BSCS 2019

# CognitiveInformatics I.

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Cognitive Informatics is a transdisciplinary enquiry on the internal information processing mechanisms and processes of the brain and the mind, the underlying abstract intelligence theories and denotational mathematics, and their engineering applications in cognitive computing and computational intelligence (ICIC, http://www.ucalgary.ca/icic/).

The central questions of this course are the relation of the neural structure and function, the nature of the neural code and neural implementation of basic neural functions as learning and reacting. The mathematical details of the supervised, unsupervised and reinforcement learning algorithms will analyzed. Then, we will use them to describe solutions and possible neural implementations of high level functions in the neural system, particularly focusing to the learning and navigation in an unknown environment and we will study neural models of animal/animat navigation which can solve such problems in real life environments.

The course will concentrate on that, how mathematics can be used to describe the emergence of neural function, from the structure and dynamics of the neural system. Science major and calculus is a great advantage for this course but it will provide interesting insight to our up-to date understanding of the brain potentially for anyone.

Background info: The Encyclopeida of Computational Neuroscience is under development:
http://www.scholarpedia.org/article/Encyclopedia_of_computational_neuroscience
You may find many interesting articles there.

Day 1: Theory of learning and its neural implementations: supervised, unsupervised and reinforcement learning in neural networks. The concept of dynamical systems and the attractors. Classical examples for learning neural networks: Perceptron, Hopfield-network, self-organizing maps, actor-critic learning, Biological implementation of learning: from Hebb's-rule to spike-time dependent plasticity.

Readings:
http://www.scholarpedia.org/article/Reward
http://www.scholarpedia.org/article/Temporal_difference_learning
http://www.scholarpedia.org/article/Models_of_synaptic_plasticity
http://icwww.epfl.ch/~gerstner/SPNM/node69.html
Érdi P and Somogyvári Z: Post-Hebbian learning algorithms
in Handbook of Brain Theory and Neural Networks:
http://www.rmki.kfki.hu/~erdi/erdi_p2.pdf

Day 2: The learned phenomena will be applied for an attempt to solve a puzzle of an ancient cortical area: the hippocampus. The specific anatomy and electro-physiology will be learned with special attention to the hippocampal oscillations.
http://en.wikipedia.org/wiki/Place_cell
http://www.scholarpedia.org/article/Grid_cells

Day 3: The basic requirements of navigational strategies and the functional correlates of the cellular activity, the possible role of place cells and grid-cells in the spatial representation and the episodic memory will be reviewed. A model of hippocampal dependent navigation using temporal difference learning rule. Hippocampus vol. 10, page1-16
http://www.kfki.hu/~soma/BSCS/Foster00.pdf

Day 4: The question of the neural code will be raised and functional models of the hippocampus will be built up by using the concept of attractor networks for the possible role of the hippocampus in navigation and episodic memory.
The description of the discussed models:
Arleo and Gerster:
Spatial cognition and neuro-mimetic navigation: a model of hippocampal place cell activity. Biological Cybernetics vol. 83, page 287-299 (2000)
http://www.kfki.hu/~soma/BSCS/Arleo00.pdf

Trullier and Meyer: Animat navigation using a cognitive graph. Biological Cybernetics vol. 83, page 271-285 (2000)
can be downloaded from:
http://www.kfki.hu/~soma/BSCS/trullier00.pdf