TECHNISCHE UNIVERSITÄT
ILMENAU

Modulhandbuch

Master

Communications and Signal Processing

Studienordnungsversion: 2021

gültig für das Wintersemester 2023/24

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Inhaltsverzeichnis

TECHNISCHE UNIVERSITÄT ILMENAU

Modul: Advanced Digital Signal Processing

Modulabschluss: mehrere Teilleistungen | Art der Notengebung: Generierte Noten

Sprache: Englisch | Pflichtkennz.: Pflichtmodul | Turnus: Wintersemester

Modulnummer: 200612 | Prüfungsnummer: 210506

Modulverantwortlich: Prof. Dr. Gerald Schuller

Leistungspunkte: 5 | Workload (h): 150 | Anteil Selbststudium (h): 116 | SWS: 3.0

Fakultät für Elektrotechnik und Informationstechnik | Fachgebiet: 2184

SWS nach Fach-semester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
	2	1	0																											

Lernergebnisse / Kompetenzen

The students have learned to identify, solve and evaluate problems in the various fields of digital signal processing, and are able to program them in Python.

The students have learned to describe the methods of advanced signal processing, and can classify them.

After attending the course they cann summarize these methods.

After attending the seminar, they have learned the skills to implement these methods in the programming language Python.

At the end they should be able to evaluate theirs and their peers performance.

Nachdem Studierende die Veranstaltung besucht haben, können sie die weitergehende Algorithmen und Anwendungen der Digitalen Signalverabreitung (entsprechend der Themen) beschreiben und erklären.
Die Studierenden sind nach Besuch der Lehrveranstaltung in der Lage, verschiedene Verfahren zu klassifizieren.
Nach dem Besuch der Vorlesung können die Studierenden die erworbenen Kenntnisse über weiterführende Verfahren der digitalen Signalverarbeitung zusammenfassen.
Nach dem Seminar haben die Studierenden ihre in der Vorlesung erworbenen theoretischen Kenntnisse gelernt anzuwenden, durch Einuebung der Fertigkeit ausgewählte Programmierprojekte in der Programmiersprache Python zu programmieren.

Vorkenntnisse

Basic knowledge of signal processing (Bachelor),
Basic knowledge of signal and system theory

Inhalt

Topics:

- Sampling, principles:
  - AD/DA conversion (Mic, Speaker)
  - Sampling rates
  - Aliasing
  - Sampling rate conversion
- Z transform: theory and properties
- Filtering:
  - FIR
  - IIR
  - design methods
  - optimization
- Complex signals and filters, analytical signal, hilbert transform
- Complex filter banks

- Wiener filter
- Prediction
  - Wiener-Hopf-Equations
  - LMS
- Filter banks, wavelets, QMF, lifting, intMDCT

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

Moodle 2, Slides, Python examples
Technische Voraussetzungen für Moodle-Exam gemäß https://intranet.tu-ilmenau.de/site/vpsl-pand/SitePages/Handreichungen_Arbeitshilfen.aspx
Computer, Browser, Internet

Literatur

- Alan V. Oppenheim, Ronald W. Schafer, John R. Buck: "Discrete-Time Signal Processing", Prentice Hall, 2nd Edition, 1998
- N.S. Jayant, Peter Noll: "Digital Coding of Waveforms", not published anymore
- P.P. Vaidyanathan: "Multirate Systems and Filter Banks", Prentice Hall, 1993
- M.Bosi, R.E. Goldberg: "Introduction to Digital Audio Coding and Standards", Kluwer Academic Publishers, 2002
- K.D.Kammeyer,K. Kroschel: "Digitale Signalverarbeitung. Filterung und Spektralanalyse mit MATLAB Übungen", B.G. Teubner Verlag, 2002
- John G. Proakis: "Digital Communications", McGraw-Hill Science/Engineering/Math, 4th Edition, 2000
- Yiteng(Arden) Huang, Jacob Benesty (Eds.): "Audio Signal Processing ForNext-Generation Multimedia Communication Systems", Kluwer Academic Publishers Group, 2004; especially Chapter 11: "Audio Coding" by G.Schuller
- A. Spanias, T. Painter, V. Atti: "Audio Signal Processsing and Coding", Wiley-Interscience, New York, 2007
- J. Breebaart, C. Faller: "Spatial Audio Processing - MPEG Surround and Other Apllications", Wiley, Chichester, 2007

Detailangaben zum Abschluss

Das Modul Advanced Digital Signal Processing mit der Prüfungsnummer 210506 schließt mit folgenden Leistungen ab:

- alternative semesterbegleitende Studienleistung mit einer Wichtung von 30% (Prüfungsnummer: 2100965)
- elektronische Abschlussleistung über 90 Minuten mit einer Wichtung von 70% (Prüfungsnummer: 2100966)

Details zum Abschluss Teilleistung 1:
Waehrend des Semsters bearbeiten die Studenten kleine 2-woechige Programmierprojekte, die den Stoff der Vorlesung umsetzen. Dies ist eine Fertigkeit die sie nur durch diese entsprechende Uebung erlernen koennen, und die auch nur dadurch geprueft werden kann.
During the semester, the students work on small 2-week programming projects. This way they aquire the skill to implement the theoretical approaches from the lecture, and this practice is the only way to aquire and test this skill.

Details zum Abschluss Teilleistung 2:
Elektronische Abschlussleistung am Ende des Semesters. Diese prueft die theoretischen Kenntnisse, welche die Studenten durch die Vorlesung erlernt haben.
Electronic exam at the end of the semester. This tests the knowledge of the theoretical concepts of the lecture.

Link zum Moodle-Kurs

verwendet in folgenden Studiengängen:

Diplom Elektrotechnik und Informationstechnik 2017
Diplom Elektrotechnik und Informationstechnik 2021
Master Communications and Signal Processing 2021
Master Elektrotechnik und Informationstechnik 2021
Master Medieningenieurwissenschaften 2023
Master Medientechnologie 2017

Modul: Communication Networks

Modulabschluss: mehrere Teilleistungen | Art der Notengebung: Generierte Noten

Sprache:Englisch | Pflichtkennz.:Pflichtmodul | Turnus:Wintersemester

Modulnummer: 200497 | Prüfungsnummer:210483

Modulverantwortlich: Prof. Dr. Jochen Seitz

Leistungspunkte: 10 | Workload (h):300 | Anteil Selbststudium (h):232 | SWS:6.0

Fakultät für Elektrotechnik und Informationstechnik | Fachgebiet:2115

SWS nach Fach-semester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
	4	2	0																											

Lernergebnisse / Kompetenzen

Telecommunication is an integral part of today's life. People are used to communicate with any person they would like to by phone, e-mail, chat, or skype at any place at any time. Students in this lecture have learned the basic characteristics of different communication networks. In a bottom-up approach, starting from the physical medium going up to the application, they are familiar with the functionality of different communication protocols and understand how these cooperate to achieve a communication service. Hence, they know different aspects of quality of service the users can expect from different protocols, and are able to specify protocols on their own based on the according protocol mechanisms. As the lecture deals with different networks (telephone network, Internet, mobile communication networks, broadband access networks), the students can characterize these networks and explain the differences.

After the lectures and exercises, the students are able to write a report on a current topic in the area of communication networks, which counts 20 % of the final grade. After this report, the students are familiar with investigating new scientific publications on communication protocols and networks from different sources and know how to judge the relevance of different publications. Furthermore, they have developed their competencies in academic writing.

Vorkenntnisse

keine speziellen Vorkenntnisse notwendig

Inhalt

1. Introduction: Definitions, History of Telecommunications, Trends
2. Fundamentals: Communications Services, Protocols and Protocol Functions
3. Protocol Specification: Extended Finite State Machines, Message-Sequence-Charts
4. Transmission Technique: Signals, Physical Medium, Coding, Multiplexing
5. Interconnection of Networks: Repeaters, Hubs, Bridges, Switches, Routers, Gateways
6. Switching Technology: Cicuit Switching, Store and Forward, Message Switching, Packet Switching, Virtual Circuit, Datagram Switching
7. The Internet: IPv4/IPv6, Routing, Transport Layer, Applications
8. Digital Subscriber Line: xDSL
9. Public Land Mobile Networks: GSM & GPRS, UMTS, LTE, 5G
10. Wireless Communication: WLAN (IEEE 802.11), Bluetooth, Mobile Ad hoc Networks
11. Automotive Communications: IEEE 802.11p, WAVE
12. Delay Tolerant Networks

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

PowerPoint-Folien, Tafelanschrieb, Seminaraufgaben, Kontrollfragen zur Prüfungsvorbereitung, Hausarbeit

Literatur

- Halsall, Fred (2000): Data Communications, Computer Networks and Open Systems. 4th edition, reprint.

Harlow: Addison-Wesley (Electronic Systems Engineering Series).

• Kurose, James F.; Ross, Keith W. (2017): Computer Networking. A Top-Down Approach. 7th edition. Hoboken, New Jersey: Pearson.

• Peterson, Larry L.; Davie, Bruce S. (2012): Computer Networks. A Systems Approach. 5th edition. Amsterdam: Morgan Kaufmann (The Morgan Kaufmann Series in Networking).

• Stallings, William (2014): Data and Computer Communications. 10th edition. Upper Saddle River, N.J.: Pearson.

• Tanenbaum, Andrew S.; Wetherall, David J. (2011): Computer Networks. 5th edition. Boston: Pearson Prentice Hall.
plus weitere themenspezifische Quellen

Detailangaben zum Abschluss

Das Modul Communication Networks mit der Prüfungsnummer 210483 schließt mit folgenden Leistungen ab:
- alternative semesterbegleitende Prüfungsleistung mit einer Wichtung von 20% (Prüfungsnummer: 2100827)
- schriftliche Prüfungsleistung über 90 Minuten mit einer Wichtung von 80% (Prüfungsnummer: 2100828)

Details of examination part 1:
Recherchehausarbeit über ein aktuelles Thema aus dem Bereich der Kommunikationsnetze auf Englisch. Themen werden zu Beginn der Vorlesungszeit vorgeschlagen. Abgabe einer Ausarbeitung im Umfang von max. 6 Seiten spätestens in der letzten Vorlesungswoche. Eine nicht abgegebene Ausarbeitung wird mit der Note 5 bewertet. Die Note einer bestandenen Recherchehausarbeit behält bis zum Bestehen der schriftlichen Abschlussprüfung ihre Gültigkeit. Die Teilleistung wird nur im Wintersemester begleitend zur Lehrveranstaltung angeboten.

Research paper on a current topic in the field of communication networks in English. Topics are suggested at the beginning of the lecture period. Submission of a paper of max. 6 pages at the latest in the last week of lectures. A paper that is not handed in will be assessed with a grade of 5. The grade of a passed research paper remains valid until the written final examination is passed. The partial performance is only offered in the winter semester accompanying the lecture.

Details of examination part 2:
Written exam, 90 minutes

Link zum Moodle-Kurs

verwendet in folgenden Studiengängen:

Master Communications and Signal Processing 2021
Master Medieningenieurwissenschaften 2023
Master Medientechnologie 2017
Master Research in Computer and Systems Engineering 2021
Master Research in Computer & Systems Engineering 2016

Modul: Communications Engineering

Modulabschluss: Prüfungsleistung schriftlich 120 min | Art der Notengebung: Gestufte Noten

Sprache:Englisch | Pflichtkennz.:Pflichtmodul | Turnus:Wintersemester

Modulnummer: 200533 | Prüfungsnummer:2100872

Modulverantwortlich: Prof. Dr. Martin Haardt

Leistungspunkte: 5 | Workload (h):150 | Anteil Selbststudium (h):105 | SWS:4.0

Fakultät für Elektrotechnik und Informationstechnik | Fachgebiet:2111

SWS nach Fach-semester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
	2	2	0																											

Lernergebnisse / Kompetenzen

After participating in the lecture, students can use the most important methods for the analysis and the design of communication systems.
In particular, the participants can handle the statistical signal description (by means of correlation theory) with confidence and know how to use the bandpass-lowpass transformation, a necessary tool for subsequent lectures.
As a result of the course, the participants will not only be able to name the most important modulation schemes, but rather evaluate their performance and design optimal receivers.
At the end of the lecture, the participants will also be able to mathematically describe advanced transmission schemes like OFDM and can argue why and when such schemes are used.
By means of the seminars, students consolidate the newly imparted knowledge and can then confidently use the system theory methods.
After the course, students can correctly assess and evaluate their own achievements and those of their fellow students.

Vorkenntnisse

Inhalt

- System theoretic basics

- Bandpass lowpass transformation for signals and systems
- Correlation functions of deterministic signals
- Correlation functions of stochastic signals

- Optimal filters

- Matched filter
- Wiener filter

- Signal space representation of waveforms

- The signal space as a generalized Euklidian vector space
- Gram-Schmidt procedure

- Discrete modulation and transmission in AWGN

- Antipodal transmission and minimum distance criterion
- Optimal detection for M-ary modulation
- Bit error rate for M-ary modulation
- Bandpass modulation schemes

- Block transmission with Cyclic prefix

- Multipath radio channel
- Block transmission model
- OFDM

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

handschriftliche Tafelentwicklung, Präsentation von Begleitfolien (Overheadprojektor/Beamer), Folienskript und Aufgabensammlung Online und im Copyshop erhältlich

Literatur

- J. Barry, E.A. Lee, and D.G. Meserschmitt. Digital Communication, Springer Science+Business Media, Third Edition

- Simon Haykin. Communication Systems. John Wiley and Sons, 2000

- J. Proakis, Digital Communications. McGraw-Hill, 4th edition, 2001.
- J. Proakis and M. Salehi, Communication Systems Engineering. Prentice Hall, 2nd edition, 2002.

Detailangaben zum Abschluss

Link zum Moodle-Kurs

verwendet in folgenden Studiengängen:

Master Communications and Signal Processing 2021

Modul: Information Theory and Coding

Modulabschluss: Prüfungsleistung schriftlich 120 min Art der Notengebung: Gestufte Noten

Sprache:Englisch Pflichtkennz.:Pflichtmodul Turnus:Wintersemester

Modulnummer: 200667 Prüfungsnummer:2101046

Modulverantwortlich: Prof. Dr. Martin Haardt

Leistungspunkte: 5 Workload (h):150 Anteil Selbststudium (h):105 SWS:4.0

Fakultät für Elektrotechnik und Informationstechnik Fachgebiet:2111

SWS nach Fach-semester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
	2	2	0																											

Lernergebnisse / Kompetenzen

After the lectures students are familar with the basic concepts of information theory. By understanding quantities such as entropy, joint entropy or mutual information, they can evaluate the theoretical limits for data compression and data transmission for simple but particularly important cases. They are also able to apply concrete schemes for source and channel coding in practice. By knowing the theoretical limits, they can assess the efficiency of these methods. With regard to channel coding, the students are familiar with both common block coding and convolutional coding schemes and can use these error correction schemes after the Exercises in Matlab. The students are also familiar with the principles of Turbo codes and LDPC codes.
Die Studierenden verstehen nach der Vorlesung die grundlegenden Konzepte der Informationstheorie. Durch das Verständnis von Größen wie Entropie, Verbundentropie oder Transinformation können sie die theoretischen Grenzen für die Datenkompression und für die Datenübertragung für einfache, aber besonders wichtige Fälle, evaluieren. Zudem sind sie in der Lage, konkrete Verfahren zur Quellen- und Kanalcodierung praktisch anzuwenden. Durch die Kenntnis der theoretischen Grenzen können Sie die Effizienz der Verfahren beurteilen. Hinsichtlich der Kanalcodierung sind die Studenten sowohl mit gängigen Verfahren der Blockcodierung und als auch der Faltungscodierung vertraut und können nach den Übungen diese Verfahren in Matlab anwenden. Zudem verstehen sie das Prinzip der Turbo-Codes und der LDPC-Codes.

Vorkenntnisse

Inhalt

1. Fundamentals of statistics and random processes
2. Entropy and mutual information of discrete random variables
3. Compression limits
4. Source coding with prefix codes
5. Channel capacity (DMC and AWGN)
6. Block codes (concept, examples)
7. Asymptotic coding gain
8. Convolutional codes (Trellis diagram, state diagramm, Viterbi-decoding, applications)
9. Recursive convolutional codes
10. Cyclic redundancy check (CRC)
11. Turbo-Codes (parallel concatenated convolutional codes (PCCC), encoder-/decoder-structure, maximum a-posteriori (MAP)-decoding)
12. Low-Density-Parity-Check Codes (LDPC)
13. Polar Codes

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

Tafel, Skript, Overheadprojektor, Übungen mit Matlab

Literatur

- Thomas M. Cover and Joy A. Thomas, Elements of Information Theory, John Wiley & Sons, Inc., 1991, ISBN 0-471-06259-6.
- Shu Lin and Daniel J. Costello, Error Control Coding, Pearson Prentice Hall, 2004, Second Edition.

Detailangaben zum Abschluss

Link zum Moodle-Kurs

verwendet in folgenden Studiengängen:

Master Communications and Signal Processing 2021

Modul: Microwave Engineering

Modulabschluss: Prüfungsleistung mündlich 30 min Art der Notengebung: Gestufte Noten

Sprache:Englisch Pflichtkennz.:Pflichtmodul Turnus:Wintersemester

Modulnummer: 200504 Prüfungsnummer:2100838

Modulverantwortlich: Prof. Dr. Matthias Hein

Leistungspunkte: 5 Workload (h):150 Anteil Selbststudium (h):105 SWS:4.0

Fakultät für Elektrotechnik und Informationstechnik Fachgebiet:2113

SWS nach Fach-semester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
	2	2	0																											

Lernergebnisse / Kompetenzen

After the lectures the students can analyse the basics of wave propagation, reflection, and superposition of RF signals on transmission lines. They have learned to design matching circuits based on lumped and distributed elements. The students are able to describe the operation of typical microwave couplers and hybrids. They are able to choose optimal transmission line types and substrate materials. They understand the principles of RF and microwave measurement systems, e.g. power detector, slotted line, vector network analyser.
Competences:
After the exercises the students are able to plan and conduct typical RF measurements. They can apply transmission lines as circuit elements in RF circuitry and understand the principles of wave-based circuit elements in the microwave frequency range.

Vorkenntnisse

Bachelor of Science in Electrical Engineering

Inhalt

1. Waveguides, line propagation, reflections
2. Reflection coefficient, Smith chart, scattering parameters
3. Special transmission lines
4. Couplers and hybrids
5. Microwave materials and line types
6. Impedance transformation and matching
7. Diode detectors, slotted line
8. Reflectometer, VSWR bridge, network analyzer
9. Multi-port measurements, mixed-mode S-parameters

Practical exercises with network analyser, hybrid coupler, detector, mixer with spectrum analyser, slotted line, impedance transformer

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

Blackboard, illustrations (projector), selected microwave components, work sheets (printable), practical classes

Literatur

Chang Kai, "Handbook of microwave and optical components: Microwave passive and antenna components", vol. 1, Wiley, 1989
Bhartia, Prakash ; Bahl, Inder Jit, "Millimeter wave engineering and applications", Wiley, 1984.
Pozar, David M., "Microwave engineering", Wiley, 2005.

Detailangaben zum Abschluss

Link zum Moodle-Kurs

https://moodle.tu-ilmenau.de/course/view.php?id=387

verwendet in folgenden Studiengängen:

Master Communications and Signal Processing 2021

Modul: Advanced Mobile Communication Networks

Modulabschluss: Prüfungsleistung schriftlich 90 min Art der Notengebung: Gestufte Noten

Sprache:Englisch Pflichtkennz.:Pflichtmodul Turnus:Sommersemester

Modulnummer: 200068 Prüfungsnummer:2200718

Modulverantwortlich: Prof. Dr. Andreas Mitschele-Thiel

Leistungspunkte: 5 Workload (h):150 Anteil Selbststudium (h):105 SWS:4.0

Fakultät für Informatik und Automatisierung Fachgebiet:2235

SWS nach Fach-semester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
				2	2	0																								

Lernergebnisse / Kompetenzen

. Fachkompetenz: Die Studierenden verfügen nach der Vorlesung über Kenntnisse und Wissen zu Aufbau und Funktionsweise von Mobilkommunikationsnetzen, insbesondere IP-basierter mobiler drahtloser Systeme und deren Protokolle, sowie Kenntnisse des Zusammenspiels verschiedener Funktionen.

. Methodenkompetenz: Die Studierenden sind in der Lage, komplexe Fragestellungen IP-basierter Mobilkommunikationssysteme und ihrer Funktionen zu verstehen und dieses Verständnis selbständig zu vertiefen.

. Systemkompetenz: Durch die Kombination aus Vorlesung und der Bearbeitung umfangreicher Testfragen zur Vertiefung des Stoffes verstehen die Studierenden im Anschluss das Zusammenwirken der verschiedenen Komponenten und Protokollfunktionen des Systems und können den Einfluss von Entwurfsentscheidungen bei der Realisierung von Protokollfunktionen auf andere Funktionen und das System als Ganzes einschätzen.

. Sozialkompetenz: Die Studierenden sind in der Lage, Problemstellungen der Mobilkommunikation selbständig zu lösen und darzustellen. Durch Diskussionen der Antworten zu unserem umfangreichen Fragekatalog haben Sie gelernt, Meinungen anderer Studierender zu beachten und diese kritisch zu hinterfragen. Das für die Lösung der Aufgaben benötige Wissen konnten sie sich selbständig bzw. in Zusammenarbeit mit anderen aus verfügbaren Quellen erarbeiten, wurden sich durch die Präsentation der verschiedenen Möglichkeiten der Herangehensweise bei der Problemlösung bewusst und sind in der Lage die Leistungen Anderer entsprechend zu würdigen.

Vorkenntnisse

Bachelor degree, basics of communication networks

Inhalt

- Introduction to mobile communications with focus on protocols and systems
- Basics of wireless transmission
- Media access schemes
- Mobility management
- Transport protocols
- Quality-of-Service
- Security
- Communication systems (802.11, GSM/GPRS, UMTS)

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

Presentations

Literatur

Jochen Schiller Mobilkommunikationsnetze (for details see intro-slide) and further literature

Detailangaben zum Abschluss

Link zum Moodle-Kurs

https://moodle.tu-ilmenau.de/course/view.php?id=373

verwendet in folgenden Studiengängen:

Master Communications and Signal Processing 2021
Master Informatik 2013
Master Informatik 2021
Master Ingenieurinformatik 2021
Master Research in Computer and Systems Engineering 2021

Modul: Antenna Engineering

Modulabschluss: Prüfungsleistung mündlich 30 min Art der Notengebung: Gestufte Noten

Sprache:Englisch Pflichtkennz.:Pflichtmodul Turnus:Sommersemester

Modulnummer: 200652 Prüfungsnummer:2101028

Modulverantwortlich: Prof. Dr. Matthias Hein

Leistungspunkte: 5 Workload (h):150 Anteil Selbststudium (h):105 SWS:4.0

Fakultät für Elektrotechnik und Informationstechnik Fachgebiet:2113

SWS nach Fach-semester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
				2	2	0																								

Lernergebnisse / Kompetenzen

After attending the lecture course, the students penetrate the fundamentals, applications, and trends in antenna engineering and its relation to ground-or satellite-based mobile communications, sensing, and signal processing. The students understand the theoretical foundations of antennas. They are able to explain how antennas function and can develop them as wave transformers, microwave systems (including feed and beam forming networks), and systems for spatial and spectral signal processing. The students can differentiate and apply types of elementary radiating elements, means to control and measure the radiation patterns, and approaches to employ antenna systems for signal processing (e.g., for MIMO applications). In the tutorials, in-depth examples of numerical problems in antenna design and simulation were covered and selected problems were treated in detail. Based on these skills and knowledge, the students present and discuss their own thoughts and solutions. Upon having visited the shielded anechoic chambers as up-to-date research facilities (antenna measurement lab and Virtual Road - Simulation and Test Area), the students know how to perform antenna-related measurements. The students have practiced and can apply in-depth theoretical and practical knowledge, identify highly relevant ongoing research activities, and can apply their soft-skills like time management, work planning, scientific reporting and presentation, and team work.

Vorkenntnisse

Bachelor of Science in Electrical Engineering and Information Technology, basic knowledge of electronic measurement and microwave engineering, information theory, advanced knowledge of electromagnetic fields and waves

Inhalt

1. Wireless technologies: Brief introduction and example applications, propagation of electromagnetic waves: Free space vs multipath, requirements for antennas (receive and transmit)
2. Fundamentals of antenna engineering: Electrodynamic foundations, basic radiating elements, examples of practical radiating elements
3. Antenna arrays: Foundations of linear arrays, performance figures of linear arrays, beam forming and spatial signal processing
4. Practical aspects of antenna engineering: Packaging and protection, design and numerical simulation, antenna measurements

Practical studies cover, for instance, the following topics: patch antenna measurement with planar nearfield scanner, complex input impedance of a quarter wavelength monopole, network analyzer measurement, and two-way propagation between dipoles; part of the seminars address the use of formal and 3D electromagnetic full-wave computer simulation tools (e.g. MATLAB, CST, EMPro)

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

Development of contents using blackboard, supplementary illustrations using overhead transparencies (available in electronic form), electronic animations (where appropriate); problem solving for in-depth learning (problem sheet available in electronic form)

Literatur

S. Drabowitch, A. Papiernik, H.Griffiths, J. Encinas, B. L. Smith. Modern antennas. Chapman & Hill, 1998.

Detailangaben zum Abschluss

Link zum Moodle-Kurs

verwendet in folgenden Studiengängen:

Master Communications and Signal Processing 2021

Modul: Mobile Communications, Complete

Modulabschluss: Prüfungsleistung schriftlich 150 min Art der Notengebung: Gestufte Noten

Sprache:Englisch Pflichtkennz.:Pflichtmodul Turnus:Sommersemester

Modulnummer: 200486 Prüfungsnummer:2100810

Modulverantwortlich: Prof. Dr. Martin Haardt

Leistungspunkte: 10 Workload (h):300 Anteil Selbststudium (h):210 SWS:8.0

Fakultät für Elektrotechnik und Informationstechnik Fachgebiet:2111

SWS nach Fach-semester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
				4	4	0																								

Lernergebnisse / Kompetenzen

After completing this module, the students are able to understand current areas of mobile communication systems. They have a deep understanding of universal (timeless) principles that are applicable in several research areas and disciplines. They can confidently use several fundamental mathematical properties and "tricks", e.g., in the areas of linear algebra, stochastic processes, and time-varying systems.
Fundamental concepts of mobile communication systems are developed in class, ranging from channel modeling to advanced multiple antenna systems. Moreover, important topics for the design of future wireless communication systems are also emphasized.
After participating in this course, the students are able to assess current hot topics from research and development in wireless communications (e.g., 5G, 6G). They are able to read and understand current IEEE journal and conference publications in this area. Moreover, they have been enabled to develop new research ideas and results that build on this published "state-of-the-art."

Vorkenntnisse

Basics in stochastics and calculus

Inhalt

1 Introduction
+ Overview of mobile communication standards and applications (1G - 5G)
+ 5G Vision and Requirements
+ The Wireless Channel
- Path loss
- Shadowing
- Fast fading
2 Mobile Communication Channels
+ Review: Representation of Bandpass Signals and Systems
2.1 Propagation Modelling
+ Time variance (Doppler)
+ Time-varying multipath channels
- Transmission functions of the time-varying channel (1st set of Bello functions)
- 4 ways to calculate the received signals
- Identification of linear time-varing (LTV) systems
2.2 Statistical Characterization of Multipath Channels
+ Rayleigh channel (fading)
+ Rician channel
+ Channel Correlation Functions and Power Spectra of Fading Multipath Channels
- Time-variations of the channel
- Characterization of a WSSUS channel (2nd set of Bello functions)
2.3 The effect of signal characteristics on the choice of a channel model
+ Frequency non-selective channels
+ Frequency selective channels
- Truncated tapped delay line model of a frequency selective channel
2.4 Space-Time Channel and Signal Models
+ Generalization of the time-varying channel impulse response
- First set of Bello functions extended to the spatial domain

- Example: specular L paths model (continued)
+ Homogeneous channels (WSSUS-HO model)
+ Correlation functions and power spectra extended to the spatial domain
- Second set of Bello functions extended to the spatial domain
- Coherence time, coherence frequency, coherence distance
+ Transmission functions extended to transmit and receive antenna arrays (MIMO)
- Definition of the array manifold
+ Notation for SISO, SIMO, MISO, and MIMO channels
- Example: L paths model (continued)
+ Classical IID Channel Model
+ Extended MIMO Channel Models
- Spatial fading correlation at the transmit and the receive arrays
> Review of the eigenvalue decomposition (EVD)
> General model
> Kronecker model
- Additional Line-of-Sight (LOS) component
+ Sampled signal model for SISO, SIMO, MISO, and MIMO channels
3 Capacity of Space-Time Channels
3.1 Differential Entropy and Mutual Information for Continuous Ensembles (review)
3.2 Capacity Theorem for the AWGN SISO Case (review)
3.3 Capacity of the Flat Fading MIMO channel
+ Differential entropy for CSCG random vectors
+ Choosing Rss (with and without CSI @ the transmitter)
- Singular Value Decomposition (SVD)
- Special case: uncorrelated Rayleigh fading and Mt very large
+ Parallel Spatial Sub-Channels
- Design of the precoder and the decoder for MIMO systems with CSI at the transmitter
- Optimum power allocation (waterpouring algorithm) with CSI at the transmitter
+ SIMO Channel Capacity
+ MISO Channel Capacity
+ Capacity of Random MIMO Channels
- Ergodic vs. non-ergodic channels
- Ergodic capacity
> Examples, e.g., Rice, correlation
- Outage capacity
3.4 Capacity of the Frequency Selective MIMO channel
+ Space-Frequency Waterpouring
4 Transmission Techniques
4.1 Bit error probability
+ Binary signaling over Rayleigh fading channel
4.2 Diversity techniques for fading multipath channels
+ Frequency diversity
+ Time diversity
+ Space diversity
+ Post-processing techniques
- Selection combining, equal gain combining, maximum ratio combining, square-law combining
4.3 Approximation of the Probability of Symbol Error
+ Fading channel with D-fold diversity
+ Chernoff bound
+ Coding gain vs. diversity gain
5 Space-Time Processing
5.1 Receive antenna diversity (SIMO channel): MRC
5.2 Transmit antenna diversity
+ MISO channel unknown to the transmitter: Alamouti scheme (1998)
+ MISO channel known to the transmitter: MRT
+ MIMO channel unknown to the transmitter: Alamouti scheme (1998)
+ MIMO channel known to the transmitter: DET
+ Definiton of the effective diversity order
+ Summary: Diversity of space-time-frequency selective channels
5.3 Space-Time Coding without channel state information (CSI) at the transmitter
+ Space-Time Coding for frequency flat channels
+ Space-Time codeword design criteria
- definition of the pairwise error probability (PEP)
- rank criterion
- determinant criterion
+ Orthogonal Space-Time Block Codes (OSTBCs)

- OSTBCs for real-valued constellations
- OSTBCs for complex-valued constellations
+ Spatial Multiplexing (SM) as a Space-Time Code
+ Encoder Structures for Spatial Multiplexing (SM)
- horizontal encoding
- vertical encoding
- diagonal encoding (D-BLAST transmission)
5.4 Gains achievable with smart antennas
+ Array Gain
+ Diversity Gain
+ Spatial Multiplexing Gain
+ Interference Reduction Gain
- frequency reuse and cluster sizes
5.5 Multi-User MIMO Systems
+ Block Diagonalization
5.6 Multiple access schemes
+ OFDM
+ Single carrier vs. OFDM vs. spread spectrum

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

Skript, Overheadprojektor, Beamer Script, projector

Literatur

- A. Goldsmith, Wireless Communications.
Cambridge University Press, 2005.

- C. E. Shannon, A mathematical theory of communication.
Bell System Technical Journal, vol. 27, pp. 379-423 and 623-656, July and October, 1948.

- G. Strang, Introduction to Linear Algebra.
Wellesley - Cambridge Press, Fifth Edition, 2016.

- G. Strang, Linear Algebra and Its Applications.
Thomson Brooks/Cole Cengage learning, 2006.

- A. Paulraj, R. Nabar, and D. Gore, Introduction to Space-Time Wireless Communications.
Cambridge University Press, 2003.

- A. Hottinen, O. Tirkkonen, and R. Wichman, Multi-antennas Transceiver Techniques for 3G and Beyond.
Wiley, 2003.

- S. Haykin, Communication Systems.
John Wiley & Sons, 4th edition, 2001.

- S. Haykin and M. Moher, Modern Wireless Communications.
Pearson Education, Inc., 2005.

- F. Jondral and A. Wiesler, Grundlagen der Wahrscheinlichkeitsrechnung und stochastischer Prozesse für Ingenieure.
Teubner Verlag, Stuttgart/Leipzig, 2000.

- A. Papoulis, Probability, Random Variables, and Stochastic Processes.
McGraw-Hill, 2nd edition, 1984.

- T. S. Rappaport, Wireless Communications.
Prentice Hall, 1996.

- J. Proakis, Digital Communications.
McGraw-Hill, 4th edition, 2001.

- G. L. Stüber, Mobile Communication.
Kluwer Academic Publishers, 2nd edition, 2001.

- R. Steele and L. Hanzo, eds., Mobile Radio Communications.

Wiley, 2nd edition, 1999.

- S. Saunders, Antennas and Propagation for Wireless Communication Systems.
Wiley, 1999.

- A. Graham, Kronecker Products and Matrix Calculus with Applications.
Halsted Press, 1981.

- E. G. Larson, P. Stoica, and G. Ganesan, Space-Time Block Coding for Wireless Communications.
Cambridge University Press, 2003.

- H. Bölcskei, D. Gesbert, C. B. Papadias, and A.-J. van der Veen, eds., Space-Time Wireless Systems From Array Processing to MIMO Communications.
Cambridge University Press, 2006.

- E. Biglieri, R. Calderbank, A. Constantinides, A. Goldsmith, A. Paulraj, and H. V. Poor, MIMO Wireless Communications.
Cambridge University Press, 2007.

- C. Oestges and B. Clerckx, MIMO wireless communictions.
Academic Press, 1 ed., 2007.

- Q. H. Spencer, A. L. Swindlehurst, and M. Haardt, ``Zero-forcing methods for downlink spatial multiplexing in multi-user MIMO channels,'' IEEE Transactions on Signal Processing, vol. 52, pp. 461-471, Feb. 2004, received the 2009 Best Paper Award of the IEEE Signal Processing Society.

- Q. H. Spencer, C. B. Peel, A. L. Swindlehurst, and M. Haardt, ``An introduction to the multi-user MIMO downlink,'' IEEE Communications Magazine, pp. 60-67, Oct. 2004, special issue on MIMO Systems.

Detailangaben zum Abschluss

Link zum Moodle-Kurs

verwendet in folgenden Studiengängen:

Diplom Elektrotechnik und Informationstechnik 2021
Master Communications and Signal Processing 2021
Master Elektrotechnik und Informationstechnik 2021
Master Ingenieurinformatik 2021
Master Mathematik und Wirtschaftsmathematik 2022
Master Medieningenieurwissenschaften 2023
Master Medientechnologie 2017

Modul: Research Project

Modulabschluss: mehrere Teilleistungen | Art der Notengebung: Generierte Noten

Sprache: Englisch | Pflichtkennz.: Pflichtmodul | Turnus: Sommersemester

Modulnummer: 200488 | Prüfungsnummer: 210479

Modulverantwortlich: Prof. Dr. Martin Haardt

Leistungspunkte: 5 | Workload (h): 150 | Anteil Selbststudium (h): 105 | SWS: 4.0

Fakultät für Elektrotechnik und Informationstechnik | Fachgebiet: 2111

SWS nach Fachsemester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
				0	4	0																								

Lernergebnisse / Kompetenzen

Nachdem die Studierenden an dieser Veranstaltung teilgenommen haben, können sie

- Publikationen, die den aktuellen Stand der Technik beschreiben, selbstständig finden, verstehen und auf ihre eigenen Forschungsaufgaben anwenden
- neue Lösungsvorschläge für Forschungsaufgaben erarbeiten, die über den Stand der Technik hinausgehen
- den Stand der Technik und ihre neuen Forschungsergebnisse in einem wissenschaftlichen Aufsatz darstellen
- den Stand der Technik und ihre neuen Forschungsergebnisse den anderen Teilnehmern und den Dozenten in einem wissenschaftlichen Vortrag präsentieren

After the students have participated in this course, they can

- find publications that describe the current state of the art in their area of research, understand them, and apply them to their own research tasks
- develop new proposals for solutions of research questions that go beyond the state of the art
- present the state of the art and their new results in a scientific paper
- present the state of the art and their new research results to the other participants and the lecturers in a scientific presentation

Vorkenntnisse

Gewünschte Zulassungsvoraussetzung:

Admission to the module Research Project is only given when students have purchased at least 15 credit points from the curriculum of the program.

Inhalt

Alle Universitätsprofessoren, die im Masterstudiengang CSP Vorlesungen anbieten, sind berechtigt, Themen für Research Projects zu vergeben.
All university professors that offer lectures in the Master's program CSP are entitled to propose and supervise topics for Research Projects.

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

Präsentation, Bericht
Presentation, report

Literatur

Abhängig von der Aufgabenstellung
Depending on project topic

Detailangaben zum Abschluss

Das Modul Research Project mit der Prüfungsnummer 210479 schließt mit folgenden Leistungen ab:

- alternative semesterbegleitende Prüfungsleistung mit einer Wichtung von 50% (Prüfungsnummer: 2100814)
- alternativee semesterbegleitende Prüfungsleistung mit einer Wichtung von 50% (Prüfungsnummer: 2100815)

Details zum Abschluss Teilleistung 1:
Research Paper
Must be passed (at least with mark 4.0)

Details zum Abschluss Teilleistung 2:
Presentation about the Research Paper + discussion
Must be passed (at least with mark 4.0)

Link zum Moodle-Kurs

verwendet in folgenden Studiengängen:

Master Communications and Signal Processing 2021

Modul: Adaptive and Array Signal Processing, Complete

Modulabschluss: Prüfungsleistung schriftlich 150 min Art der Notengebung: Gestufte Noten

Sprache:Englisch Pflichtkennz.:Pflichtmodul Turnus:Wintersemester

Modulnummer: 200484 Prüfungsnummer:2100807

Modulverantwortlich: Prof. Dr. Martin Haardt

Leistungspunkte: 10 Workload (h):300 Anteil Selbststudium (h):210 SWS:8.0

Fakultät für Elektrotechnik und Informationstechnik Fachgebiet:2111

SWS nach Fach-semester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
							4	4	0																					

Lernergebnisse / Kompetenzen

After completing this module, the students are able to understand the fundamental concepts of adaptive filters and array signal processing. These concepts include the mathematical background, in particular concepts and "tricks" that can be used for the derivation of new research results. Furthermore, they range from adaptive temporal and spatial filters to (multi-dimensional) high-resolution parameter estimation techniques and tensor-based signal processing concepts. The students have a deep understanding of these universal (timeless) principles that are applicable in several research areas and disciplines.
The students are enabled to read and understand current research publications in the areas of adaptive filters and array signal processing. They are able use these concepts and results for their own research and understand the presentations about these topics at international conferences. Furthermore, they are able to read and understand current IEEE journal and conference publications in this area. Moreover, they have been enabled to develop new research ideas and results that build on this published "state-of-the-art."

Vorkenntnisse

Inhalt

1Introduction
- Adaptive Filters
- Single channel adaptive equalization (temporal filter)
- Multi channel adaptive beamforming (spatial filter)

2 Mathematical Background
2.1 Calculus
- Gradients
- Differentiation with respect to a complex vector
- Quadratic optimization with linear constraints (method of Lagrangian multipliers)
2.2 Stochastic processes
- Stationary processes
- Time averages
- Ergodic processes
- Correlation matrices
2.3 Linear algebra
- Eigenvalue decomposition
- Eigenfilter
- Linear system of equations
- Four fundamental subspaces
- Singular value decomposition
- Generalized inverse of a matrix
- Projections
- Low rank modeling

3 Adaptive Filters
3.1 Linear Optimum Filtering (Wiener Filters)
- Principle of Orthogonality

- Wiener-Hopf equations
- Error-performance surface
- MMSE (minimum mean-squared error)
- Canonical form of the error-performance surface
- MMSE filtering in case of linear Models
3.2 Linearly Constrained Minimum Variance Filter
- LCMV beamformer
- Minimum Variance Distortionless Response (MVDR) spectrum: Capon's method
- LCMV beamforming with multiple linear constraints
3.3 Generalized Sidelobe Canceler
3.4 Iterative Solution of the Normal Equations
- Steepest descent algorithm
- Stability of the algorithm
- Optimization of the step-size
3.5 Least Mean Square (LMS) Algorithm
3.6 Recursive Least Squares (RLS) Algorithm

4 High-Resolution Parameter Estimation
- Data model (DOA estimation)
- Eigendecomposition of the spatial correlation matrix at the receive array
- Subspace estimates
- Estimation of the model order
4.1 Spectral MUSIC
- DOA estimation
- Example: uniform linear array (ULA)
- Root-MUSIC for ULAs
- Periodogram
- MVDR spatial spectrum estimation (review)
4.2 Standard ESPRIT
- Selection matrices
- Shift invariance property
4.3 Signal Reconstruction
- LS solution
- MVDR / BLUE solution
- Wiener solution (MMSE solution)
- Antenna patterns
4.4 Spatial smoothing
4.5 Forward-backward averaging
4.6 Real-valued subspace estimation
4.7 1-D Unitary ESPRIT
- Reliability test
- Applications in Audio Coding
4.8 Multidimensional Extensions
- 2-D MUSIC
- 2-D Unitary ESPRIT
- R-D Unitary ESPRIT
4.9 Multidimensional Real-Time Channel Sounding
4.10 Direction of Arrival Estimation with Hexagonal ESPAR Arrays

5 Tensor-Based Signal Processing and Machine Learning
5.1 Introduction and Motivation
5.2 Fundamental Concepts of Tensor Algebra
5.3 Elementary Tensor Decompositions
- Higher Order SVD (HOSVD)
- CANDECOMP / PARAFAC (CP) Decomposition
5.4 Tensors in Selected Signal Processing and Deep Neural Network Applications

6 Maximum Likelihood Estimators
6.1 Maximum Likelihood Principle
6.2 The Fisher Information Matrix and the Cramer Rao Lower Bound (CRLB)
- Efficiency
- CRLB for 1-D direction finding applications
- Asymptotic CRLB

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

Skript, Overheadprojektor, Beamer Script, projector

Literatur

- T. Kaiser, A. Bourdoux, H. Boche, Smart Antennas State of The Art.
Hindawi Publishing Corporation, 2005.
- A. H. Sayed, Fundamentals of Adaptive Filtering.
John Wiley & Sons, Inc., New York, NY, 2003.
- T. K. Moon and W. C. Stirling, Mathematical Methods and Algorithms for Signal Processing.
Prentice-Hall, 2000.
- S. Haykin and M. Moher, Modern Wireless Communications.
Pearson Education, Inc., 2005.
- S. Haykin, Adaptive Filter Theory.
Prentice-Hall, 4th edition, 2002.
- A. Paulraj, R. Nabar, and D. Gore, Introduction to Space-Time Wireless Communications.
Cambridge University Press, 2003.
- H. L. V. Trees, Optimum Array Processing.
John Wiley & Sons, Inc., New York, NY, 2002.
- M. Haardt, Efficient One-, Two-, and Multidimensional High-Resolution Array Signal Processing.
Shaker Verlag GmbH, 1996, ISBN: 978-3-8265-2220-8.
- G. Strang, Linear Algebra and Its Applications.
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- G. Strang, Introduction to Linear Algebra.
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- L. L. Scharf, Statistical Signal Processing.
Addison-Wesley Publishing Co., 1991.
- S. M. Kay, Fundamentals of Statistical Signal Processing, Estimation Theory.
Prentice-Hall, Englewood Cliffs, N.J., 1993.
- M. Haardt, M. Pesavento, F. Roemer, and M. N. El Korso, Subspace methods and exploitation of special array structures.
in Academic Press Library in Signal Processing: Volume 3 - Array and Statistical Signal Processing (A. M. Zoubir, M. Viberg, R. Chellappa, and S. Theodoridis, eds.), vol. 3, pp. 651 - 717, Elsevier Ltd., 2014, Chapter 15, ISBN 978-0-12-411597-2 ISBN: 978-3-8265-2220-8.

Detailangaben zum Abschluss

Link zum Moodle-Kurs

verwendet in folgenden Studiengängen:

Diplom Elektrotechnik und Informationstechnik 2017
Diplom Elektrotechnik und Informationstechnik 2021
Master Communications and Signal Processing 2021
Master Elektrotechnik und Informationstechnik 2021
Master Ingenieurinformatik 2021
Master Mathematik und Wirtschaftsmathematik 2022
Master Medieningenieurwissenschaften 2023
Master Medientechnologie 2017

Modul: Multirate Signal Processing

Modulabschluss: mehrere Teilleistungen | Art der Notengebung: Generierte Noten

Sprache:Englisch | Pflichtkennz.:Wahlmodul | Turnus:Sommersemester

Modulnummer: 200615 | Prüfungsnummer:210509

Modulverantwortlich: Prof. Dr. Gerald Schuller

Leistungspunkte: 5 | Workload (h):150 | Anteil Selbststudium (h):116 | SWS:3.0

Fakultät für Elektrotechnik und Informationstechnik | Fachgebiet:2184

SWS nach Fach-semester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
				2	1	0																								

Lernergebnisse / Kompetenzen

The students understand algorithms for multirate signal processing, and are able to program them in Python.
The students have learned to describe the methods of multirate signal processing, and can classify them.
After attending the course they cann summarize these methods.
After attending the seminar, they have learned the skills to implement these methods in the programming language Python.
At the end they should be able to evaluate theirs and their peers performance.

Nachdem Studierende die Veranstaltung besucht haben, können sie Verfahren der Multiraten Signalverarbeitung beschreiben und erklären.Die Studierenden sind nach Besuch der Lehrveranstaltung in der Lage, verschiedene dieser Verfahren zu klassifizieren.

Nach dem Besuch der Vorlesung können die Studierenden die erworbenen Kenntnisse über die Multiraten Signalverarbeitung zusammenfassen.

Nach dem Seminar haben die Studierenden ihre in der Vorlesung erworbenen theoretischen Kenntnisse gelernt anzuwenden, durch Einuebung der Fertigkeit ausgewählte Programmierprojekte in der Programmiersprache Python zu programmieren.
Nach Beendigung der Veranstaltung können die Studierenden die eigenen Leistungen und die ihrer Kommilitonen richtig einschätzen und bewerten.

Vorkenntnisse

Bachelor in Media Technology or Electrical Engineering, Digital Signal Processing

Inhalt

1. Sampling in one and more dimensions (Images...)
2. z-Transforms in multirate systems

3. Filter banks for coding applications
4. Polyphase representation
5. Low Delay Filter banks
6. Integer Filterbanks
7. Prediction
8. Application examples

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

Moodle 2, Slides, Python examples
Computer, Browser, Internet
Technischen Voraussetzungen für Moodle-Exam gemäß https://intranet.tu-ilmenau.de/site/vpsl-pand/SitePages/Handreichungen_Arbeitshilfen.aspx

Literatur

- G. Strang, T. Nguyen, "Wavelets and Filter Banks", Wellesley College, 1996N. J. Fliege, "Multirate Digital Signal Processing", John Wiley & Sons Ltd., 1993
- N. Fliege, "Multiraten-Signalverarbeitung: Theorie und Anwendungen", Teubner, Stu
- ttgart, 1993

Detailangaben zum Abschluss

Das Modul Multirate Signal Processing mit der Prüfungsnummer 210509 schließt mit folgenden Leistungen ab:

- alternative semesterbegleitende Prüfungsleistung mit einer Wichtung von 30% (Prüfungsnummer: 2100971)
- elektronische Abschlussleistung über 90 Minuten mit einer Wichtung von 70% (Prüfungsnummer: 2100972)

Details zum Abschluss Teilleistung 1:
Waehrend des Semsters bearbeiten die Studenten kleine 2-Woechige Programmierprojekte, die den Stoff der Vorlesung umsetzen. Dies ist eine Fertigkeit die sie nur durch diese entsprechende Uebung erlernen koennen, und die auch nur dadurch geprueft werden kann.
During the semester, the students work on small 2-week programming projects. This way they aquire the skill to implement the theoretical approaches from the lecture, and this practice is the only way to aquire and test this skill.

Details zum Abschluss Teilleistung 2:
Elektronische Abschlussleistung am Ende des Semesters. Diese prueft die theoretischen Kenntnisse, welche die Studenten durch die Vorlesung erlernt haben.
Electronic exam at the end of the semester. This tests the knowledge of the theoretical concepts of the lecture.

Link zum Moodle-Kurs

verwendet in folgenden Studiengängen:

Diplom Elektrotechnik und Informationstechnik 2021
Master Communications and Signal Processing 2021
Master Elektrotechnik und Informationstechnik 2014 Vertiefung IKT
Master Elektrotechnik und Informationstechnik 2021
Master Medieningenieurwissenschaften 2023
Master Medientechnologie 2017

Modul: Video Coding

Modulabschluss: mehrere Teilleistungen | Art der Notengebung: Generierte Noten

Sprache:Englisch | Pflichtkennz.:Wahlmodul | Turnus:Sommersemester

Modulnummer: 200616 | Prüfungsnummer:210510

Modulverantwortlich: Prof. Dr. Gerald Schuller

Leistungspunkte: 5 | Workload (h):150 | Anteil Selbststudium (h):116 | SWS:3.0

Fakultät für Elektrotechnik und Informationstechnik | Fachgebiet:2184

SWS nach Fach-semester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
				2	1	0																								

Lernergebnisse / Kompetenzen

The students understand algorithms of video coding and are able to program a simple video coder in Python.

The students have learned to describe the methods of video coding, and can classify them.
After attending the course they cann summarize these methods.
After attending the seminar, they have learned the skills to implement these methods in the programming language Python.
At the end they should be able to evaluate theirs and their peers performance.

Nachdem Studierende die Veranstaltung besucht haben, können sie Verfahren der Videocodierung beschreiben und erklären.Die Studierenden sind nach Besuch der Lehrveranstaltung in der Lage, verschiedene dieser Verfahren zu klassifizieren.
Nach dem Besuch der Vorlesung können die Studierenden die erworbenen Kenntnisse über die Videocodierung zusammenfassen.
Nach dem Seminar haben die Studierenden ihre in der Vorlesung erworbenen theoretischen Kenntnisse gelernt anzuwenden, durch Einuebung der Fertigkeit ausgewählte Programmierprojekte in der Programmiersprache Python zu programmieren.
Nach Beendigung der Veranstaltung können die Studierenden die eigenen Leistungen und die ihrer Kommilitonen richtig einschätzen und bewerten.

Vorkenntnisse

Signals and Systems, Grundlagen der Videotechnik, Advanced Digital Signal processing

Inhalt

1. 2-D und 3-D signal processing (2-D z-transform, 2-D filter banks and Wavelets, also 3-D for motion compensation)
2. Motion estimation and compensation
3. Prediction
4. Psycho-Optical effects (CSF, motion blurring...)
5. Application in coding
6. Image processing
7. 3-D video

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

Moodle 2, Slides, Python examples
Computer, Browser, Internet
Technischen Voraussetzungen für Moodle-Exam gemäß https://intranet.tu-ilmenau.de/site/vpsl-pand/SitePages/Handreichungen_Arbeitshilfen.aspx

Literatur

- H.R. Wu (Editor), K.R. Rao (Editor): Digital Video Image Quality and Perceptual Coding
- J.S. Lim: Two-Dimensional Signal and Image Processing

Gonzalez, Woods: Digital Image Processing

- Puri, Chen: Multimedia Systems, Standards, and Networks -Pereira, Ebrahimi: MPEG-4 Book

Detailangaben zum Abschluss

Das Modul Video Coding mit der Prüfungsnummer 210510 schließt mit folgenden Leistungen ab:

- alternative semesterbegleitende Prüfungsleistung mit einer Wichtung von 30% (Prüfungsnummer: 2100973)
- elektronische Abschlussleistung über 90 Minuten mit einer Wichtung von 70% (Prüfungsnummer: 2100974)

Details zum Abschluss Teilleistung 1:
Waehrend des Semsters bearbeiten die Studenten kleine 2-Woechige Programmierprojekte, die den Stoff der Vorlesung umsetzen. Dies ist eine Fertigkeit die sie nur durch diese entsprechende Uebung erlernen koennen, und die auch nur dadurch geprueft werden kann.
During the semester, the students work on small 2-week programming projects. This way they aquire the skill to implement the theoretical approaches from the lecture, and this practice is the only way to aquire and test this skill.

Details zum Abschluss Teilleistung 2:
elektronische Abschlussleistung am Ende des Semesters. Diese prueft die theoretischen Kenntnisse, welche die Studenten durch die Vorlesung erlernt haben.
Electronic examat the end of the semester. This tests the knowledge of the theoretical concepts of the lecture.

Link zum Moodle-Kurs

verwendet in folgenden Studiengängen:

Master Communications and Signal Processing 2021
Master Medieningenieurwissenschaften 2023
Master Medientechnologie 2017

Modul: Advanced Research Project

Modulabschluss: mehrere Teilleistungen | Art der Notengebung: Generierte Noten

Sprache: Englisch | Pflichtkennz.: Wahlmodul | Turnus: Wintersemester

Modulnummer: 200636 | Prüfungsnummer: 210523

Modulverantwortlich: Prof. Dr. Martin Haardt

Leistungspunkte: 10 | Workload (h): 300 | Anteil Selbststudium (h): 210 | SWS: 8.0

Fakultät für Elektrotechnik und Informationstechnik | Fachgebiet: 2111

SWS nach Fachsemester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
							0	8	0																					

Lernergebnisse / Kompetenzen

Nachdem die Studierenden an dieser Veranstaltung teilgenommen haben, können sie

- Publikationen, die den aktuellen Stand der Technik beschreiben, selbstständig finden, verstehen und auf ihre eigenen Forschungsaufgaben anwenden
- neue Lösungsvorschläge für Forschungsaufgaben erarbeiten, die über den Stand der Technik hinausgehen
- den Stand der Technik und ihre neuen Forschungsergebnisse in einem wissenschaftlichen Aufsatz darstellen
- den Stand der Technik und ihre neuen Forschungsergebnisse den anderen Teilnehmern und den Dozenten in einem wissenschaftlichen Vortrag präsentieren

After the students have participated in this course, they can

- find publications that describe the current state of the art in their area of research, understand them, and apply them to their own research tasks
- develop new proposals for solutions of research questions that go beyond the state of the art
- present the state of the art and their new results in a scientific paper

- present the state of the art and their new research results to the other participants and the lecturers in a scientific presentation

Vorkenntnisse

Gewünschte Zulassungsvoraussetzung:
Admission to the module Advanced Research Project is only given when students have successfully passed the Research Project.

Inhalt

Alle Universitätsprofessoren, die im Masterstudiengang CSP Vorlesungen anbieten, sind berechtigt, Themen für Advanced Research Projects zu vergeben.
All university professors that offer lectures in the Master's program CSP are entitled to propose and supervise topics for Advanced Research Projects.

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

Präsentation, Bericht
Presentation, report

Literatur

Abhängig von der Aufgabenstellung
Depending on project topic

Detailangaben zum Abschluss

Das Modul Advanced Research Project mit der Prüfungsnummer 210523 schließt mit folgenden Leistungen ab:

- alternative semesterbegleitende Prüfungsleistung mit einer Wichtung von 50% (Prüfungsnummer: 2101006)
- alternative semesterbegleitende Prüfungsleistung mit einer Wichtung von 50% (Prüfungsnummer: 2101007)

Details zum Abschluss Teilleistung 1:
Research Paper
Must be passed (at least with mark 4.0)

Details zum Abschluss Teilleistung 2:
Presentation about the Research Paper + discussion
Must be passed (at least with mark 4.0)

Link zum Moodle-Kurs

verwendet in folgenden Studiengängen:

Master Communications and Signal Processing 2021

Modul: Applications and Signal Processing Methods of Radar Technology

Modulabschluss: mehrere Teilleistungen | Art der Notengebung: Generierte Noten

Sprache: Englisch | Pflichtkennz.: Wahlmodul | Turnus: Sommersemester

Modulnummer: 201139 | Prüfungsnummer: 210549

Modulverantwortlich: Prof. Dr. Thomas Dallmann

Leistungspunkte: 5 | Workload (h): 150 | Anteil Selbststudium (h): 105 | SWS: 4.0

Fakultät für Elektrotechnik und Informationstechnik | Fachgebiet: 2114

SWS nach Fachsemester

1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
			2	2	0																								

Lernergebnisse / Kompetenzen

Students are familiar with various applications of radar systems and know which specifics must be taken into account when designing the systems. They confidently master various signal processing techniques used in radar systems to achieve higher resolution of radar targets along range and angle, to achieve imaging of terrain and targets, and to analyze physical effects occurring at targets. They know the specifics of bistatic, multistatic and passive configurations and are able to account for them in signal processing. They can independently differentiate between the advantages and disadvantages of using various analog and digital waveforms and design them according to a given application scenario. By studying a topic in-depth, they are able to autonomously explore a signal processing method or an application of radar technology in detail and are able to communicate this to an audience in a comprehensible manner.

Vorkenntnisse

Fundamentals of electromagnetic waves, fundamentals of microwave engineering, fundamentals of signals and systems, fundamentals of digital signal processing, fundamentals of adaptive and array signal processing.

Inhalt

1. Introduction to radar
2. Classification of different signal processing methods
3. Polarimetric radar
4. MIMO radar
5. Bistatic radar, passive radar
6. Multistatic radar, radar networks
7. Imaging techniques: SAR, ISAR
8. Analog waveforms: Noise radar, SFCW radar
9. Digital waveforms and codes
10. High resolution methods
11. Cassification of different applications
12. Radar remote sensing
13. Automotive radar
14. Weather radar
15. Presentation of selected topics by the students

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

Slideshow for video projector, notes on whiteboard, exhibits and demonstrations, offers for participation and co-design. Technical requirements: Video projector, whiteboard.

Literatur

M. Skolnik, "Radar Handbook, Third Edition", McGraw-Hill Education, 2008, ISBN 0071485473
H. Griffiths, G. W. Stimson, C. Baker, D. Adamy, "Stimson's Introduction to Airborne Radar", SciTech Publishing, 2013, ISBN 1613530226J.-S. Lee, E. Pottier, "Polarimetric Radar Imaging", CRC Press, 2009, ISBN 9781420054972

Detailangaben zum Abschluss

The module Applications and Signal Processing Methods of Radar Technology with the examination number

210549 completes with the following examination parts:

- Oral examination (30 minutes) with a weighting of 70% (examination number: 2101094)
- alternative semester accompanying course achievement with a weighting of 30% (examination number: 2101095)

Detail of examination part 2 (alternative semester accompanying course achievement):
In the course of the exercise, the students prepare a topic related to applications and signal processing methods of radar technology from a given pool of topics. The topic is prepared in the form of a presentation (20 minutes) and presented to the other students at the end of the lecture. The presentation will be graded by the lecturer, the grade will be 30% of the overall grade.

Link zum Moodle-Kurs

Applications and signal processing methods of radar technology

verwendet in folgenden Studiengängen:

Diplom Elektrotechnik und Informationstechnik 2021
Master Communications and Signal Processing 2021
Master Elektrotechnik und Informationstechnik 2021

Modul: Audio Coding

Modulabschluss: mehrere Teilleistungen | Art der Notengebung: Generierte Noten

Sprache:Englisch | Pflichtkennz.:Wahlmodul | Turnus:Wintersemester

Modulnummer: 200611 | Prüfungsnummer:210505

Modulverantwortlich: Prof. Dr. Gerald Schuller

Leistungspunkte: 5 | Workload (h):150 | Anteil Selbststudium (h):116 | SWS:3.0

Fakultät für Elektrotechnik und Informationstechnik | Fachgebiet:2184

SWS nach Fach-semester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
							2	1	0																					

Lernergebnisse / Kompetenzen

The goal was to understand algorithms for audio compression and being able to program them in Python.
The students have learned to describe the methods of audio coding, and can classify them.After attending the course they can summarize these methods.
After attending the seminar, they have learned the skills to implement these methods in the programming language Python.
At the end they should be able to evaluate theirs and their peers performance.

Nachdem Studierende die Veranstaltung besucht haben, können sie die Algorithmen und Prinzipien der Audiocodierung beschreiben und erklären.
Die Studierenden sind nach Besuch der Lehrveranstaltung in der Lage, verschiedene Typen der Audiocodierung zu klassifizieren.
Nach dem Besuch der Vorlesung können die Studierenden die erworbenen Kenntnisse über die Audiocodierung zusammenfasser
Nach dem Seminar haben die Studierenden ihre in der Vorlesung erworbenen theoretischen Kenntnisse gelernt anzuwenden, durch die Implementierung einzelner Teile aus der Audiocodierung in der Programmiersprache Python.

Vorkenntnisse

Knowledge in Media Technology, Electrical Engineering, Digital Signal Processing, Advanced Digital Signal Processing

Inhalt

Topics:

1. Overview
2. Psychoacoustics

3. Quantization and Coding

4. Filterbanks 1

5. Filterbanks 2;

6. MPEG-1/2 BC Audio

7. PAC

8. MPEG-2/4 AAC

9. Audio Quality Assessment
10. Parametric Coding

11. Stereo Coding

12. Prediction and Lossless Coding

13. IntMDCT
14. Ultra Low Delay Coder

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

Moodle 2, Lecture slides, script, Python example programs
Technischen Voraussetzungen für Moodle-Exam gemäß https://intranet.tu-ilmenau.de/site/vpsl-pand/SitePages/Handreichungen_Arbeitshilfen.aspx
Computer, Browser, Internet

Literatur

- Alan V. Oppenheim, Ronald W. Schafer, John R. Buck: "Discrete-Time Signal Processing", Prentice Hall, 2nd Edition, 1998
- N.S. Jayant, Peter Noll: "Digital Coding of Waveforms", not published anymore
- P.P. Vaidyanathan: "Multirate Systems and Filter Banks", Prentice Hall, 1993
- M.Bosi, R.E. Goldberg: "Introduction to Digital Audio Coding and Standards", Kluwer Academic Publishers, 2002
- K.D.Kammeyer,K. Kroschel: "Digitale Signalverarbeitung. Filterung und Spektralanalyse mit MATLAB Übungen", B.G. Teubner Verlag, 2002
- John G. Proakis: "Digital Communications", McGraw-Hill Science/Engineering/Math, 4th Edition, 2000
- Yiteng(Arden) Huang, Jacob Benesty (Eds.): "Audio Signal Processing ForNext-Generation Multimedia Communication Systems", Kluwer Academic Publishers Group, 2004; especially Chapter 11: "Audio Coding" by G.Schuller
- A. Spanias, T. Painter, V. Atti: "Audio Signal Processsing and Coding", Wiley-Interscience, New York, 2007
- J. Breebaart, C. Faller: "Spatial Audio Processing - MPEG Surround and Other Apllications", Wiley, Chichester, 2007

Detailangaben zum Abschluss

Das Modul Audio Coding mit der Prüfungsnummer 210505 schließt mit folgenden Leistungen ab:

- alternative semesterbegleitende Prüfungsleistung mit einer Wichtung von 30% (Prüfungsnummer: 2100963)
- elektronische Abschlussleistung über 90 Minuten mit einer Wichtung von 70% (Prüfungsnummer: 2100964)

Details zum Abschluss Teilleistung 1:
Waehrend des Semsters bearbeiten die Studenten kleine 2-Woechige Programmierprojekte, die den Stoff der Vorlesung umsetzen. Dies ist eine Fertigkeit die sie nur durch diese entsprechende Uebung erlernen koennen, und die auch nur dadurch geprueft werden kann.
During the semester, the students work on small 2-week programming projects. This way they aquire the skill to implement the theoretical approaches from the lecture, and this practice is the only way to aquire and test this skill.

Details zum Abschluss Teilleistung 2:
Elektronische Abschlussleistung am Ende des Semesters. Diese prueft die theoretischen Kenntnisse, welche die Studenten durch die Vorlesung erlernt haben.
Electronic exam at the end of the semester. This tests the knowledge of the theoretical concepts of the lecture.

Link zum Moodle-Kurs

verwendet in folgenden Studiengängen:

Diplom Elektrotechnik und Informationstechnik 2017
Diplom Elektrotechnik und Informationstechnik 2021
Master Communications and Signal Processing 2021
Master Elektrotechnik und Informationstechnik 2014 Vertiefung IKT
Master Elektrotechnik und Informationstechnik 2021
Master Mathematik und Wirtschaftsmathematik 2022
Master Medieningenieurwissenschaften 2023
Master Medientechnologie 2017

Modul: Cellular Communication Systems

Modulabschluss: mehrere Teilleistungen | Art der Notengebung: Generierte Noten

Sprache: Englisch | Pflichtkennz.: Wahlmodul | Turnus: Wintersemester

Modulnummer: 200070 | Prüfungsnummer: 220447

Modulverantwortlich: Prof. Dr. Andreas Mitschele-Thiel

Leistungspunkte: 5 | Workload (h): 150 | Anteil Selbststudium (h): 105 | SWS: 4.0

Fakultät für Informatik und Automatisierung | Fachgebiet: 2235

SWS nach Fach-semester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
							2	2	0																					

Lernergebnisse / Kompetenzen

Technical competence:
After completion of the lectures, students will have knowledge and understanding of the structure and operation of modern cellular mobile communication systems, in particular GSM, GPRS/EDGE, UMTS, LTE and 5G and their protocols.

Methodological competence:
Students are able to understand complex issues of cellular mobile communication systems, to deepen this understanding independently and to develop their own solutions based on this.

Systems Competency:
Through a combination of lecture and individual work, students will subsequently understand the interaction of the components and individual functions of the system and be able to assess the impact of design decisions on the system as a whole.

Social Competence:
Students are able to independently solve and showcase problems of cellular mobile communication systems. By developing their own proposed solutions for selected topics individually, as well as presenting and discussing them in the group, they have learned to take other students' opinions into account and to critically question them. They were able to acquire the knowledge required for solving the tasks from available sources independently or in cooperation with others, became aware of the approach for problem solution through the presentation of the different possibilities and are able to appreciate the achievements of others accordingly.

Vorkenntnisse

Communication protocols and networks, basics of mobile communication networks

Inhalt

- Review of mobile communication basics
- Overview on GSM and GPRS
- UMTS architecture (mobility management, connection and session management, wideband CDMA, management of radio resources
- UMTS radio access network
- High-Speed Packet Access (HSPA)
- Long-Term Evolution (LTE)
- System Architecture Evolution (SAE)
- Self-organization in LTE

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

Presentations with beamer, presentation slides

Literatur

- Kaaranen, Ahtiainen, Laitinen, Naghian, Niemi. UMTS Networks - Architecture, Mobility and Services. Wiley, 2001
- Holma, Toskala. WCDMA for UMTS. revised edition, Wiley, 2002
- Dahlmann, Parkvall, Sköld. 4G: LTE/LTE-Advanced for Mobile Broadband, AP, 2011
- Stefania Sesia, Issam Toufik, Matthew Baker. LTE - The UMTS Long Term Evolution: From Theory to Practice

Detailangaben zum Abschluss

Das Modul Cellular Communication Systems mit der Prüfungsnummer 220447 schließt mit folgenden Leistungen ab:

- alternative semesterbegleitende Prüfungsleistung mit einer Wichtung von 40% (Prüfungsnummer: 2200720)
- mündliche Prüfungsleistung 20 Minuten mit einer Wichtung von 60% (Prüfungsnummer: 2200721)

Details zum Abschluss Teilleistung 1:
The course consists of two parts: In the first part of the semester, lectures on the material are given. In the second part, individual studies (semester-long research projects that include a term paper and a presentation) help to improve understanding of the material.

Link zum Moodle-Kurs

https://moodle.tu-ilmenau.de/course/view.php?id=372

verwendet in folgenden Studiengängen:

Master Communications and Signal Processing 2021
Master Informatik 2013
Master Informatik 2021
Master Research in Computer and Systems Engineering 2021
Master Research in Computer & Systems Engineering 2016

Modul: Deep Learning

Modulabschluss: mehrere Teilleistungen | Art der Notengebung: Generierte Noten

Sprache: Englisch | Pflichtkennz.: Wahlmodul | Turnus: ganzjährig

Modulnummer: 200131 | Prüfungsnummer: 220488

Modulverantwortlich: Prof. Dr. Patrick Mäder

Leistungspunkte: 5 | Workload (h): 150 | Anteil Selbststudium (h): 105 | SWS: 4.0

Fakultät für Informatik und Automatisierung | Fachgebiet: 2252

SWS nach Fachsemester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
							2	2	0																					

Lernergebnisse / Kompetenzen

Professional competence gained through lectures and examined through written exam:

- Students have knowledge about theoretical foundations of deep neural networks.
- Students have knowledge about CNN architectes and their applications.
- Students have knowledge about architectures for sequence modeling and their applications.

Methodological competence gained through seminars and examined through aPl (assignments):

- Students gained the ability to implement and apply a variety of deep learning algorithms.
- Students gained the ability to evaluate and troubleshoot deep learning models.
- Students gained the ability to use computational resources for training and application of deep learning models.

Social competence gained through lectures and seminars:

- Students gained insights in ethical aspects of machine learning (e.g., bias, autonomous driving) through discussions in lectures and seminars.
- Students can discuss advantages and disadvantages of different deep learning approaches among each other and with their lecturers and gained professionality in mastering discussions beyond their mother tongue.
- Students learn to discuss and solve a scientific problem in a team of peers

Vorkenntnisse

- basic programming skills in Python
- basic understanding of machine learning preferable

Inhalt

Deep learning has recently revolutionized a variety of application like speech recognition, image classification, and language translation mostly driven by large tech companies, but increasingly also small and medium-sized companies aim to apply deep learning techniques for solving an ever increasing variety of problems. This course will give you detailed insight into deep learning, introducing you to the fundamentals as well as to the latest tools and methods in this rapidly emerging field.
Deep learning thereby refers to a subset of machine learning algorithms that analyze data in succeeding stages, each operating on a different representation of the analyzed data. Specific to deep learning is the ability to automatically learn these representations rather than relying on domain expert for defining them manually.
The course will teach you the theoretical foundations of deep neural networks, which will provide you with the understanding necessary for adapting and successfully applying deep learning in your own to implement, parametrize and apply a variety of deep learning (CNNs) as well as recurrent neural networks (RNNs) and transformers for image, text, and time series analysis. You will further become familiar with advanced data science tools and in using computational resources to train and apply deep learning models.

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

- Presentations
- Assignments incldung code stubs
- Jupyter cloud services (personal computer required)
- All material will be shared via Moodle, accessible [HERE]

Technical Requirements

- personal computer required for all seminars and assignments
- ... with access to moodle.tu-ilmenau.de
- ... with access to colab.google.com

Literatur

- Deep Learning: Ian Goodfellow, Yoshua Bengio, and Aaron Courville, MIT Press (2016)
- Pattern Recognition and Machine Learning: Christoper M. Bishop, Springer (2006)
- Hands-On Machine Learning with Scikit-Learn and TensorFlow: Aurélien Géron, O'Reilly Media (2017)

Detailangaben zum Abschluss

Das Modul Deep Learning mit der Prüfungsnummer 220488 schließt mit folgenden Leistungen ab:

- alternative semesterbegleitende Prüfungsleistung mit einer Wichtung von 50% (Prüfungsnummer: 2200822)
- alternative semesterbegleitende Prüfungsleistung mit einer Wichtung von 50% (Prüfungsnummer: 2200823)

Details zum Abschluss Teilleistung 1:

- multiple coding assignments evaluating methodological and practical competence in the taught concepts - to be individually solved at home with due date and submission via Moodle
- result determined as average across the evaluated solutions to the assignments
- students must register via thoska for this exam, typically within the 3rd and 4th week of the semester

Details zum Abschluss Teilleistung 2:

- one or multiple written tests consisting of multiple-choice and free-form questions evaluating the professional competence in the course's topics
- preferably conducted digitally via Moodle and on the student's device
- final results may be scaled or individual questions may be excluded depending on best performing percentile of students
- students must register via thoska for this exam, typically within the 3rd and 4th week of the semester

Link zum Moodle-Kurs

accessible [HERE]

verwendet in folgenden Studiengängen:

Diplom Elektrotechnik und Informationstechnik 2017
Diplom Elektrotechnik und Informationstechnik 2021
Master Communications and Signal Processing 2021
Master Elektrotechnik und Informationstechnik 2021
Master Fahrzeugtechnik 2014
Master Fahrzeugtechnik 2022
Master Informatik 2013
Master Informatik 2021
Master Ingenieurinformatik 2021
Master Mathematik und Wirtschaftsmathematik 2022
Master Medieningenieurwissenschaften 2023
Master Medientechnologie 2017
Master Research in Computer and Systems Engineering 2021
Master Research in Computer & Systems Engineering 2016
Master Technische Physik 2023
Master Wirtschaftsinformatik 2021

Modul: Fundamentals and Systems of Radar Technology

Modulabschluss: Prüfungsleistung mündlich 30 min Art der Notengebung: Gestufte Noten

Sprache:Englisch Pflichtkennz.:Wahlmodul Turnus:Wintersemester

Modulnummer: 201190 Prüfungsnummer:2101096

Modulverantwortlich: Prof. Dr. Thomas Dallmann

Leistungspunkte: 5 Workload (h):150 Anteil Selbststudium (h):105 SWS:4.0

Fakultät für Elektrotechnik und Informationstechnik Fachgebiet:2114

SWS nach Fach-semester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P

Lernergebnisse / Kompetenzen

The students know the basic radar systems and their typical application scenarios. They are able to analyze the physical processes of signal propagation and signal processing. They can use mathematical estimates to determine the power budget for a given radar system and make statements about the detectability of radar targets. They know how to identify the scattering mechanisms occurring at the radar target. For different types of radar systems, they can derive and quantify the limits of achievable resolution using mathematical estimates. They understand the signal processing chain required for different radar systems and know components of RF technology which are suitable for them. They have practical experience in the configuration and operation of radars.

Vorkenntnisse

Fundamentals of electromagnetic waves, fundamentals of microwave engineering, fundamentals of signals and systems

Inhalt

1. Basic terms and history of radar2. Relation to localization, navigation and locating methods3. Plane waves and polarization4. Propagation effects and their occurrence5. Radar equation: derivation, noise processes, variants 6. Detection theory7. Radar cross section: Derivation, canonical scatterers, polarimetric behavior of canonical scatterers, complex scattering behavior, radar cross section optimization 8. Radar cross section measurement techniques9. Antenna as primary sensor, common antenna types and their dimensioning, antenna arrays, monopulse operation10. Pulse radar: Architecture, resolution of range and Doppler11. Fixed target suppression12. Matched filtering, pulse compression, ambiguity function13. Continuous wave radar: architecture, modulation and waveforms, resolution of range and Doppler14. Microwave components and their use in radars15. Practical exercise to learn the function of radar systems

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

Slideshow for video projector, notes on whiteboard, exhibits and demonstrations, offers for participation and co-design. Technical requirements: Video projector, whiteboard.

Literatur

M. Skolnik, "Radar Handbook, Third Edition", McGraw-Hill Education, 2008, ISBN 0071485473H. Griffiths, G. W. Stimson, C. Baker, D. Adamy, "Stimson's Introduction to Airborne Radar", SciTech Publishing, 2013, ISBN 1613530226C. A. Balanis, "Antenna Theory: Analysis and Design", John Wiley & Sons, 2012, ISBN 1118585739E. F. Knott, J. F. Schaeffer, M. T. Tulley, "Radar Cross Section", SciTech Publishing, 2004, ISBN 1891121251

Detailangaben zum Abschluss

Link zum Moodle-Kurs

verwendet in folgenden Studiengängen:

Diplom Elektrotechnik und Informationstechnik 2021
Master Communications and Signal Processing 2021
Master Elektrotechnik und Informationstechnik 2021
Master Fahrzeugtechnik 2014
Master Fahrzeugtechnik 2022

Modul: Measurements in Communications

Modulabschluss: Prüfungsleistung mündlich 30 min Art der Notengebung: Gestufte Noten

Sprache:Englisch Pflichtkennz.:Wahlmodul Turnus:Wintersemester

Modulnummer: 200664 Prüfungsnummer:2101043

Modulverantwortlich: Prof. Dr. Giovanni Del Galdo

Leistungspunkte: 5 Workload (h):150 Anteil Selbststudium (h):105 SWS:4.0

Fakultät für Elektrotechnik und Informationstechnik Fachgebiet:2112

SWS nach Fach-semester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
							2	2	0																					

Lernergebnisse / Kompetenzen

After attending the lectures, students can describe basic measurement methods for the characterization of transmission and communication systems.

They can explain Measurement methods and test their usability in new applications.
After attending the course, students are able to develop strategies for new measurement setups.
After attending the lecture, the student can summarize the knowledge about the measuring systems of information and communication technology.
After the seminar, the students deepened their knowledge gained in the lecture using selected examples.
After the event, students can systematize, plan and carry out more complex tasks.

Vorkenntnisse

Bachelor in communciations engineering (or similar)

Inhalt

- RF network analyzer
- Signal generators
- Broadband Receiver Techniques
- Applications
- Measurement and simulation of wave propagation in mobile radio

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

Presence or online
Beamer, Tafel

Literatur

R. Pintelon, J. Schoukens. System Identifikation - A Frequency Domain Approach. IEEE Press, Piscata-way, NJ, 2001

R.S. Thomä, M. Landmann, A. Richter, U. Trautwein. Multidimensional High-Resolution Channel Sounding. in T. Kaiser et. al. (Ed.), Smart Antennas in Europe - State-of-the-Art, EURASIP Book Series on SP&C, Vol. 3, Hindawi Publishing Corporation, 2005

Detailangaben zum Abschluss

Link zum Moodle-Kurs

https://moodle.tu-ilmenau.de/course/view.php?id=714

verwendet in folgenden Studiengängen:

Diplom Elektrotechnik und Informationstechnik 2017
Master Communications and Signal Processing 2021

Modul: Multimedia Standards

Modulabschluss: Prüfungsleistung schriftlich 90 min Art der Notengebung: Gestufte Noten

Sprache:Englisch Pflichtkennz.:Wahlmodul Turnus:Sommersemester

Modulnummer: 200626 Prüfungsnummer:2100990

Modulverantwortlich: Dr. Stephan Werner

Leistungspunkte: 5 Workload (h):150 Anteil Selbststudium (h):116 SWS:3.0

Fakultät für Elektrotechnik und Informationstechnik Fachgebiet:2181

SWS nach Fach-semester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
				2	1	0																								

Lernergebnisse / Kompetenzen

After attending the lectures, students can describe process of standardisation. They can explain tasks when participating in a standards committee. After attending the course, students are able to develop a media format standard. After the seminar the students have deepened their knowledge out of the lectures by means of selected examples. After the event, students can correctly assess and evaluate their own achievements and those of their fellow students.

Vorkenntnisse

Basic understanding of digital signal processing

Inhalt

Selection of Topics:
Introduction to standardisation of multimedia content, i.e. mainly standardisation of speech, high quality audio, picture and video information including standards for metadata and systems aspect.
The lecture starts with examples from standardisation and continues with the process of standardisation of media formats mainly in ITU and ISO/IEC organisations.
The lecture series does contain information about all the major standards series in media and at least one more detailed example (including introduction to the technology and bit stream details) for each major area of media standards, i.e. speech, audio, pictures, video, systems, metadata.

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

Lecture slides online as well as individual consultations or consultations in the group after consultation with the teachers, see moodle-course: https://moodle2.tu-ilmenau.de/course/view.php?id=2633

Literatur

for details see: https://www.tu-ilmenau.de/mt/lehrveranstaltungen/lehre-fuer-andere-studiengaenge/multimedia-standards/

Detailangaben zum Abschluss

Link zum Moodle-Kurs

https://moodle2.tu-ilmenau.de/course/view.php?id=2633

verwendet in folgenden Studiengängen:

Diplom Elektrotechnik und Informationstechnik 2021
Master Communications and Signal Processing 2021
Master Elektrotechnik und Informationstechnik 2021
Master Medieningenieurwissenschaften 2023
Master Medientechnologie 2017

Modul: Radio Standards

Modulabschluss: Prüfungsleistung mündlich 30 min Art der Notengebung: Gestufte Noten

Sprache:Englisch Pflichtkennz.:Wahlmodul Turnus:Wintersemester

Modulnummer: 200665 Prüfungsnummer:2101044

Modulverantwortlich: Prof. Dr. Giovanni Del Galdo

Leistungspunkte: 5 Workload (h):150 Anteil Selbststudium (h):105 SWS:4.0

Fakultät für Elektrotechnik und Informationstechnik Fachgebiet:2112

SWS nach Fach-semester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
							2	2	0																					

Lernergebnisse / Kompetenzen

After attending the lectures, students can describe the existing technologies based on radio transmission (e.g. from 100 kHz up to 100 GHz).
They can explain Broadcasting Systems from both a technical point of view and from a political/business point of view.
After attending the course, students are able to develop a media format standard.
After the seminar, the students deepended their knowledge gained in the lecture using selected examples.
After the event, students can correctly assess and evaluate their own achievements and those of their fellow students.

Vorkenntnisse

basic engineering knowledge (e.g. math, physics)

Inhalt

Non-technical part:

- Standardization bodies
- Patenting
- business models
- market access strategies (exemplary tops and flops)

Technical part:

- Review of propagation, antennas, modulation schemes, FEC, source coding, multiple access schemes
- OFDM
- For the different applications: main characteristics of the channel and the engineering choices made consequently for the technologies

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

Presence or online
Beamer, Tafel

Literatur

Online public documents, e.g.:
The specifications for DVB-S, DVB-T and DVB-C may be downloaded at https://dvb.org/specifications/
The specifications for the 3GPP mobile communications standards are available at https://www.etsi.orghttps://www.etsi.org

Detailangaben zum Abschluss

Link zum Moodle-Kurs

https://moodle.tu-ilmenau.de/course/view.php?id=708

verwendet in folgenden Studiengängen:

Diplom Elektrotechnik und Informationstechnik 2017
Diplom Elektrotechnik und Informationstechnik 2021

Master Communications and Signal Processing 2021
Master Elektrotechnik und Informationstechnik 2021
Master Ingenieurinformatik 2021

Modul: Systems Optimization

Modulabschluss: Prüfungsleistung schriftlich 90 min Art der Notengebung: Gestufte Noten

Sprache:Englisch Pflichtkennz.:Wahlmodul Turnus:Wintersemester

Modulnummer: 200008 Prüfungsnummer:2200638

Modulverantwortlich: Prof. Dr. Pu Li

Leistungspunkte: 5 Workload (h):150 Anteil Selbststudium (h):105 SWS:4.0

Fakultät für Informatik und Automatisierung Fachgebiet:2212

SWS nach Fach-semester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
							2	2	0																					

Lernergebnisse / Kompetenzen

The students know and can explain

- fundamentals, problem formulation, and classification of optimization methods
- methods and tools for optimization
- different problem formulations and mathematical derivation of optimization methods
- applications in industrial processes

The students have learned the theory, models, methods, and algorithms of the corresponding subjects in the lectures. In the exercises, they had been activated to solve example tasks.

Vorkenntnisse

Fundamentals of Mathematics and Control Engineering

Inhalt

Linear Optimization:
Theory of linear programming, degree of freedom, feasible region, graphical description/solution, Simplex method, mixing problem, optimal production planning

Nonlinear Optimization:
Convexity analysis, problems without uand with constraints, optimality condition, the gradient-, Newton-, Quasi-Newton-methods, KKT conditions, sequential quadratic programming (SQP) methods, active-set method, approximation of the Hessian matrix, application in optimal design of industrial processes.

Mixed-Integer Optimization :
Mixed-Integer Linear Programming (MILP), Branch-and-Bound method, optimization software GAMS, application in optimal design of industrial processes.
Dynamic Optimization:
Discretization in time, Euler method, orthogonal collocation, solution of the problem with SQP

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

Video on Demand, Moodle-Kurs, Webex-Veranstaltungen, Folien, Skripte

Literatur

U. Hoffmann, H. Hofmann: Einführung in die Optimierung, Verlag Chemie, Weinheim, 1982
T. F. Edgar, D. M. Himmelblau: Optimization of Chemical Processes, McGraw-Hill, New York, 1989
Teo, K. L., Goh, C. J., Wong, K. H: A Unified Computational Approach to Optimal Control Problems. John Wiley & Sons, New York, 1991
C. A. Floudas: Nonlinear and Mixed-Integer Optimization, Oxford University Press, 1995
L. T. Biegler, I. E. Grossmann, A. W. Westerberg: Systematic Methods of Chemical Process Design. Prentice Hall, New Jersey, 1997
M. Papageorgiou: Optimierung, Oldenbourg Verlag, München, 2006

J. Nocedal, S. J. Wright: Numerical Optimization, Springer-Verlag, 1999

Detailangaben zum Abschluss

Link zum Moodle-Kurs

verwendet in folgenden Studiengängen:

Master Communications and Signal Processing 2021
Master Research in Computer and Systems Engineering 2016
Master Research in Computer and Systems Engineering 2021
Master Research in Computer & Systems Engineering 2016
Master Wirtschaftsingenieurwesen 2021 Vertiefung AT

TECHNISCHE UNIVERSITÄT ILMENAU

Master´s Thesis with Colloquium

Fachabschluss: mehrere Teilleistungen | Art der Notengebung: Generierte Noten

Sprache:English/German | Pflichtkennz.:Pflichtmodul | Turnus:ganzjährig

Fachnummer: 201047 | Prüfungsnummer:99000

Fachverantwortlich: Cornelia Scheibe

Leistungspunkte: 30 | Workload (h):900 | Anteil Selbststudium (h):900 | SWS:0.0

Fakultät für Elektrotechnik und Informationstechnik | Fachgebiet:2111

SWS nach Fach-semester	1.FS			2.FS			3.FS			4.FS			5.FS			6.FS			7.FS			8.FS			9.FS			10.FS		
	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P	V	S	P
										900 h																				

Lernergebnisse / Kompetenzen

With the Master's thesis, the students are able to work independently on a given extensive engineering task within a set time frame.
The students were able to deepen and expand their previously acquired skills in a specific technical topic. They are thus able to thoroughly familiarize themselves with a topic and organize their own thoughts on the problem. Using the theoretical and methodological competences acquired so far, they are able to work on the problem independently according to scientific methods and to classify it in a scientific context. They are able to assess a concrete problem and document it according to scientific standards.
Through the analysis of technical literature regarding the task and their own scientific work, they are trained to apply their acquired knowledge and skills to new systems and the problem.
Students have been able to acquire problem-solving skills and are able to evaluate and classify their own work.
The students are able to present the concern of their worked scientific topic in a lecture in front of a general and/or professionally involved audience, to present the research results in a condensed form in the context of a final colloquium and to both present and defend the gained knowledge in the scientific discussion. They are able to pay attention to comments and appreciate criticism and are able to critically question their work. They are able to pay attention to comments and appreciate criticism and are able to critically challenge their work.
They have learned to present and substantiate their own findings and results in a clear and comprehensible manner and are thus able to write scientifically sound texts on other topics as well.

Vorkenntnisse

defined at: Examination and Study Regulations - Special Provisions - CSP

Inhalt

Independent processing of a subject-specific topic under supervision
Documentation of the work (conception of a work plan, literature research, state of the art,)
Scientific activities (e.g. analysis, synthesis, modeling, simulations, design and construction, measurement)
Evaluation and discussion of results
Composition of a written thesis
Scientific presentation with subsequent scientific discussion

Medienformen und technische Anforderungen bei Lehr- und Abschlussleistungen in elektronischer Form

Written documentation and lecture with digital presentation

Literatur

Topic-specific literature will be named by the supervisor at the beginning of the thesis or must be researched independently.

Detailangaben zum Abschluss

- Alternative semester examination with a weighting of 67% (examination number: 99001)
- Colloquium Examination with a weighting of 33% (Examination number: 99002)

Details on the degree Partial achievement 1:
Independent written scientific work, 750 hours within 5.5 months.

Details on the completion of the examination Partial achievement 2:

Presentation approx. 30 min + discussion approx. 30 min
Colloquium with digital presentation within 2 weeks after submitting the written work

Link zum Moodle-Kurs

verwendet in folgenden Studiengängen:

Master Communications and Signal Processing 2021

Glossar und Abkürzungsverzeichnis:

LP	Leistungspunkte
SWS	Semesterwochenstunden
FS	Fachsemester
V S P	Angabe verteilt auf Vorlesungen, Seminare, Praktika
N.N.	Nomen nominandum, Platzhalter für eine noch unbekannte Person (wikipedia)
Objekttypen lt. Inhaltsverzeichnis	K=Kompetenzfeld; M=Modul; P,L,U= Fach (Prüfung,Lehrveranstaltung,Unit)