2.7 Module aus dem B.Sc./M.Sc. Physik

Physics of Imaging

Code MWInf5	**Name** Physics of Imaging	
Leistungspunkte 4 LP	**Dauer**	**Turnus**
Lehrform Lecture 4 SWS	**Arbeitsaufwand** 120 h	**Verwendbarkeit**
Lernziel	Basics of the Physics of Imaging; common principles and techniques of imaging for atomic to astronomical scales.	
Inhalt	– Projective geometry, optics, wave optics, Fourier optics and lens aberrations – Radiometry of imaging – Methods of imaging: scanning electron microscopy, X-ray, EDX, FLIM, FRET, fluorescence imaging, near-field imaging – CCD and CMOS technology – Holography, ultrasound imaging, CT-computer tomography, magnetic resonance imaging – Satellite imaging, synthetic aperture radar, radio astronomy	
Voraussetzungen	recommended are: UKInf2, PEP1 - PEP4	
Prüfungs-modalitäten	Defined by lecturer before beginning of course	
Nützliche Literatur		

Entnommen aus dem Modulhandbuch MScPhysik, Version 2012.2/v3.

Image Processing

Code MWInf6	**Name** Image Processing	
Leistungspunkte 8 LP	**Dauer**	**Turnus**
Lehrform Lecture 4 SWS, Exercises 2 SWS	**Arbeitsaufwand** 210 h	**Verwendbarkeit**
Lernziel	Learn how to analyze signals from time series, images, and any kind of multidimensional signals and to apply it to problems in natural sciences, life sciences and technology.	
Inhalt	- Continuous and discrete signals, sampling theorem, signal representation - Fourier transform - Random variables and fields, probability density functions, error propagation - Homogeneous and inhomogeneous point operations - Neighbourhood operations, linear and nonlinear filters, linear system theory - Geometric transformations and interpolation - Multi-grid signal presentation and processing - Averaging, edge and line detection, local structure analysis, local phase and wave numbers - Motion analysis in image sequences - Segmentation - Regression, globally optimal signal analysis, variation approaches, steerable and nonlinear filtering, inverse filtering - Morphology and shape analysis, moments, Fourier descriptors - Bayesian image restoration - Object detection and recognition	
Teilnahme-Voraussetzungen		
Voraussetzungen	recommended are: UkInf1	
Prüfungs-modalitäten	Defined by lecturer before beginning of course	
Nützliche Literatur	B. Jähne, Digital Image Processing, 6th edition, Springer	

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Introduction to Image Processing on the GPU

Code IGPU	**Name** Introduction to Image Processing on the GPU	
Leistungspunkte 2 LP	**Dauer** ein Semester	**Turnus**
Lehrform Four day block course, equivalent of 2 SWS	**Arbeitsaufwand** 60 h, thereof 30 h Lectures and lab exercises 30 h Preparation and home exercises	**Verwendbarkeit**
Lernziel	For certain computation tasks which are colloquially called „embarassingly parallel“, and which occur quite frequently for example in image analysis, an implementation on a GPU (i.e. graphics card) can be orders of magnitude faster than a similar CPU implementation. In this short course, the students learn: - what kind of code can and can not be parallelized on a graphics processing unit (GPU) - the structure of a GPU, the different types of memory and how and when to use them - how to program the GPU using nVidia CUDA - how to perform various image analysis tasks using the GPU - ways to optimize the speed of GPU code	
Inhalt	The four days will be broken up into theoretical and practical segments. In the (short) theoretical lectures, I will introduce the concepts necessary for GPU programming and basic image analysis, which you will immediately try out afterwards in lab sessions. This way, the course will be highly practical and interactive. Students will work in small groups, each of which will have the task to write a small program solving an image analysis problem of their choice. Note that while image analysis tasks are a focus of the course because they give immediately visible results, the acquired techniques can be of course be employed in other fields as well, e.g. for solving large linear algebra problems or PDEs.	
Teilnahme-Voraussetzungen	none	
Voraussetzungen	recommended are: Solid knowledge of C programming, in particular no fear of pointers and direct memory access Some basics of image processing are helpful, but not strictly necessary	

Prüfungs-modalitäten	Active participation in the sessions and completion of the assigned program.
Nützliche Literatur	e.g. nVidia CUDA Programming Guide, available in the „CUDA zone“ on www.nvidia.com

Fast Parallel Implementations of Image Labeling Problems

Code IMLP	**Name** Fast Parallel Implementations of Image Labeling Problems	
Leistungspunkte 4 LP	**Dauer** ein Semester	**Turnus**
Lehrform 2 SWS Lecture, 1 SWS Exercise	**Arbeitsaufwand** 120 h; thereof 45 h Lectures and lab exercises 60 h Revision and home exercises 15 h Exam preparation	**Verwendbarkeit**
Lernziel	Image labeling problems are a fundamental class of problems appearing in image analysis, which dominate tasks in low-level computer vision like depth and motion estimation. Recently, many algorithms have been developed to solve this kind of problems in a variational framework, which allows for fast parallel implementations on the GPU. In this short course, the students learn: - Theoretical background for solving labeling problems in a variational framework - Efficient algorithms to solve the related class of optimization problems with parallel algorithms, which can be implemented on the GPU - How to implement these algorithms using nVidia CUDA - Techniques and tricks to make the implementations efficient	
Inhalt	The lecture is aimed at students who either participated in my CUDA course at the beginning of the semester and want to learn more about image analysis and the theoretical background, or participated in a theoretical course on variational image analysis and want to learn more about state-of-the art labeling algorithms and the practical side of their implementation. If you are new to both topics, you might still take part in the course, but must be prepared to take (potentially a lot of) additional time learning the prerequisites.	
Teilnahme-Voraussetzungen	none	
Voraussetzungen	recommended are: either „Introduction to Image Processing on the GPU“ offered at the beginning of the semester, or an introduction to Variational Image Analysis from e.g. last semester.	

Prüfungs-modalitäten	Active participation in lecture and exercises, oral exam.
Nützliche Literatur	e.g. Chambolle et al. 2010 „An Introduction to Total Variation for Image Analysis“ for theoretical background, and nVidia CUDA Programming Guide, available in the „CUDA zone“ on www.nvidia.com, for the practical one.