CCNM17-CN-103: Cognitive Informatics in Human Vision
Course Description

Aim of the course

Aim of the course: The course will cover cognitive and computational aspects of human vision that extends beyond biological vision. It will start with a historical overview of major technological inventions that influenced our understanding of human vision. Each lecture will frame the topic according David Marr's levels of explanations. Then, through a variety of examples the course will step-by-step introduce information theory from Shannon information to the formalism of mutual information and finally the Bayesian model. In the course we will overview the major pathways of visual information processing, discuss the differences between bottom-up, top-down and reverse hierarchy models. Special focus will be given to different perceptual biases, signal detection, choice-probability, game theory and decision-making. The second half of the course will cover higher visual functions, object recognition, semantics, spatial cognition, visual imagery, causality perception, active vision and eye movements. These functions will be illustrated through models using neural networks, machine learning algorithms and artificial intelligence examples. Disorders of vision will be discussed. Finally, the course will end with an outlook to the future by discussing brain-machine interfaces and neural enhancements along with their potential clinical and everyday applications.

Learning outcome, competences

knowledge:

- complex nature of the higher order cognitive mechanisms

attitude:

- comprehensive theoretical interest

skills:

- ability to test theoretical questions and for relevant hypotheses

Content of the course

Topics of the course

- Introduction to Computational Approaches to Visual Processing
- The Hierarchy of Visual Processing
- Perceptual Decision Making: Classical approaches
- Classical approaches II.: Drift Diffusion Model
- Bayesian Models of Perceptual Decisions
- Predictive Coding, Confidence
- Attention, Multisensory integration
- Reinforcement Learning, Exploration /Exploitation
- Active Vision and Eye Movements
- Modeling Sensory Abnormalities in Psychiatric Disorders
- Visual Recognition in Deep Neural Networks
- Brain-computer interface

Learning activities, learning methods

Lectures and interactive discussions

Evaluation of outcomes

Learning requirements, mode of evaluation, criteria of evaluation:

requirements

- active participation at the lectures.
- Programming Tutorials
- Final Project
- Lecture Exam, which can be substituted by submitting a short weekly reading summary

mode of evaluation:

- examination and practical course mark, 1-5 grades

criteria of evaluation:

- quality and quantity of knowledge encomppasing the course
- quality of pracitcal exercises, homework, essays

Reading list

Compulsory reading list

- Hoffman, D. D. (1998). Visual intelligence: how we create what we see (1st ed.). New York: W.W. Norton.
- Marr, D. C. (1982). Vision: A Computational Investigation into the Human Representation and Processing of Visual Information. New York: Freeman.
- Zeki, S. (1993). A vision of the brain. Oxford ; Boston: Blackwell Scientific Publications.
- Rieke, F., Warland, D., van Steveninck, R. R., & Bialek, W. (1997). Exploring the Neural Code (Computational Neuroscience). Cambridge MA: Bradford Book - MIT Press.

Recommended reading list

- If any, it shall be specified in the course description for each semester.