Module System Theory

Module Name: System Theory

Module Number		Level	Master	Short Name	SYSTHEO
Responsible Lecturers	Prof. Dr. rer. nat. Thorsten M. Buzug Prof. Henrik Botterweck				
Department, Facility	UzL and THL, Medical Technology and Applied Natural Sciences				
Course of Studies	Biomedical Engineering, Master				
Compulsory/elective	Compulsory	ECTS Credit Points	6		
Semester of Studies	1	Semester Hours per Week	4		
Length (semesters)	1	Workload (hours)	180		
Frequency	WiSe	Presence Hours	60		
Teaching Language	English	Self-Study Hours	120		
Consideration of Gender and Diversity Issues	☒ Use of gender-neutral language (THL standard) ☐ Target group specific adjustment of didactic methods ☐ Making subject diversity visible (female researchers, cultures etc.)				
Applicability	Biomedical Engineering				
Remarks	None				

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Module Course

Course 1: Signals and Systems

Course Number		Short Name	SIGSYS
Course Type	Lecture	Form of Learning	Presence
Mandatory Attendance	☐	ECTS Credit Points	3
Participation Limit	120	Semester Hours per Week	2
Group Size (practical training, exercises, …)	None	Workload (hours)	90
Teaching Language	English	Presence Hours	30
Study Achievements („Studienleistung“, SL)	None	Self-Study Hours	60
SL Length (minutes)	n. a.	SL Grading System	n. a.
Exam Type	Oral Exam	**Exam Language**	English
Exam Length (minutes)	20	**Exam Grading System**	One-third Grades
Learning Outcomes	• Students can create an overview of the signal processing chain for medical imaging. • They can explain the mathematical background of the reconstruction of CT images. • They can explain the basics of the physical relationships regarding X-rays. • They can enumerate the different generations of computer tomographs and explain differences. • They can apply the Fourier transform. • They can reproduce and explain the mathematical principles of two-dimensional reconstruction of CT images. • They can apply the algebraic approach to solving a reconstruction problem. • They can apply the static approach to solving a reconstruction problem. • They can highlight the differences between two-dimensional reconstruction and three-dimensional reconstruction. • They can sketch the transition from two-dimensional reconstruction to three-dimensional reconstruction.		
Participation Prerequisites	None		
Contents	• Signal processing (recapitulation of fundamental principles in signal processing) • Mathematical methods in image reconstruction and signal processing • X-Ray (fundamental principles, quantum statistics) • Computed Tomography (devices, current and past technology, signal processing, Fourier-based 2D and 3D image reconstruction,		

	algebraic and statistical image reconstruction, image artifacts, technical and clinical applications, dose)
Literature	• T. M. Buzug, *„Computed Tomography, From Photon Statistics to Modern Cone Beam CT“*, Springer-Verlag, Berlin/Heidelberg, 2008. • T. M. Buzug, *„Einführung in die Computertomographie - Mathematisch-physikalische Grundlagen der Bildrekonstruktion“*, Springer-Verlag, Berlin/Heidelberg, 2004.
Remarks	None

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Module Course

Course 2: Numerical Methods

Course Number		Short Name	NUM
Course Type	Lecture	Form of Learning	Presence
Mandatory Attendance	☐	ECTS Credit Points	3
Participation Limit	60	Semester Hours per Week	2
Group Size (practical training, exercises, …)	None	Workload (hours)	90
Teaching Language	English	Presence Hours	30
Study Achievements („Studienleistung“, SL)	Flexible	Self-Study Hours	60
SL Length (minutes)	90	SL Grading System	One-third Grades
Exam Type	Written Exam	**Exam Language**	English
Exam Length (minutes)	90	**Exam Grading System**	One-third Grades
Learning Outcomes	The students are aware of typical numerical effects when solving engineering problems. They can map reasonable complex real-world situations to a mathematical model. They know of typical approaches toward a solution. They may use basic mathematical techniques as working tools.		
Participation Prerequisites	None		
Contents	Numerical error propagation. Stability and condition. Linear systems. Basic differential equations. Eigenvector decomposition. Ill-posed problems. Basic statistical distributions. Maximum likelihood approaches.		
Literature	• *„Introduction to numerical methods“*, MIT OpenCourseWare 2019: https://ocw.mit.edu/courses/mathematics/18-335j-introduction-to-numerical-methods-spring-2019/ • Frank C. Hoppensteadt and Charles Peskin, *„Modeling and simulation in medicine and the life sciences“*, Springer, 1992.		
Remarks	None		