NEWSLETTER

Centre for Acoustic Signal Processing Research (CASPR)

August 2020

The Centre for Acoustic Signal Processing Research (CASPR) is a research centre at the Section for Signal and Information Processing, Department of Electronic Systems, Aalborg University, Denmark. CASPR is supported by the Demant Foundation, Oticon A/S, and Aalborg University.

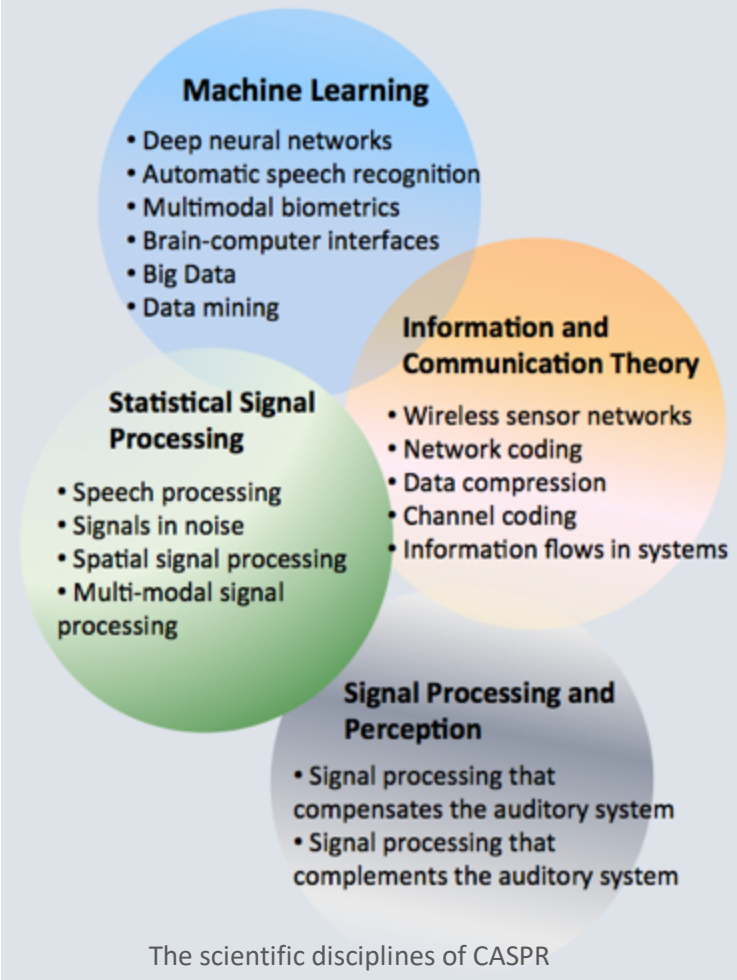
Contents

Department of Electronic Systems
Signal and Information Processing Section
Aalborg University

Research in CASPR

CASPR is conducting research related to advanced statistical signal processing solutions for assistive listening. The research finds direct use in communication devices such as hearing aids, helmets, headphones, cochlear implants, ear monitor, ear pieces, diagnostic equipment, etc. However, the envisioned research also finds use in related areas such as robust speech/speaker recognition, brain computer interfaces, acoustic event detection, etc.
The scientific scope of CASPR encompasses

- statistical signal processing.
- machine learning.
- information and communication theory with applications to wireless exchange of information between listening devices and other external devices.
- pattern recognition.
- data mining in body worn sensor data.
- perception-based statistical signal processing.



The scientific disciplines of CASPR

CASPR will navigate in a rapidly changing technological landscape: we envision a near future, where the technological landscape allows very different, and better, hearing assistive devices than are known today. Specifically, we envision that near-future hearing assistive devices will:

- increase the wireless exchange of information with each other, with other body-worn devices and with devices outside the body.
- make use of additional microphones on or outside the body, and will employ other types of body-worn or outside-the-body sensors.
- work in a much closer symbiosis with the user.

Teaching in CASPR

Current courses related to CASPR

CASPR is heavily involved in teaching and education at B.Sc., M.Sc., PhD., and Postdoc level in disciplines that are relevant to the scientific scope of CASPR:

- Machine Learning (PhD Course), Spring 2020.
- Deep Learning (PhD course), Spring 2020.

CASPR is currently involved in 7 student projects:

Project 1
Designing an Ad-hoc Document Ranking System for Bank Financial Advisors.
Engineering Psychology, Master thesis project.
Michael Damsbo Lyngs and Mathias Huus Olsen.

Project 2
Machine-Learning-based Evaluation of Feedback Management Systems in Hearing Aids.
Signal Processing and Acoustics, Master thesis project with Oticon A/S.
Jakob Sloth Lauridsen.

Project 3
Deep Learning based Adversarial Audio Example Detection.
Vision, Graphics and Interactive Systems, Master thesis project.
Christian Heider Nielsen.

Project 4
Reliable estimation of directional entropy.
Mathematical Engineering, long M.Sc. thesis project.
Martin Kamp Dalgaard.

Project 5
Bayesian dictionary learning for EEG source identification.
Mathematical Engineering, long M.Sc. thesis project.
Trine Nyholm Kragh, Laura Nyrup Mogensen.

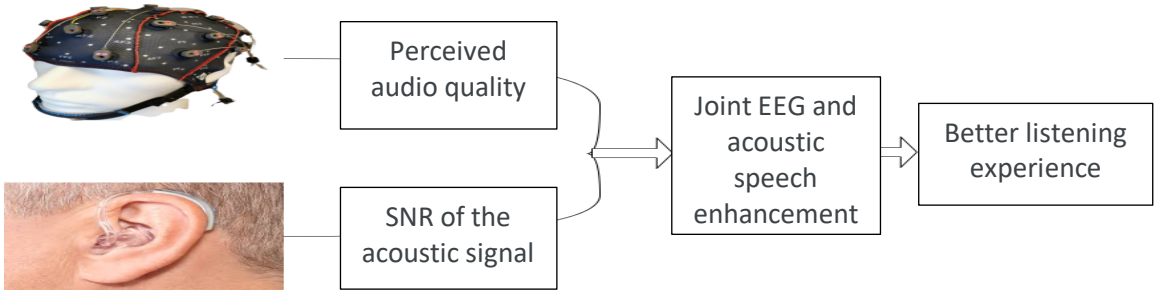
Project 6
Adaptive Acoustic Beamforming for Sound Zones.
Signal Processing and Acoustics, Master thesis project with B&O A/S.
Thomas Damsgaard, Mads Hulegaard Jensen.

Project 7
Accelerated Singular Value Decomposition With Applications in Deep Neural Networks.
Signal Processing and Acoustics, 8th semester project.
Kasper Steensig Jensen.

PhD Project: Signal Quality Estimation for Speech Enhancement using EEG
Start date: February 15th, 2019.
Collaboration with Eriksholm Research Center.

Signal processing algorithms applied in modern hearing assistive devices (HADs) to enhance noisy speech and audio, rely upon knowledge of the signal-to-noise ratio (SNR) of the acoustic signal received by the HADs. The SNR is generally time-varying and depends upon the target speaker and the environment. The SNR can be estimated using conventional adaptive signal processing techniques. Unfortunately, the SNR is an objective measure that does not necessarily correlate well with how the listener perceives the quality of the acoustic signal. The perceived audio quality is a subjective measure and it can change for different people. For example, a hearing impaired person might perceive the quality of the acoustic signal differently than a normal hearing person. If one could combine the objective SNR with a subjective measure of the speech quality, then it could potentially be used to improve the signal processing enhancement algorithms as shown in the figure below.

PhD student Payam S. Baboukani.



In this project, correlates of the perceived speech quality will be obtained by measuring and analyzing the brain activity of the listener. Advanced signal processing techniques, non-linear time-series analysis, and information theory will be combined in order to construct a reliable estimator that can be applied to the noisy multi-channel EEG signals. For example, the time-varying causal information flow between the EEG sensors contain a lot of insights about the brain state of the listener. Our recent findings demonstrate how to obtain reliable estimates of the information flow and at the same time significantly reduce false-positive classifications due to e.g., noise and volume conduction effects.

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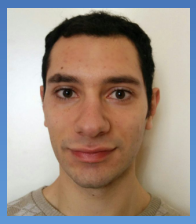

PhD student Giovanni Morrone from the University of Modena and Reggio Emilia, Italy, is visiting CASPR for five months. Giovanni is working on new approaches in speech inpainting that will exploit both audio and visual information (e.g., lip-reading) to recover missing parts of corrupted speech.

Phd researcher Mathias Bach Pedersen presented his paper entitled "A Neural Network for Monaural Intrusive Speech Intelligibility Prediction" at the IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP) conference in April 2020.

Phd researcher Poul Hoang presented his paper entitled "Maximum Likelihood Estimation of the Interference-plus-Noise Cross-Power Spectral Density Matrix for Own Voice Retrieval" at the IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP) conference in April 2020.

Postdoc researcher Adel Zahedi presented his paper entitled "A Constrained Maximum Likelihood Estimator of Speech and Noise Spectra with Application to Multi-Microphone Noise Reduction" at the IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP) conference in April 2020.

Members of CASPR are part in two new industrial PhD Projects together with our partners

- *Cortical tracking of auditory object-based selective attention to improve perceived sound quality*.
- Company: B&O
- PhD student: Adele Simon

- *Informed adaptive multi-microphone pre-processing based speech enhancement for wireless speech communication*.
- Company: RTX A/S
- PhD student: Andreas Jonas Fuglsig.

Students at AAU supervised by CASPR staff successfully defended their theses in June 2020:

- Laura Nyrup Mogensen
- Trine Nyholm Kragh
- Michael Damsbo Lyngs
- Mathias Huus Olsen
- Thomas Damsgaard
- Mads Hulegaard Jensen
- Jakob Sloth Lauridsen
- Christian Heider Nielsen
- Martin Kamp Dalgaard

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Zheng-Hua Tan gave the following invited talks:

How do we accelerate collaboration on AI
Tech Talk at Danish Academy of Technical Sciences, June 2020.

Deep Learning for Robust Speech and Multimodal Signal Processing
Presentation for Facebook Labs, May 2020.

Deep Representation Learning for Prediction and Recommendation
Presentation for Data Analytics Forum at Danfoss A/S, February 2020.

Zheng-Hua Tan was a Track Co-Chair for Machine Learning and a Session Chair at the 45th International Conference on Acoustics, Speech, and Signal Processing (ICASSP 2020), Barcelona, Spain, May 4-8, 2020.

Jesper Jensen received the EURASIP Group Technical Achievement Award.
The 2020 European Association for Signal Processing (EURASIP) Group Technical Achievement Award given to the head of a group in academia or industry that has achieved significant contributions in signal processing and related areas over a number of years. Given for "Prof. Jensens leadership and outstanding contributions to the fields of acoustic signal processing and speech enhancement".

A new demo on *Vocoder-based speech synthesis from silent videos* based on the work of PhD researcher Daniel Michelsanti has been released.

All demos are available on the CASPR website:
http://caspr.es.aau.dk/demos

Recent CASPR Related Research

Journal papers

1. Bounds on the Sum-Rate of MIMO Causal Source Coding Systems with Memory under Spatio-Temporal Distortion Constraints. P.A. Stavroe, J. Østergaard, M. Skoglund. Accepted for publication in Entropy.

2. Deep InterBoost Networks for Small-sample Image Classification. X. Li, D. Chang, Z. Ma, Z.-H. Tan, J.-H. Xue, J. Cao and J. Guo. Accepted by Neurocomputing, 2020.

3. OSLNet: Deep Small-Sample Classification with an Orthogonal Softmax Layer. X. Li, D. Chang, Z. Ma, Z.-H. Tan, J.-H. Xue, J. Cao, J. Yu and J. Guo. Accepted by IEEE Transactions on Image Processing, 2020.

4. On the Comparisons of Decorrelation Approaches for non-Gaussian Neutral Vector Variables. Z. Ma, X. Lu, J. Xie, Z. Yang, J.-H. Xue, Z.-H. Tan, B. Xiao and J. Guo. Accepted by IEEE Transactions on Neural Networks and Learning Systems, 2020.

5. Improved External Speaker-Robust Keyword Spotting for Hearing Assistive Devices. I. L. Espejo, Z.-H. Tan, J. Jensen. IEEE/ACM Transactions on Audio, Speech and Language Processing, Vol. 28, p. 1233-1247, 2020.

6. On Loss Functions for Supervised Monaural Time-Domain Speech Enhancement. M. Kolbæk, Z.-H. Tan, S. H. Jensen and J. Jensen. IEEE/ACM Transactions on Audio, Speech and Language Processing, Vol. 28, No. 1, pp. 825-838, January, 2020.

7. A Moving Horizon Framework for Sound Zones. M. B. Møller & J. Østergaard. IEEE/ACM Transactions on Audio, Speech, and Language Processing. Vol. 28, s. 256-265, 2020.

Conference Papers

1. Estimation of Directed Dependencies in Time Series Using Conditional Mutual Information and Non-linear Prediction. P.S. Baboukani, C. Graversen, and J. Østergaard, Proc. Eusipco 2020, Accepted.

2. Exploring Filterbank Learning for Keyword Spotting. I. L. Espejo, Z.-H. Tan, J. Jensen, Proc. Eusipco 2020, Accepted.

3. Adversarial Example Detection by Classification for Deep Speech Recognition. S. Samizade, Z.-H. Tan, C. Shen and X. Guan. IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP 2020), Barcelona, 2020.

4. A Neural Network for Monuaral Intrusive Speech Intelligibility Prediction. M. B. Pedersen, A. H. Andersen, S. H. Jensen, J. Jensen. Proc. IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), 2020, pp. 336-340.

5. Maximum Likelihood Estimation of the Interference-plus-noise Cross Power Spectral Density Matrix for Own Voice Retrieval. P. Hoang, Z.-H. Tan, T. Lunner, J. M. de Haan, J. Jensen. Proc. IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), 2020, pp. 6939-6943.

6. A Constrained Maximum Likelihood Estimator of Speech and Noise Spectra with Application to Multi-Microphone Noise Reduction. A. Zahedi, M. S. Pedersen, J. Østergaard, L. Bramsløw, T. U. Christiansen, J. Jensen. Proc. IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), 2020, pp. 6944-6948.

7. The Exponential Distribution in Rate Distortion Theory: The Case of Compression with Independent Encodings. U. Erez, J. Østergaard, and R. Zamir. Proc. IEEE Data Compression Conference, March 2020.

CASPR Winter School – November 2020
Signal Processing for Hearing Assistive Devices

Building on the success of our previous CASPR Winter School in 2017, we are happy to announce that there will be a new CASPR Winter School in November 2020. The Winter School is also open for Industry.

Hearing assistive devices (HADs) are ubiquitous. They include, for example, devices such as headsets for speech communication in noisy environments (air plane crews, emergency/rescue teams, combat soldiers, police forces, etc.), headsets for office use, gaming, etc., and hearing care systems, e.g. hearing aids and cochlear implants.

The Winter school consists of lectures and hands-on exercises, which allow the participants to understand in-depth the technical problems related to HADs and their potential solutions. The school has three main parts. The first part is an introductory part, which lays the foundation for the rest of the course, covering fundamental topics such as auditory perception (normal and impaired hearing) and a discussion of the basic principles of HADs. The second part provides an overview of fundamental signal processing problems encountered in HADs, and an in-depth treatment of state-of-the-art solutions. These include methods for beamforming and noise reduction, direction-of-arrival estimation, feedback and echo control, hearing loss compensation, etc. Furthermore, an overview is given of methodologies for evaluating HADs with a particular focus on methods for intelligibility assessment and estimation. The third part of the Winter school presents emerging technologies for hearing assistive devices, including machine learning techniques for processing of speech in noise, audio-visual signal processing, user-aware/symbiotic signal processing, methods for own-voice processing, etc. While the course focuses on the HAD application, many of the discussed techniques are very general and find use in the much broader field of general sound processing. The course is multi-disciplinary, including topics such as basic auditory perception, statistical signal processing, deep learning, practical do's and don'ts.

The course also bridges the gap between theoretical background and practical/robust application. The course is a one-week concentrated course to be held in the Fall, 2020. The course involves course preparation (approximately 1 ECTS), course presence (1 ECTS), assignment finalization and hand-in (1 ECTS). The course schedule (which is subject to change) is available here: preliminary program.

Date of Winter School: 2nd – 6th November, 2020.
Place: Aalborg University, Fredrik Bajers Vej 7b, 9220 Aalborg, Denmark.
The Winter School will be held physically in Aalborg, and it will not be possible to participate online.

For more information about the Winter School, feel free to contact the organizers:
Prof. Jesper Jensen (jje@es.aau.dk), Prof. Zheng-Hua Tan (zt@es.aau.dk), and Prof. MSO Jan Østergaard (jo@es.aau.dk).

To register for the Winter School please use the following link: registration link.

Course Fee: 1500 DKK (200 EUR) for PhD students and postdocs and 7500 DKK (1000 EUR) for industrial participants. The registration fee includes one dinner at the social gathering Wednesday (a tentative date) evening, as well as daily lunch and coffee during the week of the Winter School.

Important: The link to payment can be found under the section Course Fee on the course page, which is accessible after finishing the course registration via the link above.
Due to the Corona situation, we restrict the number of participants to at most 30.