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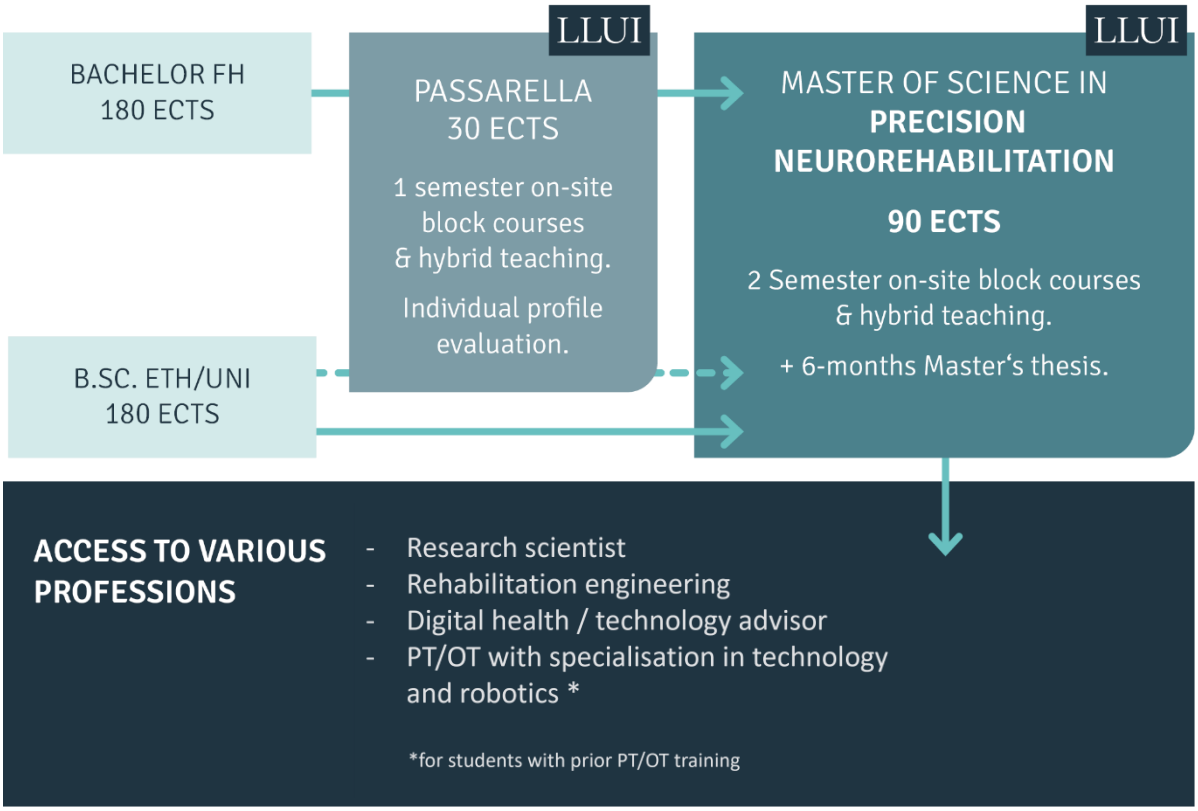
MASTER OF SCIENCE
PRECISION NEUROREHABILITATION (PNR)

PNR Course Handbook

PRECISION NEUROREHABILITATION MASTER

The master's program uniquely equips students with comprehensive knowledge and practical skill, positioning them at the forefront of healthcare and technology advancements.



OUR STUDENTS WILL…

- Gain in-depth expertise in concepts and methodologies in neurorehabilitation, engineering and applied movement science. Learn to use this expertise to effectively implement a technology-driven approach to precision neurorehabilitation.
- Acquire the competence to critically analyze and evaluate evidence-based practices and scientific findings, fostering a reflective and informed approach to professional decision-making.
- Acquire communication and professional skills to lead teams in a variety of healthcare settings and across the neurorehabilitation industry.

COURSE OVERVIEW YEAR 1 & 2

FALL SEMESTER 1 - BRIDGE

PNR-P101 1 ECTS
DESIGN THINKING 1

PNR-P102 4 ECTS
MOVEMENT FUNDAMENTALS: UNDERSTANDING MECHANICS FOR HUMAN MOVEMENT

PNR-P103 4 ECTS
INTRODUCTION TO MECHATRONICS

PNR-P104 4 ECTS
MATHEMATICS FOR MOVEMENT ANALYSIS

PNR-P201 4 ECTS
LOGIC AND PROBABILITY

PNR-P202 1 ECTS
SCIENTIFIC METHODS AND LITERATURE REVIEW

PNR-P203 6 ECTS
INTRODUCTION TO PROGRAMMING

PNR-P301 5 ECTS
INTRODUCTION TO NEUROSCIENCE

PNR-P401 1 ECTS
SPOTLIGHT SERIES 1

SPRING SEMESTER 2

PNR-M121 3 ECTS
DESIGN THINKING 2

PNR-M122 3 ECTS
QUANTIFYING HUMAN PHYSIOLOGY: TECHNOLOGIES AND TECHNIQUES

PNR-M221 3 ECTS
INTRODUCTION TO DATA SCIENCE

PNR-M222 3 ECTS
DIGITAL TWIN IN NEUROREHABILITATION

PNR-M321 2 ECTS
NEUROPSYCHOLOGY, MOTIVATION AND PSYCHIATRY

PNR-M421 1 ECTS
SPOTLIGHT SERIES 2

PNR-EXTERNAL 14 ECTS
ENGINEERING & REHABILITATION SCIENCE TECHNOLOGY

FALL SEMESTER 3

PNR-M123 4 ECTS
FROM BIOMECHANICS TO MOVEMENT ANALYSIS

PNR-M223 3 ECTS
ADVANCED DATA SCIENCE

PNR-M422 2 ECTS
NON-MOTOR ASPECTS OF NEUROREHABILITATION

PNR-M322 2 ECTS
NEUROPATHOLOGY

PNR-M421 1 ECTS
SPOTLIGHT SERIES 2

PNR-M921 6 ECTS
SEMESTER PROJECT

PNR-E432 1 ECTS
GOOD CLINICAL PRACTICE

PNR-EXTERNAL 6 ECTS
ENGINEERING & REHABILITATION SCIENCE TECHNOLOGY

SPRING SEMESTER 4

PNR-M922 30 ECTS
MASTER THESIS

PNR-EXTERNAL 6 ECTS
ENGINEERING & REHABILITATION SCIENCE TECHNOLOGY

COURSE ABSTRACTS

PNR-P101
DESIGN THINKING 1

ECTS: 1
Semester: Fall Semester 1 - Bridge

Lecturers: Dr. Jaime Duarte, further lecturers

Summary: This course will introduce students to the general principles of design thinking, a unique approach to problem solving and innovation. We will explore how to understand the needs of the users using concepts of user-centric design, how to define a problem effectively, how to generate ideas, and how to iteratively and rapidly prototype and test possible solutions. Through project-based activities, students will learn how to apply these principles to their professional lives. Finally, students will be introduced to methods to quantitatively and qualitatively gather requirements for a technological solution for neurorehabilitation.

PNR-P102
MOVEMENT FUNDAMENTALS: UNDERSTANDING MECHANICS FOR HUMAN MOVEMENT

ECTS: 4
Semester: Fall Semester 1 - Bridge

Lecturers: Dr. Jaime Duarte, further lecturers

Summary: This course will introduce students to the general principles of movement (kinematics) and the forces that cause or change motion (kinetics). We will use examples from human movement and biomechanics to study how a person's movements and forces generated by muscles, or applied by external objects, influence its motion. This course will emphasize real-world applications that students may encounter in their professional environments of neurorehabilitation such as orthotic devices and systems used while training a patient.

PNR-P103
INTRODUCTION TO MECHATRONICS

ECTS: 4
Semester: Fall Semester 1 – Bridge

Lecturers: Dr. Jaime Duarte, further lecturers

Summary: This course is designed to introduce students to the key principles to design and build robotic devices with emphasis on technology used for neurorehabilitation. We will explore concepts of sensors and actuators, electronic circuits, and how to combine these with mechanical elements to create a robotic device. Through hands-on experience, students will be able to create simple circuits, 3D print mechanical structures, and combine these with sensors and actuators to create intelligent robotic devices for neurorehabilitation.

PNR-P104
MATHEMATICS FOR MOVEMENT ANALYSIS

ECTS: 4
Semester: Fall Semester 1 - Bridge

Lecturers: Dr. Jaime Duarte, further lecturers

Summary: This course will give students the mathematical tools needed to understand and describe movement. We will review concepts from basic algebra, calculus, and mathematical functions needed to analyze and interpret human and mechanical motion. Students will work through real-world examples to learn how to apply mathematical tools to quantify and describe motion. This course will be closely linked with the mechanics for movement analysis where the mathematical tools will be applied.

PNR-P201
LOGIC AND PROBABILITY

ECTS: 4
Semester: Fall Semester 1 - Bridge

Lecturers: Dr. Josef Schönhammer

Summary: This course will give students an introduction into concepts of logical thinking, sets, and probability. Logical thinking will serve as a basis for courses like Scientific Methods and Literature Research where students will critically review theories, hypotheses, and deduction of results. It will also introduce students to essential concepts for computer programming like logical connectors and types of lists (both unordered and ordered). Finally, both logical thinking and probability will help students when performing data analysis by introducing them to probability theory, conditional probability, expected values, and regression.

PNR-P202
SCIENTIFIC METHODS AND LITERATURE RESEARCH

ECTS: 1
Semester: Fall Semester 1 - Bridge

Lecturers: Dr. Cat Maher, Francesco Piluso, Harry Stevens, Vincent Diehl

Summary: This course offers a comprehensive introduction to the fundamental principles of scientific methods and literature research within the context of Precision Neurorehabilitation. Students will gain insights into the process of scientific inquiry, contemporary practices and methodologies, and the essential tools required for conducting clinical research. Our focus includes critical assessment of scientific procedures, understanding levels of evidence, formulating and executing research questions, exploring study designs, and structuring scientific communications. Additionally, we address ethical considerations and introduce practical research tools such as literature databases, referencing software and artificial intelligence-powered resources.

PNR-P203
INTRODUCTION TO PROGRAMMING

ECTS: 6
Semester: Fall Semester 1 - Bridge

Lecturers: André Böni, Dr. Josua Zimmermann

Summary: This course is designed for health professionals with no programming background. It covers programming fundamentals, including data types, control structures, and debugging, plus clinical problem-solving with algorithms to simplify patient care. Students will gain core programming skills, understand patient data management, and develop automated healthcare solutions. The curriculum emphasizes practical applications in healthcare, from managing patient records to using programming supporting effective treatment solutions. The aim is to empower health professionals with programming skills for healthcare innovations.

PNR-P301
INTRODUCTION TO NEUROSCIENCE

ECTS: 5
Semester: Fall Semester 1 - Bridge

Lecturers: Dr. med. Traian Popa, Saskia Neumann, Dr. Sandra Giovanoli, further lecturers

Summary: This course will equip students with basic knowledge of neuroscience to understand the underlying mechanism and neural processes in neurorehabilitation. In the context of different pathologies of neurorehabilitation, the course will dive into the cellular, physiological, and anatomical basis of the central and peripheral nervous system. The course contains on-site and remote lecturing and is complemented by a variety of available earning applications and external online lectures for self-studying.

PNR-P401
SPOTLIGHT SERIES 1

ECTS: 1
Semester: Fall Semester 1 - Bridge

Lecturers: Prof. Andreas Luft, Prof. Gregor Hasler, Prof. Paolo Gasparini, various guest lecturers

Summary: In this Series, students will have the chance to visit regular spotlight events in an interdisciplinary clinical and research environments. Each Spotlight is an self-contained event with at least one expert presentation on a topic from diverse fields, all highly relevant for neurorehabilitation. Students will have the chance to actively participate in a critical scientific discussion. Through the interdisciplinary setup, students will acquire the skills for successful communication among clinicians, researchers, and industry partners.

PNR-M121
DESIGN THINKING 2

ECTS: 3
Semester: Spring Semester 2

Lecturers: Dr. Jaime Duarte, further lecturers

Summary: This course is second part of a two-course series that will introduce students to the general principles of design thinking, a unique approach to problem solving and innovation. We will explore how to understand the needs of the users using concepts of user-centric design, how to define a problem effectively, how to generate ideas, and how to iteratively and rapidly prototype and test possible solutions. Through project-based activities, students will learn how to apply these principles to their professional lives.

PNR-M122
QUANTIFYING HUMAN PHYSIOLOGY: TECHNOLOGIES AND TECHNIQUES

ECTS: 3
Semester: Spring Semester 2

Lecturers: Dr. Roman Kuster, further lecturers

Summary: This course will cover the topic of the role that physiological parameters play in informing medical personnel and patients about the patient's health status and on the possible paths to improve the patient's health status. Before measuring physiological parameters, it is important to understand how the underlying physiological principles can be reliably measured using biomedical sensors. This course provides the fundamental knowledge behind the physics, methods, and systems that are currently used to measure some of the most relevant physiological parameters for neurorehabilitation. These include electrocardiograph (ECG), electroencephalography (EEG), electromyography (EMG), imaging (x-rays, CT scans, MRI, ultrasound), photoplethysmography (PPG), respiratory, and motion sensors. The technology available to measure the underlying physiological parameters will be presented and critically discussed. Students will gain the understanding needed to select specific systems and signal processing steps for different healthcare applications, making them aware of the limits of the adopted measurement systems.

PNR-M123
FROM BIOMECHANICS TO MOVEMENT ANALYSIS

ECTS: 4
Semester: Fall Semester 3

Lecturers: Assis. Prof. Christoph Bauer, Marwen Mokni, Saskia Neumann, further lecturers

Summary: This course is divided into three parts. The first part will be an on-site or remote lecture where the theory of movement analysis will be explained and underlined with examples, furthermore, the required biomechanical principles underlying movement analysis are repeated. Attendees will understand principles and terminologies of movement analysis and are able to deepen their knowledge with online sources. The second part consists of practical classes where the students learn movement analysis in movement labs (overground, possibly CAREN) and non-stationary systems such as accelerometers. The third part is a small project. Attendees must develop their own measurement protocol (in groups), carry it out and evaluate it.

PNR-M221
INTRODUCTION TO DATA SCIENCE

ECTS: 3
Semester: Spring Semester 2

Lecturers: Dr. Josua Zimmermann, further lecturers

Summary: This course will equip students with essential skills for understanding and analyzing clinical data. Through engaging lectures and interactive sessions, students will explore diverse data types and methodologies for investigating correlations and group differences. Practical applications and hands-on exercises using Python will enable students to develop proficiency in data processing, visualization, and statistical analysis. Emphasis will be placed on fostering interpretation and critical thinking in evaluating clinical data. Additionally, students will develop the ability to translate research questions into testable hypotheses. By the end of the course, students will be able to interpret results and assess statistical accuracy in clinical research articles.

PNR-M222
DIGITAL TWIN IN NEUROREHABILITATION

ECTS: 3
Semester: Spring Semester 2

Lecturers: Dr. Chris Awai, Dr. Jaime Duarte, further lecturers

Summary: In this course, students will explore the representation of patients using data, a concept known as a digital twin. We will address questions like: How can we build explainable and trustworthy models? How can we build trust between stakeholders? How can we implement high quality data in clinical routine? Students will follow an example patient in her journey through disease stages and her interactions with medical services. In each stage, we will discuss relevant data recording, data reporting, data transactions, laws/policies, and technologies. After each theoretical input, students will program code snippets to address a specific need to create a digital twin. Finally, we will create an example digital twin, employing knowledge from previous courses in programming and data science.

PNR-M223
ADVANCED DATA SCIENCE

ECTS: 3
Semester: Fall Semester 3

Lecturers: Dr. Josua Zimmermann, further lecturers

Summary: This course provides students with the skills needed to comprehend and apply advanced machine learning techniques to clinical data. Students will delve into various topics covering classification, clustering, and deep learning. Through hands-on Python exercises, students will gain practical experiences building clinical prediction models with real-world data. Students will also learn to address current challenges in machine learning, such as explainability and biases. By the end of the course, students will possess the capability to extract valuable insights from complex clinical data using advanced data science methods, empowering them to contribute significantly to advancements in healthcare and medicine.

PNR-M321
NEUROPSYCHOLOGY, MOTIVATION AND PSYCHIATRY

ECTS: 2
Semester: Spring Semester 2

Lecturers: Dr. Lore Legrand, Prof. Gregor Hasler, further lecturers

Summary: This course is designed to help students understand and proficiently discern the influence of cognitive, motivational, and psychiatric parameters on motor neurorehabilitation. Students acquire knowledge in cognitive neuroscience and neuropsychology to understand the different cognitive functions and how they contribute to motor output, body perception, and motor rehabilitation. From neuroscience of motivation to motivational psychology, students learn how motivational processes can be harnessed to foster successful rehabilitation in traditional and gamified settings. Students are familiarized with psychiatric disorders. They are educated about affective and motor symptoms in psychiatric disease as well as drug-based effects either enhancing or impairing motor performance and rehabilitation.

PNR-M322
NEUROPATHOLOGY

ECTS: 2
Semester: Fall Semester 3

Lecturers: Dr. Traian Popa, further lecturers

Summary: This course will expand upon students' foundational neuroscientific knowledge. It will provide detailed exploration of the various diseases that require neurorehabilitation, focusing on their neuro-physiological underpinnings and neuropathological characteristics. Using patient case studies, students will develop the skills needed to use tools for assessments, and using these assessments develop personalized care protocols to meet the individual need of a patient.

PNR-M421
SPOTLIGHT SERIES 2

ECTS: 2
Semester: Throughout

Lecturers: Prof. Andreas Luft, Prof. Gregor Hasler, Prof. Paolo Gasparini, various guest lecturers

Summary: In this Series, students will have the chance to visit regular spotlight events in an interdisciplinary clinical and research environments. Each Spotlight is an self-contained event with at least one expert presentation on a topic from diverse fields, all highly relevant for neurorehabilitation. Students will have the chance to actively participate in a critical scientific discussion. Through the interdisciplinary setup, students will acquire the skills for successful communication among clinicians, researchers, and industry partners.

PNR-M422
NON-MOTOR ASPECTS OF NEUROREHABILITATION

ECTS: 2
Semester: Fall Semester 3

Lecturers: Various lecturers

Summary: This course delves into the integral role of nursing, speech therapy, language therapy, swallowing therapy, and nutrition in enhancing patient outcomes beyond the restoration of motor function. It complements the course “neuropsychology, psychiatry and motivation” to address a holistic view of care and patient well-being. Through interactive sessions and case studies, students will explore the multidisciplinary approach required for effective neurorehabilitation, emphasizing collaborative efforts between nurses, therapists, and other healthcare professionals. This course will equip students with essential knowledge and skills in holistic patient assessment and care planning, preparing them to deliver comprehensive and personalized support to individuals undergoing neurorehabilitation.

PNR-M921
SEMESTER PROJECT

ECTS: 6
Semester: Fall Semester 3

Summary: The semester project incorporates principles of design thinking into real-world clinical applications. The project will be conducted under the supervision of a research scientists who will guide the student through the management of research projects and clinical processes used in neurorehabilitation. Students will gain hands-on experience into the formulation of research questions, planning of experiments, gathering and analysis of data, and the formulation of conclusions based on the experimental results. The semester project is design to prepare students for their Master's thesis.

PNR-M922
MASTER THESIS

ECTS: 30
Semester: Spring Semester 4

Summary: A master's thesis at the end of the Master's program will demonstrate the student's ability to conduct independent research, analyze data, and contribute original insights to the field of precision neurorehabilitation. The thesis will be the culmination of the knowledge and skills acquired throughout the program and should reflect critical thinking, analytical rigor, and academic integrity. The thesis can be conducted in close collaboration with clinical practice during a time period of 6 months under the supervision of a research scientist and is evaluated by a committee of faculty members and an external expert. The students will undergo a final presentation and examination, during which they will defend their research findings and methodology to the panel, showcasing their ability to communicate their research process, address questions, and defend their conclusions.

EXTERNAL LECTURES

PNR-E432
GOOD CLINICAL PRACTICE

ECTS: 1
Semester: not specified

Lecturers: Self-Study online course

Summary: The Good Clinical Practice (GCP) course covers essential basic knowledge in research ethics. Module 1 of the self-learning platform offered at the Training and Resources in Research Ethics Evaluation (TRREE) platform introduces students to the fundamentals of GCP. It covers the ethical principles governing clinical research, the history and evolution of GCP, and the roles and responsibilities of various stakeholders involved in clinical trials. Module 2 delves into the regulatory framework surrounding clinical research, emphasizing international guidelines and standards. It also explores the importance of obtaining informed consent from participants and the principles of data protection and confidentiality.

PNR-EXTERNAL

ENGINEERING & REHABILITATION SCIENCE

ECTS: 26
Semester: Throughout

Summary: The LLUI PNR program will be supplemented by external courses in basic and advanced topics of neurorehabilitation. In these courses, students will learn the fundamentals of engineering design processes, biomechanical movement analysis, and data science models used in neurorehabilitation technologies. The external courses will bring students in contact with industry colleagues and engineering students; this will support their development of important skills for interdisciplinary collaborations in the field of neurorehabilitation.

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