**Faculty common course 2021**

English course title: Brain-Inspired Computing

Swedish course title: hjärninspirerade dator

Extent (credits): 5

Language of instruction: English

Recommended prerequisites: electronics, basic physics, university mathematics (calculus, linear algebra)

Learning outcomes of the course: Upon completion of the course, the student shall be able to (1) understand the biological aspects and the physical models at different levels of individual neurons, (2) calulate and predict neuronal activities using the leaky integrate-and-fire (LIF) model of neurons, (3) master the mathematical tools of phase plane analysis to describe the dynamics of neurons, (4) explain the biological aspects and physics of synaptic connections and their roles in learning process, (5) describe population activities, (6) discuss the physics underying the cognitive processes in the brain, e.g., memory, perception and feature recognition, (7) know how the knowledge of neuroscience is applied to develop the new generation AI computation model, spiking neural networks (SNN), and (8) understand how the state-of-the-art neuromorphic hardwares implement the principles of SNNs by using e.g., IBM TrueNorth chip and Intel Loihi as examples.

Specify which learning outcomes of the doctoral degree that are address/covered (see appendix 1 of the call or the template of ISP). Describe how: Upon completion of the course, the third-cycle students shall (1) obtain broad knowledge of neuromorphic computing spanning from the working principles of the brain to the emulation of the brain-like computing implemented in software and hardware, (2) be familiar with, at advanced and in-depth level, the physical models of neuronal systems, (3) acquire up-to-date knowledge in brain-inspired SNN computation model and the hardware implmentation, (4) be familiar with the method of phase plane analysis, equivalent electrical circuit used for analysis of the dynamics of neuronal systems.

Course contents: This course introduces biophysical models of neurons and explores working principles of computation in biological and artificial neural networks. The contents of the course include a series of lectures and hands-on exercises in (1) the essence, history, strength, applications and the science base of the brain-inspired neuromorphic computing, (2) the biological facts and physical models of individual neurons, (3) the phase plane analysis of physical models of neurons, (4) the biological facts and physical models of synaptic connections, (5) the learning mechanisms with the dynamics of sysnapse, (6) the physics of neuronal population, (7) the dynamics of cognitive processes, e.g., perception, memory, recogintion, (8) the fundamentals and learning rules of SNN, and (9) the architectural design of neuromorphic chips with IBM TruethNorth or Intel Loihi as examples. Assignments following all lectures. The main course materials include "Neuroscience" (by Dale Purves etc., Oxford University Press for biological facts about the brain), "Neuronal Dynamics" (by Wulfram Gerstner etc., Cambridge University Press for the physics of neuronal systems), and a list of review and research articles.

Instruction (course structure): Lectures, tutorials and assignments

Assessment (form of examination): The students will get 4 credits upon actively attending the lectures and tutorials and passing the written examination at the end of the course, and 1 credit upon completing the assignements.

Course examiner (name, e-mail): Dr. Zhibin Zhang, zhibin.zhang@angstrom.uu.se

Department with main responsibility: Department of Electrical Engineering

Contact person/s (course responsible teacher) (name, e-mail): Zhibin Zhang, zhibin.zhang@angstrom.uu.se

Course dates/period: from May, 2021, 6 weeks

Maximum number of participants: 20

Submit the application for admission to:

Submit the application not later than: