Course Package

Biorobotics – Q1 + Q2

Name module	Biorobotics - Q1 + Q2
Educational programme	MSc Biomedical Engineering
Period	First semester (quartiles Q1 + Q2)
Study load	30 ECTS
Coordinator	J. Huttenhuis

Biorobotics			
Quartile 1	**Quartile 2**	**Quartile 3**	**Quartile 4**
Technology for Health 201500222 (5 EC)	**Robotics for Medical Applications 201300004** (5 EC)		
Electives: choose 10 EC	**Biostatistics 201400285** (5 EC)		
Integrative Design of Bio. Prod. - 191150700 (5 EC)			
Modelling, Dynamics, and Kinematics - 202200101 (5 EC)			
Machine Learning I - 201600070 (5 EC)	**Control System Design for Robotics 202200104** (5 EC)		
Clinical Research Methods - 201400286 (5 EC)			

Required preliminary knowledge: Bachelor BMT or equivalent; Experience with a Design Methodology; Linear Algebra; Familiarity with MATLAB; Basic knowledge on Differential Equations, Classical Dynamical Mechanical Modelling, Linear Systems, Laplace and Fourier Transforms, PID control.

Quartile 1

201500222 - Technology for Health

This course is offered at the beginning of the Master Biomedical Engineering (BME) and is primarily designed for students of the Master Biomedical Engineering. The aim of biomedical engineering is to provide technological solutions for health care problems, for example for the support of human functions which are impaired by trauma or disease. As a biomedical engineer, you will be actively involved in technology research for advancing new ideas, concepts or intermediate results on the translation chain towards innovation of clinical practice and commercial exploitation. The overall goal of this course is to outline the identity of the biomedical engineering discipline and to generate awareness of key aspects of biomedical engineering by focusing on the key roles of the biomedical engineer in:

- Healthcare Innovation – Biomedical engineers analyze today's healthcare problems to recognize technological limitations and to envision the potential impact of new technology.
- Technology Research – Biomedical engineers develop new concepts, tools and skills for measuring, analysis, modeling or controlling of quantities, or realization of materials.

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

- Technology Transfer – Biomedical engineers synthesize new technological concepts and stake-holders interests into validated and innovative solutions for health care problems.

In this course you will learn through active engagement in online and face-to-face learning activities aiming at your professional development, especially your competences in meeting societal challenges, ensuring impact of your ideas and work, and communication and collaboration with fellow professionals and stakeholders. You will be challenged to connect insights acquired from several course materials to the practice of research presently performed at the TechMed institute and to reflect on your own professional development.

Electives: choose 10 EC

191150700 - Integrative Design of Biomedical Products

Designing biomedical products requires a specific methodical design process, because of the diversity of the stakeholders, the multidisciplinary background of the project participants, the limitation of the amount of background information, the complexity of the working environment in which the products are used and the required safety of the products in combination with a human operator. During this course, a design philosophy/process and accompanying tools are presented, discussed and applied by the students in teams. Illustrative examples will be discussed following the entire design engineering cycle. These include problem analysis, design approach, topology synthesis, system alternatives and improvements, dimensional optimization, choice of components, user input and co-creation, human factors. Topics addressed include prosthetics, orthotics and exoskeletons, minimally access orthopedic surgery, arthroscopy, transmission of forces, static balancing, low-friction mechanisms, medical terminology, human-machine interface, tissue-instrument interface, waterjetting of bone. Students apply the design process by performing by performing a biomedical design project. In addition, the importance of project management, teamwork, communication skills are discussed. Students will apply them to stimulate collaboration between participants of different backgrounds

202200101 - Modelling, Dynamics, and Kinematics

Goal: To give the students a basic knowledge on how energy based physical modeling is and how this can be used to model 3D multi-body systems and control them. The presented techniques are the state of the art on physical modeling and robotics and very powerful tools. They can be used to model, control and analyse complex 3D systems like manipulators, walking machines and flying robots.

201600070 - Machine Learning I

The course is an in-depth introduction to the theory and practicalities of Machine Learning (ML), in which the emphasis is on an overview of the various techniques, their workings, associated complexity and application domains. We also look into the theoretical aspects of machine learning techniques, such as over- and under-fitting and the Bias/Variance Dilemma. Emphasis is on basic ML models, on methodology (how to achieve reliable models systematically) and the evaluation of the learnt/trained models.

201400286 - Clinical Research Methods

Clinical research is the systematic process of examining clinical conditions and outcomes, in order to establish relationships among clinical phenomena and to generate evidence for decision making toward improved clinical practice. As a Biomedical Engineer, you will continuously encounter clinical research, either by performing a clinical study yourself or by using the results of clinical research for development or validation of new technologies or medical devices. Furthermore, you will frequently be working with professionals for whom clinical research is a main source of knowledge toward theory building and clinical innovation - c.f., evidence based medicine. This course will provide the foundations of clinical research by addressing key aspects of theory building, concepts of measurements, study design, interpretation of data. Students will assess and interpret clinical methods and results and use clinical results for developing new concepts or for assessment or validation of new technology. The course consists of lectures disclosing the structure of the subject material, explaining approaches and concepts and providing illustrative examples from the clinical research practice.

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Quartile 2

201300004 - Robotics for Medical Applications

This is a Master's Level course offered to Biomedical, Mechanical, and Electrical Engineering, and System & Control students. This course provides an introduction to robotics with emphasis on the mathematical tools for describing the kinematics and control of robotic manipulators. In addition, selected topics concerning modeling of soft biological tissues and haptics, are also discussed. In minimally invasive surgery, instruments should be manipulated and navigated remotely. Principles from robotics are used to describe this manipulation and navigation mathematically. The result of the operation should be observed and fed back to a surgeon. Although often the image of a video camera is sufficient, sometimes tactile information is needed about the mechanical properties of the tissue. There are haptic interfaces developed, which gives the surgeon 'the feeling' of the tissue remotely. The technical background required for this, is being handled and applied in lab/practical assignments involving Phantom Omni Haptic Devices.

201400285 - **Biostatistics**

Central concepts of probability theory like (conditional) probability, expectation and variance are treated. Also the calculation of expectations and variances of linear functions of the observations is a topic of the course and this topic ends with principal components. The principles of statistical testing theory are explained considering the case of one sample (discrete and continuous data). Statistical tests are focused towards: the comparison of two samples, regression, analysis of variances (including repeated measures) and logistic regression. Within analysis of variance we spend some time on multiple comparison / post hoc analysis / simultaneous confidence intervals.

Each week the student has to do an assignment. The student has to deliver a written report for all assignments. The student has to use SPSS (or an other statistical package if the student prefers that) for the last 5 assignments. Assignments 5 and 6 have to be discussed individually, on campus or using TEAMS.

202200104 - Control System Design for Robotics

- State-space models and linearization
- Lyapunov stability theory, LaSalle’s invariance principle, passivity analysis
- Inverse dynamics compensation, feedback linearization, computed torque control, control in joint space, and operation space
- Controllability and observability of a state-space model, pole placement, linear-quadratic regulator, Kalman filter, separation principle, and observer-based controller synthesis
- Transfer function and frequency response, feedback and feed-forward, loop gain and sensitivities, characteristic polynomial and internal stability, Bode and Nyquist stability criteria, stability margins, loop-shaping, nominal performance analysis and robust stability analysis, waterbed effect and bandwidth limitations
- Sampling and discretization, sampling rate selection, computer implementation and simulation
- Legal aspects of autonomous robots (for MSc Robotics students)
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