**DESCRIPTION/Syllabi of Curricula/Module**

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| **Short Name of the University/Country code Date (Month / Year)** | **HIT**  **Jan 2019** |
| **TITLE OF THE MODULE** | **Code** |
| Neural Implants – Applications |  |

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| **Teacher(s)** | **Department** |
| **Coordinating:** Ronen Sosnik, PhD  **Others:** | Electrical and Electronics Engineering |

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| **Study cycle**  **(BA/MA)** | **Level of the module**  **(Semester number)** | **Type of the module**  **(compulsary/elective)** |
| Bachelor/Masters | 7th/8th semester (fourth year) for Bachleor, or any semester for Masters | Elective |

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| **Form of delivery**  **(theory/lab/exercises)** | **Duration**  **(weeks/months)** | **Language(s)** |
| Lectures, Seminary | 15 weeks | English |

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| **Prerequisites** | |
| **Prerequisites:**  Knowledge: the course “Introduction to Neural Implants”  Skills: none  Competences: none | **Co-requisites (if necessary):**  none |

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| **ECTS  (Credits of the module)** | **Total student workload hours** | | **Contact hours** | | **Individual work hours** |
| 6 | 90 | | 30 | | 60 |
| **Aim of the module (course unit): competences foreseen by the study programme** | | | | | |
| Students should be able to:  - Understand the use, advantages and disadvantages of different electrodes arrays and micro arrays for recording and stimulation in the central nervous system  - Compare between different spike sorting techniques concerning technique complexity, false positive to false negative ratio, dimension reduction, adaptivity and use in on-line applications  - Understand and simulate the function of various neural implants, including cochlear and grasping implants and implants for restoring function for foot drop or flaccid bladder patients, and brain computer interfaces for rehabilitation of stroke, ALS and locked-in syndrome patients  - Differentiate different recording and stimulation techniques with regards to signal-to-noise ratio (SNR), invasiveness, bio compatibility, tissue damage, place selectivity, temporal and spatial resolution and current injection efficiency | | | | | |
| **Learning outcomes of module (course unit)** | | **Teaching/learning methods**  **(theory, lab, exercises)** | | **Assessment methods**  **(written exam, oral exam, reports)** | |
| **Knowledge:**  Present the student with the implementation of neural recording and stimulating techniques and the planning and production of peripheral and central nervous system implants including auditory and motor Neuroprostheses | | Work with the lecture notes as well as on the available fundamental subject literature | | Knowledge test | |
| **Skills:**  Ability to simulate and analyze the function of various peripheral and central nervous system neural implants, including cochlear implant, invasive/ partially invasive / non-invasive motor brain computer interfaces (BCIs), prostheses for treating foot drop and flaccid bladder, etc... | | Lectures, project, consultation | | Active attendance on lectures, individual/group project and presentation | |
| **Competences:**  Study the subject literature, exchange knowledge, working in group | | Lectures, project, consultation | | Individual/group project and presentation | |

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| **Themes** | **Contact work hours** | | | | | | | **Time and tasks for individual work** | |
| Lectures | Consultations | Seminars | Practiacl work | Laboratory work | Placements | **Total contact work** | **Individual work** | **Tasks** |
| Recording from the Peripheral Nervous System (PNS) – Electrodes Types and Applications | 4 |  |  |  |  |  | 6 | 8 | Study noninvasive, subcutaneous, epimysial, intramuscular, epimysial, intra-fascicular, epineural and intra-neural electrodes. Study the electrical and mechanical considerations for choosing an electrode for an implant. Study regeneration electrode for neural rehabilitation – engineering challenge. Understand making use of recording electrodes in various functional electrical stimulation (FES) systems as a means of closing a control loop: detection of heel strike in ground in foot drop patients, grasping prostheses for stroke patients, neural implants for the treatment of flaccid bladder and detrusor hyperreflexia |
| 2. Invasive, Partially Invasive and Non-invasive Recording and Stimulation in the Central Nervous System (CNS) | 4 |  |  |  |  |  | 2 | 6 | Understand the differences between PNS and CNS recording and stimulation. Study Electroencephalogram (EEG), Electrocorticogram (ECoG) and extracellular recordings – signal source, temporal and spectral features, advantages, disadvantages and recording setups. Stusy the use of EEG event-related potentials (ERP) in non-invasive brain computer interfaces (BCIs) for stroke and neuro degenerative disease patients. Study micro electrodes arrays and their use in various neural implants |
| 3. Spikes Sorting – Techniques and Algorithms | 6 |  |  |  |  |  | 6 | 6 | Study spike sorting using threshold level method and principle component analysis (PCA). Study cluster analysis methods, Bayesian sorting and classification of spikes. Get familiar with high dimensionality spike classification and on-line template adjustment. Study blind source separation (BSS) techniques and independent component analysis (ICA) method for spike sorting. Limiting factors in spike sorting |
| 4. Motor Neural Implants – Anatomy, Physiology and Psychophysics of the Volitional Motor System | 6 |  |  |  |  |  | 6 | 12 | Study various aspects of motor psychophysics - volitional movement, reaction time, ballistic movement, reference frame and isochrony. Study the motor cortical areas – their neuroanatomy and function and get acquainted with the motor and sensory homunculus. Study the neural firing patterns in the primary motor area (M1) – preferred direction (PD) and local population algorithm. Study a neural implant for controlling a 4-D robotic arm through motor imagery – practice, recording setup and challenges |
| 5. Cochlear Implant – Anatomy, Physiology and Neural Pathways | 4 |  |  |  |  |  | 4 | 8 | Study the auditory neural pathway – from the ear to the auditory cortexand the ear anatomy – outer, middle and inner ear. Study the anatomy and physiology of the cochlea – tonotopy, Corti organ and hair cells. Understand active amplification mechanism in the cochlea and the auditory nerve response to acoustic stimulation – adaptation, frequency selectivity and encoding of stimulation amplitude. Study conductive hear loss and neural hearing loss – etiology and characteristics. Study the cochlear implant – its physiology and functionality, the outer and inner part of the implant, use of automatic gain control (AGC), digital signal processing (DSP), amplitude mapping and output decoding. Understand the transmission of data and power through the tissue and use of reverse telemetry for device monitoring. Study the implant electronics |
| 6. Seminars on each of the five themes (1 to 5) |  |  | 6 |  |  |  | 6 | 20 | Study advanced topics in:   * Device of novel cochlear implants and their function * Use of advanced machine learning techniques for spike sorting for motor neural implants * Use of reverse telemetry for monitoring implant function |
| **Total** | 24 |  | 6 |  |  |  | 30 | 60 |  |

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| **Assessment strategy** | **Weight in %** | **Deadlines** | **Assessment criteria** |
| Individual or group final project referred during seminars | 20 | 3th - 14th week | Project |
| Final exam | 80 |  | Test |

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| **Author** | **Year of issue** | **Title** | **No of periodical or volume** | **Place of printing. Printing house or internet link** |
| **Compulsory literature** | | | | |
| Kenneth WH, Gurpreet SD | 2015 | Neuroprosthetics: Theory and Practice |  | University of Utah, USA |
| Eric R. Kandel (Editor), James H. Schwartz (Editor), Thomas M. Jessell (Editor), Steven A. Siegelbaum (Editor), A. J. Hudspeth (Editor | 2019 | Principles of Neural Science, fifth edition |  | <https://www.amazon.com/Principles-Neural-Science-Fifth-Kandel/dp/0071390111> |
| **Additional literature** | | | | |
| Warren E Finn, Peter G LoPresti | 2002 | Handbook of Neuroprosthetic Methods |  | Oklahoma State University, Tulsa, Oklahoma, USA |