ISTITUTO DI BIOROBOTICA

Sant'Anna
Scuola Universitaria Superiore Pisa

PhD in Biorobotics

Teaching Activities 2019-2020

COURSE	TEACHER(S)	ECTS	HOURS	ABSTRACT
Introduction of biorobotics	**Paolo Dario**	**1**	10	The course will present the objectives, the international context and the main research topics of the Biorobotics, with particular reference to the methodology adopted to carry out research projects in this area.
Post-Human, Trans-Human, Human-Enhancement. Philosophy of technology in the past and in the present	**Barbara Henry**	**2**	20	The course will focus on the most recent national and international scientific contributions on "Enhancement" ("Optimierung"; "potenziamento") of the human condition. These topics will be considered under different theoretical and methodical points of view. The main aim will be to tackle assuming a critical/interpretative perspective - typical for the philosophy of technology as such - some of the ethical, political, philosophical and anthropological approaches and acceptances (Post-Human, Trans-Human among others) which are implicitly embedded in a wide range of technologies which is promoted, supported and applied by different agencies. A specific focus will be devoted to the following issues: What does it mean to be a "human subject" in the technological era?; The mind/body dialectic "technologically" reconsidered; theoretical insights for an anthropology of vulnerability; how to reframe the meanings of categories such dignity' and 'self-determination' with reference to the so-called "self's technologies" and to the mechatronic implants into the human body.
Human and Animal Models for BioRobotics	**Cecilia Laschi**	**2**	20	The course focuses on bioinspired robotics and biorobotic platforms for neuroscience and biology. The course provides the knowledge about the models of the human brain, of human intelligence, of muscle-skeletal systems, and of perceptual systems that are relevant in biorobotics. The students will learn principles of bioinspiration and biomimetics in robotics and the design methods and the technical tools for implementing such brain models and other animal models in robots. The students will have the opportunity to challenge themselves in their own design of robots inspired to functional mechanisms of human beings and other animals. Where appropriate, hands-on activities and student projects will be included in the course.
Introduction to statistics and	**Angelo Maria**	**4**	40	This course is an introduction to key statistical ideas and principles concerning the

data analysis	**Sabatini**			collection, display and analysis of data needed to make inferences about real-world phenomena. In particular, the course will cover: methods of data collection and the construction of effective graphical and numerical displays to understand the data; how to estimate and describe the error in estimates of some important quantities; and how statistical tests can be used to separate significant differences from those that only reflect the natural variability in data.
Summer School GNB: Advanced bioengineering methods, technologies and tools in surgery and therapy	**Arianna Menciassi**	**3**	30	The main objective of the course is providing students with design rules for microrobots for medical applications.
Creative Engineering	**Cesare Stefanini**	**2**	20	The objective of this course is to give participants an introduction to methods used in many international universities, and in some design firms in “Silicon Valley,” to promote user-centered design. The course focuses on the early stages of product development when the main challenge is to determine what to design. Specific methods introduced in the first part of the course include: structured brainstorming and design definition, user and technology benchmarking, persona development and critical experience and critical function prototyping. For the purposes of this course, participants will form teams to address a technology-driven challenge with sample materials provided by the instructor. After experiencing and practicing the various design methods introduced, participants will present design proposals for possible product development.
Introduction of neural engineering	**Silvestro Micera**	**4**	40	Neuroengineering is a novel discipline combining engineering including micro and nanotechnology, electrical and mechanical, and computer science with cellular, molecular, cognitive neuroscience with two main goals: (i) increase our basic knowledge of how the nervous system works; (ii) develop systems able to restore functions in people affected by different types of neural disability. In the past years, several breakthroughs have been reached by neuroengineers in particular on the development of neurotechnologies able to restore sensorimotor functions in disabled people. Content: Peripheral Neurprostheses; Brain-Machine Interfaces; Sensory Neuroprostheses; Neurorehabilitation.
Graphical programming for measurement, test, and control systems in wearable robotics	**Nicola Vitiello**	**3**	30	Students will learn how to develop a control system by means of the National Instrument software packages Labview core, Labview RT and Labview FPGA module. Experimental activities with a real robot will be carried out to mature experience with the use of DC motors and position/torque sensors.
Graphical programming for measurement, test, and control systems in bioengineering	**Calogero Oddo**	**3**	30	The course will provide technical and hands-on competences in the use of graphical programming tools for bioengineering applications. During the course, the students will learn how to use the LabVIEW software, with selected topics from Core 1, Core 2, Real-time and FPGA modules. The hands-on activities will demonstrate how to use development boards for interfacing with electronic measurement instruments, for

				acquiring and processing data from sensors, or for controlling biorobotic systems.
Bipedal locomotion: from humans to humanoids	**Vito Monaco, Marcello Calisti, Egidio Falotico**	**3**	30	
Innovative Actuation Technology	**Matteo Cianchetti**	**2**	20	The course aims at providing an advanced knowledge on novel soft and smart materials for bionics. Different technologies will be analysed from the basic principles to their exploitation as smart sensors or actuators. The course will enable the student to implement a comparative analysis for the choice of the most suitable technologies for specific engineering problems. The second part of the course will also deal with the use Finite Element Analysis (theory and implementation with a commercial software) for designing new soft based systems. The students will be asked to use advanced design principles and tools as well as to carry out hands-on lab activities.
Elements of Internet of things and cloud robotics	**Filippo Cavallo**	**2**	20	This course aims to provide basic knowledge and methodology for the design and implementation of service robotics solutions based on the integration of mobile robotic platforms, sensor networks and Cloud computing. This module presents the main challenges and concepts related to: 1) software and hardware architectures, 2) perception-reasoning/control actuation paradigm, 3) Cloud-based services for robotics, 4) distributed wearable and environmental sensor networks.
Computer integrated image based technologies for robotic surgery	**Gastone Ciuti**	**1**	10	The frontal lessons of the course, within the minimally invasive surgical robotic framework, will ground on specific topics such as the introduction and description of innovative computer-integrated technologies and control strategies for guided, targeted and focused therapy with particular attention to preoperative, intraoperative and postoperative image-based data acquisition, management and processing (e.g., from US, MRI, TAC, camera sources et cetera) for planning, adaptation and improvement of diagnostic and therapeutic actions. In the course, students will be exposed to a computer vision instrument, i.e., OpenCV library under C/C++ interface, for image data acquisition, management and processing (with real examples of software implementations) towards the implementation of computer-integrated image-based strategies for robotic surgery.
Microfabrication through soft lithography and SEM/AFM characterization	**Leonardo Ricotti**	**2**	20	This course aims at providing students with the key theoretical and practical knowledge related to the fabrication and characterization of materials at the micro-scale. Students will be trained to produce microstructures in clean room enviroment by using soft lithography procedures (based on photoresist spinning, UV exposure, chemical development and thermal baking). Then, they will also trained to perform a detailed morphological characterization of such structures, by scanning electron microscope (SEM) and atomic force microscope (AFM) imaging techniques.
Bioinnovation for people	**Giuseppe Roberto Tortora**	**2**	20	Inspiring case studies of BioInnovations for People. Surgical robots, endoscopic capsules, the IoT, artificial intelligence, autonomous vehicles, drones for delivery in healthcare and their potential applications from research to market.

Information theory and neural modelling for neural engineering	**Alberto Mazzoni**	**2**	20	Neural Engineering is a field of ever-increasing complexity. The amount of data about the dynamics of the nervous system that can be currently collected with a variety of recording procedures requires advanced analysis techniques to be correctly interpreted. Moreover, neural engineering is now aiming at replacing/controlling functions regulated by tangled neural circuits, so predicting the consequences of neural stimulations might be challenging. This course aims at teaching two powerful tools from computational neuroscience that are helping neural engineers to solve the aforementioned issues. The first tool is information theory, a general approach to find and quantify relationships between arbitrary sets of variables. The first part of the course will start with the mathematical foundations of the theory and end with applications in the field of neuroscience and beyond. The second tool is neural modeling. The second part of the course will then introduce the main neuronal models with different level of detail and the main network architectures, and will finally present and discuss several examples of computational neuroengineering. The final part of the course will be dedicated to a particular field of applications of these tools: the study of basal ganglia in healthy and pathological conditions (e.g.,Parkinson's Disease and Tourette's Syndrome) and the quest for finding the optimal Deep Brain Stimulation protocol to cure motor and cognitive symptoms of such conditions. Hands-on lessons will include computation of information breakdown with a dedicated Matlab toolbox and design and characterization of single neuron models.
Introduction to machine learning	**Andrea Mannini**	**2**	20	Machine learning (ML) is the class of algorithms that allows a computer to solve a problem without being specifically programmed, extracting the information to do it from data. ML is used to solve problems of classification, regression or prediction building on datasets of available examples that allow the machine to gain experience about the problem. As a result, ML plays a major role in pervasive artificial intelligence solutions and currently finds daily-use applications in many fields such as anti-spam filters, speech recognition systems and web search engines. This course is an introduction to ML methods and solutions with a particular focus on biomedical applications and biorobotics. It will guide the PhD student in the understanding of main concepts at the basis of ML as well as in the description of practical solutions of simple classification or regression problems using classical ML algorithms. The final target of the course is to make the student able in practically design, run and evaluate the results of a ML solution implementing each of these steps in lab sessions.
Rehabilitation Robotics	**Stefano Mazzoleni**	**3**	30	The objectives of this course is to provide PhD students with 1) a comprehensive scientific and tecnological overview of robotic devices used for rehabilitation and assistance of persons with disabilities and 2) a detailed theoretical framework of robotics mathematical modeling (in terms of differential kinematics, geometrical and analytical

				Jacobian, dynamical model of a robotic system, compliance control and impedance control).
Mechanics of elastic solids and biorobotics structures	**Antonio De Simone**	**6**	60	
Introduction to the fourth industrial revolution	**Maria Chiara Carrozza**	**2**	20	The objective of the course is to introduce PhD students to the main implications of the fourth industrial revolution. The course is interdisciplinary and is offered to candidates interested in undesrtanding the economy, the history and the social consequences that are related to the development of robots and artificial intelligences and their introduction not only in manufacturing and services but also in the society. The modules comprise: 1. industrial revolutions and their evolution, 2. enabling technologies of the fourth industrial revolution, 3. the relation between innovation and enabling technology, 3. geopolitics of the digital transformation, 4. how to translate scientific results into technology and products, 5. the most innovative companies and Amazon and Google, what are platform, 6. the digital transformation in health care, 7. UN development goals, social innovation and science, 7. how to present an idea and to transform it into a successful industrial project, 8. social robotics and its possible application in society.
Brain inspired motor control	**Egidio Falotico**	**2**	20	
Bioelectronic tools for probing the peripheral nervous system: microneurography and microstimulation	**Vaughan Macefield**	**2**	20	The course will address the electrophysiological methods named microneurography and microstimulation. Such bioelectronic tools allow accessing the peripheral nervous system in a minimally invasive manner, with high selectivity, in recording or stimulation modality. Microneurography and microstimulation allow addressing neurophysiological questions related to the encoding-decoding of sensory, motor and autonomic information. Microneurography and microstimulation can also be used to accelerate the development of bionic limb prostheses for restoring sensorimotor capabilities or implantable devices for endocrinological or cardiovascular functions. The course will address the following topics: Overview of the development and application of microneurography; Recording from muscle spindle afferents; Recording from Golgi tendon organ afferents; Recording from tactile afferents; Recording from joint receptors; Recording muscle sympathetic nerve activity; Recording skin sympathetic nerve activity; Combining microneurography with fMRI; Microstimulation of sensory axons; Microstimulation of motor axons. The course is organized in two modules, for a total of 2 ECTS: 1 ECTS of frontal lectures (10 hours of classes; free attendance); 1 ECTS of laboratory activities at the N2Lab facility (25 hours of student activities; registration required).
Projectual work on biorobotics	**To be defined**	**3**	60	Study and research activities supervised by a faculty member, on specific topics related to the educational path. This allows for a personalized training offer. The final reporting of the hours will be approved by the PhD Coordinator.