Course Package

Physiological Signals and Systems - 2B

Name module	Physiological Signals and Systems - 2B
Educational programme	MSc Biomedical Engineering
Period	Second block of the second semester (block 2B)
Study load	15 ECTS
Coordinator	J. Huttenhuis

Physiological Signals and Systems			
block 1A	**block 1B**	**block 2A**	**block 2B**
			Bioelectromagnetics - 201400282 (5 EC) Or **Topics in Human Anatomy - 200900040** (5 EC)
			Dyn. Beh. Of neural networks - 193810100 (5 EC) Or **Optimal est. in Dyn. Systems - 191210920** (5 EC)
			Identification of Human Physiological Systems - 201700071 (5 EC)

Required preliminary knowledge: BSc in Biomedical Engineering, Technical Medicine or another relevant technical BSc. Knowledge of MatLab is preferred. Basic Knowledge of Anatomy and Physiology. Signal Analysis (incl. Sampling, Fourier Transform, Filtering, Windowing), Matlab basic programming skills

201400282 **Bioelectromagnetics**
In this course a general introduction into the theory of volume conduction of ionic currents (bioelectric sources), based on the quasi-static expression of Maxwell's equations, is presented. This generalized, mathematical approach can be applied to the various electrophysiological and biophysical processes underlying the generation of bioelectrical activity (nervous system and muscles) which generate the electrical and magnetic signals that can be measured on the body surface, such as the electroencephalogram (EEG), the electrocardiogram (ECG), the electromyogram (EMG) and the electroneurogram (ENG). These signals are clinically relevant because they provide information on the (patho)physiological condition of the corresponding tissues.

The modules are tentative and subject to change. Please check the website regularly.

200900040 **Topics in Human Anatomy**
This course will focus at different topics in the field of human anatomy and physiology with a focus on sport injuries and physiology. Lectures and practical courses will be used alternatively. In addition, guest speakers who are experts in the field of sport injuries and rehabilitation will provide one or more lectures. The course will be examined by a written exam and three assignments throughout the course. Some lectures/practicals will be held at Roessingh Research and Development.

193810100 **Dynamic Behaviour of Neuronal Networks**
Complex networks of interacting neurons define the physiological properties of various brain functions, including motor control, language, perception, autonomic control, and memory. Intuitive reasoning about these networks is often sufficient for some global understanding or guiding a particular treatment or experiment. A more profound understanding, however, will provide tools to contribute to new developments and insights, relevant for improved diagnostics and innovative therapeutic approaches.

In the 2nd year course (Neural System), various issues related to membrane and network dynamics were touched upon. The emphasis, however, was rather conceptual, and various issues were treated at the introductory level. This course will present a much more in-depth treatment of physiology and dynamic behaviour of neurons and neural networks. From the clinical perspective, this will be integrated in relation with various diseases of the central or peripheral nervous system and the EEG.

We will discuss basic concepts from nonlinear dynamics, including equilibrium, limit cycles, homoclinic orbits, stability and synchronization. Modeling and simulation will be introduced to better understand individual behavior of neurons and their interactions.

Various examples from basis neuroscience to clinical neurology and neurophysiology will be treated, with an emphasis on epilepsy, ischaemia and neuromodulation (e.g. for the treatment of seizures or movement disorders). The course also discusses how modeling and simulation can contribute to a better understanding of normal and pathological EEG rhythms.

191210920 **Optimal Estimation in Dynamic Systems**
The course addresses the following problem: How to estimate the dynamic quantities in a physical process given the data from a sensory system? Although the applications are wide: (ranging from production processes, water management, orbit determination, telecommunication and so on), the course will concentrate on robotic applications: navigation and tracking. Especially, the SLAM problem will be addressed. SLAM = simultaneous localisation and mapping, e.g. a mobile robot that has to navigate within an unseen environment. The course will familiarise the student with methods for the estimation of state variables in dynamic systems. The course starts with an introduction of the topic 'parameter estimation' which is the fundament for state estimation. After that, the estimation paradigm will be embedded in a dynamic framework. For linear-Gaussian systems this leads to the well-known Kalman filter which is an online estimation method. An extension of the Kalman filter makes it applicable to offline estimation, and to prediction. For nonlinear dynamic systems, the so-called 'extended Kalman filter' is a suboptimal solution which only works well if the nonlinearities are not severe and the disturbances are Gaussian. Another estimation method is the 'particle filter'. This method is generally applicable, and is optimal, but it is computationally intensive. An important aspect of the course is bringing a theoretical concept to a practical solution. Students that attend this course will design an estimator for a given navigation process. Various estimation methods (e.g. Kalman, extended Kalman, particle filtering) will be tested and evaluated with a tracking and SLAM problem. Matlab is used as a development platform.

201700071 **Identification of Human Physiological Systems**
Distorted physiological control systems underlie various impairments in motor control, respiration and cardiovascular function. For instance, a hyperactive control loop to regulate muscle length is the underlying cause for spasticity. Clinicians are perfectly able to see that something is wrong and can use available clinical scales to quantify the severity of the impairment or disability. However, they are much less able to see what is wrong. System identification techniques make it possible to characterize the distorted physiological control systems for various conditions in a standardized way. In this course, we will cover different approaches and techniques to be able to identify a linear system. The addressed topics vary from correlation functions, identification in the frequency and time domain, open and closed loop system identification, perturbation signal design and parameter estimation and optimization. In the course we will focus on distorted human motor control. Yet, the learned methods and techniques can be applied to a wide range of physiological and technical systems.