Self-Organizing Maps

Gute Ideen in der Systembiologie
Marten Jäger & Thomas Schüler
Outline

- Self Organization in the nervous system
- SOMs in artificial neuronal networks
  - Kohonen nets
SOMs in the Nervous System


Self Organization

- process by which individuals organize their communal behavior
- no external influences
- examples:
  - molecular self-assembly (DNA)
  - flocking behavior (fish swarms)
  - human society
    - group thinking
    - herd behavior

http://www.faculty.iu-bremen.de/mhuett/images/research1.gif
Self Organization in the Nervous System

- structure of brain extremely complex
  - number of genes not sufficient to completely specify neural connectivity
  - self-organization of cells very likely

- requires external influences
  - from other regions of the NS
  - from sensory stimulation
Cerebral Cortex

- layer of cells on the brain surface
- lobes have different functions
  - information processing
  - thinking
  - perceiving
Cortical Organization

- layers are planar
- columnar structure

Obermayer (bibliography)

http://www.cerebromente.org.br/n05/opiniaoa/cortex4p.jpg
cortical map

- topographic map
  - local neighborhoods are kept
  - divergent projection
  - → better differentiation of nearby stimuli

http://www.bmo.physik.uni-muenchen.de/lehre/SS05/HaSeTheoBiopNeuro Netze/talks/kortex_karten.pdf

http://pharyngula.org/~pzmyers/neuro/chap9/
visual path

- retina cells project to the primary visual cortex
- nearby locations in the retina → neighboring locations in the cortex
- cortical maps
  - process all possible elements in natural scenes e.g.:
    - contours
    - texture
    - color

http://webvision.med.utah.edu/imageswv/capas-cortex.jpg
primary visual cortex

- **ocular dominance**
  - response depends on the eye that gave the input

- **orientation selectivity**
  - response depends on orientation of the input pattern

http://hubel.med.harvard.edu

http://www.vnc.brain.riken.jp/simulator/sample/C

http://fourier.eng.hmc.edu/e180/handouts/figures/
Hebbian learning

- basis for the network’s ability to learn
Hebbian learning

- cells that fire together, wire together

http://openwetware.org/images/thumb/e/ed/Hebbian.bmp/
neural networks

- natural neural networks
  - lead to abstract models
  - → uncover basics in neural information processing
  - transfer knowledge to technical appliances

http://www.weiprecht.de/ANN/knn.pdf
structure of cortical maps

- Pattern Formation by unsupervised learning
  - competitive learning networks
  - cells strongly coupled, coupling is essential for their specific properties

- Kohonen
  - algorithm for self-organizing feature maps
  - explains development of cortical maps
  - creates dimension reducing maps
Bibliography


  - Self–organization
  - Molecular_self–assembly

- [Neural Nets by Kevin Gurney](http://www.shef.ac.uk/psychology/gurney/notes/)