Computational Brain Science at CST, CSC, KTH

Örjan Ekeberg, Erik Fransén, Jeanette Hellgren Kotaleski, Pawel Herman,
Arvind Kumar, Anders Lansner and Tony Lindeberg

Mission

The scientific mission of the Computational Brain Science Lab at CSC is to be at the forefront of mathematical modelling, quantitative analysis and mechanistic understanding of brain function.

We perform research on:

- computational modelling of biological brain function and on
- developing theory, algorithms and software for building computer systems that can perform artificial brain-like functions.

Our research answers scientific questions and develops methods in these fields.

We

- integrate results from our science-driven brain research into our work on brain-like algorithms

and likewise

- use theoretical results about artificial brain-like functions as hypotheses for biological brain research.

Biological brain research

Our research on biological brain function includes:

- sensory perception (vision, hearing, olfaction, pain),
- cognition (action selection, memory, learning) and
- motor control

at different levels of biological detail (molecular, cellular, network) and mathematical/functional description.

Methods development for investigating biological brain function and its dynamics as well as dysfunction comprises

- biomechanical simulation engines for locomotion and voice,
- machine learning methods for analysing functional brain images,
- craniofacial morphology and
- neuronal multi-scale simulations.

Projects are conducted in close collaborations with Karolinska Institutet and Karolinska Hospital in Sweden as well as other laboratories in Europe, U.S., Japan and India.

Brain-like computing

Our research on brain-like computing concerns:

- methods development for perceptual systems that extract information from sensory signals (images, video and audio),
- analysis of functional brain images and EEG data,
- learning for autonomous agents as well as
- development of computational architectures (both software and hardware) for neural information processing.

Our brain-inspired approach to computing also applies more generically to other computer science problems such as pattern recognition, data analysis and intelligent systems.

Recent industrial collaborations include analysis of patient brain data with MentisCura and the startup company 13 Lab bought by Facebook.

Vision

Our long term vision is to contribute to:

- deeper understanding of the computational mechanisms underlying biological brain function and
- better theories, methods and algorithms for perceptual and intelligent systems that perform artificial brain-like functions

by

- performing interdisciplinary and cross-fertilizing research on both biological and artificial brain-like functions.

Philosophy

On one hand,

- biological brains provide existence proofs for guiding our research on artificial perceptual and intelligent systems.

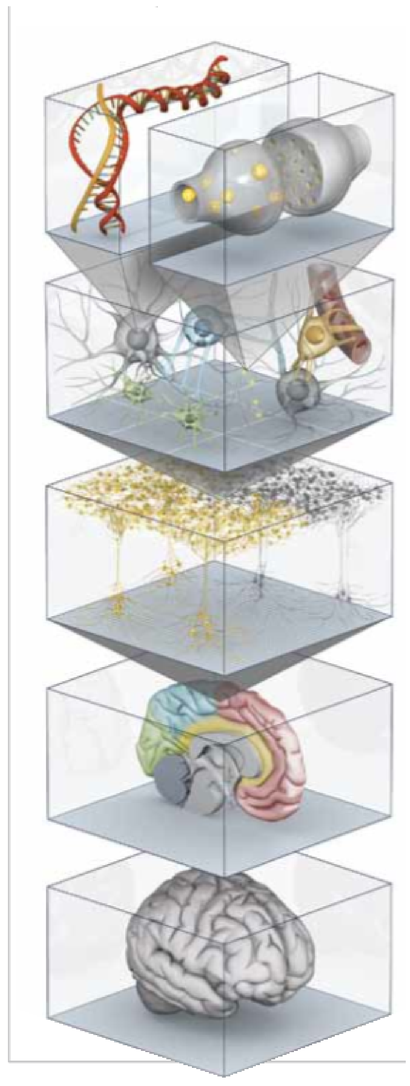
On the other hand,

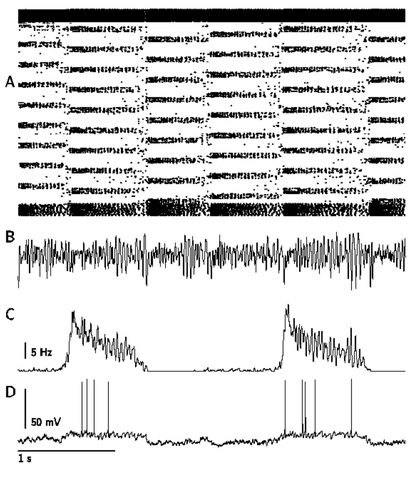
- applying Richard Feynman's famous statement "What I cannot create I do not understand" to brain science

implies that

- we can only claim to fully understand the computational mechanisms underlying biological brain function if we can build and implement corresponding computational mechanisms on a computerized system that performs similar brain-like functions.

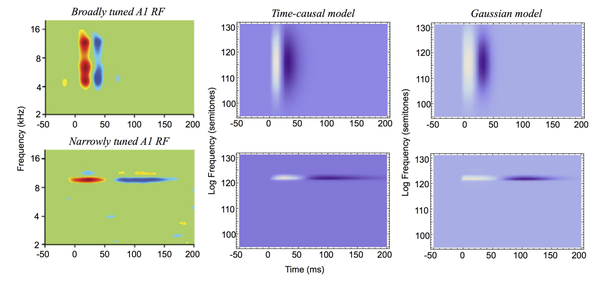
The brain at different scales



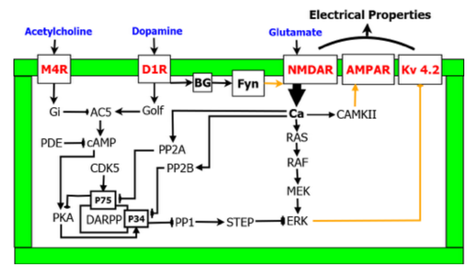


Sample research topics

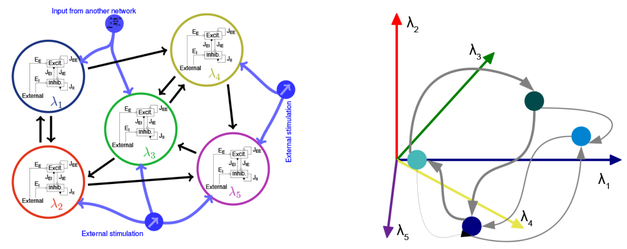
Theory of visual and auditory receptive fields (Tony Lindeberg)



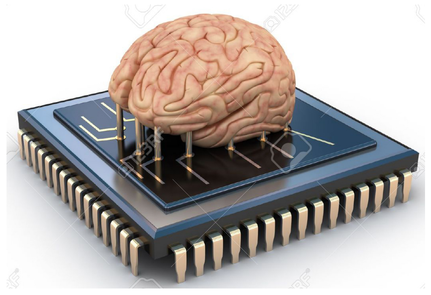
Modelling ion channels in the basal ganglia (Jeanette Hellgren Kotaleski)



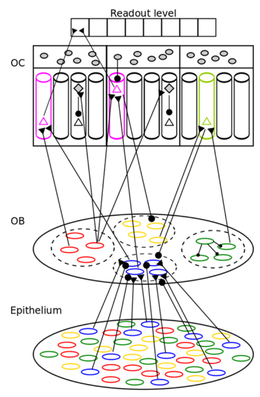
Dynamics of brain networks (Arvind Kumar)



Brain-like computing architectures (Anders Lansner)



Cortex-inspired information processing networks (Pawel Herman)



Neuromuscular control (Örjan Ekeberg)

Mechanisms for chronic pain (Erik Fransén)