

## Joint Master's program Biomedical Engineering

<b>Module X4M 2100: Imaging</b>	
Aims:	<p>The students get a sound knowledge of the main imaging technologies concerning the applied principles and technologies.</p> <p>The students know about the great influence of mathematics on the result of computed images</p>
Workload:	Lecture attendance: 90 h Self-study: 150 h
Credit-points:	10
Person responsible for module:	Henrik Botterweck
Courses (lecturer):	Imaging lecture (Botterweck) Image Processing lecture (Ahlborg) Numerical Methods in Medicine lab (Botterweck)
Language:	English
Curriculum:	Master`s program Biomedical Engineering, 2nd Semester
<b>Medical Imaging</b>	<b>Lecture, 2 SWS</b>
Prerequisites according to examination regulations	None
Recommended prerequisites:	Numerical Methods in Medicine (lecture), Mathematics and Physics on an graduate (engineering bachelor) level
Learning outcomes:	Students will be able to 'translate' the medical requirements of imaging diagnostics by users to technical terms for developers and engineers.
Content:	Principles and classification of medical imaging, Optical Imaging, Sonography, Doppler, Diagnostic use of X-Rays, Transmission Tomography, Emission Tomography, Physical principles of nuclear magnetic resonance, typical MR imaging sequences, principles of maximum likelihood/a posteriori reconstruction, basic image processing.
Literature:	Th. Buzug: Computed Tomography (Springer) O. Dössel: Bildgebende Verfahren in der Medizin (Springer)
Examination:	Written examination.
Teaching methods:	Lecture, Discussion, Exercises
<b>Image Processing</b>	<b>Lecture, 2 SWS</b>
Prerequisites according to examination regulations	None

Recommended prerequisites:	Mathematical knowledge and knowledge in the field of signal-theory
Learning outcomes:	<ul style="list-style-type: none"> <li>• Development of the basics of the 2D signal processing (colors spaces, image scanning, discretisation of two-dimensional signals, discrete geometry)</li> <li>• Getting to know simple signal processing methods concerning feature extraction, filtering, and contrast adaption</li> <li>• Getting to know different methods to restore an image</li> <li>• Getting to know the basics of different image processing methods such as image segmentation and image registration</li> <li>• Getting to know the mathematical description, numerical solutions, and algorithmic implementation in digital signal processing</li> <li>• Knowledge about lecturer's current research projects</li> </ul>
Content:	<p>Medical image processing is an active area of research. This lecture aims at developing a principle understanding for methods used in medical image processing and image analysis. The lecture will cover the mathematical description, the numerical solution as well as the algorithmic implementation of different methods used in medical image processing. Apart from the introduction into very general image processing methods this lecture will also provide some insight into state-of-the-art image processing algorithms.</p> <p>This lecture is not thought as a brief overview of medical image processing and its applications. It is rather thought as a comprehensive discussion of some explicitly chosen methods in depth. Therefore, the students will not only learn how to process two dimensional signals but also gain a deep insight into applied mathematics and computer science.</p> <p>The developed mathematical and numerical understanding will not only allow to understand the beauty of medical image processing but also supply the students with a basic understanding of mathematical methods, which indeed is of great value in many other fields.</p> <p>In the very beginning of the lecture the students will be supplied with the basics of the representation of digital images. Subsequently several methods used for feature extraction, contrast enhancement and filtering in the spatial as well as the Fourier domain will be explained. These very lectures form the basis for the understanding of higher image processing methods such as image restauration, image segmentation and image registration, all of which to date still represent a highly active field of research with many unsolved problems. The lecture will not only focus on the theoretical background but will be accompanied with illustrative examples to further develop an understanding of the theoretically presented mathematical and numerical methods.</p>
Literature:	Gonzales, R. C.: Digital Image Processing, Prentice Hall, New

	<p>Jersey, 2008.</p> <p>Jähne, B.: Digital Image Processing, Springer, Berlin Heidelberg, 2002.</p> <p>Lehmann, Th. et al.: Bildverarbeitung für die Medizin, Springer, Berlin Heidelberg, 1997.</p> <p>Pratt, W. K.: Digital Image Processing: PIKS Scientific Inside, John Wiley &amp; Sons, 2007.</p>
Examination:	Written examination
Teaching methods:	Board, LCD-projector, Software-Presentations
<b>Numerical Methods in Medicine</b>	<b>Lab, 2 SWS</b>
Prerequisites according to examination regulations	None
Recommended prerequisites:	Lecture „Numerical Methods in Medicine“
Learning outcomes:	<p>After getting to know the basic numerical approaches and methods in the lecture the students can learn and practise the concrete application to realistic medical problems in this lab. The students become aware of aspects and criteria of the implementation and improvement of an algorithm.</p> <p>Knowledge about lecturer's current research projects</p>
Content:	<p>Simple, yet realistic problems in the fields of</p> <ul style="list-style-type: none"> <li>• medical image processing and visualization,</li> <li>• tomographic reconstruction,</li> <li>• statistical data evaluation,</li> <li>• simulation (epidemics...), and</li> <li>• medical -/bio-informatics (large data-sets)</li> </ul> <p>are posed together with example input data. The students apply given numerical tools (Matlab) and/or develop simple programs given numerical libraries in order to model, solve and analyze the tasks. A critical assessment of the results (Are the chosen methods adequate? Is the outcome realistic? What is the range of applicability? What could be improved?) is an important part of the work.</p>
Literature:	Computer (Programming/Simulation/Visualization tools), hand-outs, short presentation of results
Examination:	Programs, graded lab-reports, presentations
Teaching methods:	Board, transparencies, LCD-projector