Master Applied Image and Signal Processing

Module description*

*upon approval

Curriculums

ECTS	Sem 1 (Typ: ECTS/SWS)	Sem 2 (Typ: ECTS/SWS)	Sem 3 (Typ: ECTS/SWS)	Sem 4 (Typ: ECTS/SWS)
1	Image Processing and Imaging (VO: 2/2 PS: 2/1)	Fourier Analysis, Filter Banks & Wavelets (VO: 4/3 PS: 3/2)	Computer Vision (VO: 3/2 PS: 2/1)	Master Seminar 2 (SE: 2/1)
2				
3				
4				
5	Imaging Beyond Consumer Cameras (VO: 2/2 PS: 2/1)			
6				
7			Geometric Modelling (VO: 3/2 PS: 2/1)	
8		Applied Statistics (IL: 4/3)		
9	Mathematics & Modelling (IL: 5/4)			
10				
11			Master Seminar 1 (SE: 3/2)	
12		Digital Signal Processing 2 (IL: 5/3)		
13				
14	Digital Signal Processing 1 (IL: 5/3)		Agile Project Management (IL: 3/2)	
15				
16				
17		Machine Learning (IL: 5/3)	Ethics & Sustainab. (IL: 1/1)	Master Thesis (IT: 23/0)
18			Elective 1 (IL: 5/3)	
19	Data Science (IL: 5/3)			
20				
21				
22		Audio Processing (VO: 3/2 PS: 2/1)		
23			Elective 2 (VO: 3/2 PS: 2/1)	
24	Analytics & Knowledge Discovery (IL: 3/2)			
25				
26				Master Exam DP: 2/0)
27	Natural Computation (VO: 2/2 PS: 2/1)	Media Data Formats (VO: 2/2 PS: 2/1)		
28			Free Elective 1 (IL/VO/PS: Summe 3/2)	Free Elective 2 (IL/VO/PS: Summe 3/2)
29				
30				

Modulname	Abkürzung	ECTS
Visual Data Processing & Representation	VPR	8
Mathematics & Modelling	MAM	16
Digital Signal Processing	DSP	10
Data Science & Analytics	DSA	17
Audio and Media	AAM	9
Visual Computing	VIC	10
Applied Sciences & Methods	ASM	7
Selected Topics in Applied Image & Signal Processing	STA	10
Free Elective	FEL	6
Master Thesis & Master Exam	MTE	27

Course and module descriptions

Modulnummer	Modultitel	Umfang
VPR	**Visual Data Processing & Representation**	**08 ECTS**
Lage im Curriculum	1. Semester	
Vorkenntnisse	Mathematical foundations (calculus, algebra, basic probability theory), procedural programming (Python, C, or comparable)	
Beitrag zu nachflg. Modulen	Elective Courses, Master Thesis & Master Exam, Visual Computing	

Titel der Lehrveranstaltung	**Image Processing and Imaging *(PLUS)***
Semester	1. Semester
ECTS / SWS	2 ECTS / 2 SWS
LV-Typ	Vorlesung (VO)
Lehrinhalte	Imaging Sensors (visible & non-visible light, CCD, CMOS), Autofocus systems (active and passive), Low-level image processing (interpolation, spatial domain enhancement, edge detection, Wavelet- and Fourier based filtering), Image segmentation techniques, Morphological image processing
Lernergebnisse	On completion of the course, students are able to understand the difference of varying imaging sensor devices and have knowledge about fundamental algorithms and procedures in spatial as well as transform-domain image processing and computer vision with an emphasis on segmentation and image filtering.
Prüfungsmethode/-charakter	abschließend
Empfohlene Fachliteratur / Lernressourcen	John C. Russ, F. Brent Neal. The Image Processing Handbook, CRC Press, 2016.

Titel der Lehrveranstaltung	**Image Processing and Imaging *(PLUS)***
Semester	1. Semester
ECTS / SWS	2 ECTS / 1 SWS
LV-Typ	Proseminar (PS)
Lehrinhalte	In small groups (2-4 students), students perform medium sized programming projects related to the topics of the lecture. No restrictions in terms of programming language usage.
Lernergebnisse	Students have first experiences in usage of image processing and vision libraries and toolboxes and are able to apply their knowledge in focused projects, also programming own code related to the tasks defined in the programming projects.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	John C. Russ, F. Brent Neal. The Image Processing Handbook, CRC Press, 2016.

Titel der Lehrveranstaltung	**Imaging Beyond Consumer Cameras *(PLUS)***
Semester	1. Semester
ECTS / SWS	2 ECTS / 2 SWS
LV-Typ	Vorlesung (VO)
Lehrinhalte	Video processing techniques (motion, superresolution), stereo and multiview acquisition and processing, time of flight, lightfield cameras, structured light, LIDAR imaging, 3D from 2D (shape from focus, shape from shading, shape from texture), microscopy imaging, satellite imaging
Lernergebnisse	On completion of the course, students are able to understand the varying acquisition techniques as discussed in the lecture and have knowledge about fundamental algorithms and procedures in the respective areas.
Prüfungsmethode/-charakter	abschließend
Empfohlene Fachliteratur / Lernressourcen	Liu, Y., Pears, N., Rosin, P.L., Huber, P. (Eds.) 3D Imaging, Analysis and Applications, Springer 2020. Borra, Surekha, Thanki, Rohit M., Dey, Nilanjan. Satellite Image Analysis: Clustering and Classification, Springer 2019. Mei Chen (editor) Computer Vision for Microscopy Image Analysis - Computer Vision and Pattern Recognition, Academic Press 2020. Murat Tekalp. Digital Video Processing, Pearson, 2015.

Titel der Lehrveranstaltung	**Imaging Beyond Consumer Cameras *(PLUS)***
Semester	1. Semester
ECTS / SWS	2 ECTS / 1 SWS
LV-Typ	Proseminar (PS)
Lehrinhalte	In small groups (2-4 students), students perform medium sized programming projects related to the topics of the lecture. No restrictions in terms of programming language usage.
Lernergebnisse	Students are able to apply their knowledge acquired in the lecture in focused projects, programming own code related to the tasks defined in the programming projects.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Liu, Y., Pears, N., Rosin, P.L., Huber, P. (Eds.) 3D Imaging, Analysis and Applications, Springer 2020. Borra, Surekha, Thanki, Rohit M., Dey, Nilanjan. Satellite Image Analysis: Clustering and Classification, Springer 2019. Mei Chen (editor) Computer Vision for Microscopy Image Analysis - Computer Vision and Pattern Recognition, Academic Press 2020. Murat Tekalp. Digital Video Processing, Pearson, 2015.

Modulnummer	Modultitel	Umfang
MAM	**Mathematics & Modelling**	**16 ECTS**
Lage im Curriculum	1. und 2. Semester	
Vorkenntnisse	Mathematical foundations (calculus, algebra, basic probability theory), procedural programming (Python, C, or comparable)	
Beitrag zu nachflg. Modulen	Elective Courses, Master Thesis & Master Exam	

Titel der Lehrveranstaltung	**Mathematics & Modelling *(FHS)***
Semester	1. Semester
ECTS / SWS	5 ECTS / 4 SWS
LV-Typ	Integrierte Lehrveranstaltung (ILV)
Lehrinhalte	Vector valued functions on n-dimensional domains, vector fields, scalar fields, partial derivatives, gradient operator, Jacobi and Hessian matrix, directional derivative, Taylor series in several variables, critical points, local minima, maxima and saddle points, convex optimization and applications. Integral calculus, Pre-Hilbert (inner-product) space, (orthonormal-) basis and basis transformation, Eigenvalues, Eigenvectors, matrix decompositions and applications (PCA).
Lernergebnisse	Students can apply functions in several variables to model problems. They are able to analyze the change behavior of these functions and to determine critical points. They can approximate complex functions by multidimensional polynomials (especially with tangent planes and second order Taylor polynomials). They are able to use gradient based methods to find local minima. They understand selected problems of convex optimization and can solve them with mathematical software. Students are able to calculate the most important matrix decompositions and apply eigenvalue theory to perform the principal components analysis for data. Students can solve multidimensional integrals. They understand the notion of a vector space (VS) with inner product and relate to it in different application areas. They master the coordinate transformation for the change of basis in finite dimensional VSs and are familiar with the relationship to Fourier analysis. They know selected application areas of the mentioned methods.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Stewart, J. (2016). Calculus. Eight Edition. Cengage Learning. Aggarwal, C. C. (2020). Linear Algebra and Optimization for Machine Learning. Springer. Vandenberghe, L. (2004). Convex Optimization. Cambridge University Press

Titel der Lehrveranstaltung	**Fourier Analysis, Filter Banks & Wavelets *(PLUS)***
Semester	2. Semester
ECTS / SWS	4 ECTS / 3 SWS
LV-Typ	Vorlesung (VO)
Lehrinhalte	Discrete and continuous Fourier theory, definition and examples of filters, filterbanks with perfect reconstruction, orthogonal and biorthogonal filterbanks, the Daubechies product filter, multiresolution analysis and wavelets, the fast wavelet transform.
Lernergebnisse	On completion of the course, students are able to understand the theoretical basics of Fourier transform, filterbanks and wavelets. They are familiar with the mathematical methods of filterbanks with perfect reconstruction. They know the explicit formula of the Daubechies filters and wavelets and can apply these filters to digital signals and images. Furthermore, the students understand the mathematical basics of the theory of wavelets and the construction of compactly supported orthogonal wavelets from quadrature mirror filters.
Prüfungsmethode/-charakter	abschließend
Empfohlene Fachliteratur / Lernressourcen	Strang, G. & Nguyen, T. (1996) Wavelets and Filter Banks (2nd edition). Wellesley-Cambridge Press, Wellesley. Malat, S. (1998) A Wavelet Tour of Signal Processing. Academic Press, Burlington

Titel der Lehrveranstaltung	**Fourier Analysis, Filter Banks & Wavelets *(PLUS)***
Semester	2. Semester
ECTS / SWS	3 ECTS / 2 SWS
LV-Typ	Proseminar (PS)
Lehrinhalte	Exercise course to the lecture of the same title.
Lernergebnisse	On completion of the course, students are able to apply techniques from Fourier and Wavelet theory to the analysis of signals with varying dimensionality, both in terms computer programs as well as in terms of theoretical considerations.
Prüfungsmethode/-charakter	abschließend
Empfohlene Fachliteratur / Lernressourcen	Strang, G. & Nguyen, T. (1996) Wavelets and Filter Banks (2nd edition). Wellesley-Cambridge Press, Wellesley. Malat, S. (1998) A Wavelet Tour of Signal Processing. Academic Press, Burlington

Titel der Lehrveranstaltung	**Applied Statistics *(FHS)***
Semester	2. Semester
ECTS / SWS	4 ECTS / 3 SWS
LV-Typ	Integrierte Lehrveranstaltung (ILV)
Lehrinhalte	Estimation theory: Point and interval estimators, maximum likelihood method, method of moments, parametric and non-parametric models (kernel density estimators, normal distributions, mixed models), statistical tests, study design and analysis of variance. Data visualization. Outlook: Random numbers and randomization; Graphical models and applications.
Lernergebnisse	Students can apply methods of inferential statistics to data and communicate the results obtained both verbally and graphically. They can describe data with models and are able to represent dependencies of random variables with graphical models. They know statistical standards and are able to plan, conduct and document experiments. They know applications of random number generators in the area of generative models and can produce corresponding data with mathematical software.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Ross, S. M. (2014). Introduction to probability and statistics for engineers and scientists. Elsevier. Ankan, A. & Panda, A. (2015). Mastering Probabilistic Graphical Models Using Python. Packt Publishing, Birmingham. Mee, L.E. et. al. (2007). A Modern Introduction to Probability and Statistics: Understanding Why and How. Springer.

Modulnummer	Modultitel	Umfang
DSP	**Digital Signal Processing**	**10 ECTS**
Lage im Curriculum	1. und 2. Semester	
Vorkenntnisse	Basics of Signals and Systems, Fourier- Laplace- and z-Transformation	
Beitrag zu nachflg. Modulen	Digital Signal Processing 2	

Titel der Lehrveranstaltung	**Digital Signal Processing 1 *(FHS)***
Semester	1. Semester
ECTS / SWS	5 ECTS / 3 SWS
LV-Typ	Integrierte Lehrveranstaltung (ILV)
Lehrinhalte	Theory of discrete signals and systems, discrete Fourier transformation, FFT, power density spectrum, discrete convolution and correlation, interpolation, calculations in z-domain, z-transfer function, stability and frequency response of discrete systems, discretization of continuous systems (bilinear transformation, impulse invariant transformation), digital filters, principle and design of FIR filters, principle and design of IIR filters, IIR filter structures, quantization problems frequency transformations, simulation of signal processing algorithms and implementation of discrete systems in lab environment (e.g. Matlab, Python, C)
Lernergebnisse	Students understand the basic mathematical concepts to describe continuous and discrete time signals and systems and know the relations between time and frequency domain. They are familiar with the foundations of signal sampling and discretization and can apply important transformations, e.g. Fourier-, Laplace and z-transformation. They understand basic algorithms in digital signal processing like FFT, convolution and correlation. They can transform continuous to discrete time systems e. g. with help of the impulse invariant or bilinear transformation and understand the restrictions. They have profound knowledge in designing and implementing digital filters and are also familiar with their applications. Students also have experience in simulation of DSP algorithms in a lab environment and are able to implement discrete systems with help of simulation software and low-level programming languages.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Oppenheim, A. V. & Schäfer, R.W. (2014) Discrete-Time Signal Processing. Pearson. Proakis, J. G. & Manolakis, D. G. (2014) Digital Signal Processing (4th Ed). Pearson. Li, T. & Jean, J. (2018) Digital Signal Processing – Fundamentals and Applications. Elsevier. Mandal, M. & Asif, A. (2007) Continuous and Discrete Time Signals and Systems. Cambridge. Gonzales, R. & Woods, R. E. (2008) Digital Image Processing (3rd Ed). Prentice Hall.

Titel der Lehrveranstaltung	**Digital Signal Processing 2 *(FHS)***
Semester	2. Semester
ECTS / SWS	5 ECTS / 3 SWS
LV-Typ	Integrierte Lehrveranstaltung (ILV)
Lehrinhalte	Designing IIR filters with 2nd order sections, notch filters and comb filters with simulation tools (e.g. Matlab) and with low level programming language (e.g. C), principle and theory of adaptive FIR filters (LMS-filter) including implementation in low level programming language, quality enhancement with help of oversampling, polyphase filters, theory and simulation of sigma delta converter, numerical programming, fixed-point and floating-point number representation, floating point arithmetics, rounding, numerical analysis, basics of 2D signal processing.
Lernergebnisse	Students know details in digital filter design such as advantages and disadvantages of different filter types and design methods. They understand the problem of quantization of filter coefficients and how to design 2nd order sections IIR filters. They know how to design special filters like notch, comb or median filters and are able to implement them in a low-level programming language (e.g. C). Students understand the concept of adaptive signal processing and can implement an adaptive LMS filter e.g. for noise cancellation. In general, they can solve complex signal processing problems on a given hardware platform. Students understand the problems of numerical programming. They know common number formats and understand details of fixed point and floating-point arithmetic. They understand the principle of applying standard DSP algorithms also for 2D-signals (images).
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Chassaing, R. (2008) Digital Signal Processing and Applications with the C6713 and C6416 DSK. Wiley. Qureshi, S. (2005) Embedded Image Processing on the TMS320C6000 DSP. Springer. Werner, M. (2019) Digitale Signalverarbeitung mit Matlab. Springer Vieweg. Von Grünigen, D. Ch. (2004) Digitale Signalverarbeitung. Hanser Verlag.

Modulnummer	Modultitel	Umfang
DSA	**Data Science & Analytics**	**17 ECTS**
Lage im Curriculum	1. und 2. Semester	
Vorkenntnisse	Mathematische Grundlagen (Analysis, Algebra, Wahrscheinlichkeitsrechnung), Programmierkenntnisse (Python, oder vergleichbar)	
Beitrag zu nachflg. Modulen	Elective Courses, Master Thesis & Master Exam	

Titel der Lehrveranstaltung	**Data Science *(FHS)***
Semester	1. Semester
ECTS / SWS	5 ECTS / 3 SWS
LV-Typ	Integrierte Lehrveranstaltung (ILV)
Lehrinhalte	Definition of Terminology in Data Science and Artificial Intelligence, Design Cycle, Extended Design Cycle, Sampling, Pre-processing, Normalization, Performance Measures, Cross Validation, Training Policies, K-nearest Neighbour and Minimum Distance Classifier, NLP Pre-processing and Features, Low Level Image Features
Lernergebnisse	Upon completion of this course, students know about types and ingredients of data science projects, entitle their structure and identify different types of team members. They understand the concepts of data, models and algorithms and use specific language to describe data. They discuss the appropriateness of a data collection or intended data acquisition process with respect to a data science or artificial intelligence project. Students are introduced to the classical approach for extracting information from data with different kind of representation (numerical, categorial, one-hot or text). They collect, pre-process and visualize this data to gain basic data understanding. They follow the design cycle for supervised methodology by implementing data-specific feature generation, sampling of training and testing data, training selected (simple) classifiers and evaluating their performance. The students use state-of-the-art development tools and scalable technology and argue their approach content-wise.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Croft, W., Metzler, D., & Strohman, T. (2010). Search engines: information retrieval in practice. Addison-Wesley. Manning, C., Raghavan, P., & Schütze, H. (2008). Introduction to information retrieval. (Vol. 1) Cambridge University Press Cambridge. Duda, R., Hart, P., & Stork, D. (1973). Pattern classification. (Vol. 2) Wiley. Bishop, C. (2006). Pattern recognition and machine learning. Springer.

Titel der Lehrveranstaltung	**Analytics & Knowledge Discovery *(FHS)***
Semester	1. Semester
ECTS / SWS	3 ECTS / 2 SWS
LV-Typ	Integrierte Lehrveranstaltung (ILV)
Lehrinhalte	Analytics, EDA Parallel Lines, Boxplots, Kernel Density Estimators, Basic Coding, Curse of Dimensionality, PCA, tSNE, Kmeans, hierarchical clustering, Spectral clustering, Distances and similarities
Lernergebnisse	The module Analytics and Knowledge Discovery leads students to classical approaches on Exploratory Data Analysis for data with different kind of representation (numerical, categorical, text). For implementing a knowledge discovery process, they apply methods to reduce the dimensionality of data, cluster it and apply various visualization methods. The course concentrates on unsupervised methodology.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Croft, W., Metzler, D., & Strohman, T. (2010). Search engines: information retrieval in practice. Addison-Wesley. Manning, C., Raghavan, P., & Schütze, H. (2008). Introduction to information retrieval. (Vol. 1) Cambridge University Press Cambridge. Duda, R., Hart, P., & Stork, D. (1973). Pattern classification. (Vol. 2) Wiley. Bishop, C. (2006). Pattern recognition and machine learning. Springer.

Titel der Lehrveranstaltung	**Natural Computation *(PLUS)***
Semester	1. Semester
ECTS / SWS	2 ECTS / 2 SWS
LV-Typ	Vorlesung (VO)
Lehrinhalte	Genetics and Evolution, Global Optimisation, Artificial Evolution, Biological Neural Networks, Artificial Neural Networks
Lernergebnisse	Upon completion of the course, students are familiar with the fundamental concepts of Natural Computation and understand theoretical foundations as well as application potential.
Prüfungsmethode/-charakter	abschließend
Empfohlene Fachliteratur / Lernressourcen	Brabazon, Anthony, O'Neill, Michael, McGarraghy, Sean. Natural Computing Algorithms, Springer 2015. Natural Computing with Python, Barnes and Noble, 2019.

Titel der Lehrveranstaltung	**Natural Computation *(PLUS)***
Semester	1. Semester
ECTS / SWS	2 ECTS / 1 SWS
LV-Typ	Proseminar (PS)
Lehrinhalte	In small groups (2-4 students), students perform medium sized programming projects related to the topics of the lecture. No restrictions in terms of programming language usage.
Lernergebnisse	Students are able to apply their knowledge acquired in the lecture in focused projects, programming own code related to the tasks defined in the programming projects.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Brabazon, Anthony, O'Neill, Michael, McGarraghy, Sean. Natural Computing Algorithms, Springer 2015. Natural Computing with Python, Barnes and Noble, 2019.

Titel der Lehrveranstaltung	**Machine Learning *(FHS)***
Semester	2. Semester
ECTS / SWS	5 ECTS / 3 SWS
LV-Typ	Integrierte Lehrveranstaltung (ILV)
Lehrinhalte	Statistical Learning Theory, no free lunch, learning curve, loss functions, bias and variance; Models: Maximum Entropy (Logistic Regression), Artificial Neural Networks, SVM (Kernel SVM, Multi-Class SVM, One-Class SVM), Naive Bayes, Minimum Risk, AI-Applications
Lernergebnisse	Students understand the assumptions and restrictions implied by a specific model choice in view of statistical learning theory setup and the "no free lunch" theorem. They select from a collection of well-known and widely available ML algorithms, accordingly, parameterize models and assess the impact of different design choices on the network complexity of neural networks. Students detect overfitting and underfitting during the training process and take corresponding counter measures such as regularization. They apply the machine learning models to different types of data (text, images, numerical) for tasks such as classification, representation learning and object detection and thereby construct examples of AI (artificial intelligence) systems.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Duda, R., Hart, P., & Stork, D. (1973). Pattern classification. (Vol. 2) Wiley. Bishop, C. (2006). Pattern recognition and machine learning. Springer. Dan Jurafsky, & James H. Martin (2019). Speech and Language Processing (Draft to 3rd edition). Ian Goodfellow, Yoshua Bengio, & Aaron Courville (2016). Deep Learning. MIT Press. John Winn, & Yordan Zaykov (2019). Model Based Machine Learning (Draft Edition).

Modulnummer	Modultitel	Umfang
AAM	**Audio and Media**	**09 ECTS**
Lage im Curriculum	2. Semester	
Vorkenntnisse	keine	
Beitrag zu nachflg. Modulen	Elective Courses, Master Thesis & Master Exam, Visual Computing	

Titel der Lehrveranstaltung	**Audio Processing *(PLUS)***
Semester	2. Semester
ECTS / SWS	3 ECTS / 2 SWS
LV-Typ	Vorlesung (VO)
Lehrinhalte	Sampling, quantization, linear shift-invariant systems, impulse response, FIR/IIR filters, Fourier methods, convolution theorem, equalizers, audio effects (phaser, wah-wah, delay, flanger, chorus), stereo effects, spatial effects (reverberation, localization, feedback delay networks), pitch shifting/stretching, non-linear effects (compressor, limiter, noise gate, overdrive), time-frequency methods, coding (predictive, psychoacoustics, MPEG), application program interfaces (data format, threading, block delay), control interfaces (MIDI, VST, DSSI).
Lernergebnisse	Upon completion of the course, students understand basic principles of audio processing
Prüfungsmethode/-charakter	abschließend
Empfohlene Fachliteratur / Lernressourcen	Zölzer, U. (2008) Digital Audio Signal Processing (2nd ed). John Wiley & Sons, New Jersey. Zölzer, U. (2011) DAFX: Digital Audio Effects (2nd ed). John Wiley & Sons, New Jersey. Boulanger, R. & Lazzarini, V. (Editors) (2010) The Audio Programming Book. The MIT press, Cambridge. Farnell, A. (2010) Designing Sound. The MIT press, Cambridge.

Titel der Lehrveranstaltung	**Audio Processing *(PLUS)***
Semester	2. Semester
ECTS / SWS	2 ECTS / 1 SWS
LV-Typ	Proseminar (PS)
Lehrinhalte	Calculation and programming exercises for the lecture of the same name
Lernergebnisse	Upon course completion, students are able to design and implement audio effects and subsystems which meet sound quality, computational performance, and real-time requirements, and embed them into various applications and platforms.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Zölzer, U. (2008) Digital Audio Signal Processing (2nd ed). John Wiley & Sons, New Jersey. Zölzer, U. (2011) DAFX: Digital Audio Effects (2nd ed). John Wiley & Sons, New Jersey. Boulanger, R. & Lazzarini, V. (Editors) (2010) The Audio Programming Book. The MIT press, Cambridge. Farnell, A. (2010) Designing Sound. The MIT press, Cambridge.

Titel der Lehrveranstaltung	**Media Data Formats *(PLUS)***
Semester	2. Semester
ECTS / SWS	2 ECTS / 2 SWS
LV-Typ	Vorlesung (VO)
Lehrinhalte	Foundations of Data compression (quantisation, lossless coding, error metrics), Image data formats (Vector vs. bitmap, Lossless (PNG, lJPEG, GIF) & lossy (JPEG, JPEG2000, JPEG XR,...), Video data formats (MPEG. H.26X, scalable video), Audio data formats (MPEG, Dolby)
Lernergebnisse	On completion of the course, students are able to understand basic principles of compression techniques for image and video data and know the major formats developed for these data types. In particular, they should be aware of the respective advantages and disadvantages of the respective formats and should be able to identify suited formats for a given target application taking constraints into consideration.
Prüfungsmethode/-charakter	abschließend
Empfohlene Fachliteratur / Lernressourcen	Nelson, G. (1995) The data compression book. Wiley and sons, New Jersey. Clarke, R. J. (1995) Digital compression of still images and video. Academic Press, Burlington. Rao, K.R. & Hwang, J. J. (1996) Techniques and standards for image, video, and audio coding. Prentice-Hall, New Jersey. Richardson, I. (2003) H.264 and MPEG-4 video compression. Wiley & sons, New Jersey.

Titel der Lehrveranstaltung	**Media Data Formats *(PLUS)***
Semester	2. Semester
ECTS / SWS	2 ECTS / 1 SWS
LV-Typ	Proseminar (PS)
Lehrinhalte	In small groups (2-4 students), students perform medium sized programming projects related to the topics of the lecture. No restrictions in terms of programming language usage.
Lernergebnisse	On completion of the course, students are able to use compression libraries and integrate those into a larger application context. Students are aware of lossy compression artefacts and the potential impact on applications using data compressed in that manner.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Nelson, G. (1995) The data compression book. Wiley and sons, New Jersey. Clarke, R. J. (1995) Digital compression of still images and video. Academic Press, Burlington. Rao, K.R. & Hwang, J. J. (1996) Techniques and standards for image, video, and audio coding. Prentice-Hall, New Jersey. Richardson, I. (2003) H.264 and MPEG-4 video compression. Wiley & sons, New Jersey.

Modulnummer	Modultitel	Umfang
VIC	**Visual Computing**	**10 ECTS**
Lage im Curriculum	3. Semester	
Vorkenntnisse	keine	
Beitrag zu nachflg. Modulen	Master Thesis & Master Exam	

Titel der Lehrveranstaltung	**Computer Vision *(PLUS)***
Semester	3. Semester
ECTS / SWS	3 ECTS / 2 SWS
LV-Typ	Vorlesung (VO)
Lehrinhalte	Deep learning techniques in computer vision with deep neural networks using Python
Lernergebnisse	On completion of the course, students understand the theoretical concepts of deep learning in computer vision and are aware of the potential application areas.
Prüfungsmethode/-charakter	abschließend
Empfohlene Fachliteratur / Lernressourcen	Ian Goodfellow and Yoshua Bengio and Aaron Courville Deep Learning. MIT Press 2016.

Titel der Lehrveranstaltung	**Computer Vision *(PLUS)***
Semester	3. Semester
ECTS / SWS	2 ECTS / 1 SWS
LV-Typ	Proseminar (PS)
Lehrinhalte	Programming exercises corresponding to the lecture of the same title using PyTorch
Lernergebnisse	Upon completion of the course, students are able to solve various computer vision tasks using PyTorch.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Ian Goodfellow and Yoshua Bengio and Aaron Courville Deep Learning. MIT Press 2016.

Titel der Lehrveranstaltung	**Geometric Modelling *(PLUS)***
Semester	3. Semester
ECTS / SWS	3 ECTS / 2 SWS
LV-Typ	Vorlesung (VO)
Lehrinhalte	Introduction to Bezier curves, splines and NURBs, differential geometry of curves and surfaces, discrete shape representations, meshes, shape editing, mesh fairing and simplification; application of geometric modeling.
Lernergebnisse	On completion of the course, students have acquired an in-depth understanding of basic (mathematical) concepts used in the modeling of curves, surfaces and shapes. They have seen and used basics of differential geometry, and have been exposed to basic topological concepts of curves and surfaces. Both continuous (e.g., spline-based) and discrete (e.g., triangle-based) representations have been examined.
Prüfungsmethode/-charakter	abschließend
Empfohlene Fachliteratur / Lernressourcen	Mortenson, M. (2006) Geometric Modeling (3rd ed). Industrial Press Inc, New York. Farin, G. (2002) Curves and Surfaces for CAGD (5th ed). Morgan Kaufmann, San Francisco.

Titel der Lehrveranstaltung	**Geometric Modelling *(PLUS)***
Semester	3. Semester
ECTS / SWS	2 ECTS / 1 SWS
LV-Typ	Proseminar (PS)
Lehrinhalte	Practical training of topics discussed in the lecture, in order to gain a better understanding and practical experience.
Lernergebnisse	On completion of the course, students are able to use fundamental concepts of geometric modelling in practical applications, ranging from simple exemplary software implementations to the completion of formal proofs and theoretical considerations.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Mortenson, M. (2006) Geometric Modeling (3rd ed). Industrial Press Inc, New York. Farin, G. (2002) Curves and Surfaces for CAGD (5th ed). Morgan Kaufmann, San Francisco.

Modulnummer	Modultitel	Umfang
ASM	**Applied Sciences and Methods**	**07 ECTS**
Lage im Curriculum	3. Semester	
Vorkenntnisse	keine	
Beitrag zu nachflg. Modulen	Master Thesis & Master Exam	

Titel der Lehrveranstaltung	**Master Seminar 1 *(PLUS)***
Semester	3. Semester
ECTS / SWS	3 ECTS / 2 SWS
LV-Typ	Seminar (SE)
Lehrinhalte	Characteristics of a scientific working style; scientific publication cycle; structured literature research, assessment of the quality of publications (quality indices), compilation of state-of-the-art including bibliography; working with Latex, Mathematica and other tools supporting scientific work.
Lernergebnisse	Students know the publication lifecycle including the review process. Furthermore, they are able to assess textual, formal and structural quality aspects of scientific papers and scientific presentations. Students have hands-on experience with various tools supporting scientific work, including LateX and Mathematica.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Leslie Lamport LATEX: A Document Preparation System: User's Guide and Reference Manual. Addison Wesley 1994.

Titel der Lehrveranstaltung	**Agile Project Management *(FHS)***
Semester	3. Semester
ECTS / SWS	3 ECTS / 2 SWS
LV-Typ	Integrierte Lehrveranstaltung (ILV)
Lehrinhalte	The focus is on the creation of software engineering projects to cope with the digitalization of companies. Project management and software engineering skills are to be applied in the practical implementation. Among other things, business case & product innovation (using business canvas & value proposition canvas), project organization (process-oriented and agile procedure models, roles, work packages, milestones, reporting, results). The project implementation is carried out with templates from Software Engineering for the development, documentation and communication of software architectures using ARC42 (Context, Requirements, Constraints, Concept of Operations, Major building blocks/components, Block diagram, interfaces, workflow, control flow).
Lernergebnisse	Students can apply theoretical and practical project management and software engineering skills in a team, based on the practical implementation of a continuous software engineering project.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Schmidt, R. F. (2013). Software engineering: architecture-driven software development. Newnes. Kerzner, H. (2017). Project management: a systems approach to planning, scheduling, and controlling. John Wiley & Sons. Osterwalder, A., & Pigneur, Y. (2010). Business model generation: a handbook for visionaries, game changers, and challengers. John Wiley & Sons ARC42. www.arc42.org.

Titel der Lehrveranstaltung	**Ethics & Sustainability *(FHS)***
Semester	3. Semester
ECTS / SWS	1 ECTS / 1 SWS
LV-Typ	Integrierte Lehrveranstaltung (ILV)
Lehrinhalte	The need for professional-ethical orientation has never been as great as it has become in the past decade. At this stage, we are being confronted with the topic of ethics from all directions: bioethics, medical ethics, animal ethics, ethics and politics, ethics and economy, ethics as a school subject instead of religion… from personalized ethics to environmental ethics, from day-to-day to systems ethics…. our very existence seems to be sailing in a sea of ethical and morally charged issues – particularly because the two terms – ethics and sustainability – are being used more and more ambiguously and prolifically. This symposium will therefore attempt to shed some light on the question of terminology and to sensitize participants to the questions behind professional ethics and sustainability.
Lernergebnisse	After successfully completing the symposium, students are able to analyse and reflect on ethical-moral dilemmas; to evaluate opinions from a lecture in their own context of action; to argue social issues with a view to their own professional environment; to articulate and justify their own opinion in the group discussion.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	A list of relevant publications will be announced yearly corresponding to the respective programming of this symposium.

Modulnummer	Modultitel	Umfang
STA	**Selected Topics in Applied Image and Signal Processing**	**10 ECTS**
Lage im Curriculum	3. Semester	
Vorkenntnisse	Understanding of the respective mathematical and algorithmic basics of the chosen electives.	
Beitrag zu nachflg. Modulen	Master Thesis & Master Exam	

Titel der Lehrveranstaltung	**Natural Language Processing *(FHS)*** *Elective 1: Natural Language Processing*
Semester	3. Semester
ECTS / SWS	3 ECTS / 2 SWS
LV-Typ	Integrierte Lehrveranstaltung (ILV)
Lehrinhalte	Methods: Natural Language Processing with Deep Neural Networks, e.g. Recurrent Neuronal Networks, Attention-Models, Transformers or BERT. Contextualized representations, Subword tokenization, Beam Search.
Lernergebnisse	Students apply attention-based models for natural language processing and implement appropriate networks for applications in areas such as machine translation and sentiment analysis in social networks. Building on previously acquired skills in pre-processing text data, they use contextualized text representations and complex network architectures. They are able to decide on network parameters and design appropriate for the problem at hand and know the limits and areas of application of the respective algorithms.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Christopher Manning, Prabhakar Raghavan, & Hinrich Schütze (2008). Introduction to Information Retrieval. Cambridge University Press. Dan Jurafsky, & James H. Martin (2019). Speech and Language Processing (Draft to 3rd edition). Ian Goodfellow, Yoshua Bengio, & Aaron Courville (2016). Deep Learning. MIT Press. Hobson Lane, Hannes Hapke, & Cole Howard (2019). Natural Language Processing in Action: Understanding, analyzing, and generating text with Python. Manning Publications.

Titel der Lehrveranstaltung	**Applied Natural Language Processing *(FHS)*** *Elective 1: Natural Language Processing*
Semester	3. Semester
ECTS / SWS	2 ECTS / 1 SWS
LV-Typ	Integrierte Lehrveranstaltung (ILV)
Lehrinhalte	Methods: Dialog-based Agents and Systems; Artificial Intelligence; task-oriented dialog systems and chatbots; Natural Language Generation, Interaction and Understanding; Question Answering, Slot Filling. Applications: Dialog systems and chatbots. Tools: Python, scikit-learn, nltk, tensorflow/keras/PyTorch, dialogflow.
Lernergebnisse	Students are aware of the difference between task-oriented systems and dialog systems. They develop algorithms for generating natural language targeted at different tasks (slot filling, question answering) or for conversational purposes. Students know about existing tools for the development of dialog systems, their differences and how to integrate these tools into other applications such as social media.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Christopher Manning, Prabhakar Raghavan, & Hinrich Schütze (2008). Introduction to Information Retrieval. Cambridge University Press. Dan Jurafsky, & James H. Martin (2019). Speech and Language Processing (Draft to 3rd edition). Ian Goodfellow, Yoshua Bengio, & Aaron Courville (2016). Deep Learning. MIT Press. Hobson Lane, Hannes Hapke, & Cole Howard (2019). Natural Language Processing in Action: Understanding, analyzing, and generating text with Python. Manning Publications. Srini Janarthanam (2018). Hands-on Chatbots and Conversational AI Development. Packt Publishing.

Titel der Lehrveranstaltung	**Reinforcement Learning *(FHS)*** *Elective 1: Reinforcement Learning*
Semester	3. Semester
ECTS / SWS	3 ECTS / 2 SWS
LV-Typ	Integrierte Lehrveranstaltung (ILV)
Lehrinhalte	Markov Decision Process, Definition of RL, Components of RL (Agent, Policy, Model), Model and Non-model based RL, Optimization of RL, Deep RL, Reinforcement Learning Algorithms
Lernergebnisse	Students identify problems suited for reinforcement learning, find suitable models and assemble solutions using toolboxes. They distinguish and differentiate between different setups based on input data type and assumptions on the environment and select corresponding algorithms and metrics. Using Deep Learning methodologies, the students design, optimize and evaluate deep reinforcement learning for a set of classical problems. They discuss current trends and upcoming areas of application.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Bertsekas, D. (2010). Dynamic Programming and Optimal Control, Control. Powell, W. (2011). Approximate Dynamic Programming: Solving the curses of dimensionality. (Vol. 703) John Wiley & Sons. Szepesvári, C. (2010). Algorithms for Reinforcement Learning Synthesis Lectures on Artificial Intelligence and Machine Learning, 4(1), 1–103. Sutton, R., & Barto, A. (2018). Reinforcement Learning: An Introduction, Second Edition, The Lancet. Lapan, M. (2018). Deep Reinforcement Learning Hands-On: Apply modern RL methods, with deep Q-networks, value iteration, policy gradients, TRPO, AlphaGo Zero and more. Packt Publishing Ltd. Puterman, M. (2014). Markov decision processes: discrete stochastic dynamic programming. John Wiley & Sons. LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning, Nature, 521(7553), 436–444.

Titel der Lehrveranstaltung	**Applied Reinforcement Learning *(FHS)*** *Elective 1: Reinforcement Learning*
Semester	3. Semester
ECTS / SWS	2 ECTS / 1 SWS
LV-Typ	Integrierte Lehrveranstaltung (ILV)
Lehrinhalte	Deep RL, Reinforcement Learning Algorithms, Model-based RL, RL by use of Physics Engines
Lernergebnisse	Students identify problems for model-base and model-free reinforcement learning, apply suitable algorithms and assemble solutions using toolboxes. They know how to use real-life simulations by physics engines for Reinforcement Learning and know the challenges when switching to robots or other hardware. They discuss current trends and upcoming areas of application.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Sutton, R., & Barto, A. (2018). Reinforcement Learning: An Introduction, Second Edition, The Lancet. Lapan, M. (2018). Deep Reinforcement Learning Hands-On: Apply modern RL methods, with deep Q-networks, value iteration, policy gradients, TRPO, AlphaGo Zero and more. Packt Publishing Ltd. Puterman, M. (2014). Markov decision processes: discrete stochastic dynamic programming. John Wiley & Sons. LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning, Nature, 521(7553), 436–444.Powell, W. (2011). Approximate Dynamic Programming: Solving the curses of dimensionality. (Vol. 703) John Wiley & Sons. Szepesvári, C. (2010). Algorithms for Reinforcement Learning Synthesis Lectures on Artificial Intelligence and Machine Learning, 4(1), 1–103. Sutton, R., & Barto, A. (2018). Reinforcement Learning: An Introduction, Second Edition, The Lancet. Lapan, M. (2018). Deep Reinforcement Learning Hands-On: Apply modern RL methods, with deep Q-networks, value iteration, policy gradients, TRPO, AlphaGo Zero and more. Packt Publishing Ltd. Puterman, M. (2014). Markov decision processes: discrete stochastic dynamic programming. John Wiley & Sons. LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning, Nature, 521(7553), 436–444.

Titel der Lehrveranstaltung	**Medical Imaging *(PLUS)*** *Elective 2: Medical Imaging*
Semester	3. Semester
ECTS / SWS	3 ECTS / 2 SWS
LV-Typ	Vorlesung (VO)
Lehrinhalte	US, X-Ray, CT, MRT, MRI, fMRI
Lernergebnisse	On completion of the course students are able to understand basics of different medical imaging modalities and their application in a clinical environment.
Prüfungsmethode/-charakter	abschließend
Empfohlene Fachliteratur / Lernressourcen	Handels, H. (2009) Medizinische Bildverarbeitung (Vol. 2). Vieweg & Teubner, Wiesbaden. Dougherty, G. (2009) Digital Image Processing for Medical Applications. Cambridge University Press, Cambridge. Smith, N. B. (2010) Introduction to Medical Imaging: Physics, Engineering and Clinical Applications. Cambridge University Press, Cambridge. Deserno, T. M. (2011) Biomedical Image Processing. Springer, Berlin. Birkfellner, W. (2011) Applied Medical Image Processing. CRC Press, London.

Titel der Lehrveranstaltung	**Medical Imaging *(PLUS)*** *Elective 2: Medical Imaging*
Semester	3. Semester
ECTS / SWS	2 ECTS / 1 SWS
LV-Typ	Proseminar (PS)
Lehrinhalte	Practical programming tasks on public medical datasets
Lernergebnisse	Students are able to apply their knowledge gained in the lecture and in more general courses to specific application areas and will learn to select the most appropriate techniques and methods in actual, application-oriented fields.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Handels, H. (2009) Medizinische Bildverarbeitung (Vol. 2). Vieweg & Teubner, Wiesbaden. Dougherty, G. (2009) Digital Image Processing for Medical Applications. Cambridge University Press, Cambridge. Smith, N. B. (2010) Introduction to Medical Imaging: Physics, Engineering and Clinical Applications. Cambridge University Press, Cambridge. Deserno, T. M. (2011) Biomedical Image Processing. Springer, Berlin. Birkfellner, W. (2011) Applied Medical Image Processing. CRC Press, London.

Titel der Lehrveranstaltung	**Biometric Systems *(PLUS)*** *Elective 2: Biometric Systems*
Semester	3. Semester
ECTS / SWS	3 ECTS / 2 SWS
LV-Typ	Vorlesung (VO)
Lehrinhalte	Introduction to biometric systems, Short review of non-visual based modalities (voice, keystroke, EEG, ECG, …), Fingerprint Recognition, Face Recognition, Eye-based System (Iris & Retina recognition), Ear biometrics, Gait, Biometric fusion, security, privacy
Lernergebnisse	Students know about the most important biometric traits, their advantages and shortcomings, and the weaknesses and strengths of biometric systems in general.
Prüfungsmethode/-charakter	abschließend
Empfohlene Fachliteratur / Lernressourcen	Jain, A. K., Flynn, P. & Ross, A. A. (2008) Handbook of biometrics. Springer, New York. Wayman, J. L. (2004) Biometric Systems: Technology, Design and Performance Evaluation. Springer, London.

Titel der Lehrveranstaltung	**Biometric Systems *(PLUS)*** *Elective 2: Biometric Systems*
Semester	3. Semester
ECTS / SWS	2 ECTS / 1 SWS
LV-Typ	Proseminar (PS)
Lehrinhalte	Practical programming tasks on public biometric datasets.
Lernergebnisse	Students are able to apply their knowledge gained in the lecture and in more general courses to specific application areas and will learn to select the most appropriate techniques and methods in actual, application-oriented fields.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Jain, A. K., Flynn, P. & Ross, A. A. (2008) Handbook of biometrics. Springer, New York. Wayman, J. L. (2004) Biometric Systems: Technology, Design and Performance Evaluation. Springer, London.

Titel der Lehrveranstaltung	**Media Security *(PLUS)*** *Elective 2: Media Security*
Semester	3. Semester
ECTS / SWS	3 ECTS / 2 SWS
LV-Typ	Vorlesung (VO)
Lehrinhalte	Media Encryption (image, video, audio, 3D-data), Media Authentication (Robust hashing, robust signatures, watermarking), Information Hiding (watermarking, steganography), Media Forensics
Lernergebnisse	Students know about the most important mechanisms in media security, their advantages and shortcomings, and the weaknesses and strengths of media security systems in general.
Prüfungsmethode/-charakter	abschließend
Empfohlene Fachliteratur / Lernressourcen	Uhl, A. & Pommer, A. (2005) Image and Video Encryption: From digital rigths management to secure personal communication. Springer, New York. Furht, B. & Kirivsk, D. (2004) Multimedia Security Handbook. CRC Press, New York.

Titel der Lehrveranstaltung	**Media Security *(PLUS)*** *Elective 2: Media Security*
Semester	3. Semester
ECTS / SWS	2 ECTS / 1 SWS
LV-Typ	Proseminar (PS)
Lehrinhalte	Practical programming tasks on forensic datasets.
Lernergebnisse	Students are able to apply their knowledge gained in the lecture and in more general courses to specific application areas and will learn to select the most appropriate techniques and methods in actual, application-oriented fields.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Uhl, A. & Pommer, A. (2005) Image and Video Encryption: From digital rigths management to secure personal communication. Springer, New York. Furht, B. & Kirivsk, D. (2004) Multimedia Security Handbook. CRC Press, New York.

Titel der Lehrveranstaltung	**Computational Geometry *(PLUS)*** *Elective 2: Computational Geometry*
Semester	3. Semester
ECTS / SWS	3 ECTS / 2 SWS
LV-Typ	Vorlesung (VO)
Lehrinhalte	Computational geometry is the study of the design and analysis of efficient algorithms for solving problems with a geometric flavour. The methodologies of computational geometry allow one to investigate solutions of numerous geometric problems that arise in application areas such as image processing, computer-aided design, manufacturing, geographic information systems, robotics and graphics. This course offers an introduction to computational geometry: We will discuss geometric searching, convex hulls, Voronoi diagrams, straight skeletons, triangulations, and robustness issues.
Lernergebnisse	The students are able to analyze geometric problems and to design algorithms for solving them in an efficient manner. They have been exposed to important paradigms of geometric computing, and have acquired in-depth knowledge of basic geometric data structures (such as triangulations and Voronoi diagrams). They have also seen sample applications of these data structures and algorithms for solving real-world problems of a geometric flavor.
Prüfungsmethode/-charakter	abschließend
Empfohlene Fachliteratur / Lernressourcen	De Berg, M., Cheong, O., Van Krefeld, M. & Overmars, M. (2008) Computational Geometry. Algorithms and Applications (3rd ed). Springer, Luxemburg. O'Rourke, J. (2000) Computational Geometry in C (2nd ed). Cambridge University Press, Cambridge.

Titel der Lehrveranstaltung	**Computational Geometry *(PLUS)*** *Elective 2: Computational Geometry*
Semester	3. Semester
ECTS / SWS	2 ECTS / 1 SWS
LV-Typ	Proseminar (PS)
Lehrinhalte	Practical programming tasks and exercises related to the lecture content.
Lernergebnisse	Students are able to apply their knowledge gained in the lecture and in more general courses to specific application areas and will learn to select the most appropriate techniques and methods in actual, application-oriented fields.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	De Berg, M., Cheong, O., Van Krefeld, M. & Overmars, M. (2008) Computational Geometry. Algorithms and Applications (3rd ed). Springer, Luxemburg. O'Rourke, J. (2000) Computational Geometry in C (2nd ed). Cambridge University Press, Cambridge.

Titel der Lehrveranstaltung	**Advanced Machine Learning *(PLUS)*** *Elective 2: Advanced Machine Learning*
Semester	3. Semester
ECTS / SWS	3 ECTS / 2 SWS
LV-Typ	Vorlesung (VO)
Lehrinhalte	Machine learning is the study of how to program computers to "learn" from available input data. In other words, it is the process of converting experience (in the form of training data) into expertise to solve a variety of different tasks (e.g., classification, regression, etc.)
Lernergebnisse	Students will learn a formal-mathematical understanding of this idea. They are exposed to fundamental concepts such as probably approximately correct (PAC) learning, Vapnik–Chervonenkis theory and applications thereof. Further, the theoretical understanding of the learning process is applied in the analysis of popular learning algorithms such as Boosting or support vector machines (SVMs) which have become so ubiquitous in many fields of science.
Prüfungsmethode/-charakter	abschließend
Empfohlene Fachliteratur / Lernressourcen	Mohri, Rostamizadeh, Talwakar: Foundations of Machine Learning,MIT Press, 2012 Shalev-Schwartz, Ben-David: Understanding Machine Learning: From Theory to Algorithm, Cambridge Univ. Press, 2014

Titel der Lehrveranstaltung	**Advanced Machine Learning *(PLUS)*** *Elective 2: Advanced Machine Learning*
Semester	3. Semester
ECTS / SWS	2 ECTS / 1 SWS
LV-Typ	Proseminar (PS)
Lehrinhalte	Practical programming tasks and exercises related to the lecture content.
Lernergebnisse	Students are able to apply their knowledge gained in the lecture and in more general courses to specific application areas and will learn to select the most appropriate techniques and methods in actual, application-oriented fields.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Mohri, Rostamizadeh, Talwakar: Foundations of Machine Learning,MIT Press, 2012 Shalev-Schwartz, Ben-David: Understanding Machine Learning: From Theory to Algorithm, Cambridge Univ. Press, 2014

Modulnummer	Modultitel	Umfang
FEL	**Free Elective**	**06 ECTS**
Lage im Curriculum	3. und 4. Semester	
Vorkenntnisse	Understanding of the respective mathematical and algorithmic basics of the chosen electives.	
Beitrag zu nachflg. Modulen		

Titel der Lehrveranstaltung	**Free Elective 1**
Semester	3. Semester
ECTS / SWS	3 ECTS / 2 SWS
LV-Typ	---
Lehrinhalte	Students are to complete free elective courses totalling 6 ECTS points (3 ECTS in the Free Elective 1 and 3 ECTS in the Free Elective 2). These free elective courses are designed to further foster the acquisition of additional professional skills and strengthen individual areas of focus within a student's course of study. They can be completed at any accredited postsecondary institution. It is recommended to take English-taught courses. It is also recommended to take courses from the module STA (elective courses in third semester of the Applied Image and Signal Processing program), or technical electives offered at either Paris Lodron University of Salzburg or Salzburg University of Applied Sciences.
Lernergebnisse	---
Prüfungsmethode/-charakter	---
Empfohlene Fachliteratur / Lernressourcen	---

Titel der Lehrveranstaltung	**Free Elective 2**
Semester	4. Semester
ECTS / SWS	3 ECTS / 2 SWS
LV-Typ	---
Lehrinhalte	Students are to complete free elective courses totalling 6 ECTS points (3 ECTS in the Free Elective 1 and 3 ECTS in the Free Elective 2). These free elective courses are designed to further foster the acquisition of additional professional skills and strengthen individual areas of focus within a student's course of study. They can be completed at any accredited postsecondary institution. It is recommended to take English-taught courses. It is also recommended to take courses from the module STA (elective courses in third semester of the Applied Image and Signal Processing program), or technical electives offered at either Paris Lodron University of Salzburg or Salzburg University of Applied Sciences.
Lernergebnisse	---
Prüfungsmethode/-charakter	---
Empfohlene Fachliteratur / Lernressourcen	---

Modulnummer	Modultitel	Umfang
MTE	**Master Thesis & Master Exam**	**27 ECTS**
Lage im Curriculum	4. Semester	
Vorkenntnisse	---	
Beitrag zu nachflg. Modulen	---	

Titel der Lehrveranstaltung	**Master Seminar 2** ***(PLUS oder FHS)***
Semester	4. Semester
ECTS / SWS	2 ECTS / 1 SWS
LV-Typ	Seminar (SE)
Lehrinhalte	Discursive defence of parts of the master thesis in group situations; presentation of scientific work as part of the state-of-the-art discussion for the thesis' topics; discussion of recent research results in connection with colleagues' theses.
Lernergebnisse	The students are able to present and discuss their own scientific work in a peer group situation. They can argue logically and in line with scientific standards as well as understand the importance of a methodical approach.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Hofmann, A.H. (2020): Scientific writing and communication: papers, proposals, and presentations. 4th Ed. Oxford University Press, N.Y. www.elsevier.com/connect/how-to-give-a-dynamic-scientific-presentation

Titel der Lehrveranstaltung	**Master Thesis** ***(PLUS oder FHS)***
Semester	4. Semester
ECTS / SWS	23 ECTS / 0 SWS
LV-Typ	Individualtraining/-phasen (IT)
Lehrinhalte	Developing and elaborating on the research questions and establishing a contentwise argumentation of a topic in applied image and signal processing with special consideration of a scientifically sound and structured presentation reflecting the current state of the literature.
Lernergebnisse	The students are able to independently write sound academic papers based on common international standards. They can proceed methodically and systematically. They can analyse and present problems, provide solutions as well as formulate these appropriately and critically scrutinise them. The students are able to defend their approach.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	---

Titel der Lehrveranstaltung	**Master Exam *(PLUS und FHS)***
Semester	4. Semester
ECTS / SWS	2 ECTS / 0 SWS
LV-Typ	Diplom/Masterarbeit (DP)
Lehrinhalte	Defensio, Technical examination talks
Lernergebnisse	The students are able to present and discursively defend the hypotheses and solution approaches developed in the master thesis. They are able to establish cross-references to contents of the study program.
Prüfungsmethode/-charakter	abschließend
Empfohlene Fachliteratur / Lernressourcen	---

4.3 Modulbeschreibung Bridge Courses

Modulnummer	Modultitel	Umfang
BRI	**Bridge Courses**	**07 ECTS**
Lage im Curriculum	---	
Vorkenntnisse	---	
Beitrag zu nachflg. Modulen	---	

Titel der Lehrveranstaltung	**Signals & Systems *(FHS)*** *Bridge Courses*
Semester	---
ECTS / SWS	3 ECTS / 3 SWS
LV-Typ	Integrierte Lehrveranstaltung (ILV)
Lehrinhalte	Basic signal and system properties, time and frequency domain, Fourier series and Fourier transformation (FT), FT of single impulses and periodic signals, power density spectrum (Parseval), convolution, convolution property, Dirac impulse, Dirac impulse sequence stochastic signals, variance and power of stochastic signals, autocorrelation and cross correlation sampling theorem, aliasing, zero order hold sampling, quantization, quantization error Laplace transformation, transfer function, pole zero map, discrete time signals and systems, z-transform, z-transfer function. Linear Time Invariant (LTI) Systems: System stability examination of continuous and discrete systems (root locus), principle of controlling, control loop, design of simple controllers.
Lernergebnisse	Students are able to understand the basic mathematical concepts for describing continuous and discrete time signals and systems. Further they can distinguish and know the relation between time and frequency domain. Further they are familiar with the foundation of signal sampling and discretization. They can apply important transformations (e.g. Fourier-, Laplace, z-Transformation) for signals and systems. Further, the students understand basic algorithms in digital signal processing like FFT, convolution and correlation. They are able to simulate continuous and discrete systems and are able to analyze signal and system properties.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Oppenheim, A. V., Willsky, A. S. & Nawab, S. H. (1997) Signals & Systems. Prentice Hall, New Jersey. Mandal, M., Asif, A., (2007) Continuous and discrete time signals and systems. Cambridge University Press, New York McClellan, J. H., Schafer, R. W. & Yoder, M. A. (2003) Signal Processing First. Pearson Prentice Hall, New Jersey. Stein, E. & Shakarchi, R. (2003) Fourier Analysis: An Introduction. Academic Press, New York.

Titel der Lehrveranstaltung	**Hardware Oriented Signal Processing *(FHS)*** *Bridge Courses*
Semester	---
ECTS / SWS	1 ECTS / 1 SWS
LV-Typ	Integrierte Lehrveranstaltung (ILV)
Lehrinhalte	Signal acquisition, sensors, signal amplifiers, digital-analog-converters (DACs), types of DACs, analog-digital-converters (ADCs), ADC-types and architectures, measurement devices and –systems, measurement and analysis of signal properties.
Lernergebnisse	The students know the basic properties of a signal and are able to describe those. The students are familiar with the principle of operational amplifiers and the different standard types of circuits in which they are used. They know ADCs and DACs and can name important properties with respect to their usage. Further, the students know the underlying measurement principles for ADCs and DACs, can distinguish them and can infer properties about those. Additionally, the students are able to generate basic signals and measure them by the means of an oscilloscope in a practical setup.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Fraden, J. (2016). Handbook of modern sensors: Physics, designs, and applications (5th edition). Springer. Horowitz, P., & Hill, W. (1989). The art of electronics (2nd ed). Cambridge University Press. Razavi, B. (1995). Principles of data conversion system design. IEEE Press.

Titel der Lehrveranstaltung	**Procedural Programming *(PLUS)*** *Bridge Courses*
Semester	---
ECTS / SWS	2 ECTS / 1 SWS
LV-Typ	Vorlesung (VO)
Lehrinhalte	Foundations of procedural programming (on the example of C/C++, matlab or Python)
Lernergebnisse	Students are able to understand the fundamental concepts of procedural programming and are able to understand and correctly interpret the source code of corresponding software.
Prüfungsmethode/-charakter	abschließend
Empfohlene Fachliteratur / Lernressourcen	Barbuddhe, VishwajitZanjat, Shraddha N.Karmore, Bhavana S. (2020): Programming for Problem Solving. Lambert Academic Publishing. Hans Petter Langtangen (2016): A Primer on Scientific Programming with Python. Springer, 5th ed.

Titel der Lehrveranstaltung	**Procedural Programming *(PLUS)*** *Bridge Courses*
Semester	---
ECTS / SWS	1 ECTS / 1 SWS
LV-Typ	Proseminar (PS)
Lehrinhalte	Foundations of procedural programming (on the example of C/C++, matlab or Python)
Lernergebnisse	Students have developed fundamental procedural programming skills on the example of one programming language and are able to write, compile, and execute corresponding software.
Prüfungsmethode/-charakter	immanent
Empfohlene Fachliteratur / Lernressourcen	Barbuddhe, VishwajitZanjat, Shraddha N.Karmore, Bhavana S. (2020): Programming for Problem Solving. Lambert Academic Publishing. Hans Petter Langtangen (2016): A Primer on Scientific Programming with Python. Springer, 5th ed.