Course Package

Physiological Signals and Systems – Q2

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

Physiological Signals and Systems			
Quartile 1	**Quartile 2**	**Quartile 3**	**Quartile 4**
	Biostatistics **201400285** (5 EC)		
	Mathematical Methods **191506001** (5 EC)		
	eHealth for Remote Patient Monitoring and Decision Making **202200149** (5 EC)		

Required preliminary knowledge: Bachelor's degree in Biomedical Engineering; Industrial Design & Engineering, or Mechanical Engineering; Knowledge of Dynamics and Control or a comparable course; Basic knowledge of Linear Algebra; Familiarity with MATLAB; Mechanics; Multi-body Kinematics and Dynamics; General Physics; General Mathematics; Principles of Signal Processing.

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 another 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.

191506001 - Mathematical Methods

1. After this course, the student is able to
2. find roots of nonlinear functions;
3. linearize near equilibria of an ODE and classify equilibria using eigenvalues;
4. simulate deterministic and stochastic ODEs as well as perform quadrature;
5. to construct solutions of second order PDE's equation using Fourier series or finite differences;

6. assess accuracy of results from algorithms using numerical error analysis;
7. choose or modify algorithms for new numerical problems.

The understanding of scientific models and solving complicated engineering problems requires the correct use of programming and mathematical algorithms. Typical problems involve numerical solutions of nonlinear equations, simulations of dynamical systems, stability via eigenvalues, finite-dimensional approximations of spatial systems by discretisation or Fourier analysis. The art is not just to be able to solve such problems but also to have an intuition for the accuracy of the solution. We will develop some analytical insight, derive several algorithms and discuss error analysis.

During the bachelor study, an engineering student learns several mathematical methods through a number of calculus and linear algebra courses. Starting from this bachelor level, this course has three aims:

1. Refresh and enrich the students' knowledge on calculus, linear algebra, and Fourier analysis,
2. Expose the student to other areas such as numerical analysis and mathematical algorithms, and stochastic and partial differential equations,
3. Practising programming using Matlab with emphasis on efficiency and correctness. After this course the student has the ability to efficiently simulate and analyse models given by differential equations. In a more complicated setting, the student will be able to choose and adopt a method for an application.

The course consists of lectures providing an intuition to the mathematical methods. A few tutorials focus on Matlab programming. The homework problems deal with applications in neuroscience and biomedical engineering.

202200149 - eHealth Technology for Remote Patient Monitoring and Decision Making

In eHealth we study theories, approaches and systems that focus on treating and assisting people in managing chronic health conditions or lifestyle changes in their own daily environment thereby supported by health care professionals when needed . To understand these systems, analyse them and to design them, we need to understand the health issues and problems that have to be addressed by the eHealth technology and we need to understand what the suitable building blocks and architectures are to design these . Furthermore, we need to be able to evaluate the eHealth technology and understand how they can be implemented in everyday care practice.

Both elderly and people with chronic diseases are more viable to become victim of all kind of complaints with the consequence of having problems with finding a balance between work and private life. Not only the number of patients seeking help for their health problems is increasing, but the health problems they report are also more complex. The number of people with chronic diseases is growing and almost half of them have multiple complex chronic conditions (multimorbidity). Complex chronic conditions pose a challenge for healthcare as it heavily impacts a person’s quality of life physically, mentally and socially. Also, it consequently imposes a high burden on the healthcare system in terms of the complexity of treatment and care delivery, manpower and costs, because of the need of receiving complex and long-term care from multiple healthcare professionals. Since health, work and well-being are closely and powerfully linked, they need to be addressed together. Consequently, in many cases the conventional ‘one size fits all’ treatment approach is no longer sufficient, and a more personalized approach is needed.

Current disease management and monitoring of patients with a complex (chronic) condition(s) now relies heavily on information acquired during time-based scheduled visits when patients are usually stable, whereas the actual symptoms and changes during common daily life triggers are not quantified. Follow-up of relevant physiological parameters at home (remote patient monitoring) can provide important quantitative insights into the severity and dynamics of a chronic disease. Next, the data will be analysed and interpreted to create targeted treatment via e.g. clinical decision-support systems. Benefits are expected to arise from earlier initiation of appropriate treatment resulting in less severe complications, accelerated recovery, and reduced healthcare utilization. Additionally, eHealth technology can be valuable for short-term monitoring, such as in the peri- or postoperative phase. Studies have shown that performing certain surgeries in day care with subsequent remote patient monitoring at home of vital signs is a safe and feasible alternative for people at low risk of complications.
Also, eHealth technologies can assist patients in their self-care behaviour and can be used to develop personalized coaching and feedback for the individual person. Especially supporting people in having a healthy lifestyle is important as for example a sedentary lifestyle is one of the main risk factors for all kind of health problems such as

cardiovascular diseases, COPD, diabetes and musculoskeletal problems and because of the existing evidence that being active contributes positively to feeling healthy and quality of life. Although people do recognize the need for a more healthy lifestyle, they often find it difficult to get started and/or to stay motivated. Technology-supported lifestyle applications, focusing at physical activity, stress and nutrition, are expected to help people to continue contributing to society, the marketplace and the economy.

As such there is an ongoing development of patient monitoring and treatment outside the hospital using telemonitoring and telemedicine technology, using analysis and interpretation of data from existing and novel sensing methods in the wider clinical and daily life context. Such an eHealth technology can be decomposed into four main functional building blocks

1. Monitoring – this part of the system takes care of sensing relevant (health-related) parameters and whenever needed environmental parameters. It will often include some data processing so as to remove measurement artifacts or to extract basic features from the sensor data. Monitoring may also include the transfer of data to some local or remote data-store facility, and it may include presentation of the (raw) data.
2. Data Analysis – this part of the system takes care of analysing and interpreting the data with respect to biomedical or clinical metrics, or to estimate the state (either physical or mental) of the data.
3. Decision Support – In decision support the outcomes of the analysis are used to make decisions on whether or not action should be undertaken and which action. The question here is how we can derive and construct decision models and how should these be used.
4. Feedback and Coaching – Once a decision has been made, proper feedback and coaching to the user is needed in order to effectuate the action and/or move the user into the desired direction.

This course is about the design and development of an end-to-end telemedicine system for remote monitoring and coaching by addressing these four different building blocks, to enable personalized intervention of the complex chronic condition, focusing on long-term care and healthy lifestyle (nutrition, physical activity).

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