Course Package

Biorobotics - Q2

Name module	Biorobotics – Q2
Educational programme	MSc Biomedical Engineering
Period	Second quartile of the first semester – Q2
Study load	15 ECTS
Coordinator	J. Huttenhuis

Biorobotics			
Quartile 1	**Quartile 2**	**Quartile 3**	**Quartile 4**
	Robotics for Medical Applications **201300004** (5 EC)		
	Medical Certification & Human Factors **202200070** (5 EC)		
	Control System Design for Robotics **202200104** (5 EC)		

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

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 a lab/practical assignments.

202200070 - Medical Certification & Human Factors

Designing medical devices requires specific attention to ensure that these products can be used safely by the users (medical professionals) on the patients. To this end, the Medical Device Regulation is applicable, which is European Union legislation that is enforced at national level. The MDR is intended for medical devices, which are defined and categorized into classes. Depending on the class stricter rules apply. To help manufacturers and hospitals to comply with the MDR, ISO norms are available as well as forms and independent committees that weigh the benefits and risks. In this course, students will familiarize with the topic of medical regulation by working in teams of three on an actual medical prototype. Each week a different aspect of the MDR is addressed in a lecture and a follow up assignment related to the prototype. This way students learn to interpret and implement the MDR. Important aspects include classification, intended use, misuse, risk analysis (mechanical/electrical – wear, breakage, electric shocks; biologic – toxicity, contamination, human factors), design for safety and usability to minimize risks of the medical device, proper documentation, pre-clinical and clinical testing, quality control during manufacturing and post-market surveillance. Students peer review the assignments of others and during tutorial the assignments are discussed. Based upon the feedback from peers and lectures the assignments are improved and submitted in a final report. Also, each student team is expected to present their overall work with a self-chosen focus point.

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)