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# Dynamical Properties of Self-Regulating Neurons

## *Problem:* How Can Brains Produce Adaptive Behaviour?

Adaptation = changes that lead to a rise in evolutionary fitness.

Adaptive behaviour is adaptation within the lifetime of an individual.

Adaptive behaviour is context-dependent (situated/embodied), normally there is no external feedback signal available (no super-vision) and adaptation is an open-ended, life-long process.

## *Answer:* HOMEOSTASIS?

Homeostasis: Maintainance of an internal variable at a target level

Ashby ("Design for a Brain",1954) proposed adaptvity through homeostatic stabilisation of essential internal variables.

Advantage: simple principle, no presuppositions about environment

At a neural level: homeostasis of neural activation?

## Experiments:

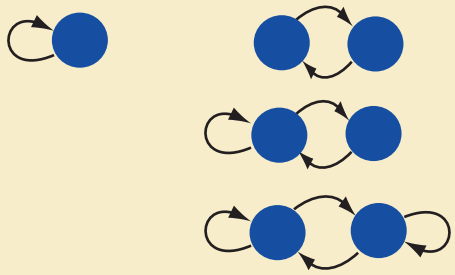
Time-discrete recurrent neural networks that adapt their synaptic weights in order to maintain the activation level homeostatically at a target value.

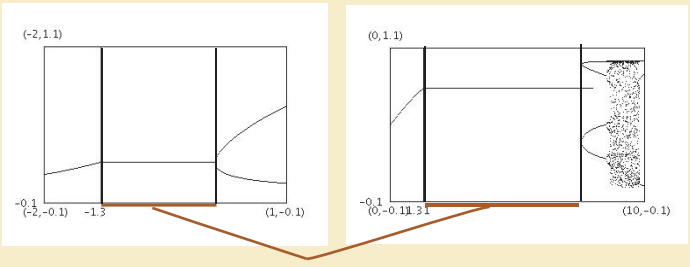
Investigation of stabilisation behaviour in one and two neuron networks under slow variation of external input.

Inhibitory and excitatory neurons, different connectivity structures.

*Hypothesis*: The proposed neuron model achieves homeostatis of neural activation for some parameter domains, in both, the single neuron and networks of two coupled homeostatic neurons.

a) b)






Homeostatic interval

**Two neuron network:**

Input value domains in which the whole system is homeostatic were found for almost all set-ups.

Additionally, stationary, periodic, quasi-periodic and chaotic behaviour could be observed.

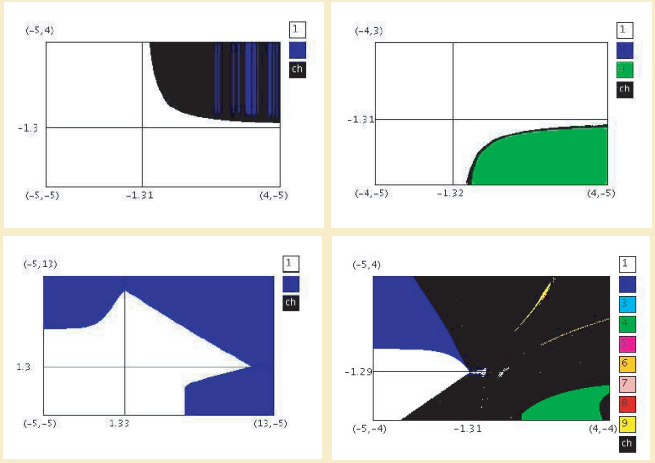
In experiments with an excitatory and an inhibitory neuron, sometimes, adaptative tendencies cancel each other out and prohibit homeostasis.

System dynamics during homeostasis mainly correspond to the dynamics observed in non-plastic networks.

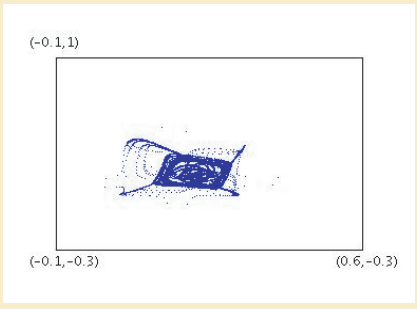
## Results:

**Single self-coupled neuron:**

Parameter domains in which the neuron had a finite homeostatic interval of external changes it could adapt to could be identified. Asymptotic behaviour outside these intervals was versatile.




Isoperiodic plots for different experimental set-ups




(Probably) chaotic orbit in phase space

## Conclusions:

The proposed neuron model has homeostatic input value domains for almost all set-ups.

- *How could homeostatic neurons produce adaptive behaviour if their activity is static?*
+ Interactive dynamics are assumed to be *transient dynamics*.
  Also: the finity of the homeostatic domains allows variation of neural responses.

- *Does homeostasis guarantee adaptivity?*
+ No, the mechanism cannot be assumed to lead to purposeful behaviour in general.
  It is conjectured that evolutionary processes can employ the model adaptively.

**It is planned to employ the homeostatic neuron model in artificial evolution to test its adaptive capacity in different environments.**

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