Course Package

Biorobotics – 1A + 1B

Name module	Biorobotics - 1A + 1B
Educational programme	MSc Biomedical Engineering
Period	First semester (block 1A + 1B)
Study load	30 ECTS
Coordinator	J. Huttenhuis

Biorobotics			
block 1A	**block 1B**	**block 2A**	**block 2B**
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's degree in Biomedical Engineering; Industrial Design & Engineering; or Mechanical Engineering; basic knowledge in Mechanics; Multi-body Kinematics and Dynamics; General Physics; General Mathematics; Principles of Signal Processing; Linear Algebra; Bachelor BMT or equivalent; experience with a Design Methodology at BSc level; Linear Algebra; Advanced Control Engineering or a comparable course; familiarity with MATLAB; Differential equations; Classical Dynamical Mechanical Modelling; Linear Systems; Laplace and Fourier Transforms; PID control.

Block 1A

201500222 - Technology for Health

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 provide an overview of key aspects of the process of biomedical engineering and the role of the biomedical engineer. Therefore, this course consists of:

- theoretical lectures on clinical problem analysis, technology research and technology transfer;
- capita selecta lectures in which experts from the field describe a clinical problem and state of the art technical solutions and future developments in technology research;
- assignments in which students individually prepare a final proposal for a research project for development of a technological solution beyond the present state of the art;

- peer groups in which students present and discuss their progress during the preparation and receive feedback from fellow students and a tutor;
- a grant competition in which final proposals are presented to and evaluated by a student jury.

Electives: choose 10 EC

191150700 - Integrative Design of Biomedical Products

During this course strategies are presented as an addition to the methodical design process. Subjects that will be discussed are project management, teamwork, communication methods for a good co-operation between medical and technical experts, application of selection processes, specific design aspects of implants, test of prototypes, including FMEA-analysis, METC-protocol and CE-certification. During the course an project assignment will be worked out by a multidisciplinary group of students.

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. During the course, students will build a portfolio based on assignments for application of the theory on a specific clinical research topic of interest and participate in peer groups for providing mutual feedback and receiving feedback from a tutor. This feedback is processed into the final version of the portfolio, which is graded at the end of the course. The final assignment in the portfolio will be a brief research proposal, to be presented to fellow students.

Block 1B

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

Short description of course content:

- Linearization and state-space models, transfer function and frequency response, feedback and feed-forward, decoupling, loop gain and sensitivities, characteristic polynomial and internal stability, Bode and Nyquist stability criterions, stability margins, loop-shaping, mixed-sensitivity synthesis, waterbed effect and bandwidth limitations.
- Reachability and observability of a state-space model, pole placement, linear-quadratic regulator, Kalman filter, separation principle and observer-based controller synthesis.
- Lyapunov stability theory, LaSalle’s invariance principle, passivity and small-gain theorems, inverse dynamics compensation, feedback linearization, computed torque control, control in joint space and operation space.
- Sampling and discretization, sampling rate selection, computer implementation and simulation.
- Legal aspects of autonomous robots (for MSc Robotics students)