UNIVERSITY
OF OSLO

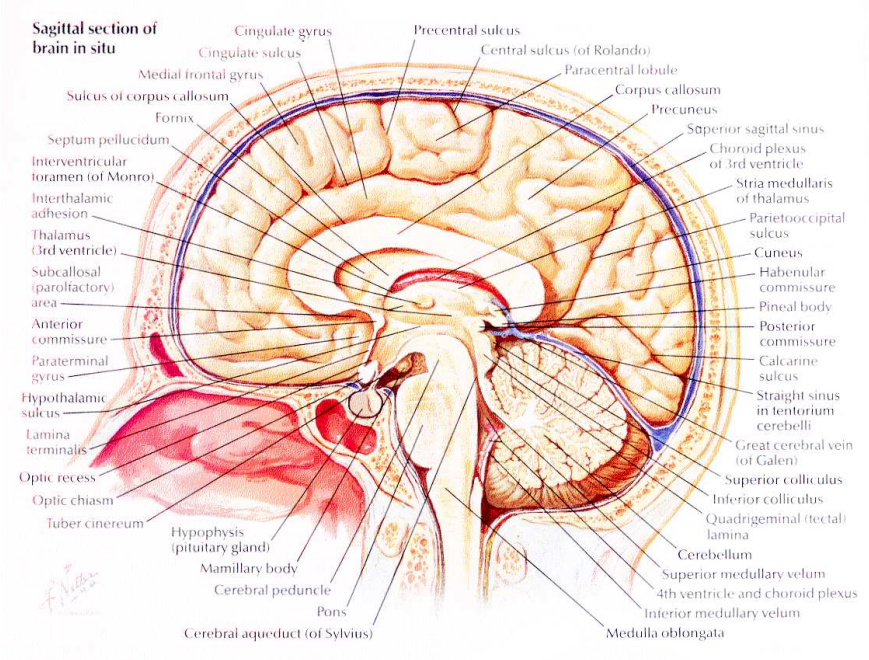
MES
Mikro Elektroniske Systemer

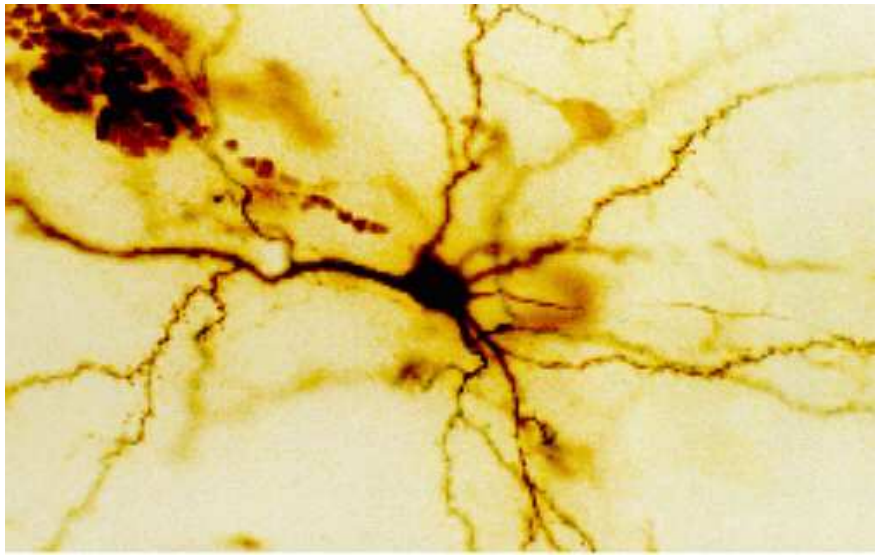
Neuromorphic Electronics

Introduction

Philipp Häfliger *hafliger@ifi.uio.no*

Brain Parts


Sagittal section of brain in situ
Cingulate gyrus
Cingulate sulcus
Medial frontal gyrus
Sulcus of corpus callosum
Fornix
Septum pellucidum
Interventricular foramen (of Monro)
Interthalamic adhesion
Thalamus (3rd ventricle)
Subcallosal (paroltactory) area
Anterior commissure
Paraterminal gyrus
Hypothalamic sulcus
Lamina terminalis
Optic recess
Optic chiasm
Tuber cinereum
Hypophysis (pituitary gland)
Mamillary body
Cerebral peduncle
Pons
Cerebral aqueduct (of Sylvius)
Precentral sulcus
Central sulcus (of Rolando)
Paracentral lobule
Corpus callosum
Precuneus
Superior sagittal sinus
Choroid plexus of 3rd ventricle
Stria medullaris of thalamus
Parietooccipital sulcus
Cuneus
Habenular commissure
Pineal body
Posterior commissure
Calcarine sulcus
Straight sinus in tentorium cerebelli
Great cerebral vein (of Galen)
Superior colliculus
Inferior colliculus
Quadrigeminal (tectal) lamina
Cerebellum
Superior medullary velum
4th ventricle and choroid plexus
Inferior medullary velum
Medulla oblongata



The biggest mystery

The human brain is maybe the biggest mystery left to explore. 10^{11} neurons with about 10^4 connections to other neurons each: The combiatorial possibilities for the network connections alone are stagering. An infinite number of electrical and chemical processes going on. How to know, which ones are important for the functioning?

How does the damned thing work?

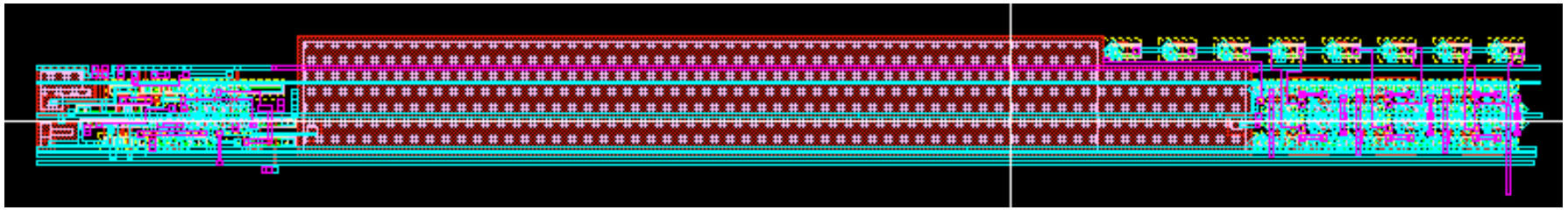
Methods

Two approaches to understand the nervous system

- top down, describe the black-box (psychology, AI)
- bottom up, take it appart and start with its components (Neuroanatomy, Neurophysiology)

Conclusion

We are no way near to an understanding of the system good enough to copy it. AI does not exist.
Some subsystems of the nervous system, however, are thoroughly explored and described and in part understood.



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A Definition of 'Understanding'

One understands something if one is able to build that thing.

Neuromorphic engineering uses the organizing principles of the nervous system to construct electronic devices. The profit is twofold:

- A better understanding of the operation of parts of the nervous system
- Efficient computational devices that are completely differently organized than computers

Computer vs. Brain

Computer	Brain

Computer vs. Brain

Computer	Brain
Serial	Parallel
One powerful central CPU, memory	10^{11} simple distributed computational and memory units
Busses shared by several components	Dedicated local point to point connections
Not very power efficient (needs cooling)	Very power efficient (hair to keep it warm ;-))
Digital, time-discrete	Analog, continuous time
Programmed	Learning
Sensitive to errors	Robust to errors (using redundancy)

Course

Teaching 15 lectures, lecture script (chapters handed out in lecture), selected papers

Exercises 4 projects (coding, I&F neuron, photocell, cochlea), workgroups with up to 2-3 students

Tools Matlab, solder iron, lab equipment

Skills electronics, biology, maths, programming, psychology, physics

Exam Oral, early in December (to be discussed)

Weekly homework

Example questions for the oral exam Try to answer the questions for each chapter with a short 5-10 minutes talk. If you manage all questions in the collection, you are well prepared for the exam.