ITI Cognitive Engineering

Module 1: repairing/augmenting the brain
Overview

General question: how does the brain learn?

- **repairing the brain**
  - sensory and motor interfaces (I,II)
  - neurocognitive interventions (I,II)

- **augmenting the brain**
  - neuroeducation (I,II)

- **modeling brain plasticity** (I,II,III)
  - biophysics, spikes, supervised, unsupervised, & reinforcement learning

- **ethics**
Sensory and motor interfaces (I)
(Alain de Cheveigné)

- Brain-computer interfaces, Thorsten Zander, TU-Berlin
  - the need
  - technology (overview)
  - potential and limitations
  - usability, plasticity, and learning
  - challenges and perspectives
Sensory and motor interfaces (II)
(Alain de Cheveigné)

- Cochlear and brainstem implants, **David McAlpine and Jessica Monaghan**, UCL Ear Institute
  - the cochlear implant: a success story
  - basics of normal and impaired auditory anatomy, physiology and function
  - implant technology, industrial and clinical aspects
  - hearing with an implant
  - success and failure
  - challenges and perspectives: brainstem and midbrain implants, electro-acoustic stimulation, binaural stimulation, optical stimulation, optogenetics, regeneration, pharmaceutics, learning and plasticity
Neurocognitive interventions (I)
(Anne Catherine Bachoud Levi/Charlotte Jacquemot, 26 septembre, 9am-1pm)

● repairing cognitive functions
  ○ functional models of cognition
  ○ localizing a deficit
  ○ cognitive training
● grafts and genetic therapies
  ○
● biblio
  ○
Neurocognitive interventions (II)
(Jean Lorenceau/ACBL, 3 octobre, 9am-1pm)

- Part I: Eye movements and applications
  - control of eye movements
  - pupil dilation
  - applications

- Part II: Practical neuroethics
  - benefit/risk balance
  - informed consents in cognitive impairment
  - placebo and control groups

- biblio
Pedagogy and social learning

● Topics
  ○ How we (and other animals) learn from others
  ○ Teaching others

● Contents
  ○ Social learning mechanisms
  ○ Natural pedagogy
  ○ Selective trust
  ○ Cultural transmission and the making of human nature
  ○ The evolved apprentice

● Biblio (* = un peu difficile)


Is technology making us stupid?

● Topics
  ○ The concept of evidence-based in educational technologies
  ○ Myths: brain gym, digital natives, multitasking, the stultifying effects of ICT, etc.
  ○ Collective intelligence, distributed cognition
  ○ Really useful technology

● Contents
  ○ From teaching machines to technology-inspired education
  ○ Serious games and motivation
  ○ The extended mind

● Biblio
Modeling brain plasticity (I)
(Srdjan Ostojic)

- **General introduction** (Ostojic)
  - basic models of neurons and synapses
  - different types of plasticity and learning
  - brain-inspired algorithms

- **Biophysical models of plasticity** (Graupner)
  - experimental evidence for synaptic plasticity
  - biophysical processes underlying induction and maintenance of plasticity
  - modeling biophysical processes
  - studying pharmaceutical interventions using biophysical plasticity models
Modeling brain plasticity (II)
(Srdjan Ostojic)

- Spike-based models of plasticity (Gerstner)
  - spike-time dependent plasticity

- Machine learning and applications (Dreyfus)
  - Getting inspiration from the brain: basic concepts of machine learning
  - Applications (computer-aided medical diagnostic and therapy, intelligent prosthesis, computer-aided drug design, BCI…)

Modeling brain plasticity (III)
(Srdjan Ostojic)

● Supervised learning (Nadal)
  ○ Perceptrons: Rosenblatt’s perceptron, the perceptron algorithm, learning capacity, hebbian learning, the Willshaw model, learning from examples
  ○ Beyond the simple perceptron: support vector machines, deep learning, applications to classification

● Reinforcement learning (Khamassi)
  ○ Classical conditionning
  ○ predictions error and dopaminergic activity
  ○ applications to robotics

● Bibliography
Neuroethics and education

- **Topics**
  - The two general problems of neuroethics
  - The special problem of cognitive enhancers
  - The specious attraction of neuroimaging images

- **Contents**
  - Does our brain relieve us of responsibility?
  - Is it OK to change our brains permanently or temporarily to perform better intellectually?
  - What’s the difference with education as an cultural cognitive enhancer?
  - What do images from fMRI actually tell us?

- **Biblio**