Tentative Summer school course schedule – UNIZG Faculty of Electrical Engineering and Computing (FER), UNIZG School of Medicine (MEF)

UNIZG Faculty of Electrical Engineering and Computing (FER)

1. day - Neurophysiological signal processing and analysis

Lectures 9:00 – 13:00

Neurophysiological signal features and recording techniques (3 hours)

Prof. Mario Cifrek, PhD / Assoc. Prof. Željka Lučev Vasić, PhD

Bioelectric potential and signal sources. Physical model of an excited neuron. Recording techniques of electrical and non-electrical biological signals. Physiological recordings and activation techniques.

Neurophysiological signal processing fundamentals (2 hours)

Prof. Igor Lacković, PhD / Assoc. Prof. Željka Lučev Vasić, PhD

Statistical signal properties. Stationary and ergodic signals. Basic methods in neurophysiological signal processing. Signal analysis in amplitude, time and frequency domain.

Lectures 15:00 - 18:15

Time-frequency analysis of biomedical signals (2 hours)

Prof. Mario Cifrek, PhD / Prof. Igor Lacković, PhD

Short-time Fourier transform. Spectrogram. Wavelet transform. Hilbert-Huang transform. Examples of applications.

Biomedical signal processing in psychophysiological studies (2 hours)

Mirta Zelenika Zeba, PhD / Krešimir Friganović, PhD

Psychophysiology studies interactions of psychological processes and physiological activity underlying cognition, emotion, and psychopathology. Students will be introduced to the methodological and computational aspects of physiological signal processing and psychological processes.

2. day – Neurophysiological diagnostic procedures (at KBC Zagreb)

Lectures 9:00 – 13:00

Signal analysis methods in neurophysiological diagnostics (1.5 hours)

Assist. Prof. Magdalena Krbot Skorić, MSc EE, PhD

The main focus of the neurophysiology is functioning of the central and peripheral nervous system. Different techniques are used for the examination of specific features of the nervous system. Students will be introduced to the methods for the signal analysis in the neurophysiological diagnostics.

Electroencephalography (EEG) in clinical practice (1.5 hours)

Prof. Željka Petelin Gadže, MD, PhD

Students will learn the techniques related to electroencephalography, method used for the analysis the electrical brain activity, useful in different clinical conditions.

Evoked potentials (EP) in clinical practice (1.5 hours)

Tereza Gabelić, MD, PhD

Students will learn about the techniques related to evoked potentials, methods which record signals evoked in the brain and nervous system, as the response to specific stimulus.

Laboratory exercise: Applications of signal analysis methods in neurophysiological diagnostic procedures (15:00 – 16:30) (2 hours)

Assist. Prof. Magdalena Krbot Skorić, PhD / Ivan Adamec, MD

Students will get insight in practical usage of different neurophysiological diagnostic devices.

Online lecture (16:45 – 18:15) (2 hours)

Prof. Ivana Išgum, PhD, Amsterdam UMC, Netherlands

3. day – Neurophysiological diagnostic procedures (at KBC Zagreb)

Lectures 9:00 – 13:00

Electromyography (EMG) in clinical practice (1.5 hours)

Prof. Ervina Bilić, MD, PhD

Students will learn about the techniques used in electromyography, electrodiagnostic procedure for recording and analysis of the activity produced by muscles.

Autonomic nervous system testing (1.5 hours)

Assoc. Prof. Mario Habek, MD, PhD

Students will learn about the different techniques for testing of the autonomic nervous system, responsible for different systems in the human body.

Polisomnography in clinical practice (1.5 hours)

Barbara Barun, MD, PhD

Students will learn about the polysomnography, method used for the analysis of the sleep quality and detection of the sleep disorders.

Laboratory exercise: Applications of signal analysis methods in neurophysiological diagnostic procedures (15:00 – 17:15) (3 hours)

Assist. Prof. Magdalena Krbot Skorić, PhD / Barbara Sitaš, MD / Ivan Adamec, MD

Students will get insight in practical usage of different neurophysiological diagnostic devices.

4. day – Nonlinear signal analysis and machine learning (at FER)

Lectures 9:00 – 13:00

Nonlinear signal analysis methods in medical applications (2 hours)

Assist. Prof. Ante Sekulić, PhD

Nonlinear dynamics of biological complex systems, like a human body, is studied by chaos inspired theories and methods: fractal dimension, correlation dimension, largest Lyapunov exponent, approximate entropy and spectral analysis. Medical applications are available giving useful results in clinical practice.

Machine learning applied to neurophysiological signals (3 hours)

Assoc. Prof. Alan Jović, PhD

Machine learning fundamentals. Machine learning tasks in neurophysiology. Data mining pipelines. Neurophysiological data acquisition. Feature extraction, dimensionality reduction, feature selection. Model evaluation and model selection. Imbalanced learning. Interpretable and black-box machine learning methods. Data privacy issues.

Laboratory exercise: Applications of machine learning methods in EEG analysis (15:00 – 16:30) (2 hours)
Ivana Čuljak, MSc, Igor Stančin, MSc, Eda Jovičić, MSc, Matija Roglić, MSc

Detection of drowsiness in multichannel EEG signals using machine learning approaches.

Online lecture (16:45 – 18:15) (2 hours)

Pavo Orepić, PhD, Department of Basic Neurosciences, University of Geneva, Switzerland

5. day – Deep learning of neurophysiological signals (at FER)

Lectures 9:00 – 11:15

Deep learning of neurophysiological signals (3 hours)

Assoc. Prof. Alan Jović, PhD

Deep learning fundamentals. Deep learning architectures. Deep learning approaches and applications in neurophysiology. Deep learning decision support systems in biomedicine. Explainable deep learning models.

Laboratory exercise: Deep learning in ECG analysis (11:30 – 13:00) (2 hours)
Ivana Čuljak, MSc, Igor Stančin, MSc, Eda Jovičić, MSc, Matija Roglić, MSc

Cardiac arrhythmias detection from multichannel ECG signals based on deep learning.

15:00 - 16:30 group discussion with UNIZG FER staff (2 hours)
Prof. Mario Cifrek, PhD, Prof. Igor Lacković, PhD, Assoc. Prof. Željka Lučev Vasić, PhD, Assoc. Prof. Alan Jović, PhD, Assoc. Prof. Mario Habek, PhD, Assist. Prof. Magdalena Krbot-Skorić, PhD, Prof. Ervina Bilić, PhD, Prof. Željka Petelin Gadže, PhD, Barbara Barun, MD, PhD, Tereza Gabelić, MD, PhD, Barbara Sitaš, MD, Assist. Prof. Ante Sekulić, PhD, Ivan Adamec, MD, PhD, Mirta Zelenika Zeba, PhD, Krešimir Friganović, PhD, Ivana Čuljak, MSc, Igor Stančin, MSc, Eda Jovičić, MSc, Matija Roglić, MSc

UNIZG School of Medicine, Department of Pharmacology – Molecular Neuropharmacology Lab rotation

1. Day - *Introduction to Neuropharmacology and modelling of human diseases.*

Lectures 9:00 – 13:00

Behavioral and molecular neuropharmacology of Alzheimer's disease (2 hours)
Prof. Melita Šalković-Petrišić MD, PhD

A bunch of molecules in the brain work together to provide biochemical basis for existence of complex phenomena such as consciousness, memory, or pain. Neuropharmacology aims to expoloit chemicals with the ability to modulate biological systems in order to exert beneficial effects on the homeostasis of the brain.

General principles of modelling of human diseases in animals (1 hour)
Prof. Melita Šalković-Petrišić, MD, PhD / Assoc. Prof. Jelena Osmanović Barilar MD,PhD

Understanding etiopathogenesis of complex human diseases and successful drug development require reliable animal models. The lecture will provide an introduction to key concepts of modelling human pathophysiology in animals.

Rat model of sporadic Alzheimer's disease (1 hour)
Ana Knezovic MBiol, PhD

Intracerebroventricular administration of streptozotocin (STZ-icv) is used to induce insulin-resistant brain state-mediated pathophysiological processes that resemble those found in patients suffering from Alzheimer's disease. Nauropathological and behavioral alterations in the STZ-icv model will be discussed.

Animal models of pain (1 hour)
Lidija Bach Rojecky, MPharm, PhD, Ivica Matak MBiol, PhD

Pain is a complex neuroscientific phenomenon defined as an unpleasant sensory/emotional experience resembling that associated with tissue damage. Animal models are often utilized in basic research to understand fundamental molecular processes that accompany painsul sensations, and elucidate potential targets for pharmacological abrogation of unpleasant sensations.

Laboratory exercise: Model induction (15:00 – 17:15) (1.5 hour)
1) Alzheimer's disease: Intracerebroventricular administration of streptozotocin
Ana Knezovic MBiol, PhD, Assist. Prof. Jelena Osmanovic Barilar MD, PhD, Ana Babic Perhoc MPharm, PhD, Davor Virag, MD
A demonstration of induction of the STZ-icv rat model of sporadic Alzheimer's disease.

2) Pain model induction (1.5 hour):
Ivica Matak MBiol, PhD, Petra Sostaric VMD, Patrik Meglic VMD, Dalija Vadjunec MPharm
Induction of formalin-induced orofacial pain, analysis of the acute nocifensive behavior and its correlation with cFos neuronal activation in the brainstem.

2. Day – *Behavioral testing in animals (data acquisition and statistical analysis). Introduction to Open Neuroscience – Part I*

Lectures 9:00 – 13:00

Behavioral tests in neuroscience research (1 hour)
Assoc. Prof. Jelena Osmanovic Barilar MD, PhD, Ana Knezovic MBiol, PhD

Behavioral tests in animals are fundamental part of neurosciences as they provide an insight in processes related to brain function. Different behavioral paradigms and their translational potential will be discussed.

Introduction to biostatistics (2 hours)
Prof. Vladimir Trkulja, MD, PhD

The complexity of neuroscientific principles make biostatistics a key tool of every neuroscientist enabling researchers to truly understand their results they obtain and biological processes they wish to explore. The lecture will introduce the students to the core concepts of biostatistics and its application in this type of research.

Conceptual and statistical framework for interpretation of behavioral data (1 hour)
Jan Homolak, MD, Davor Virag MD
Statistical analysis of behavioral data is has its peculiarities, and the failure to acknowledge them will often lead to misinterpretation of behavioral results. The lecture aims to elucidate some critical concepts of reliable design of behavioral experiments alongside the statistical framework and help students acknowledge the aforementioned as parts of a whole rather than its separate entities.

Open neuroscience – Introduction to Open Source Hardware and Software (1 hour)
Jan Homolak, MD, Davor Virag MD

Widely available low-cost electronics encourage the development of highly modular open-source tools for neuroscientific research that can be fully customized to address specific methodological challenges. Introduction to the concept and an overview of open neuroscience will be provided.

Laboratory exercise: Hands-on Fundamentals of Programming 1 (14:00 – 16:15) (3 hours)
Jan Homolak MD, Davor Virag MD

The students will learn basic concepts of microcontroller programming, and will be able to make their own simple open-source neuroscientific instruments.

Online lecture (16:45 – 18:15) (2 hours):

3. Day - *Behavioral testing in animals (data acquisition and statistical analysis). Introduction to Open Neuroscience – Part II*

(9:00 – 13:00) (2 hours)
Interactive seminar: Experimental design
Formation of two subgroups and problem oriented discussion with UNIZG mentors:
(The main goal of the seminar is to discuss disease models that are going to be used in the exercises with a focus on **technical context of model induction procedures**, define **main outcomes** students are going to assess and identify potential confounders that should be taken into account prior to defining a **strategy for experimental design** that is going to be used). For example, AD group will discuss how streptozotocin will be administered, what anesthetics are appropriate for the specific experiment, what type of behavioral assessment is the most appropriate and what time-point will provide the most reliable data in the context of specific analysis,… Pain group will discuss what type of pain induction procedure is the most appropriate for the specific experimental design, how the experimenter should approach the induction procedure, what type of control group will be used to best control for potential confounding factors, …

Alzheimer's disease group I

Ana Knezovic MBiol, PhD, Assoc. Prof. Jelena Osmanovic Barilar MD, PhD, Ana Babic Perhoc MPharm, PhD, Jan Homolak MD, Davor Virag MD
Pain group II
Ivica Matak, MBiol, PhD, Petra Sostaric VMD, Patrik Meglic VMD, Dalija Vadjunec MPharm

Laboratory exercise 1: Making Open Source Research Tools (3 hours)
Jan Homolak, MD, Davor Virag MD

The students will learn basic concepts of hardware design, and will be able to make their own simple open-source neuroscientific instruments implementing previously acquired knowledge of microcontroller software.

(15:00 – 17:15)
Laboratory exercise 2: Experimental design (3 hours)
Ivica Matak, MBiol, PhD, Petra Sostaric VMD, Ana Knezovic, MBiol, PhD, Jan Homolak MD

Based on the previous knowledge on the specific **experimental models** and **biostatistics**, groups will *design acute experiments* to answer specific predefined research questions and make a proposal how open-source neurosciento tools developed in a previous laboratory exercise might be used to provide insight into biological processes in animal models of AD and pain.

4. Day – *From theory to practice – Part I*

Laboratory exercise: Conducting behavioral performance and pain assessment experiments with mentors (9:00 – 13:00) (5 hours)

Ana Babic Perhoc MPharm, PhD, Jan Homolak MD, Ivica Matak, MBiol, PhD, Petra Sostaric VMD, Patrik Meglić VMD

A step by step introduction to how behavioral experiments are conducted will be provided.

Laboratory exercise: Experimental data extraction with mentors (14:00 – 16:15) (3 hours)

Ana Babic Perhoc MPharm, PhD, Jan Homolak MD, Ivica Matak, MBiol, PhD, Petra Sostaric VMD, Davor Virag MD

The students will learn how to obtain and extract data from behavioral experiments.

Online lecture (16:45 – 18:15) (2 hours)

5. day - From theory to practice – Part II. Concluding remarks.

(9:00 – 13:00)

Data structure / Data quality (1 hour)
Jan Homolak MD, Davor Virag MD

Tidy and structured datasets are a prerequisite for high-quality data analysis and drawing well-founded conclusions. The aim of the lecture is to introduce the students to the concept of data preparation and communicate why and how data should be prepared to provide strong foundations for further processing.

Biostatistics in practice: Extracting biologically relevant information from a bunch of numbers (1 hour)
Prof. Vladimir Trkulja, MD, PhD
Famous British statistician said: “All models are wrong, but some are useful”. The lecture will provide an insight in the peculiarities of the field of biostatistics and introduce the students why the numbers without a proper context still remain just numbers and fail to inform us about relevant biological processes.

Laboratory exercise: Design of data analysis strategy; Statistical analysis of experimental data; Data visualization (2 hours)
Jan Homolak MD, Davor Virag MD

Group discussion with UNIZG mentors (1 hour)
Prof. Melita Salkovic-Petrisic, MD, PhD, Prof. Vladimir Trkulja, MD, PhD, Ana Knezovic MBiol, PhD, Assoc. Prof, Jelena Osmanovic Barilar MD, PhD, Ana Babic Perhoc MPharm, PhD, Jan Homolak MD, Ivica Matak, MBiol, PhD, Petra Sostaric VMD, Davor Virag MD, Patrik Meglic VMD

Presentation of the obtained results (15:00 – 17:15) (3 hours)
Prof. Melita Salkovic-Petrisic, MD, PhD, Prof. Vladimir Trkulja, MD, PhD, Ana Knezovic MBiol, PhD, Assisst. Prof, Jelena Osmanovic Barilar MD, PhD, Ana Babic Perhoc MPharm, PhD, Jan Homolak MD, Ivica Matak, MBiol, PhD, Petra Sostaric VMD, Davor Virag MD, Patrik Meglic VMD