Neuro System Design	
Offered by	Department of Electrical Engineering
Language	English
Primarily interesting for	Electrical Engineering, Biomedical Engineering, Computer Science and Engineering, Applied Physics
Prerequisites	Required: Electronics (5ECB0, 5ECC0 or 5XCA0), Linear algebra (2DE20 or a similar course) Recommended: Computation (5EIA0 or 2IP90 & 2IC30)
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Content and composition

This elective package focuses on analysis and interpretation of neurological data as well as circuit design for analysis of neural signals and stimulation of the neural system. We start the courses with introducing the fundamental structures and algorithms of neurological and neuromorphic data processing, and show how this relates to current trends in AI. With this basis we take a closer look at health electronics and cover the low-power circuit design techniques used for data collection and early processing. Finally, we also look at the implementation of the data processing algorithms on modern mixed signal hardware accelerators.

Overall, this elective package should give you a good overview of the current techniques involved in neurological data acquisition and processing, as well as, teaching you the skills to start working on your own projects in the topic.

Course code	Course name	Level classification
5XSL0	Fundamentals of machine learning	3, advanced
5XCC0	Biopotential and neural interface circuits	3, advanced
5XIF0	Neuro computation	3, advanced

The preferred order for students to follow the courses is as stated above: 1st 5XSL0, 2nd 5XCC0, and 3rd 5XIF0.

Course description

5XSL0 Fundamentals of machine learning

We live in the age of data. The amount of data has been increasing at an exponential rate over the last decades and is expected to continue. Not only is the volume of the data larger than ever before, also the variety in types of data is consistently growing. Due to the enormous progress in sensor technology, we can measure more than ever before. The vast amounts of heterogeneous data harbor useful information that can help in e.g. disease detection, natural language processing and accident prevention. However, due to its growing volume and complexity, it becomes increasingly harder for humans to extract this information by manually analyzing the patterns in the data. Machine learning is a subfield of Artificial Intelligence (AI) that focuses on building mathematical models that can extract information from data by learning from examples. This course aims to offer a solid theoretical basis for modern machine learning methods. It will teach students the mathematical foundations of machine learning, introduce a number of elementary techniques and discuss methods for evaluation of model performance. These concepts are the fundamental building blocks of modern AI approaches, such as deep learning, and offer insight and understanding in the workings of such models.

5XCC0 Biopotential and neural interface circuits

This course gives an overview of low-power IC design techniques in the healthcare domain, with special focus to interfaces for the acquisition of neural signals and stimulation of the neural system. It also gives you the opportunity to practice these concepts in several circuit design assignments. Contents: Health applications, electronics fundamentals, low power design principles, low power analog and digital design, amplifiers, filters, ADCs, layout techniques, biomedical circuits, bio-inspired circuits, neural interfaces, Cadence software tutorials (schematic and layout), design assignments.

5XIF0 Neuro Computation

Current artificial intelligence approaches do not scale well; they constantly require more energy and data. Thus, researchers are taking inspiration from the brain to develop a new generation of efficient and bio-inspired artificial neural networks to mimic the effectiveness and efficiency of biological neural systems. This involves studying the computational properties of neural systems and designing specialized "neuromorphic" hardware architectures that support bio-inspired neural networks. The Neuro Computation course aims to teach students about the fundamental characteristics of neural circuits and their computational properties. Additionally, it will teach students how to design spiking neural networks using analog "neuromorphic" electronic circuits, which can express complex non-linear dynamics and are endowed with adaptation and online learning mechanisms. Content: basic neuroscience knowledge, mixed-signal neuromorphic circuits, systems, and architectures.