# Franz Pernkopf

*Curriculum Vitae*

## Contact Information


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## Personal Data

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|---|---|
| Date of birth | 28. April, 1975 |
| Citizenship | Austria |
| Language Skills | German, English |
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## Education

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|---|---|
| 7/2010 | **Habilitation**, *Venia Docendi for Intelligent Systems*, Graz University of Technology, Austria, Thesis: Graphical Models: Discriminative Learning, Inference, and Applications. |
| 10/1999–3/2002 | **Ph.D. (Dr. mont.)**, University of Leoben, Institute for Automation, Austria, Thesis: Automatic Visual Inspection of Metallic Surfaces, with distinction. |
| 10/1994–6/1999 | **MSc (Dipl.-Ing.**, *Electrical Engineering/Biomedical Engineering*, Graz University of Technology, Austria and University of Edinburgh, Scotland (UK), Thesis: Control Software for a 64 by 64 pixel Spatial Light Modulator. |
| 9/1989–6/1994 | **Technical College**, *Electrical Engineering*, HTBLA Steyr, Austria, with distinction. |

## Professional Experience

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|---|---|
| 1/2011 – present | Associate Professor at the Institute of Signal Processing and Speech Communication, Head of the Intelligent Systems Group, Graz University of Technology, Austria. |
| 06/2010 – 12/2010 | Senior Research Scientist at the Institute of Signal Processing and Speech Communication, Graz University of Technology, Austria. |
| 09/2005 – 01/2006 | Research Associate (Erwin Schrödinger fellow) at the University of Washington, Department of Electrical Engineering, Seattle, USA. |

09/2004 – 05/2010 University Assistant (Assistant Professor level) at the Institute of Signal Processing and Speech Communication, Graz University of Technology, Austria.

12/2003 – 8/2004 Research Associate (Erwin Schrödinger fellow) at the University of Washington, Department of Electrical Engineering, Seattle, USA.

09/2003 – 11/2003 Research Associate (Erwin Schrödinger fellow) at the Oakland University, Department of Computer Science and Engineering, Rochester, USA.

11/2002 – 08/2003 University Assistant (Assistant Professor level) at the Institute of Signal Processing and Speech Communication, Graz University of Technology, Austria.

06/2001 – 10/2002 University Assistant at the Institute for Automation, University of Leoben, Austria.

10/1999 – 05/2001 Research Assistant at the Institute for Automation, University of Leoben, Austria.

## Professional Interests

Machine Learning and Statistical Pattern Recognition; Statistical Data Processing and Modeling; Feature Selection, Graphical Models (Bayesian Networks, Discriminative Parameter and Structure Learning, Belief Propagation); Deep Learning, Bayesian Deep Neural Networks, Particle Filters for Tracking; Data Clustering (Unsupervised Learning and Finite Mixture Models); Intelligent Systems; Medical and Speech Processing Applications.

## Teaching

2011 – 2018 Computational Intelligence (lecture course).

2011 – 2015 Einführung in die Wissensverarbeitung (lecture course).

2003 – 2018 Speech Communication II (lecture course).

2008 – 2018 Verfassen wissenschaftlicher Arbeiten (seminar).

2005 – 2018 Advanced Signal Processing Seminar. The following topics have been treated over the years:

- Resource-efficient Neural Networks (WS 2017/2018)
- Signal Processing for Assisted Living (WS 2016/2017)
- Acoustic Event Detection, Classification, and Keyword spotting (WS 2015/2016)
- Deep Models and Learning (WS 2014/2015)
- Speech Information Processing (WS 2013/2014)
- Fundamental Technologies in Modern Speech Recognition (SS 2013)
- Signal Processing in Geophysical Problems (WS 2012/2013)
- Probabilistic Models of Cognition (SS 2012)
- Convex Optimization for Signal Processing (WS 2011/2012)
- Graphical Models for Signal Processing (SS 2011)
- Iterative Decoding Methods and Applications (WS 2010/2011)
- Kernel Methods (WS 2009/2010)
- Distributed Signal Processing in Sensor Networks and Applications (WS 2008/2009)
- Biometrics (WS 2007/2008)
- Statistical Machine Translation (WS 2006/2007)
- Graphical Models (SS 2005)

2003 – 2018 Speech Communication Laboratory.

2003 – 2009 Computational Intelligence (problem class).

2005 – 2009 Einführung in die Wissensverarbeitung (problem class).

2004 – 2017 Digital Signal Processing Laboratory.

2001, 2002 Autonomous Robot Seminar.

2001, 2002 Automatic Surface Inspection (lecture course).

## Research Projects

01/2018 – 06/2019 **Artificial Intelligence in Motion Laboratoy (aiMotionLab)**, *Funding institution: Land Steiermark, Total: 390000 €, SPSC: 334000 €*, Involvement: joint project with FH Joanneum (project leader) and University of Leoben.

1/2018 – 12/2020 **Smart Accelerated Hardware for Radar Sensors enabling Autonmous Driving**, *Funding institution: FFG, Total: 518.396 €, SPSC: 259.131 €*, Involvement: Project leader (joint project with Infineon Technolgogies Austria AG, Magna Steyr Engineering AG & CoKG).

1/2018 – 12/2019 **Automatic and Reliable Classification of Highly Inline Measured Wafer Edge Defects using Embedded Screeners (ARCHIMEDES)**, *Funding institution: FFG, Total: 689.256 €, SPSC: 147.000 €*, Involvement: (joint project with Bright Red Systems GmbH (project leader).

01/2017 – 06/2019 **PipeSense**, *Funding institution: Industry, Total: 300000 €, SPSC: 125000 €*, Involvement: Project Leader - Institute of Engineering Geodesy and Measurement Systems, Graz University of Technology, Partners: (joint project with Graz University of Technology, Institute of Engineering Geodesy and Measurement Systems, Österreichische Vereinigung für Gas- und Wasserfach, Energienetze Steiermark GmbH, Linz Gas Netz GmbH, Netz Burgenland Erdgas GmbH, Netz Niederösterreich GmbH, Netz Oberösterreich GmbH, Salzburg Netz GmbH.

07/2016 – 09/2016 **Anschubfinanzierung**, *Funding institution: TU Graz, 7000 €*.

01/2015 – 12/2018 **Multichannel Acoustic Event Classification and Recognition for Low-resource Platforms**, *Funding institution: Industry, 150000 €*, Involvement: Project Leader, Partner: Ognios GmbH, Salzburg, Austria.

10/2016 – 09/2019 **Resource-Efficient Deep Models for Embedded Systems**, *Funding institution: Austrian Science Fund (FWF), Total: 380000 €, SPSC: 215000 €, I2706-N31*, Involvement: Project leader (joint project with University of Heidelberg, H. Fröning).

01/2016 – 12/2019 **Dependable Internet of Things in Adverse Environments, Subproject: Dependable Composition**, *Funding institution: LEAD Project (excellence programm at TU Graz), 150000 €*.

07/2015 – 06/2018 **Learning of Bayesian Network Classifiers and Sum-Product Networks**, *Funding institution: Austrian Science Fund (FWF), 260000 €, P27803-N15*, Involvement: Project leader.

03/2015 – 07/2015 **Anschubfinanzierung**, *Funding institution: TU Graz, 7300 €*.

03/2015 – 02/2017 **Brain, Ears & Eyes - Pattern Recognition Intiative**, *Funding institution: BioTechMed Graz, 120000 €*, Involvement: Project leader at TU Graz (joint project with Medical University Graz, P. Marschik).

05/2014 – 07/2016 **Computerunterstützte akustische Diagnostik thorakaler Erkrankungen**, *Funding institution: Land Steiermark, Total: 159000 €, SPSC: 100000 €*, Involvement: Project leader (joint project with Medical University Graz, F.-M. Smolle-Juettner).

02/2013 – 08/2016 **Probabilistic Graphical Models For Time-Series Signal Mixtures**, *Funding institution: Austrian Science Fund (FWF), 443000€, P25244-N15*, Involvement: Project leader.

06/2011 – 12/2014 **National Research Network: Signal and Information Processing in Science and Engineering - Part II, Subproject: Nonlinear Dynamics and Machine Learning**, *Funding institution: Austrian Science Fund (FWF), 328000€, S10610-N13*, Involvement: Project leader.

06/2011 – 01/2014 **Discriminative Learning of Graphical Models with Application to Speech and Image Processing**, *Funding institution: Austrian Science Fund (FWF), 302000€, P22488-N23*, Involvement: Project leader.

06/2008 – 05/2011 **National Research Network: Signal and Information Processing in Science and Engineering - Part I, Subproject: Nonlinear Dynamics and Machine Learning**, *Funding institution: Austrian Science Fund (FWF), 270000€, S10604-N13*, Involvement: Deputy project leader, scientific consultant.

10/2007 – 09/2010 **Discriminative Learning of Bayesian Network Classifiers**, *Funding institution: Austrian Science Fund (FWF), 104000€, P19737-N15*, Involvement: Project leader.

09/2005 – 01/2006, 12/2003 – 08/2004, 09/2003 – 11/2003 **Shape Description and Classification using Probabilistic Graphical Models**, *Funding institution: Austrian Science Fund (FWF), 50000USD, J2243-N04, Schrödinger Fellowship*, Involvement: Project leader, Partners: University of Washington, Department of Electrical Engineering, Seattle, USA; Oakland University, Department of Computer Science and Engineering, Rochester, USA.

03/2001 – 10/2002 **Detection of Surface Defects on Raw Milled Steel Blocks using Range Imaging**, *Funding institution: Industry*, Involvement: Responsible project collaborator, Partner: Voest Donawitz Stahl, Leoben, Austria.

11/1999 – 12/2000 **Automatic Inspection System for Detection and Classification of Flaws on Turned Parts**, *Funding institution: Industry*, Involvement: Responsible project collaborator, Partner: Mec.Com, Austria.

## Reviewing Activities

Journals IEEE Transactions on Pattern Analysis and Machine Intelligence, JMLR, IEEE Transactions on Audio, Speech, and Language Processing, JASA, IEEE Transactions on Signal Processing, Machine Learning, Pattern Recognition Letters, IEEE Transactions on Data Mining and Knowledge Engineering, Data Mining and Knowledge Discovery, Artificial Intelligence in Medicine, Machine Vision and Applications, International Journal of Approximate Reasoning, IEEE Signal Processing Letters, IEEE Transactions on Medical Imaging, Artificial Intelligence Review, International Journal of Pattern Recognition and Artificial Intelligence.

Conferences ICASSP-2018, ICASSP-2017, Interspeech-2017, NIPS-2016, MLSP-2016, Interspeech-2016, ICASSP-2016, Interspeech-2015, ICASSP-2015, ICML-2014, ICASSP-2014, ICASSP-2013, ICML-2013, Interspeech-2013, EUSIPCO-2014, EUSIPCO-2010; EUSIPCO-2012; EUSIPCO-2013; ITG-Fachtagung-2012, International Symposium on Chinese Spoken Language Processing (ISCSLP 2012)

Funding Institutions ERC, Czech Science Foundation, Serbia Innovation Project (2011 - 2018)

## Professional Activities and Memberships

5/2018 Invited Talk, University of Passau, Germany.

2017 – Advisory Board of Swiss Innovation Valley AG.

10/2017 Invited Talk, Graz University of Technology, Austria.

10/2017 Invited Talk, University of Heidelberg, Germany.

2017 Session Chair at the Interspeech 2017, Stockholm, Sweden.

6/2017 Invited Talk, University of Innsbruck, Austria.

2017 Habilitation Committee of Pejman Mowlaee Beikzadehmahaleh, Graz University of Technology.

6/2016 Talk, "Efficient Probabilistic Models for Cochlea Implants", Med-El, Innsbruck.

2016 Substitute member of the works council for academic personnel, Graz University of Technology.

2016 Program Committee for the IEEE Workshop on Machine Learning for Signal Processing (MLSP).

2016 Scientific Committee of 4$^{th}$ CHiME Workshop.

2016 Organizing Committee of Interspeech 2019 in Graz.

1/2015 Invited Talk, "Efficient Probabilistic Models: Learning and Reduced-Precision Analysis", Technical University Munich, Germany.

2015 Scientific Committee of Interspeech.

2014 Signal Processing Theory and Methods (SPTM) Technical Committee of the IEEE Signal Processing Society.

2014 Senior Member of the IEEE.

2013 Coordination Team of the Doctoral School *Information and Communications Engineering* at Graz University of Technology.

2013 Session Chair at the European Conference on Machine Learning (ECML 2013), Prague, Czech Republic.

Invited Tutorial, "Probabilistic Graphical Models", Academic Press Library in Signal Processing, Vol. 1, Ch. 18, pp. 989-1064, 2014.

2008, 2012 Program Committee for the International Conference on Signal and Image Processing (SIP).

06/2011 Invited Talk, "Discriminative Learning of Bayesian Networks and Applications", Machine Learning Technical Meeting, Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), Vienna.

Editorial Board of ISRN Artificial Intelligence.

04/2011 Invited Talk, "Discriminative Learning of Bayesian Network Classifiers", University of Bonn, Bonn.

10/2010 Invited Talk, "Discriminative Learning of Bayesian Network Classifiers", Austrian Research Institute for Artificial Intelligence, Vienna.

10/2009 Invited Talk, "Machine Learning for Speech Processing", ITG Fachgruppe, Graz.

2008 Session Chair at the International Conference on Computer Vision and Computer Graphics Theory and Applications (VISIGRAPP 2008), Madeira, Portugal.

2/2007 Invited Tutorial, "Discriminative learning of Bayesian networks for classification", Tutorial on Pattern Recognition, FTW Forschungszentrum Telekommunikation Wien GmbH, Vienna.

## Awards and Scholarships

2016 Finalist of best student paper, *DNN-based Speech Mask Estimation for Eigenvector Beamforming*, ICASSP, 2016.

2016 Finalist of best student paper, *A Robust Multichannel Lung Sound Recording Device*, BIODEVICES, 2016.

2012 Kardinal-Innitzer-Förderungspreis (Kardinal-Innitzer Young Investigator Award), Vienna, Austria.

2010 Young Investigator Award of the Province Styria (Förderungspreis des Landes Steiermark), Graz, Austria.

2010 Finalist of best student paper, *A Factorial Sparse Coder Model for Single Channel Source Separation*, Interspeech, 2010.

2003 Fahrzeugverband-Jubiläumsstiftung Forschungspreis (Fachverband der Fahrzeugindustrie), Wien, Österreich.

2002 Erwin Schrödinger Fellowship, Vienna, Austria.

2002 Erwin-Wenzel-Preis, Linz, Austria.

2002 Fred-Margulies Preis, Vienna, Austria.

## Cooperation Partners (Selected)

- Pedro Domingos,Jeff Bilmes, University of Washington, USA.
- Holger Fröning, University of Heidelberg, Germany.
- Sebastian Tschiatschek, Microsoft Research Cambridge, UK.
- Robert Peharz, University of Cambridge, UK.
- Peter Marschik, Freyja-Maria Smolle-Jüttner, Horst Olschewski, Medical University Graz, Austria.

## Soft Skills

2017 Nichts Neues ohne Innovation, Graz University of Technology, Austria.

2017 Psychologische Ansätze zur Personalführung, Graz University of Technology, Austria.

2015 - 2016 Advanced Leadership Program, Graz University of Technology, Austria.
- Hochschuldidaktik für Führungskräfte
- Erfolgreich führen und kommunizieren mit Konzepten der Transaktionsanalyse
- Führungskompetenz kompakt
- Sich und andere verändern
- Strategieentwickung für Führungskräfte
- Arbeitsrecht für Führungskräfte
- Wie wir uns unsere Probleme selber machen

2015 Management von Forschungsprojekten, Graz University of Technology, Austria.

2014 Forschungsprojekt- und Programmmanagement für Projektauftraggeber/innen, Graz University of Technology, Austria.

2010 – 2011 Management Development Program at Graz University of Technology, Austria.

2011 Leading Technical Teams, Graz University of Technology, Austria.

2011 Didaktik 2: Durchführen von Lehrveranstaltungen im akademischen Bildungsbereich, Graz University of Technology, Austria.

2010 Erfolgreich in die Öffentlichkeit: Dos and Don'ts für den Umgang mit Medien, Graz University of Technology, Austria.

2010 Didaktik 1: Grundlage des Lehrens und Lernens im akademischen Bildungsbereich, Graz University of Technology, Austria.

2009 Führen, Delegieren, Motivieren, Graz University of Technology, Austria.

## Supervised PhD Students

2010 Stefan Petrik, Phonetic Similarity Matching of Non-Literal Transcripts in Automatic Speech Recognition.

2010 Michael Stark, Source-Filter Model Based Single Channel Speech Separation.

2012 Michael Wohlmayr, Probabilistic Model-Based Multiple Pitch Tracking of Speech.

2013 Christina Leitner, Speech Enhancement using Kernel PCA.

2014 Sebastian Tschiatschek, Maximum Margin Bayesian Networks: Asymptotic Consistency, Hybrid Learning, and Reduced-Precision Analysis.

2014 Dietmar Schabus, Audio-visual Speech Synthesis Based on Hidden Markov Models, external PhD Candidate at FTW Forschungszentrum Telekommunikation Wien GmbH, Vienna.

2015 Robert Peharz, Foundations of Sum-Product Networks for Probabilistic Modeling.

running Matthias Zöhrer, Deep Learning in Speech Processing (Expected Graduation: 2018).

running Martin Ratajczak, Neural Higher-Order Conditinal Random Fields in Speech Processing (Expected Graduation: 2018).

running Christian Knoll, Fixed Point Analysis of Belief Propagation (Expected Graduation: 2019).

running Elmar Messner, Computational Lung Sound Analysis (Expected Graduation: 2018).

running Lukas Pfeifenberger, Multichannel Acoustic Event Classification and Recognition for Low-resource Platforms (Expected Graduation: 2019), external PhD Candidate funded from Ognios (industry partner), Salzburg.

running Wolfgang Roth, Bayesian Deep Neural Networks (Expected Graduation: 2019).

running Martin Trapp, Bayesian Non-Parametric Models and Sum-Product Networks (Expected Graduation: 2019), external PhD Candidate at Austrian Research Institute for Artificial Intelligence (OFAI), Vienna.

running Kimtruc Nguyen, Acoustic Scene Classification and Event Detection (Expected Graduation: 2019).

## Supervised Master Students

2007 Christoph Böhm, Unsupervised Speaker Segmentation in One-Channel Speech Data.

2007 Christian Wallinger, A Flexible Sender-Based Packet Loss Recovery Method.

2008 Christoph Schmauder, Schwingungsanalyse für Störstoffdetektion und Schnittspalteinstellung einer Müllzerkleinerungsmaschine, joint project with Komptech.

2008 Michael Wiesenegger, Wavelet-Based Speaker Change Detection in Single Channel Speech Data.

2010 Robert Peharz, Single Channel Source Separation using Dictionary Design Methods for Sparse Coder.

2012 Gregor Pirker, A Speech Database for Pitch Determination.

2012 Christoph Klug, RTBlocks: A Cross-Platform Algorithm Design Framework for Real-Time Audio Processing on Android.

2013 Nikolaus Mutsam, Maximum Margin Hidden Markov Models.

2013 Klaus Dobbler, Vibroakustisches Monitoring in Smart Homes.

2013 Florian Pokorny, Detection of Negative Emotions in Speech Signals Using Bags-of-Audio-Words.

2013 Lukas Pfeifenberger, Evaluation, Simulation and Implementation of a Multi-Channel Speech Enhancement System.

2013 Andreas Zehetner, Keyword Spotting for Emergency.

2014 C.E. Cancione Chacón, On Belief Propagation and Higher Order Power Methods.

2014 Erwin Nindl, Traffic Flow Reconstruction on Motorways by Data Fusion.

2014 Georg Kapeller, Speech Enhancement with Sum-Product Networks.

2015 Michael Rath, Message Scheduling in Loopy Belief Propagation.

2015 Wolfgang Roth, Hybrid Generative-Discriminative Training of GMMs.

2015 Christopher Walles, Segmental Conditional Random Fields for Phone Recognition.

2016 Johannes S. Innerbichler, Cloud Storage Performance Analysis.

2016 Markus Feuerstein, Refractory Wear Modelling Using Statistical Methods.

2016 Michael Peitler, Acoustic Event Detection of General Sounds.

2017 Fridtjof Sterna, Real-time Automatic Recognition of Spoken Digits on an Embedded System using Deep Recurrent Neural Networks.

2018 Christoph Aigner, Specification of a Systems Engineering Tool using Machine Learning.

# References

Prof. Dr. Gernot Kubin
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Prof. Dr. Mario Kupnik
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Department of Electrical Engineering and Information Technology
Technische Universität Darmstadt
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Prof. Dr. Jeff A. Bilmes
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## Research Statement

In data science and machine learning, where the amount of available data has increased dramatically over the recent past, intelligent systems modeling complex dependencies are in desperate need for commercial applications. We are at the beginning of a decades-long trend toward data-intensive, evidence-based decision making across many aspects of science and commerce. Steadily increasing data impose new demands such as computationally tractable algorithms, personal data raise the need for algorithms protecting privacy issues, and huge amounts of unlabeled data require learning methods to take advantage of it.

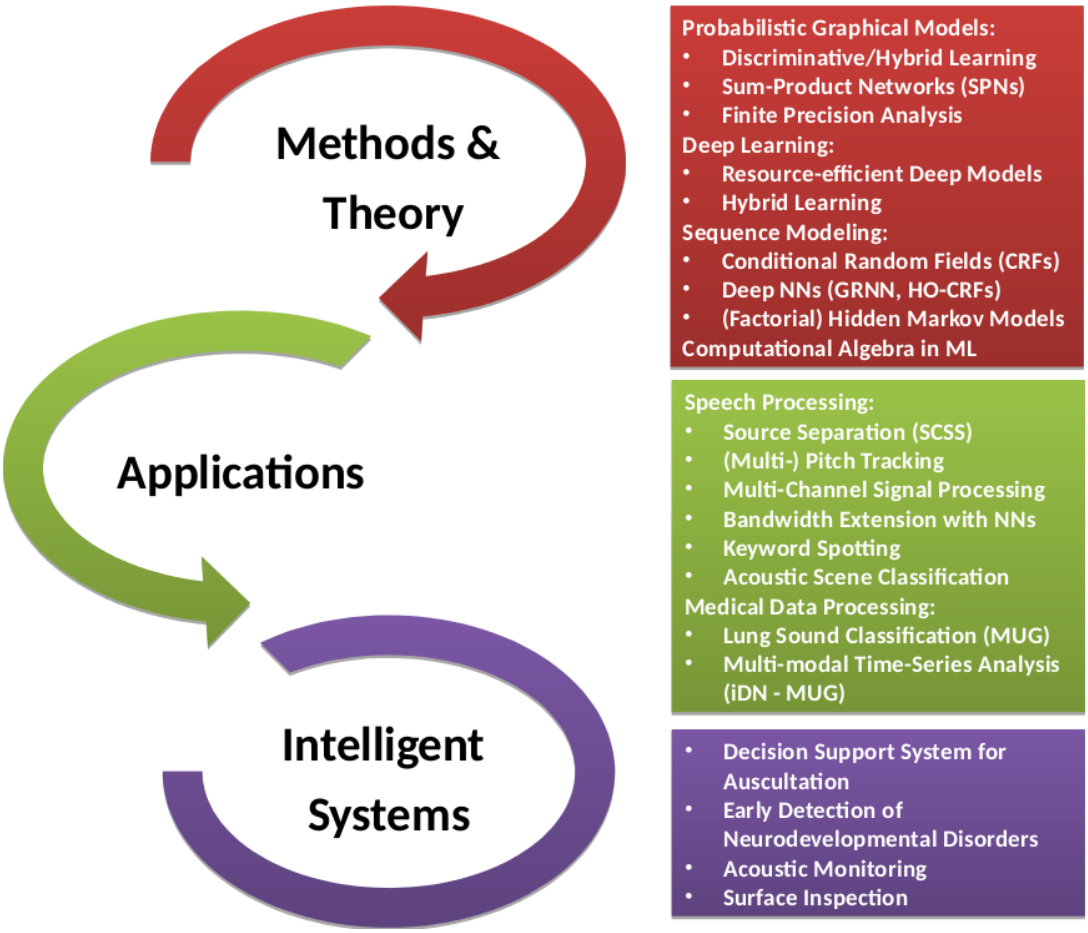


Figure 1: Scope of Research.

My research is focused on pattern recognition, machine learning, and computational data analytics with application in various fields ranging from signal and speech processing to medical data analysis and other data modeling problems from industrial applications. My aim is to bridge the gap between basic research, applications and intelligent systems as shown in Figure 1. There is a mutual benefit, i.e. real-world problems are inspiring the development of basic methods and vice versa. The methods of my current research directions are listed in this figure. At the methods and theory side I am particularly interested in probabilistic graphical models for reasoning under uncertainty, discriminative and hybrid learning paradigms, deep learning, and sequence modeling. Graphical models unite probability and graph theory and allow to efficiently formalize both static and dynamic, as well as linear and nonlinear systems and processes.

They provide an approach to deal with two inherent problems throughout applied mathematics and engineering, namely, uncertainty and complexity. In particular, I am interested in how we can specify and learn probabilistic models that can capture higher-order relations among multiple random variables, how we can efficiently reason in such models without an exponential increase in complexity, and how to deal with the computational challenges of inference. My recent interest in deep learning is nourished by the remarkable performance boost in many image, signal and speech processing problems. This is particularly true when having big amounts of data and almost unlimited computing resources available. Here, I am particularly interested in (i) scale-able semi-supervised learning to exploit huge amounts of unlabeled data during learning and in (ii) resource-efficient deep learning for constraint computing infrastructure of real-world applications.
We have successfully published research papers in major machine learning conferences and journals (TPAMI, ICML, AISTATS, NIPS, JMLR, ECML, AAAI, Pattern Recognition), as well as application oriented journals and conferences for speech processing (TASLP, Speech Communication, ICASSP, Interspeech, ASRU). More details about my research highlights are summarized in the Section *Key Publications* below.

## Industrial Research Collaborations

In addition to purely academic research I successfully established industrial collaborations to unleash the potential of data science and pattern recognition in *real-world cyber-physical* systems. One collaboration is with the refractory wear producer RHI Magnesita. The aim is *predictive maintenance and condition monitoring* of an electro arc furnace (EAF) or a basic oxygen furnace (BOF) at a steel plant. In particular, we model the interaction between residual lining thickness, production parameters and maintenance data for refractory wear. At the long term a fully automatic maintenance assistant should be developed. The company Ognios is currently funding a PhD student in the area of resource-efficient deep learning with application to multi-channel speech enhancement. The collaboration with Siemens AG is about data analysis and pattern recognition of rail vehicle data. This also includes to optimize the measurement setup and data hosting in the cloud. The aim is to predict the remaining useful life of the components of a rail-bound traveling mechanism. The project with Borealis is concerned with non-invasive particle detection and recognition at the loop reactor of the production plant. Therefore, a measurement hardware has been developed. In a recent project with Infineon Technologies, we are developing a resource-efficient data processing approach for radar sensors to detect obstacles. This sensor is used in the automotive industry.

## Prospective Research

Despite its practical and commercial success, there are many under-explored research opportunities. Ultimately, the question is how to construct systems that automatically improve through experience. My long-term goal is to continue to contribute to the knowledge of modeling, learning and reasoning of complex highly-dependable large-scale data. The insights enable new and improved services for science and society including health care, manufacturing, education amongst many other fields. In my future research I aim to address the questions: How can we build sufficiently structured models and systems allowing for tractable reasoning, trading-off running time, computational requirements and prediction accuracy? How can we build self-adaptive tractable systems by making use of complex heterogeneous large-scale data? How can we make systems amenable for end-to-end learning. In order to make progress on these long-term goals and to tackle these challenges, we need to identify intermediate steps and directions along the way, some of which I outline in the following:

1. Probabilistic graphical models for reasoning under uncertainty: Many well-known statistical models, e.g., (dynamic) Bayesian networks, mixture models, factor analysis, hidden Markov models, Kalman Filters, Boltzmann machines, the Ising model, et cetera, can be represented by graphical models. The framework of graphical models provides techniques for inference (sum/max-product algorithm also known as belief propagation) and learning. Discriminative learning of Bayesian networks for classification

tasks is often beneficial compared to generative learning. This is particularly true in case of model mismatch, i.e. the classifier model can not represent the true data distribution. We developed maximum margin parameter learning for probabilistic graphical models. Furthermore, we used the margin objective for structure learning. The research perspective for the next years is as follows:
   - We aim to exploit homotopy methods to gain insights in the fixed points of loopy belief propagation.
   - We aim at extending our discriminative learning framework to semi-supervised, missing features, and latent variable scenarios. This requires efficient inference during iterative parameter optimization.
2. Hardware-aware machine learning: Most commonly deep models are using GPUs to enable efficient processing, where single precision floating-point numbers are common for parameter representation and arithmetic operations. To facilitate deep models in everyday intelligent systems, the model usually has to be scaled down to be implemented efficiently on embedded or low power systems. One direction is to reduce the number of model parameters using sparsity constraints or by parameter sharing determined by Dirichlet processes. In addition to sparse weight matrices, I aim to perform finite-precision analysis of the parameters and arithmetic operations in deep models. Recently, we analyzed reduced precision implementations of directed probabilistic graphical models. Motivated by the convincing performance of deep models, I am interested for using them in intelligent systems emerging virtually everywhere. Long-term goal is to enable resource-efficient implementation of deep models for pattern recognition.
3. Sequential modeling: The aim is to develop models for sequence modeling beyond traditional hidden Markov models or linear-chain conditional random fields (CRFs). Deep observation models with multiple layers significantly improve the performance in CRFs. Currently, these models often consider only a single output label. We suggest to use higher-order factors for modeling these observations in CRFs to improve performances on sequence labeling tasks. These factors model both sub-sequences of input and output labels. In particular, deep models are investigated for these factors. Unfortunately, these higher-order factors are prone to overfitting and appropriate regularization techniques are required. This problem can be addressed by techniques such as (virtual) adversarial training. Furthermore, we aim to extend sequential deep models to benefit from additional unlabeled data in a semi-supervised fashion.
4. Another interesting research question is to develop pattern recognition models which are predictable, i.e. a guaranteed bounded response is obtained subjective to several constraints such as time or complexity. Currently, the attention is mostly narrowed down to prediction performance. Here, the focus is different. A *predictable* model behavior under external constraints is the driving factor. One option is to introduce ordering property for representing the information, i.e. harsh and detailed information is represented by distinct parts in the model. This allows for scalable models.
5. Medical data processing: In cooperation with the Medical University Graz we are developing a decision support system for lung sound analysis. The optimal system for recording a lung sound database has been developed. We aim to develop and implement signal enhancement and machine learning algorithms for accurate lung sound classification and probabilistic decision support. One of the major challenges is the handling of the variability in the bio-signals and the suppression of noise and heart signals.
   Furthermore, we established the Brain, Ears & Eyes – Pattern Recognition Initiative (BEE–PRI) funded by BioTechMed-Graz (www.biotechmedgraz.at) by strengthening and extending the collaboration with the Research Unit Interdisciplinary Developmental Neuroscience (iDN) at Medical University Graz (www.physiologie.medunigraz.at/research/idn/). Our common goal is an earlier detection of neurodevelopmental and neurodegenerative disorders by means of pattern recognition and statistical analysis tools using multi-modal time-series data.

I believe that these directions pose great opportunities for excellent research. The obtained models and algorithms will have real-world impact with benefits to our society. In summary, I see a strong connection with the main research directions of the University.

# Teaching Statement

Teaching is not only about passing on knowledge to students - it is rather about getting the students enthusiastic about a subject and to raise their curiosity and interest. This is crucial for releasing their potential and to pave the way for fruitful continuations in research projects and theses. Teaching is also about motivating and inspiring students, helping them to foster their interests and to ask critical questions considering the existing knowledge. Ultimately, students should become independent in the area of the subject by providing the right tools for answering their own questions.

## Experience as a lecturer

My experience as lecturer ranges from classical lectures such as *Computational Intelligence* or *Speech Communication*, to seminars and practical laboratories and problem classes for Master and Bachelor students. In *Computational Intelligence* I have about 250 students while in *Speech Communication* only 20 students are registered. *Computational Intelligence* focuses on classical areas from data science, machine learning and artificial intelligence such as decision making under uncertainty involving various topics like parameter estimation, statistics, algorithms, supervised/unsupervised learning, probabilistic reasoning, and a gentle introduction into probabilistic graphical models. In *Speech Communication* the focus is on automatic speech recognition and sequence modeling techniques. Furthermore, the production of speech and its representation are discussed and approaches for language modeling are presented. Both classes are complemented by practical problem classes and laboratories, respectively. In the *Advanced Signal Processing seminar* we review recent advances in the scientific community. We discuss important papers and scientific publications.

## Experience as a supervisor

During the course of my appointment at Graz University of Technology, I was able to supervise several Bachelor, Master and PhD students. This is in particular very exciting, as it enables to help the students to select and work on interesting and challenging projects and problems. For most of my supervised students, I got the impression that they really enjoyed working on the selected projects and developed a deeper understanding of the covered topics. Especially, supervision of PhD students is very interesting since this long-term collaboration is very beneficial for both the student and me as supervisor. It is always a nice experience to observe how the student become more and more independent and experienced during the course of the PhD project.

## Teaching philosophy

Currently my lectures are complemented by practical problem classes, seminars, and projects. It is important to provide a solid basis of the methods which are further consolidated in projects, reading groups, and problem classes. This is well-known as *active learning* where students engage in activities, such as writing, discussion, or problem solving that promote application of the content of the class. Furthermore, *collaborative* and *cooperative* learning and discussion among students in small groups is an important ingredient. I consider a healthy mix between individual and group-based learning as appropriate. I usually derive methods on the blackboard to communicate the underlying concepts and methods. To avoid dry lectures, it is important to connect the lecture material to practical applications so that the *real-world* implications become obvious. This also fosters the motivation of students.

## Teaching interests

My teaching experience spans areas such as computational intelligence, statistical pattern recognition, graphical models and application areas such as speech processing . This correlates well with my research interests which is important for recruiting motivated students for projects, Master and PhD theses.
On the undergraduate level, I would like to teach introductory courses in *Computational Intelligence* and *Pattern Recognition*. On the graduate level I would be keen to teach an advanced class on *Machine Learning* and *Probabilistic Graphical Models*, giving students insights into powerful methods for reasoning under uncertainty and deep learning. Furthermore, pattern recognition for sequential data or for selected

applications such as speech recognition are interesting lecture topics. Furthermore, I aim to complement these classes with problem classes and projects using existing toolkits (e.g. libDAI, TensorFlow, Theano). In addition to learning about various computational data analytics methods, the students acquire project management experience, communication and presentation skills which will be helpful in developing their careers in future. In all taught courses I would make use of modern presentation technologies and provide students with lecture material, additional exercises to deepen their understanding and motivate students to actively interact in the courses.

## Key Publications

Most of my research relates to the area of machine learning, statistical modeling, and artificial intelligence. In particular, the focus is on developing innovative methods and techniques for extraction of information and modeling of data including the empirical verification of the methods. In the sequel, some key publications (ordered by year) including a short summary are listed.

1. C.Knoll, D. Mehta, T.Chen, F. Pernkopf, *"Fixed Points of Belief Propagation - An Analysis via Polynomial Homotopy Continuation"*, IEEE Transactions on Pattern Analysis and Machine Intelligence, accepted, pp. –, 2017.

   Belief propagation (BP) is an iterative method to perform approximate inference on arbitrary graphical models. Whether BP converges and if the solution is a unique fixed point depends on both the structure and the parametrization of the model. To understand this dependence it is interesting to find all fixed points. In this work, we formulate a set of polynomial equations, the solutions of which correspond to BP fixed points. To solve such a nonlinear system we present the numerical polynomial-homotopy-continuation (NPHC) method. Experiments on binary Ising models and on error-correcting codes show how our method is capable of obtaining all BP fixed points. On Ising models with fixed parameters we show how the structure influences both the number of fixed points and the convergence properties. We further asses the accuracy of the marginals and weighted combinations thereof. Weighting marginals with their respective partition function increases the accuracy in all experiments. Contrary to the conjecture that uniqueness of BP fixed points implies convergence, we find graphs for which BP fails to converge, even though a unique fixed point exists. Moreover, we show that this fixed point gives a good approximation, and the NPHC method is able to obtain this fixed point.

2. R. Peharz, R. Gens, F. Pernkopf, P. Domingos, *"On the Latent Variable Interpretation in Sum-Product Networks"*, IEEE Transactions on Pattern Analysis and Machine Intelligence, accepted, pp. –, 2017.

   One of the central themes in Sum-Product networks (SPNs) is the interpretation of sum nodes as marginalized latent variables (LVs). This interpretation allows the application of the EM algorithm and to efficiently perform MPE inference. In literature, the LV interpretation was justified by explicitly introducing the indicator variables corresponding to the LVs' states. However, as pointed out in this paper, this approach is in conflict with the completeness condition in SPNs and does not fully specify the probabilistic model. We propose a remedy for this problem by modifying the original approach for introducing the LVs, which we call SPN augmentation. We discuss conditional independencies in augmented SPNs, formally establish the probabilistic interpretation of the sum-weights and give an interpretation of augmented SPNs as Bayesian networks. Based on these results, we find a sound derivation of the EM algorithm for SPNs, which was presented mistaken in literature. Furthermore, the Viterbi-style algorithm for MPE proposed in literature was never proven to be correct. We show that this is indeed a correct algorithm, when applied to selective SPNs, and in particular when applied to augmented SPNs.

3. S. Tschiatschek and F. Pernkopf, *"On Bayesian Network Classifiers with Reduced Precision Parameters"*, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 37, No. 4, pp. 774–785, 2015.

   For Bayesian network classifiers (BNCs) we performed reduced-precision analysis and published several papers. In this paper, we present novel theoretical results and extended empirical results for BNCs with finite precision fixed-point parameters. All our results are based on the assumption that parameters are learned in full-precision and rounded to the desired precision for classification. We derive three types of bounds on the classification performance after parameter precision reduction and compare these in experiments. Additionally, we empirically compare the classification performance and robustness of BNCs with respect to precision reduction for different learning paradigms.

4. M. Zöhrer, R. Peharz, and F. Pernkopf, *"Representation Learning for Single-Channel Source Separation and Bandwidth Extension"*, IEEE Transactions on Audio, Speech, and Language Processing, Vol. 23, No. 12 pp. 2398–2409, 2015.

   In this paper, we use deep representation learning for model-based single-channel source separation (SCSS) and artificial bandwidth extension (ABE). Both tasks are ill-posed and source-specific prior knowledge is required. In addition to well-known generative models such as restricted Boltzmann machines and higher order contractive autoencoders two recently introduced deep models, namely generative stochastic networks (GSNs) and sum-product networks (SPNs), are used for learning spectrogram representations. For SCSS we evaluate the deep architectures on data of the $2^{\text{nd}}$ CHiME speech separation challenge and provide results for a speaker dependent, a speaker independent, a matched noise condition and an unmatched noise condition task. GSNs obtain the best PESQ and overall perceptual score on average in all four tasks. Similarly, frame-wise GSNs are able to reconstruct the missing frequency bands in ABE best, measured in frequency-domain segmental SNR.

5. M. Zöhrer, F. Pernkopf, *"General Stochastic Networks for Classification"*, Neural Information Processing Systems (NIPS), 2014.

   In this work, we introduce a new training procedure for supervised learning of representations. In particular we define a hybrid training objective for general stochastic networks, dividing the cost function into a generative and discriminative part, controlled by a trade-off parameter. We are able to obtain state-of- the-art performance on the MNIST dataset, without using permutation invariant digits and significantly outperform baseline models on sub-variants of the MNIST and rectangle database.

6. M. Wohlmayr and F. Pernkopf, *"Model-Based Multiple Pitch Tracking Using Factorial HMMs: Model Adaptation and Inference"*, IEEE Transactions on Audio, Speech, and Language Processing, Vol. 21, No. 8, pp. 1742–1754, 2013.

   Robustness against noise and interfering audio signals is one of the challenges in speech recognition and audio analysis technology. One avenue to approach this challenge is single-channel multiple-source modeling. Factorial hidden Markov models (FHMMs) are capable of modeling acoustic scenes with multiple sources interacting over time. While these models reach good performance on specific tasks, there are still serious limitations restricting the applicability in many domains. In this paper, we generalize these models and enhance their applicability. In particular, we develop an EM-like iterative adaptation framework which is capable to adapt the model parameters to the specific situation (e.g. actual speakers, gain, acoustic channel, etc.) using only speech mixture data. Currently, source-specific data is required to learn the model. Inference in FHMMs is an essential ingredient for adaptation. We develop efficient approaches based on observation likelihood pruning. Both adaptation

and efficient inference are empirically evaluated for the task of multipitch tracking using the GRID corpus.

7. R. Peharz, S. Tschiatschek, F. Pernkopf, *"The Most Generative Maximum Margin Bayesian Networks"*, International Conference on Machine Learning (ICML), 2013.

   This paper introduces hybrid parameter learning of Bayesian networks (BNs). BNs represent distributions and are therefore well-suited for generative learning. Even when the conditional distribution obtained by discriminative training of BNs is unique, the representation as a BN might be not unique. A natural approach is to use this degree of freedom to improve the generative aspect of the model, i.e. to select the representation with highest likelihood. This describes a domain of likelihood-aware discriminative models, justifying a generative usage, such as sampling new examples, versatile inference scenarios, and consistent treatment of missing features during test time. We use a large margin formulation for discriminative training, introducing a likelihood-weighted $\ell^1$-norm. This simultaneously optimizes the data likelihood and therefore partly maintains the generative character of the model. For many network structures, our method can be formulated as a convex problem, guaranteeing a globally optimal solution.

8. F. Pernkopf, M. Wohlmayr, S. Tschiatschek, *"Maximum Margin Bayesian Network Classifiers"*, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 34, No. 3, pp. 521–532, 2012.

   We present a maximum margin parameter learning algorithm for Bayesian network classifiers using a conjugate gradient (CG) method for optimization. In contrast to previous approaches, we maintain the normalization constraints on the parameters of the Bayesian network during optimization, i.e., the probabilistic interpretation of the model is not lost. This enables us to handle missing features in discriminatively optimized Bayesian networks. In experiments, we compare the classification performance of maximum margin parameter learning to conditional likelihood and maximum likelihood learning approaches. Discriminative parameter learning significantly outperforms generative maximum likelihood estimation for naive Bayes and tree augmented naive Bayes structures on all considered data sets. Furthermore, maximizing the margin dominates the conditional likelihood approach in terms of classification performance in most cases. Margin-optimized Bayesian network classifiers achieve classification performance comparable to support vector machines (SVMs) using fewer parameters. Moreover, we show that unanticipated missing feature values during classification can be easily processed by discriminatively optimized Bayesian network classifiers, a case where discriminative classifiers usually require mechanisms to complete unknown feature values in the data first.

9. F. Pernkopf and D. Bouchaffra, *"Genetic-based EM Algorithm for Learning Gaussian Mixture Models"*, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 27, No. 8, pp. 1344–1348, 2005.

   We propose a genetic-based expectation-maximization (GA-EM) algorithm for learning Gaussian mixture models from multivariate data. This algorithm is capable of selecting the number of components of the model using the minimum description length (MDL) criterion. Our approach benefits from the properties of Genetic algorithms (GA) and the EM algorithm by combination of both into a single procedure. The population-based stochastic search of the GA explores the search space more thoroughly than the EM method. Therefore, our algorithm enables escaping from local optimal solutions since the algorithm becomes less sensitive to its initialization. The GA-EM algorithm is elitist which maintains the monotonic convergence property of the EM algorithm.

# Publications

## Book Chapter

1. F. Pernkopf, R. Peharz, S. Tschiatschek, *"Introduction to Probabilistic Graphical Models"*, Academic Press Library in Signal Processing, Vol. 1, Ch. 18, pp. 989-1064, 2014.

## Journal Articles (peer-reviewed)

1. W. Roth, R. Peharz, S. Tschiatschek, F. Pernkopf, *"Hybrid Generative-Discriminative Training of Gaussian Mixture Models"*, Pattern Recognition Letters, revised , 2018
2. E. Messner, M. Zöhrer, F. Pernkopf, *"Heart Sound Segmentation - An Event Detection Approach using Deep Recurrent Neural Networks"*, IEEE Transaction on Biomedical Engineering (TBME), revised, 2018.
3. W. Roth and F. Pernkopf, *"Bayesian Neural Networks with Weight Sharing using Dirichlet Processes"*, IEEE Transactions on Pattern Analysis and Machine Intelligence, revised, 2018.
4. M. Ratajczak, S. Tschiatschek, and F. Pernkopf, *"Sum-Product Networks for Structured Prediction"*, IEEE Transactions on Pattern Analysis and Machine Intelligence, revised, pp. –, 2017.
5. C.Knoll, D. Mehta, T.Chen, F. Pernkopf, *"Fixed Points of Belief Propagation - An Analysis via Polynomial Homotopy Continuation"*, IEEE Transactions on Pattern Analysis and Machine Intelligence, accepted, pp. –, 2017.
6. G. Lammer, R. Lanzenberger, A. Rom, A. Hanna, M. Forrer, M. Feuerstein, F. Pernkopf, N. Mutsam *"Digital Refractory Age"*, Bulletin – The Journal of Refractory Innovations, 2017.
7. L. Pfeifenberger, M. Zöhrer and F. Pernkopf, *"Representation Learning for Multi-Channel Speech Enhancement"*, IEEE Transactions on Audio, Speech, and Language Processing, major revision, 2016.
8. P. Aichinger, M. Hagmüller, I. Roesner, W. Bigenzahn, B. Schneider-Stickler, J. Schoentgen, F. Pernkopf, *"Estimation of Fundamental Frequencies in Diplophonic Voices"*, IEEE Transactions on Audio, Speech, and Language Processing, accepted, 2017.
9. R. Peharz, R. Gens, F. Pernkopf, P. Domingos, *"On the Latent Variable Interpretation in Sum-Product Networks"*, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 39, No. 10, pp. 2030–2044, 2017.
10. P.B. Marschik, F.B. Pokorny, R. Peharz, D. Zhang, J. OMuircheartaigh, H. Roeyers, S. Bölte, B. Urlesberger, W.E. Kaufmann, B. Schuller, L. Poustka, F. Pernkopf, T. Pock, K. Tammimies, C. Enzinger, M. Krieber, I. Tomantschger, K.D. Bartl-Pokorny, J. Sigafoos, M. Gugatschka, K. Nielsen-Saines, C. Einspieler, *"A Novel Way to Measure and Predict Development: A Heuristic Approach to Facilitate the Early Detection of Neurodevelopmental Disorders"*, Current Neurology Neuroscience Reports, accepted, 2016
11. M. Krieber, K.D. Bartl-Pokorny, F.B. Pokorny, D. Zhang, K. Landerl, C. Körner, F. Pernkopf, T. Pock, C. Einspieler, P.B. Marschik, *"Eye movements during silent and oral reading in a regular orthography: Basic characteristics and correlations with childhood cognitive abilities and adolescent reading skills"*, PLOS One, accepted, 2016.
12. P. Aichinger, M. Hagmüller, I. Roesner, W. Bigenzahn, B. Schneider-Stickler, J. Schoentgen, F. Pernkopf, *"Fundamental Frequency Tracking in Diplophonic Voices"*, Biomedical Signal Processing and Control, accepted, 2016.
13. N. Mutsam and F.Pernkopf, *"Maximum Margin Hidden Markov Models for Sequence Classification"*, Pattern Recognition Letters, Vol. 77, pp. 14–20, 2016.
14. M. Zöhrer, R. Peharz, and F. Pernkopf, *"Representation Learning for Single-Channel Source Separation and Bandwidth Extension"*, IEEE Transactions on Audio, Speech, and Language Processing, Vol. 23, No. 12 pp. 2398–2409, 2015.
15. S. Tschiatschek and F. Pernkopf, *"On Bayesian Network Classifiers with Reduced Precision Parameters"*, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 37, No. 4, pp. 774–785, 2015.
16. C. Leitner and F. Pernkopf, *"On Pre-Image Iterations for Speech Enhancement"*, SpringerPlus, accepted,

2015.

17. M. Wohlmayr and F. Pernkopf, *"Model-Based Multiple Pitch Tracking Using Factorial HMMs: Model Adaptation and Inference"*, IEEE Transactions on Audio, Speech, and Language Processing, Vol. 21, No. 8, pp. 1742–1754, 2013.
18. F. Pernkopf and M. Wohlmayr, *"Stochastic Margin-based Structure Learning of Bayesian Network Classifiers"*, Pattern Recognition, Vol. 46, No. 2, pp. 464–471, 2013.
19. R. Peharz and F. Pernkopf, *"Sparse Nonnegative Matrix Factorization with $\ell^0$ Constraints"*, Neurocomputing, vol. 80, pp. 38–46, March, 2012.
20. F. Pernkopf, M. Wohlmayr, S. Tschiatschek, *"Maximum Margin Bayesian Network Classifiers"*, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 34, No. 3, pp. 521–532, 2012.
21. M. Wohlmayr, M.Stark, and F. Pernkopf, *"A Probabilistic Interaction Model for Multipitch Tracking With Factorial Hidden Markov Models"*, IEEE Transactions on Audio, Speech, and Language Processing, Vol. 19, No. 4, pp. 799–810, 2011.
22. M. Stark, M. Wohlmayr, and F. Pernkopf, *"Source-Filter based Single Channel Speech Separation using Pitch Information"*, IEEE Transactions on Audio, Speech, and Language Processing, Vol. 19, No. 2, pp. 242–255, 2011.
23. F. Pernkopf and J. Bilmes, *"Efficient Heuristics for Discriminative Structure Learning of Bayesian Network Classifiers"*, Journal of Machine Learning Research, Vol. 11, pp. 2323–2360, 2010.
24. S. Petrik, C. Drexel, L. Fessler, J. Jancsary, A. Klein, G. Kubin, J. Matiasek, F. Pernkopf, H. Trost, *"Semantic and Phonetic Automatic Reconstruction of Medical Dictations"*, Computer Speech & Language, Vo. 25, No. 2, pp. 363–385, 2011.
25. C. Tantibundhit, F. Pernkopf, and G. Kubin, *"Joint Time-Frequency Segmentation Algorithm for Transient Speech Decomposition and Speech Enhancement"*, IEEE Transactions on Audio, Speech, and Language Processing, Vol. 18, No. 6, pp. 1417–1428, 2010.
26. F. Pernkopf, *"Tracking of Multiple Targets Using On-line Learning for Appearance Model Adaptation"*, IEEE Transactions on Systems, Man, and Cybernetics: Part B, Vol. 38, No. 6, pp. 1465–1475 , 2008.
27. F. Pernkopf, T. V. Pham, and J. Bilmes, *"Broad Phonetic Classification Using Discriminative Bayesian Networks"*, Speech Communication, Vol. 51, No. 2, pp. 151–166, 2009.
28. F. Pernkopf, *"3D Surface Analysis Using Coupled HMMs"*, Machine Vision and Applications, Vol. 16, No. 5, pp. 298–305, 2005.
29. F. Pernkopf, *"3D Surface Acquisition and Reconstruction for Inspection of Raw Steel Products"*, Computers in Industry, Vol. 56, pp. 876–885, 2005.
30. F. Pernkopf and D. Bouchaffra, *"Genetic-based EM Algorithm for Learning Gaussian Mixture Models"*, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 27, No. 8, pp. 1344–1348, 2005.
31. F. Pernkopf, *"Bayesian Network Classifiers versus Selective $k$-NN Classifiers"*, Pattern Recognition, Vol. 38, No. 1, pp. 1–10, 2005.
32. F. Pernkopf, *"Detection of Surface Defects on Raw Steel Blocks Using Bayesian Network Classifiers"*, Pattern Analysis and Applications, Vol. 7, No. 3, pp. 333–342, 2004.
33. F. Pernkopf and P. O'Leary, *"Floating Search Algorithm for Structure Learning of Bayesian Network Classifiers"*, Pattern Recognition Letters, Vol. 24, pp. 2839–2848, 2003.
34. F. Pernkopf and P. O'Leary, *"Image Acquisition Techniques for Automatic Visual Inspection of Metallic Surfaces"*, NDT&E International, Vol. 36, No. 8, pp. 609–617, 2003.
35. F. Pernkopf and P. O'Leary, *"Visual Inspection of Machined Metallic High-Precision Surfaces"*, Eurasip Journal on Applied Signal Processing, Vol. 2002, No. 7, pp. 667–678, 2002.

## Conference Articles (peer-reviewed)

1. C. Knoll, F. Kulmer and F. Pernkopf, *"Self-Guided Belief Propagation - Iterative Enhancement of the Bethe Approximation"*, Uncertainty in Artificial Intelligence (UAI), submitted, 2018.
2. E. Messner, M. Fediuk, P. Swatek, S. Scheidl, F.-M. Smolle-Jüttner, H. Olschewski, F. Pernkopf,

*"Crackle and Breathing Phase Detection in Lung Sounds with Deep Bidirectional Gated Recurrent Neural Networks"*, IEEE Engineering in Medicine and Bilogy Society (EMBC), submitted, 2018.

3. W. Roth and F. Pernkopf, *"Discrete-Valued Neural Networks Using Variational Inference"*, Intern. Conf. on Machine Learning (ICML), submitted, 2018.
4. M. Zöhrer, L. Pfeifenberger, G. Schindler, H. Fröning, F. Pernkopf, *"Resource Efficient Deep Eigenvector Beamforming"*, IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP), accepted, 2018.
5. P. Aichinger, I. Roesner, J. Schoentgen, F. Pernkopf, *"Modelling of Random Extra Pulses During Quasi-Closed Glottal Cycle Phases"*, MAVEBA, accepted, 2017.
6. C. Knoll and F. Pernkopf, *"On Loopy Belief Propagation – Local Stability Analysis for Non-Vanishing Fields"*, Uncertainty in Artificial Intelligence (UAI), accepted, 2017.
7. M. Trapp, T.Madl, R. Peharz, F. Pernkopf and R. Trappl, *"Safe Semi-Supervised Learning of Sum-Product Networks"*, Uncertainty in Artificial Intelligence (UAI), accepted, 2017.
8. L. Pfeifenberger, M. Zöhrer and F. Pernkopf, *"Eigenvector-based Speech Mask Estimation using a Logistic Regression for Multi-Channel Speech Enhancement"*, Interspeech, accepted, 2017.
9. M. Ratajczak, S. Tschiatschek and F. Pernkopf, *"Frame and Segment Level Recurrent Neural Networks for Phone Classification"*, Interspeech, accepted, 2017.
10. M. Zöhrer and F. Pernkopf, *"Virtual Adversarial Training and Data Augmentation for Acoustic Event Detection with Gated Recurrent Neural Networks"*, Interspeech, accepted, 2017.
11. G. Lammer, A. Yaseen, R. Lanzenberger, A. Rom, A. Hanna, M. Forrer, M. Feuerstein, F. Pernkopf, N. Mutsam, *"Advanced Data Mining for Process Optimizations and Use of A.I. to Predict Refractory Wear and to Analyse Refractory Behavior"*, AISTech – The Iron & Steel Technology Conference and Exposition, accepted, 2017.
12. E. Messner, M. Hagmüller, P. Swatek, F.-M. Smolle-Jüttner, F. Pernkopf, *"Respiratory Airflow Estimation from Lung Sounds Based on Regression"*, IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP), accepted, 2017.
13. L. Pfeifenberger, M. Zöhrer, F. Pernkopf, *"DNN-based Speech Mask Estimation for Eigenvector Beamforming"*, IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP), accepted, 2017.
14. E. Messner, M. Hagmüller, P. Swatek, F. Pernkopf, *"Impact of Airflow Rate on Amplitude and Regional Distribution of Normal Lung Sounds"*, BIOSIGNALS, accepted, 2017.
15. C.Knoll, F. Pernkopf, D. Mehta, T.Chen, *"Fixed Points Solutions of Belief Propagation"*, Neural Information Processing Systems (NIPS) workshop, accepted, 2016.
16. W. Roth and F. Pernkopf, *"Variational Inference in Neural Networks using an Approximate Closed-Form Objective"*, Neural Information Processing Systems (NIPS) workshop, accepted, 2016.
17. M. Trapp, R. Peharz, M. Skowron, T. Madl, F. Pernkopf and R. Trappl, *"Structure Inference in Sum-Product Networks using Infinite Sum-Product Trees"*, Neural Information Processing Systems (NIPS) workshop, accepted, 2016.
18. T. Schrank, L. Pfeifenberger, M. Zöhrer, J. Stahl, P. Mowlaee, F. Pernkopf, *"Deep Beamforming and Data Augmentation for Robust Speech Recognition: Results of the 4$^{th}$ CHiME Challenge"*, CHiME 4 Workshop, accepted, 2016.
19. M. Zöhrer and F. Pernkopf, *"Gated Recurrent Networks applied to Acoustic Scene Classification"*, Eusipco, accepted, 2016.
20. F.B. Pokorny, B.W. Schuller, R. Peharz, F. Pernkopf, K.D.Bartl-Pokorny, C. Einspieler, P.B. Marschik, *"Retrospektive Analyse frühkindlicher Lautäußerungen in "Home-Videos": Ein signalanalytischer Ansatz zur Früherkennung von Entwicklungsstörungen"*, Österreichische Linguistiktagung (ÖLT42), 2016.
21. T. Schrank, F. Röck, M. Tappler, F. Pernkopf, R. Bloem, B. Aichernig *"Poster: Learning Models of a Network Protocol using Neural Network Language Models"*, IEEE Symposium on Security and Privacy, accepted, 2016.

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26. E. Messner, M. Hagmüller, P. Swatek, F. Pernkopf, *"A Robust Multichannel Lung Sound Recording Device"*, Biodevices, accepted, 2016.
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29. S. Tschiatschek and F. Pernkopf, *"Generatively Optimized Bayesian Network Classifiers Under Computational Constraints"*, International Conference on Machine Learning (ICML), Workshop on Resource-Efficient Machine Learning, 2015.
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31. M. Ratajczak, S. Tschiatschek, F. Pernkopf, *"Structured Regularizer for Neural Higher-Order Sequence Models"*, European Conference on Machine Learning (ECML), 2015.
32. S. Tschiatschek, F. Pernkopf, *"Learning of Bayesian Network Classifiers Under Computational Constraints"*, European Conference on Machine Learning (ECML), 2015.
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36. R. Peharz, S. Tschiatschek, F. Pernkopf and P.Domingos, *"On theoretical properties of sum-product networks"*, AISTATS, 2015.
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40. M. Ratajczak, S. Tschiatschek and F. Pernkopf, *"Context-Specific Deep Conditional Random Fields for Structured Prediction"*, International Conference on Machine Learning (ICML), Workshop on Learning Tractable Probabilistic Models, 2014.
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49. R. Peharz, B. Geiger, F. Pernkopf, *"Greedy Part-wise Learning of Sum-Product Networks"*, European Conference on Machine Learning (ECML), LNCS, pp. 612–627, 2013.
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**MONTANUNIVERSITÄT LEOBEN**
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## Bescheid

über die Verleihung des akademischen Grades

### Spruch

Sie haben am 27. Februar 2002 gem. § 11 des Bundesgesetzes für montanistische Studienrichtungen vom 10. Juli 1969, BGBl. 291/1969 Ihr Rigorosum zur Erlangung des Titels eines Doktors der montanistischen Wissenschaften gem. § 51 UniStG positiv abgelegt. Es wird Ihnen somit gem. § 66 Abs.1 UniStG 1997, BGBl. I Nr. 48/1997, der akademische Grad

**Doktor der montanistischen Wissenschaften**
**abgekürzt Dr. mont.**

verliehen. Sie haben daher das Recht erworben, den in diesem Bescheid angeführten akademischen Grad gem. § 67 UniStG zu führen, Ihrem Namen voranzustellen und die Eintragung in öffentliche Urkunden in abgekürzter Form zu verlangen.

### Rechtsmittelbelehrung

Gegen diesen Bescheid ist binnen zwei Wochen ab Zustellung das Rechtsmittel der Berufung zulässig. Die Berufung hat einen begründeten Berufungsantrag zu enthalten und ist schriftlich beim Studiendekan einzubringen.

Der Studiendekan:

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Graz, am 31.08.2010

**Betr.: Verleihung der Lehrbefugnis**

## BESCHEID

Sie haben mit Ihrem Antrag vom 1. Juni 2009 um die Verleihung der Lehrbefugnis für das wissenschaftliche Fach "Intelligent Systems" angesucht.

### SPRUCH

Aufgrund des positiven Beschlusses der Habilitationskommission in der Abschlusssitzung vom 21. Juli 2010 wird Ihnen gemäß § 103 Abs.9 UG 2002 i.d.g.F. die Lehrbefugnis für das wissenschaftliche Fach **"Intelligent Systems"** verliehen. Ihre Zuordnung zum Institut für Signalverarbeitung und Sprachkommunikation bleibt dadurch unberührt.

### BEGRÜNDUNG

Die Habilitationskommission hat die wissenschaftliche Qualifikation sowie die didaktischen Fähigkeiten und damit die nötigen Voraussetzungen für die Erteilung der Lehrbefugnis geprüft.
Aufgrund der von Ihnen eingereichten Habilitationsschrift und der sonstigen wissenschaftlichen Arbeiten als auch den eingeholten positiven Gutachten, wurden sowohl Ihre wissenschaftlichen als auch Ihre didaktischen Qualifikationen positiv beurteilt. Gemäß § 103 Abs.9 UG 2002 war daher spruchgemäß zu entscheiden.

### RECHTSMITTELBELEHRUNG

Gegen diesen Bescheid ist kein ordentliches Rechtsmittel zulässig.
Gegen diesen Bescheid kann binnen 6 Wochen ab Zustellung eine Beschwerde an den VfGH und/ oder den VwGH erhoben werden. Die Beschwerde muss von einem Rechtsanwalt unterschrieben sein. Spätestens zum Zeitpunkt der Überreichung der Beschwerde ist eine Gebühr in Höhe von EUR 220,-- zu entrichten.

Der Rektor

# Urkunde

Die Steiermärkische Landesregierung
hat beschlossen, den

**Förderungspreis für Wissenschaft und Forschung des Landes Steiermark 2010**

**Herrn Universitätsdozent**
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Technische Universität Graz

zu verleihen.

Graz, am 10. Dezember 2010
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