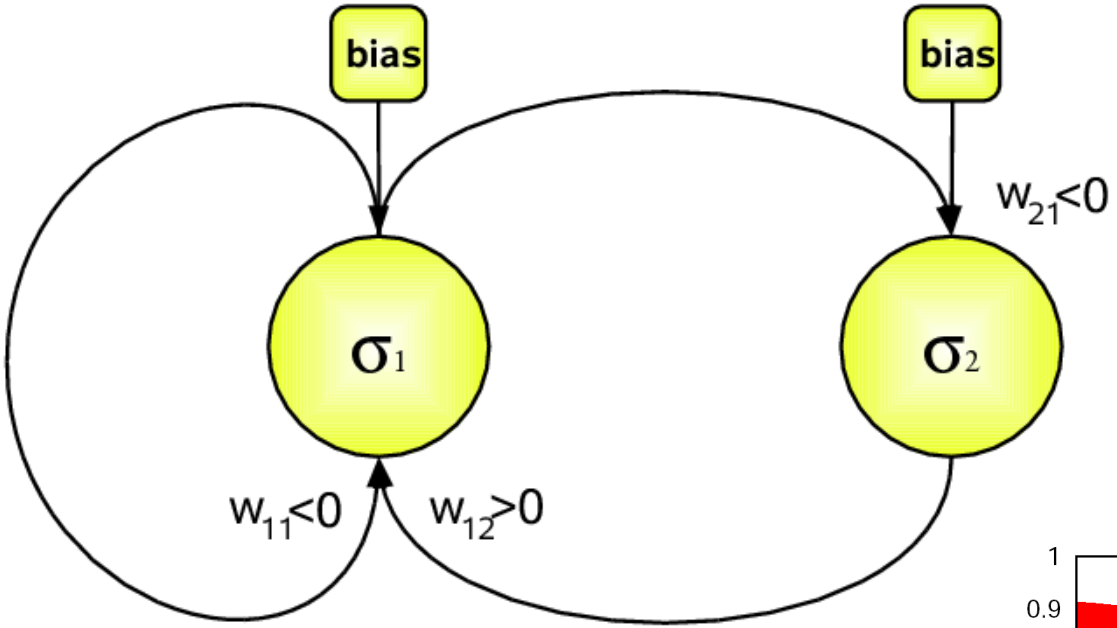




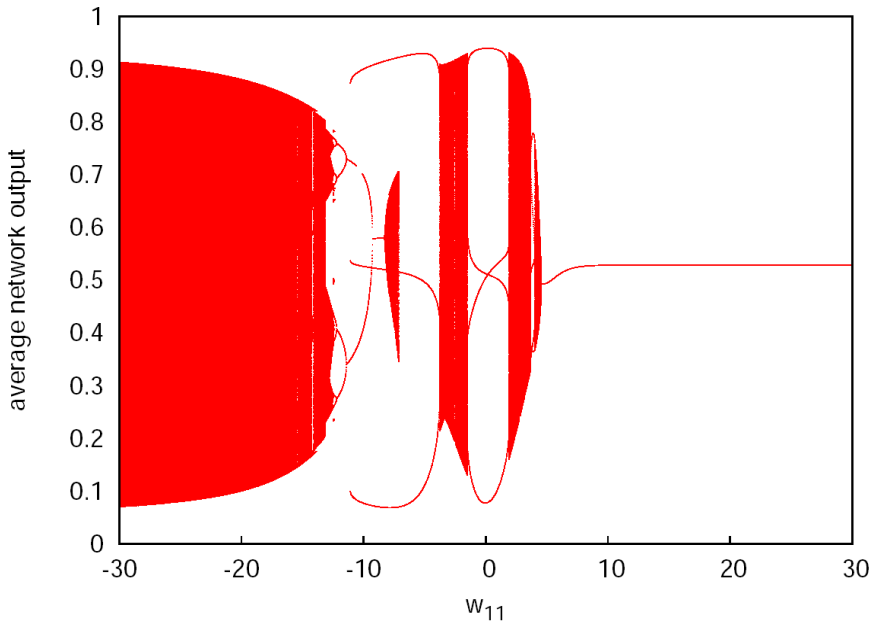
>30 Sensors, 19 DOF
71 neurons

Nature Physics 2010

Two neurons suffice to create a large behavioural repertoire

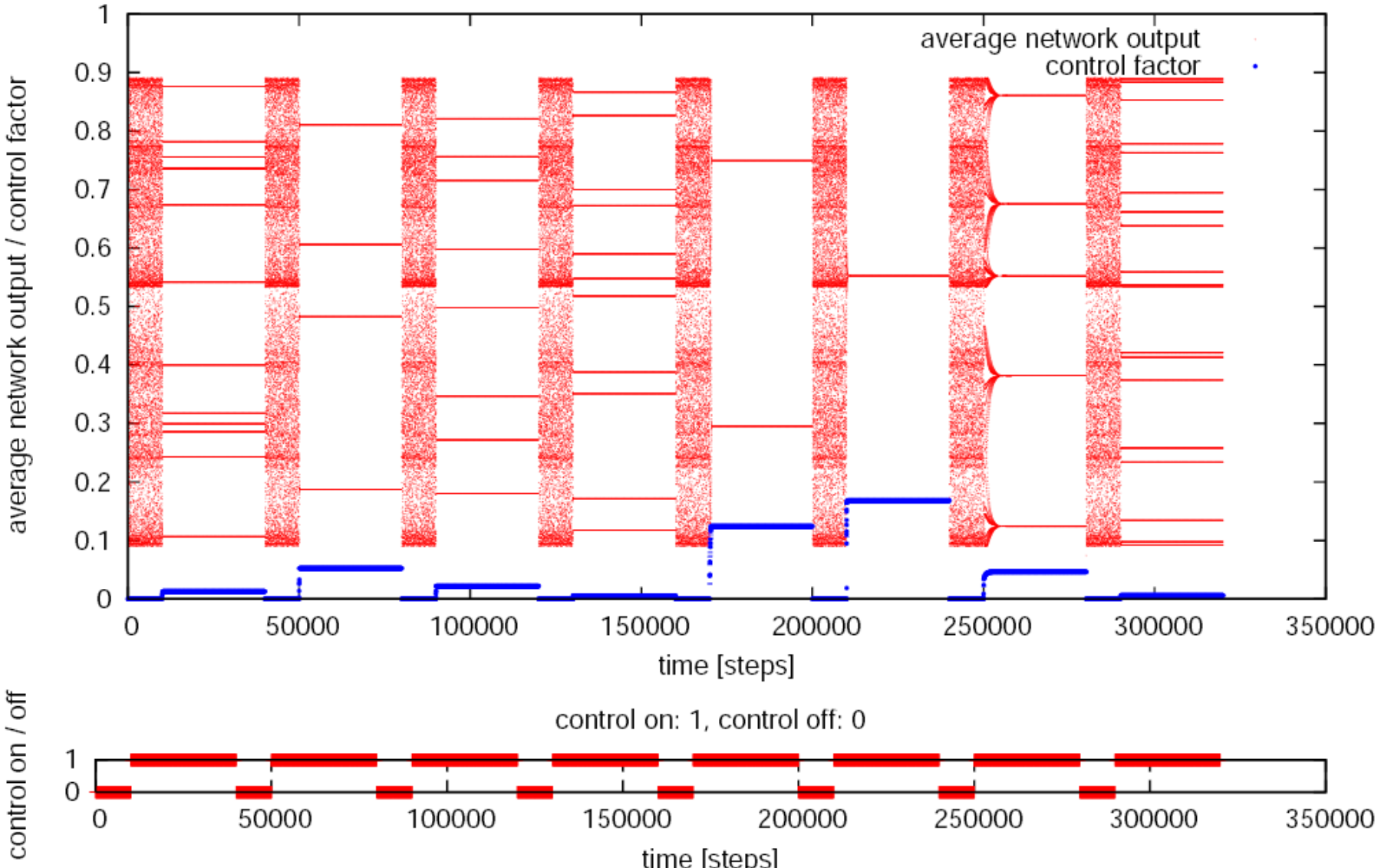


The bad news is: these circuits almost always produce chaotic outputs (Pasemann)



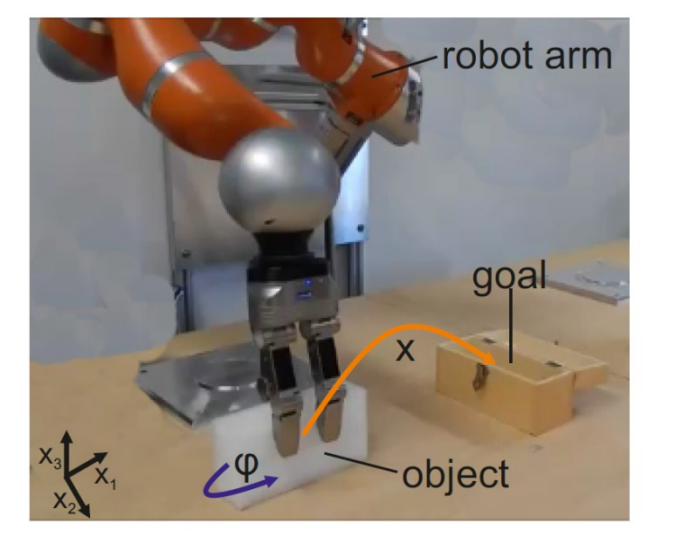
Nature Physics 2010

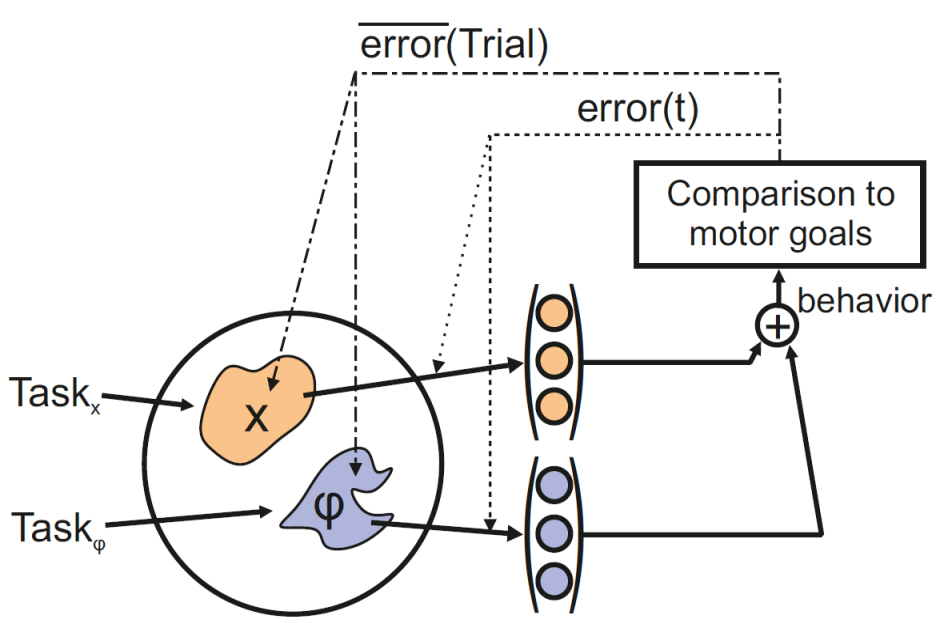
Chaos control can be used to create periodic outputs



Supplementary Information for
Self-organized adaptation of simple neural circuits enables complex robot behavior
Supplementary Video 2
Silke Dreissigacker, Marc Timme
Florentin Woergoetter, and Poramate Manoonpong

Robot Arm Control
The self-organization of large networks

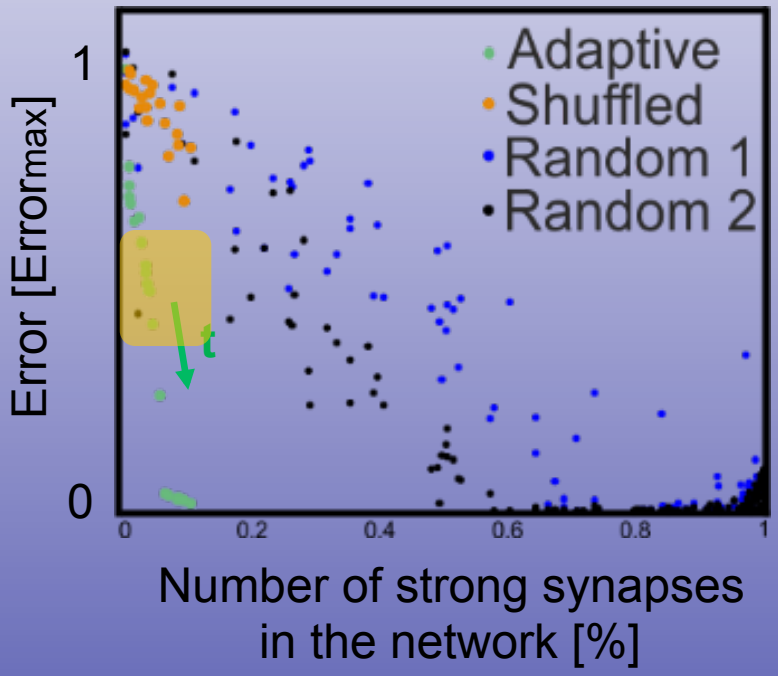


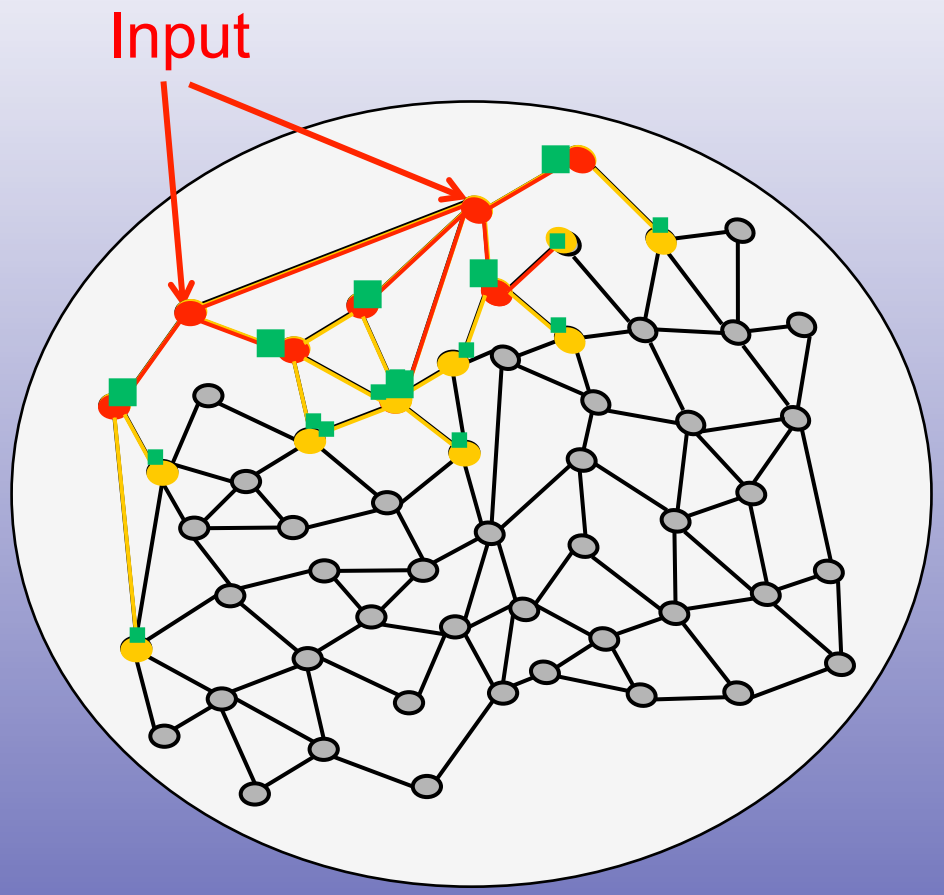


The robot has to learn to **rotate** and **translate** the object into the box. Thereby, both movements are learned **independently** from each other (alternating).

Camera as sensor, 7 DOF, >1000 neurons

Growing a behavior-control network



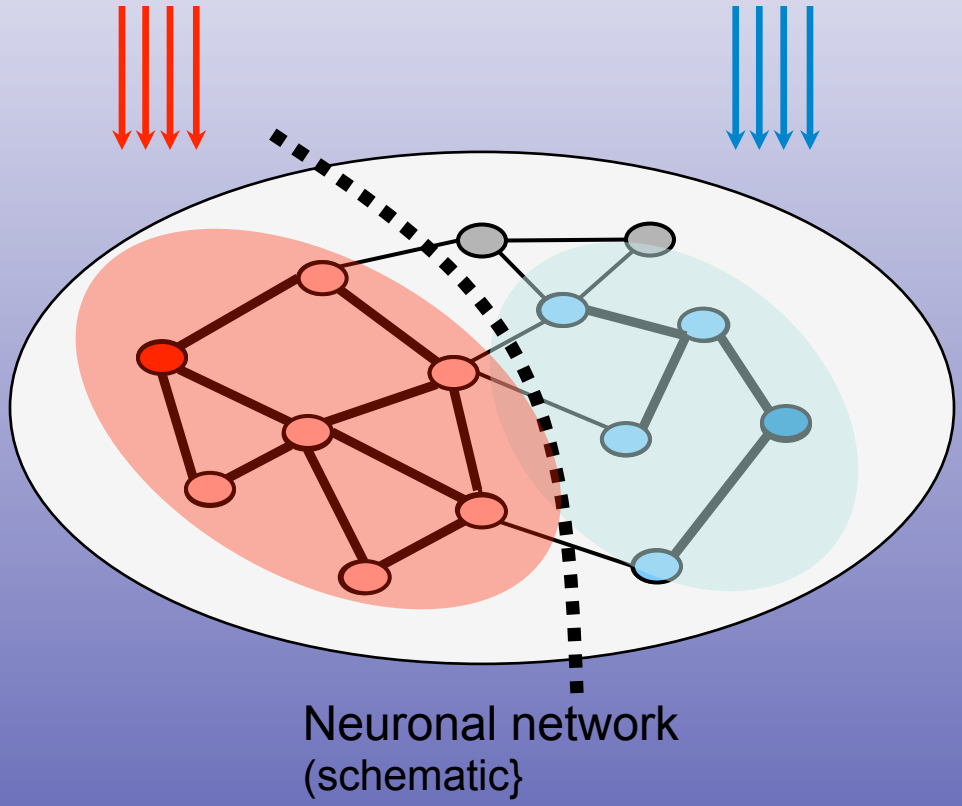


Neuronal network
(schematic}

Growing (non-static) Network

Self Organized Network Formation

The combination of Hebbian Learning with Synaptic Scaling allows input driven self-structuring of large networks into many small but powerful Reservoirs.

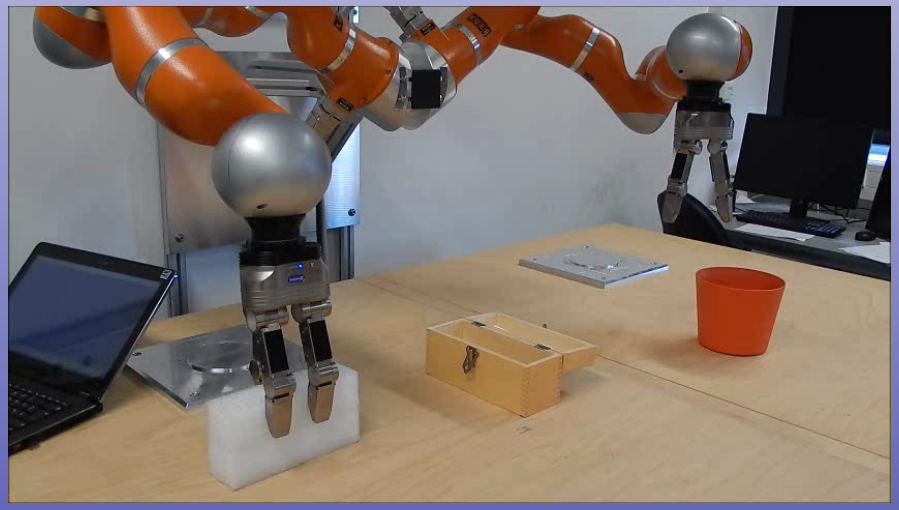


Neuronal network
(schematic}

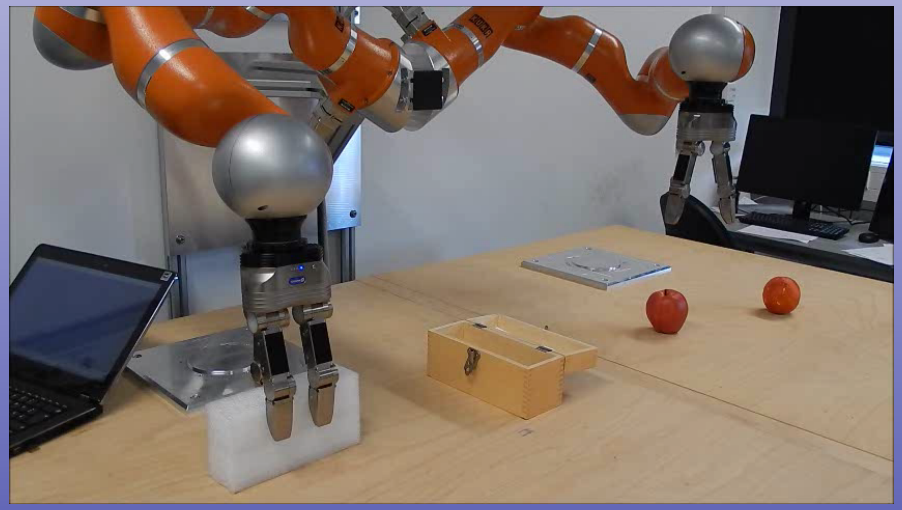
Growing (non-static) Network

Robotic Arm Movement with Reservoir Cell Assemblies

Before Learning of Cell Assemblies



After Learning of Cell Assemblies



One decade of raising the complexity of neural control and self-organization

- Tao Geng)
- Poramate Manoonpong
- Christian Tetzlaff
- Tomas Kulvicius
- Sakya Dasgupta
- Minija Tamosiunaite
- And many others

Thanks

Funded by EU-FP7, EU-H2020,
Bernstein Center for Computational Neuroscience (BMBF),
DFG,