Technology
Arts Sciences
TH Köln

Course Manual DSP

Digital Signal Processing

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General information

Long name	Digital Signal Processing
Approving CModule	DSP_MaCSN, DSP_MaTIN
Responsible	Prof. Dr. Harald Elders-Boll Professor Fakultät IME
Valid from	winter semester 2020/21
Level	Master
Semester in the year	winter semester
Duration	Semester
Hours in self-study	60
ECTS	5
Professors	Prof. Dr. Harald Elders-Boll Professor Fakultät IME
Requirements	No formal requirements, but students will be expected to be familiar with: Basic Knowledge of Signals and Systems: Continuous-Time LTI-Systems and Convolution, Fourier-Transform Basic Knowledge of Probability and Random Variables

Literature

John G. Proakis and Dimitris K. Manolakis. Digital Signal Processing (4th Edition). Prentice Hall, 2006.

Alan V. Oppenheim, Ronald W. Schafer. Discrete-Time Signal Processing (3rd Edition). Prentice Hall, 2007.

Vinay Ingle and John Proakis. Digital Signal Processing using MATLAB. Cengage Learning Engineering, 2011.

Final exam

Language	English
Separate final exam	Yes

Details	In the written exam students shall demonstrate that they are able to solve problems dealing with the design, analysis and implementation of DSP systems in soft and hardware considering computational complexity and hardware resource limitation, by using their thorough understanding of the theoretical concepts, especially frequency domain analysis, and insights gained from the practical implementation of DSP systems in software using Python and on microprocessors, such that they are able to design, select, use and apply actual and future DSP systems for various signal processing application in commercial products.
Minimum standard	At least 24 of the 50 points that can be gained in total in the final exam and the two midterm tests during the semester. In the final exam 40 points can be gained in total, in the two midterm test 5 points can be gained each yielding 10 points in total for the two tests.
Exam Type	EN Klausur

− Lecture / Exercises

Learning goals

Goal type	Description
Knowledge	Signals, Systems and Digital Signal Processing Basic Elements of DSP Systems Classification of Signals Continuous-Time and Discrete-Time Signals Deterministic and Random Signals Even and Odd Signals Periodic and Aperiodic Signals Energy and Power of Signals Some Fundamental Signals
Knowledge	Discrete-Time Linear Time-Invariant Systems Difference Equations Discrete-Time Convolution Unit-Pulse and Impulse Response Basic Systems Properties: Causality, Stability, Memory
Knowledge	Ideal Sampling and Reconstruction Ideal Sampling and the Sampling Theorem Aliasing
Knowledge	Fourier-Transform of Discrete-Time Signals Eigenfunctions of Discrete-Time LTI Systems Frequency response of Discrete-Time LTI Systems The Fourier-Transform of Discrete-Time Signals Ideal Continuous-Time Filters
Knowledge	The z-Transform The Two-sided z-Transform Properties of the z-Transform The Inverse z-Transform Analysis of LTI Systems using the z-Transform
Knowledge	Discrete Fourier-Transform Sampling the DTFT The DFT and the Inverse DFT The Fast Fourier Transform Radix-2 FFT Algorithms Linear Convolution Using the FFT Overlap-And-Add
Knowledge	Design of Digital Filters Design of FIR Filters Design of IIR Filters

Special requirements

none

Accompanying material	lecture slides as pdf-files, list of problems and solutions manual as pdf-files old exams and solutions
Separate exam	Yes

Separate exam

Exam Type	EN Übungsaufgabe mit fachlich / methodisch eingeschränktem Fokus unter Klausurbedingungen lösen
Details	Two midterm tests with excercises dealing with the subjects from the lecture/tutorial that were covered up to that point, suich the by passing the midterm tests students demonstrate that they have the required skills to sucessfully participate in the corresponding labs and/or projects.
Minimum standard	Two out of five points that can be scored in total per test.

Knowledge	Random Signals Review of Probablity and Random Variables Ensemble Averages Correlation Functions Stationary and Ergodic Processes Power Spectral Density Transmission of Random Signals over LTI Systems
Knowledge	Advanced Sampling Techniques Quantization and Encoding Sampling of Bandpass Signals Sampling of Random Signals Sample Rate Conversion Sample Rate Reduction by an Integer Factor Sample Rate Increase by an Integer Factor Sample Rate Conversion by a Rational Factor Oversampling and Noise Shaping
Knowledge	Optimum Linear Filters Linear Prediction The Wiener Filter Orthogonality Principle FIR Wiener Filter IIR Wiener Filter
Knowledge	Spectrum Estimation The Periodogram Window Functions Eigenanalysis Algorithms MUSIC Algorithm ESPRIT Algorithm
Skills	Students understand the fundamentals of discrete-time signals and systems
Skills	Students can analyse the frequency content of a given signal using the appropriate Fourier-Transform and methods for spectrum estimation
Skills	Analysis of discrete-time LTI Systems Students can calculate the output signal via convolution Students can determine the frequency response of a given system Students can characterize a given system in the frequency domain and in the z-domain

Skills	Implementation of discrete-time LTI systems Students can implement the convolution sum in software Students can implement different structures for IIR systems in software Sudents can use the FFT to implement an FIR system
Skills	Analyze effects of practical sampling Quantization noise Aliasing Trade-off pros and cons of advanced implementations like noise shaping

Expenditure classroom teaching

Type	Attendance (h/Wk.)
Lecture	2
Exercises (whole course)	2
Exercises (shared course)	0
Tutorial (voluntary)	0

− Practical training

Learning goals

Goal type	Description
Knowledge	Review of Probablity and Random Variables Moments, Averages and Distribution Functions
Knowledge	Random Signals Ensemble Averages Correlation Functions Stationary and Ergodic Processes Power Spectral Density Transmission of Random Signals over LTI Systems
Knowledge	Sampling Sampling and coding for speech and/or audio signals
Skills	Analysis of random variables by means of Mean and moments Distribution
Skills	Analysis of random signals Determine whether a given random signal is stationary or not Analyse whether a random signal contains discrete harmonic components by using the autocorrelation function by using the power spectral density
Skills	Combatting noise Remove or suppress high-frequency noise from low-pass signals
Skills	Abilty to trade-off different methods for digital coding of speech and audio signals
Skills	Determine the quatization noise and the SNR for different sampling schemes

Expenditure classroom teaching

Type	Attendance (h/Wk.)

Special requirements

none

Accompanying material	Instructions for lab experiments as pdf-files
Separate exam	Yes

Separate exam

Exam Type	EN praxisnahes Szenario bearbeiten (z.B. im Praktikum)
Details	Sucessful solution of the lab problems and/or projects in small groups consisting of two students, in general. The corresponding midterm test from the lecture/tutorial needs to be passed as a prerequisite for participation in the lab.
Minimum standard	Successful participation of all labs and/or the corresponding small projects. To pass the corresponding midterm test 2 out of 5 points have to be gained.

Practical training	1
Tutorial (voluntary)	0