Activity Report 2018–2019
Institute of Communications Engineering
Prof. Dr.-Ing. Martin Bossert
Prof. Dr.-Ing. Robert Fischer
Prof. Dr. Dr.-Ing. Wolfgang Minker
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Preface

The institute for Communications Engineering provides research and teaching for several courses of study in the area of communications within the faculty of Electrical Engineering, Computer Science, and Psychology of the Ulm University. Since 2014 the institute has been largely responsible for the international Master Course Communications Technology. Research areas and offered lectures and labs range from physical-layer methods over reliable and secure information transmission in time and space, up to man-machine interfaces.

The present report covers all activities of members of our institute from January 2018 through December 2019.
People

Professors

Prof. Dr.-Ing. Martin Bossert  
Prof. Dr.-Ing. Robert Fischer  
Prof. Dr.-Ing. Wolfgang Minker  

Associated and Retired Professors

Prof. Dr.-Ing. Uwe-Carsten Fiebig  
Prof. Dr. Hans Peter Großmann  
Prof. Dr.-Ing. Jürgen Lindner  

Senior Researchers

Dr. rer. nat. Sven Müelich  
Dr.-Ing. Sebastian Stern  
Dr. rer. nat. Werner Teich  

Secretary

Michaela Baumann  
Fe Hägele  

Technical Staff

Werner Birkle  
Dipl.-Ing. (FH) Werner Hack  
Heike Schewe  

Lecturers

Dr.-Ing. Dejan Lazich  
Prof. Dr. Max Riederle  
Prof. Dr.-Ing. Georg Schmidt  

Retired

Hochschule Ulm  
Hochschule Esslingen
Research Assistants

Annalena Aicher, M.Sc., M.Sc.
Oleg Akhtiamov, M.Sc.
Patricia Braunger, M.Sc.
Zaid Dhannoon, M.Sc.
Denis Dresvyanskiy, M.Sc.
Dmitrii Fedotov, M.Sc.
Dipl.-Ing. Martin Frassl
Dipl.-Ing. Felix Frey
Dipl.-Ing. Günther Haas
Denis Ivanko, M.Sc.
Eleni Kamateri, M.Sc.
Matthias Kraus, M.Sc.
Jakob Landesberger, M.Sc.
Danila Mamontov, M.Sc.
Juliana Miehle, M.Sc.
Cornelia Ott, M.Sc.
Johannes Pfeiffer, M.Sc.
Louisa Pragst, M.Sc.
Sven Puchinger, B.Sc., B.Sc.
Niklas Rach, M.Sc.
Alexei Romanenko, M.Sc.
Maria Schmidt, M.Sc.
Dipl.-Ing. Martin Schüssel
Carmen Sippel, M.Sc.
Dipl.-Ing. Susanne Sparrer
Anastasiia Spirina, M.Sc.
Daniela Stier, M.Sc.
Dmitrii Ubskii, M.Sc.
Oxana Verkholyak, M.Sc.
Nicolas Wagner, M.Sc.
Sabine Wieluch, M.Sc.
George Yammine, M.Sc.
Sebastian Zepf, M.Sc.
annalena.aicher@uni-ulm.de
oleg.akhtiamov@uni-ulm.de
patricia.braunger@uni-ulm.de
zaid.dhannoon@uni-ulm.de
denis.dresvyanskiy@uni-ulm.de
dmitrii.fedotov@uni-ulm.de
(until 07/18)
(until 11/19)
guenther.haas@uni-ulm.de
denis.ivanko@uni-ulm.de
eleni.kamateri@uni-ulm.de
matthias.kraus@uni-ulm.de
jakob.landesberger@uni-ulm.de
danila.mamontov@uni-ulm.de
juliana.miehle@uni-ulm.de
cornelia.ott@uni-ulm.de
johannes.pfeiffer@uni-ulm.de
louisa.pragst@uni-ulm.de
(untill 04/18)
niklas.rach@uni-ulm.de
alexei.romanenko@uni-ulm.de
maria-1.schmidt@uni-ulm.de
(untill 06/18)
carmen.sippel@uni-ulm.de
(untill 06/18)
(untill 11/18)
daniela.stier@uni-ulm.de
dmitrii.ubskii@uni-ulm.de
overkholyak@gmail.com
nicolas.wagner@uni-ulm.de
(untill 07/18)
george.yammine@uni-ulm.de
sebastian.zepf@uni-ulm.de
Visiting Scholars

- **ITMO University of Saint Petersburg, Russia**
  - Denis Ivanko
  - 10/2017–03/2018

- **ITMO University of Saint Petersburg, Russia**
  - Alexei Romanenko
  - 10/2017–03/2018

- **Nara Institute of Science and Technology (NAIST), Japan**
  - Yuki Matsuda
  - 10/2017–09/2018

- **Sun Yat-sen University, Guangzhou, China**
  - Jiongyue Xing
  - 02/2018–12/2019

- **University of Granada, Spain**
  - Prof. Zoraida Callejas Carrión
  - 03/2018

- **Ulster University, UK**
  - Prof. Mike McTear
  - 03/2018

- **Nara Institute of Science and Technology (NAIST), Japan**
  - Prof. Keiichi Yasumoto
  - 03/2018

- **University of the Witwatersrand Johannesburg, South Africa**
  - Yuval Genga
  - 06/2018–11/2018

- **Ulster University, UK**
  - Prof. Paul McKeveit
  - 08/2018

- **Nara Institute of Science and Technology (NAIST), Japan**
  - Prof. Yutaka Arakawa
  - 09/2018

- **Nara Institute of Science and Technology (NAIST), Japan**
  - Shogo Kawanaka
  - 09/2018–11/2018

- **University of Granada, Spain**
  - Prof. Zoraida Callejas Carrión
  - 01/2019

- **University of the Basque Country, Spain**
  - Prof. Maria Inés Torres
  - 08/2019

- **Nara Institute of Science and Technology (NAIST), Japan**
  - Prof. Yuki Matsuda
  - 09/2019
- **Kyushu University, Japan**  
  Prof. Yutaka Arakawa  
  09/2019

- **ITMO University of Saint Petersburg, Russia**  
  Dmitrii Ubskii  
  10/2019–03/2020

- **Nara Institute of Science and Technology (NAIST), Japan**  
  Prof. Koichiro Yoshino  
  11/2019

- **School of Electronics and Information Technology, Sun Yat-sen University, Guangzhou, China**  
  Jiongyue Xi  
  12/2018–12/2019

### Research Stays at other Universities

- **Nara Institute of Science and Technology (NAIST), Japan**  
  Juliana Miehle  
  11/2018–12/2018

- **Nara Institute of Science and Technology (NAIST), Japan**  
  Dmitrii Fedotov  
  03/2019–05/2019

- **Nara Institute of Science and Technology (NAIST), Japan**  
  Niklas Rach  
  03/2019–05/2019, 09/2019–12/2019

- **Technical University Vienna, Austria**  
  Robert Fischer  
  08/2019

- **University of Granada, Spain**  
  Matthias Kraus, Nicolas Wagner  
  09/2019–11/2019

- **Institut d’Électronique de Microélectronique et de Nanotechnologie (IEMN), Lille, France**  
  Werner Teich  
  12/2019
3 Awards

- **Prof. Minker and Prof. Glimm**
  Google Faculty Research Award, May 2018
  *Project: Mungo Multi-User indoor Navigation using natural spoken dialog and self-learning Ontologies*

- **Dmitrii Fedotov**
  Best Demonstration Award, March 2019, Kyoto, Japan,
  IEEE Conference on Pervasive Computing and Communications 2019
  *Towards Real-Time Contextual Touristic Emotion and Satisfaction Estimation with Wearable Devices*

- **Sven Puchinger**
  Südwestmetall-Förderpreis, April 2019, Stuttgart Dissertation
  *Construction and Decoding of Evaluation Codes in Hamming and Rank Metric*

- **Sven Puchinger**
  Award of the Ulmer Universitätsgesellschaft, July 2019, Ulm Dissertation
  *Construction and Decoding of Evaluation Codes in Hamming and Rank Metric*
A detailed description of the modules is available online.

**Advanced Channel Coding** (English)  
Master 2L/1E  
Symbol-by-Symbol APP Decoding; Iterative Decoding of Concatenated Codes; LDPC Codes; Algebraic List Decoding

**Angewandte Mathematik für Ingenieure** (German)  
Master 3L/1E  
(Applied Mathematics for Engineers)  
Stochastic Processes; Normal Forms of Matrices and their Application in System Theory; Special Functions (e.g., Bessel Functions) and their Application; Algebraic Structures (e.g., Finite Fields)

**Applied Information Theory** (English)  
Master 3L/2E/1P  
Uncertainty (Entropy); Mutual Information; Source Coding Theorem; Source Coding Schemes (Shannon–Fano, Huffman, Tunstall, Arithmetic Coding); Universal Source Coding (Lempel–Ziv, Elias–Willems); Channel Capacity and Channel Coding Theorem; Gaussian Channel; Random Coding; Multi-User Information Theory; Dirty Paper Coding; Tomlinson–Harashima Precoding; Information Theory and Cryptology

**Benutzerschnittstellen** (German)  
Bachelor/Master 2L/2S  
(User Interfaces)  
Introduction into the area of human-computer interaction (HCI); Focus: design and development principles of multimodal user interfaces; Usability engineering and evaluation of multimodal user interfaces

**Channel Coding** (English)  
Master 3L/2E/1P  
Block Codes (BCH, Reed–Solomon, Reed–Muller, Hamming, Simplex, Golay); Decoding Algorithms (Majority Logic, Algebraic, Soft, Hard, GMD); Convolutional Codes and Decoding (Viterbi, Fano, Zigangirov–Jelinek); Generalized Code Concatenation; Coded Modulation
Communications Engineering Seminar (German/English) Master 2S

each semester a current, changing topic from the fields of Communications Engineering, Digital Transmission, Information Theory, Coding Theory, and Signal Processing and its related disciplines is addressed

Communication Systems (English) Master 2L/1E

Mobile Radio Channel; Basics of Mobile Communication Systems; GSM, UMTS, and LTE

Compressed Sensing (English) Master 2L/1E

Geometry of $N$ Dimensions; Geometrical Interpretation of Systems of Linear Equations; Convex Polytopes; Arrangements of Hyperplanes; Approximation Theory; Distance Measures in Banach Spaces; Optimization and Linear Programming; Sampling by Compressed Sensing; Data Acquisition by Compressed Sensing

Dialogue Systems (German) Master 2L/2E

Introduction into the area of multimodal spoken natural language dialogue systems; Focus: Acoustic Processing; Speech Signal Analysis; Speech Recognition; Spoken Natural Language Understanding; Dialogue Processing and Speech Synthesis

Dialogue Systems Project (German/English) Master 4-6S

Multimodal spoken language dialogue systems; component development; practical studies; evaluation

Dialogue Systems Proseminar (German/English) Bachelor 2S

Participants deal with current topics in Spoken Dialogue Systems research

Dialogue Systems Seminar (German/English) Bachelor 2S

Participants deal with current topics in Spoken Dialogue Systems research

Digital Communications (English) Master 4L/2E

Equivalent Complex Baseband; Pulse-Amplitude Modulation (PAM); Variants of PAM Transmission Schemes; Signal-Space Representation; Digital Frequency and Phase Modulation; Channel Models; Equalization of Dispersive Channels; Orthogonal Frequency-Division Multiplexing (OFDM)
Einführung in die Nachrichtentechnik  (German)  Bachelor 3L/2E/2P
(Introduction to Communications Engineering)
History and Milestones of Communications; Models in Communications; Shannon's Uncertainty and Source Coding; Signals for Transmission of Information Channels; Decision Theory; Error Probability; Channel Coding Theorem; Error Correcting Codes; Reliable Data Transmission; Multiple Access; Routing; Security

Embedded Security  (German/English)  Master 3L/1E
Implementation and Side-Channel Attacks in Cryptology; Countermeasures to Implementation Attacks; Arithmetic for Cryptographic Hardware; Random Number Generators; Physical Unclonable Functions; Digital Tachograph System; Secure Software Download for Electronic Control Units in Cars

Iterative Methods for Wireless Communications  (English)  Master 2L/1E
Fix-Point Iteration; Convergence and Convergence Rate of Iterative Methods; Vector-Valued Transmission; (Iterative) Vector Equalization; Probability Theory for Iterative Decoding; Tanner Graph; Low-Density Parity Check Codes; BCJR Algorithm; Turbo Codes; Iterative Joint Demapping, Equalization, and Decoding (Turbo Equalization)

Laboratory Digital Communications  (English)  Master 4P

Mathematik der digitalen Medien  (German)  Bachelor 2L/1E
Navigation (correlation, random sequences); Mobile phone (channel estimation, convolutional codes); MP3 (digital signal processing); CD (error correction); DVD (source coding); Internet (routing, crypto)

Network and Storage Coding  (English)  Master 2L/1E
Decoding of Reed-Solomon codes beyond half the minimum distance using modular minimization, power decoding, list decoding, interleaved RS codes, burst error correction; Rank metric codes, subspace codes and applications to network coding, linearized polynomials, Gabidulin codes, error correction in networks; Coding for flash memories, non-volatilize memories, memory with defects, write-once memories based on cyclic codes; Coding for insertions and
deletions, Varshamov-Tenengolts codes; Coding for distributed data storage, locally repairable codes, regeneration codes

**Research Trends in Dialogue Systems Seminar** (German/English) Master 2S
Participants deal with current topics in Spoken Dialogue Systems research

**Satellite Communications and Navigation** (English) Master 2L/1E
History, Development, and Potential of Satellite Communications; Satellite Orbits; Launch and Installation in Orbit; Modulation and Multiple Access; Satellite Channel; Link Budget Calculations; Mobile Satellite Communication Systems; Satellite Navigation

**Seminar zur Industriepraxis** (German/English) Bachelor/Master 3S
Subject-related knowledge and experience from professional practice; experience the business of a typical workday; carry out typical engineering tasks in research and development, quality control, and technical distribution; gain insight into modern techniques and facilities for development and fabrication of electric, electronic, mechatronic and mechanical devices as well as software and hardware components and systems; learn typical operating procedures and organization in industry, as well as the social structure in companies

**Signal Theory** (English/German) Master 2L/2E
Part I: Stochastic Signals: Random Variables and their Characterization; Principles of Estimation; Stochastic Processes and their Characterization; Mean-Square Estimation and Ergodicity; Part II: Deterministic Signals: Sampling and Interpolation; Principles of Compressed Sensing

**Signale und Systeme** (German) Bachelor 3L/2E/2T/1P
(Signals and Systems)
Discrete Signals and Systems; z-Transformation; Generalized Functions and Distributions; Continuous Signals and Systems; Fourier-Transformation; Sampling Theorem; Fast Fourier Transform; Laplace-Transformation its Application to Continuous LTI Systems; Stochastic Processes
5 Research

5.1 Research Topics

The research carried out at the institute is divided into the subsequent three groups.

Algebraic Coding Theory — Prof. Bossert

Block and convolutional codes for error correction and detection over Hamming, rank, and combinatorial metrics are constructed and analyzed. The main focus is also on the soft- and hard-decision and list decoding of these code classes. Especially soft-decision decoding of Reed-Solomon codes is an important research area. The applications are random linear network coding, storage coding, compressed sensing, interleaved codes, concatenated codes, and hybrid ARQ protocols. Recently, the application of algebraic coding for cryptology was started.

Communication Theory — Prof. Fischer

The members of the Communication Theory group address the challenges of next-generation communications systems. The main focus is on the mathematical and theoretical foundations of communication and signal processing schemes. This includes equalization methods and the utilization of interference in multiantenna and multiuser systems, in particular, in form of precoding. The problems caused by nonlinearities in the transmission channel, both, the peak-power problem (e.g., in OFDM transmission), as well as nonlinear transmission media (e.g., fiber optics) are addressed. Moreover, the structure of signal is exploited, e.g., via compressed sensing methods, and transmission schemes without any channel knowledge are designed. Finally, security aspects, in particular physical-layer security via coded modulation, are treated.

Dialogue Systems — Prof. Minker

The Dialogue Systems Group has placed its general research focus on the development and evaluation of user-friendly Spoken Language Dialogue Systems (SLDS). This objective is based on the following major aspects: adaptive dialogue management, assistiveness as well as evaluation and usability issues.
The Dialogue Systems Group is joint founder of the interdisciplinary Competence Center Perception and Interactive Technologies. Research groups from Ulm University aim at developing innovative technologies in different application domains and settings for the human-computer interaction. Major research areas include sensor-based models for perception, learning mechanisms and adaptivity, interactive systems in networked applications, ubiquitous computing, multimedia and visualization as well as spoken language dialogue systems interaction and multimodality. The center proposes a framework for fundamental and applied research and combines different interdisciplinary issues.
5.2 Research Projects

5.2.1 DFG Projects

During 2018–2019 the following projects were supported by the German Research Council “Deutsche Forschungsgemeinschaft” (DFG).¹

**Komplexwertige Reed-Solomon Codes für deterministisches Compressed Sensing**
- Project Leader: Bossert, Grant: Bo 867/35-1 (SPP Compressed Sensing in der Informationsverarbeitung)
- Duration: 36 months, Begin: June 2015

**Aufwandsgünstige HF-Frontends und incohärente Detektionsverfahren für “Massive MIMO”**
- Project Leader: Fischer, Grant: Fi 982/12-1, cooperation with Prof. Waldschmidt
- Duration: 36 months, Begin: December 2015

**Lipschitz Integers für Codierte Modulation und Vorcodierung**
- Project Leader: Fischer, Grant: Fi 982/13-1, cooperation with Prof. Freudenberger
- Duration: 36 months, Begin: December 2015

**Codierte Modulation, optimierte Decoder und Entzerrer für faseroptische Kanäle**
- Project Leader: Fischer, Grant: Fi 982/14-1, cooperation with Dr. J. Fischer
- Duration: 36 months, Begin: February 2016

**A Companion-Technology for Cognitive Technical Systems**
- Project Leader: Minker, Grant: SFB Transregio 62 T3 Projekt
- Duration: 36 months, Begin: November 2016

**Do it yourself, but not alone: Companion-Technologie für die Heimwerkerunterstützung**
- Project Leader: Minker, Grant: SFB Transregio 62
- Duration: 36 months, Begin: January 2017

¹SPP: “Schwerpunktprogramm” (priority programme); SFB: “Sonderforschungsbereich” (SFB).
DFG SPP 1999 Robust Argumentation Machines (RATIO) Mit Argumenten begeistern, Teilprojekt: Verbesserung der Überzeugungskraft von virtuellen Argumenten
  Project Leader: Minker, Grant: Mi 741/8-1
  Duration: 36 months, Begin: April 2018

Iterative Signal Recovery Algorithms — A Unified View of Turbo and Message-Passing Approaches
  Project Leader: Fischer, Grant: Fi 982/8-1, (SPP Compressed Sensing in der Informationsverarbeitung)
  Duration: 36 months, Begin: March 2019

Multi-Valued Physical Unclonable Functions
  Project Leader: Fischer, Grant: Fi 982/15-1, (cooperation with Prof. Dr.-Ing. Maurit Ortmanns)
  Duration: 36 months, Begin: May 2019

5.2.2 BMBF Projects

During 2018–2019 the following projects were supported by the Federal Ministry of Education and Research (BMBF).

EUREKA-Projekt SENDATE-Secure-DCI (SEcure Networking for a DATa center cloud in Europe — Sichere und flexible Datenzentrums-Interkonnektivität)
  Code- und Lattice-basierte Sicherheitskonzepte auf der physikalischen Schicht und für „post-quantum“-Kryptographie
  Project Leader: Fischer, Grant: 16K/S0483
  Duration: 41 months, Begin: June 2016

Forschungsprogramm zur Mensch-Technik Interaktion des BMBF: Kooperative Interaktion und Zielverhandlung mit lernenden autonomen Robotern (RobotKoop)
  Project Leader: Minker, Grant: 16SV7967
  Duration: 36 months, Begin: June 2018
Deep-Learning-Based Low-Complexity Multi-User Massive MIMO Receivers for Future Wireless Communication Networks

  Project Leader: Fischer, Grant: DAAD-BMBF German University in Cairo: Towards Excellence in Research and Teaching
  Duration: 24 months, Begin: January 2020

5.2.3 EU — Horizon 2020

During 2018–2019 the following projects were supported by the EU (Horizon 2020 programme).

KRISTINA: A Knowledge-Based Information Agent with Social Competence and Human Interaction Capabilities

  Project Leader: Minker, Grant: HORIZON 2020-LEIT-ICT 22 - 2014
  Duration: 36 months, Begin: March 2015

EU-Projekt 2020-MSCA-RISE-2018: Mental Health Monitoring through Interactive Conversations (MENHIR)

  Project Leader: Minker, Grant: EU-RISE: EU-Projekt 2020-MSCA-RISE-2018
  Duration: 48 months, Begin: February 2019

5.2.4 Industry Project

Offline-DSP für OIF 400ZR Konformitätstest

  Project Leader: Fischer, Grant: Frauenhofer Institut für Nachrichtentechnik, Heinrich-Hertz-Institut, Berlin
  Duration: 5 months, Begin: August 2019

MUNGO: Multi-User Indoor Navigation using natural spoken dialog and self-learning Ontologies

  Project Leader: Minker, Grant: Google Faculty Research Award
  Duration: 12 months, Begin: March 2018
The publications are sorted according to the respective professor, which coincides with the research groups.

**Publications by Prof. Bossert’s Group**

**Books and Book Chapters**


**Journal and Conference Papers**


**Publications by Prof. Fischer’s Group**

**Books and Book Chapters**

Journal and Conference Papers


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Publications by Prof. Minker’s Group

Journal and Conference Papers


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Publications by Other Members of the Institute


8 Ph.D. Theses

8.1 Supervised Ph.D. Theses

- Sven Puchinger. *Construction and Decoding of Evaluation Codes in Hamming and Rank Metric*, Institute of Communications Engineering, Ulm University, 2018. Reviewers: Prof. M. Bossert, Prof. T. Høholdt, Technical University of Denmark, Copenhagen, Denmark.


- Anastasiia Spirina. *Automatic Assessment of Interaction Quality in Human-Human Conversations*, Institute of Communications Engineering, Ulm University, 2018. Reviewers: Prof. W. Minker, Prof. A. Karpov, ITMO University, St. Petersburg, Russia.


- Sebastian Patrick Stern. *Advanced Equalization and Coded-Modulation Strategies for Multiple-Input/Multiple-Output Systems*, Institute of Communications Engineering, Ulm University, 2019. Reviewers: Prof. R. Fischer, Prof. C. Ling, Imperial College London, United Kingdom.

- Susanne Sparrer. *Algorithms for (Discrete) Compressed Sensing — A Communi-
8.2 Co-Supervised Ph.D. Theses

  Reviewers: Prof. G. Sigl, Prof. M. Bossert.


  Reviewers: Prof. E. André, Prof. B. Möller, Prof. W. Minker.

  Reviewers: Prof. H. Neumann, Prof. W. Minker.

  Reviewers: Prof. R. Weigel, Prof. R. Münzner, Prof. R. Fischer.

  Reviewers: Dr. Miloš Železný, University of West Bohemia, Pilsen, Czech Republic, Prof. W. Minker.

  Reviewers: Prof. W. Rosenkranz, Prof. R. Fischer.

- Stefan Birgmeier. *Message Passing for Multidimensional Inverse Problems*, TU Vienna, Austria, 2019
  Reviewers: Prof. N. Görtz, Prof. R. Fischer.
8.3 Co-Supervised Habilitations

  Reviewers: Prof. A. Wendemuth, Prof. W. Schuller, University Augsburg, Prof. W. Minker.
9 Theses

9.1 Master Theses


9.2 Bachelor Theses


The following meetings were organized and/or hosted by members of our institute:

- **Leopoldina Meeting**
  February 26, 2018, Ulm University

- **Electronic Speech Signal Processing ESSV 2018**
  March 7–9, 2018, Ulm University

- **ITG-Fachgruppe “Angewandte Informationstheorie”**
  March 21, 2019, Ulm University

- **ITG-Fachausschuss “KT1 Informations- und Systemtheorie”**
  March 22, 2019, Ulm University
The members of the institute are active in various committees and at the university self-administration.

**Prof. Martin Bossert**
- Member of *Leopoldina, Deutsche Akademie der Wissenschaften*
- Member of *ITG-Fachausschuss KT1 Informations- und Systemtheorie*
- Head of *Promotionsausschuss Dr.-Ing.* (until Sept. 2019)
- Ombudsperson of *Ulm University*

**Prof. Robert Fischer**
- *Dean of Studies (Engineering)* of the Faculty of Engineering, Computer Science, and Psychology (until March 2019)
- Member of *Studienkommission “Elektrotechnik”*
- Member of *Promotionsausschuss Dr.-Ing.* (since Sept. 2019)
- Member of *kiz-Ausschuss*
- Member of *Selection Committee for the Argus Award*
- Member of *ITG-Fachausschuss KT1 Informations- und Systemtheorie*

**Prof. Wolfgang Minker**
- *Co-Director of the International Research Laboratory Multimodal Biometric and Speech Systems at ITMO University St. Petersburg, Russia*
- Member of *Admission Board for the Master Course “Informationssystemtechnik”* and the *Admission Board for the International Master Course “Communications Technology”*
- Member of *Habilitationsausschuss* (since Sept. 2019)
Dr. Werner Teich

- Academic Advisor “Elektrotechnik”, “Informationssystemtechnik”, and “Communications Technology”
- Erasmus Incoming Students Advisor
- Member of Studienkommission “Informationssystemtechnik”
- Member of Fachprüfungsausschüsse der ingenieurwissenschaftlichen Studiengänge “Elektrotechnik”, “Communications Technology” and “Sensorsystemtechnik”
- Member of Fachprüfungsausschuss “Informationssystemtechnik”
- Member of Admission Boards for the Master Courses “Elektrotechnik”, “Informationssystemtechnik”, and the International Master Course “Communications Technology”