AALBORG UNIVERSITY
DENMARK

NEWSLETTER

Centre for Acoustic Signal Processing Research (CASPR)

August 2022

The Centre for Acoustic Signal Processing Research (CASPR) is a research centre at the Section for Artificial Intelligence & Sound, 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
Section on Artificial Intelligence & Sound
Aalborg University

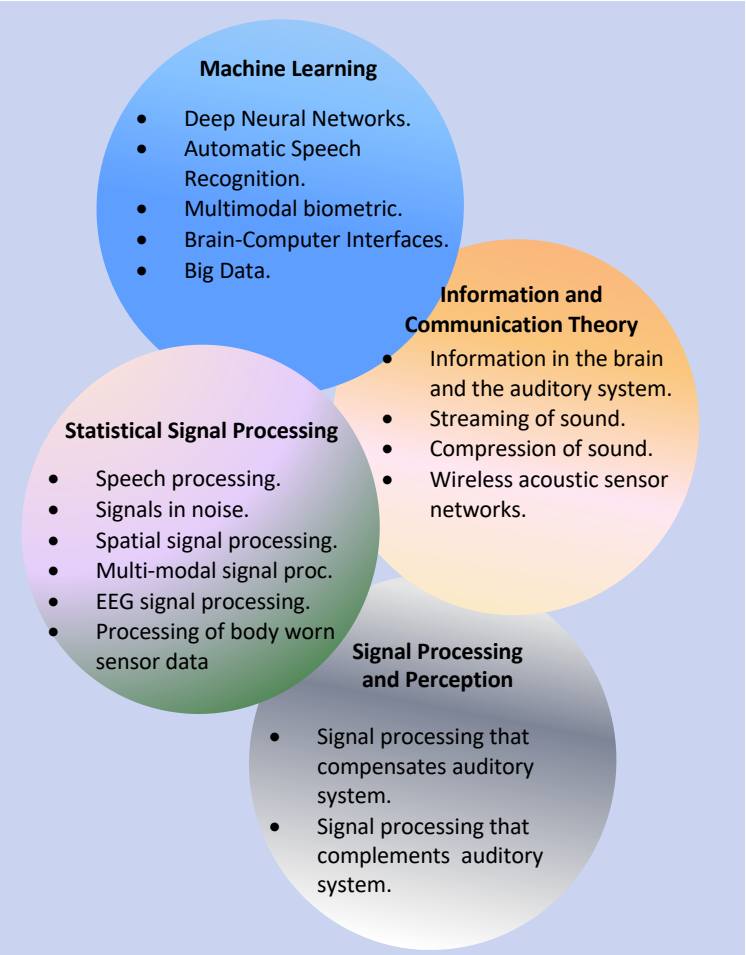
Research in CASPR

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.

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.

The scientific scope of CASPR encompasses

- Signal processing for hearing assistive devices that use multiple modalities such as sound, vision, EEG, and other body signals.
- Advanced signal processing concepts in closer symbiosis with the user in order to e.g., automatically adapt to the user's needs.
- Beyond audibility. Restore audibility, increase intelligibility, decrease listening effort.



Scientific disciplines of CASPR

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:

- Control and optimization, PhD course.
- Machine learning, Master and PhD courses.
- Deep learning, PhD course.
- CASPR Seasonal Schools on Signal Processing for Hearing Assistive Devices.
- Optimization methods, Master course.
- Information theory, Master course.
- Platforms and methods for multi-modal system architectures, Master course.

During Spring 2022, CASPR was involved in 10 student projects

Self-Supervised Learning for Audio-Visual Keyword Spotting.
Signal Processing and Acoustics, Master thesis project.
Holger Severin Bovbjerg.

Self-Supervised Learning for Human Pose Recognition.
Control and Automation, Master thesis project.
Yuheng Wang.

Sign Language Recognition in the Context of Education.
Vision, Graphics and Interactive Systems, Master thesis.
Daria Oskina

Real-time Voice Activity Detector based on Machine Learning.
Signal Processing and Acoustics, long Master thesis.
Claus Meyer Larsen

Zero-delay Multiple-description Audio Coding.
Mathematical Engineering, long Master thesis.
Kristian Søgaard.

Analysis of Scale-Invariance in EEG Microstates due to Acoustic Stimuli.
Mathematical Engineering, long Master thesis.
Rasmus Lykke Vestergaard.

Greedy Deep Sparse Representation Learning: Electroencephalogram Signal Analysis
Mathematical Engineering, 8th semester.
Magnus Berg Ladefoged, Alexander Djupnes Fuglkjær, Andreas Kühne Larsen, Mads Arnløv Jørgensen, Frederik Appel Vardinghus-Nielsen

EEG Signal Analysis Using K-SVD
Mathematical Engineering, 8th semester.
Sisse Hyldig Pedersen, Benjamin Bitsch Knudsen, Frederik Christensen, Magnus Jónhardsson.

Eye-gaze Steered Beamforming for Hearing Aid Systems
Mathematical Engineering, long Master thesis.
Simone Birk Bols Thomsen.

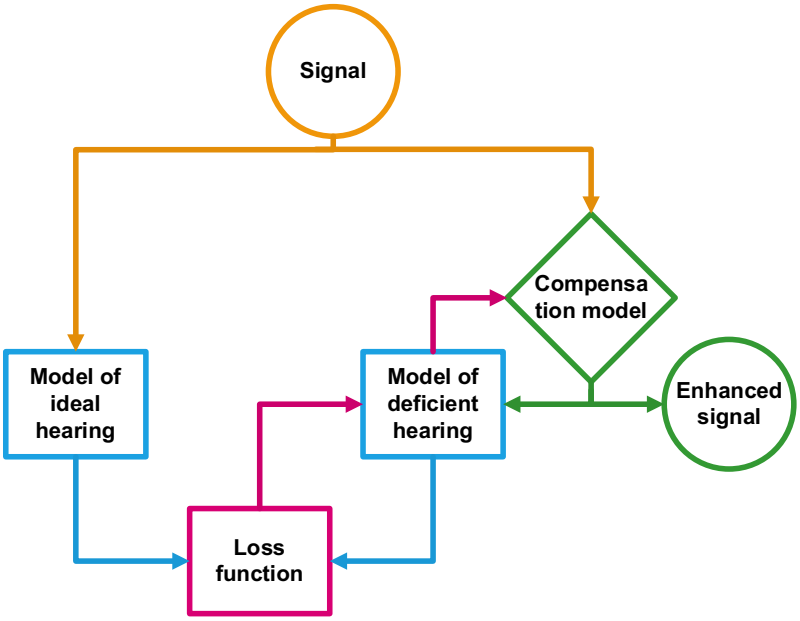
Improved Audio-Visual Speech Inpainting
Mathematical Engineering, long Master thesis.
Mikkel Fjord Olsen and Dennis Grøndahl Andersen.

Research in Focus

PhD project: Hearing loss compensation using computational models of hearing and deep learning

PhD student: Peter Asbjørn Leer Bysted
Start date: November 1st, 2020.
Company supervisor: Lars Bramsløw, Eriksholm Research Center, Oticon A/S.

Hearing loss is the inability to partially or totally hear and is a very common disease affecting over than 1 billion people, although there is a large disparity in how hearing loss can manifest in different patients, leading to a large variation in intervention outcomes. In the recent years computational models describing the auditory system have emerged, enabling researchers to explain the intricacies of human hearing, but it is unclear how these findings can be leveraged for hearing loss compensation in hearing assistive devices. Concurrently with the development of computational auditory models, neural networks have seen a major resurgence, solving a wide variety of complex problems. While the application of neural networks for various speech enhancement applications are a very active research area, using them for hearing loss compensation is an essentially unexplored research field.



The main idea of the project is to use computational auditory models to generate representations of speech in the inner auditory domain, e.g., at the auditory nerve level. In particular, the input speech signal in question is passed through two different computational auditory models, one that represents a normal auditory system and the other that represents a "hearing-impaired" auditory system, which can be parameterized as a function of various physiological or psychoacoustic measures. The resulting signals can be seen as abstractions of the auditory nerve signal activity for a normal and a deficient auditory system.

We hypothesize that a deep learning based hearing loss compensation strategy can be developed, by training deep learning based compensation models, which aim to process the input signal in such a way that the resulting auditory nerve signal is as close as possible – as measured by a loss function to be derived in the project - to the auditory nerve signal of the "normal hearing" computational auditory model. The overall goal of the project is to explore variants of this approach in the hope that this would lead to novel signal processing strategies and improved hearing loss compensation algorithms for hearing aid systems.

News

(From left to right) PhD researchers Mohammad Bokaei, Andreas J. Fuglsig, Payam Baboukani, and Professor Zheng-Hua Tan attended the International Conference on Acoustics, Speech, and Signal Processing (ICASSP), which was held in Singapore, May 22 – 27, 2022.

PhD researcher Juan Felipe Montesinos Garcia from Pompeu Fabra University in Barcelona is visiting CASPR from March to June, 2022. Juan's research is in the area of audio-visual analysis and will be working on audio-visual inpainting, while visiting CASPR.

Former CASPR postdoc Iván López-Espejo has received a prestigious European Union MSCA PF Fellowship grant. The project, which is a collaboration between University of Texas at Dallas (UTD) and Aalborg University, is entitled "A Giant Leap for Keyword Spotting" and is mentored by Prof. John Hansen, UTD and Profs. Zheng-Hua Tan and Jesper Jensen, CASPR, AAU.

PhD researcher Andreas J. Fuglsig presented his work: "Joint Far- and Near-End Speech Intelligibility Enhancement based on the Approximated Speech Intelligibility Index", at ICASSP 2022.

PhD researcher Payam Baboukani presented his work: "A Stimuli-Relevant Directed Dependency Index for Time Series", at ICASSP 2022.

Prof. Zheng-Hua Tan gave an invited talk entitled "Self-Supervised Learning: Training Targets and Loss Functions" and co-moderated a panel on "Data Science Education: The Signal Processing Perspective" at ICASSP 2022, Singapore, May 22-27, 2022.

Industrial Postdoc Daniel Michelsanti gave an invited talk on Audio-Visual Speech Processing at the Future Sound Forum meeting organized by Danish Sound Cluster on May 4, 2022 in Copenhagen,Denmark.

Prof. Zheng-Hua Tan is appointed as a member of the IEEE Signal Processing Society Conferences Board for the term 2022-2024. He is also a member of the IEEE Signal Processing Society Technical Directions Board.

PhD researcher Peter Asbjørn presented his work: "A neural network framework for modelling parameterized auditory models", at the Baltic Nordic Acoustic Meeting (BNAM) in Aalborg, May 2022.

PhD researcher Adele Simon presented her work on:

- "Cortical auditory attention decoding: differences between speech and music listening" at the 6th International Conference on Cognitive Hearing Science for Communication.
- "Optimal latencies for linear cortical auditory attention detection: differences between speech and music listening" at the 19th International Symposium on Hearing.
- "Electrode selection for cortical auditory attention decoding with EEG during speech and music listening" at the 25th International Conference on Information Fusion.

Students at AAU supervised by CASPR staff successfully defended their theses in June 2022:

Holger Severin Bovbjerg, Yuheng Wang, Claus Meyer Larsen, Kristian Søgaard, Rasmus Lykke Vestergaard, Simone Birk Bols Thomsen, Mikkel Fjord Olsen, and Dennis Grøndahl Andersen.

Recent CASPR Related Research

Journal papers

1. Speech to noise ratio improvement induces nonlinear parietal phase synchrony in hearing aid users. P.S. Baboukani, C. Graversen, E. Alickovic, J. Østergaard. Frontiers in Neuroscience, August 2022.
2. Incremental Refinements and Multiple Descriptions with Feedback. Østergaard, J., Erez, U. & Zamir, R., 2022. Accepted for publication in IEEE Transactions on Information Theory.
3. The Minimum Overlap-Gap Algorithm for Speech Enhancement. P. Hoang, Z.-H. Tan, J. M. de Haan, J. Jensen. IEEE Access, pp. 14698-14716, Vol. 10, 2022.
4. Deep Spoken Keyword Spotting: An Overview. I. López-Espejo, Z.-H. Tan, J. Hansen, and J. Jensen. IEEE Access, pp.4169-4199, Vol.10, 2022.
5. Multichannel Speech Enhancement with Own Voice-Based Interfering Speech Suppression for Hearing Assistive Devices. P. Hoang, J. M. de Haan, Z.-H. Tan, and J. Jensen. IEEE Trans. Audio, Speech, Language Process., pp. 706-720, Vol. 30, Jan 2022.
6. A Family of Split Kernel Adaptive Filtering Algorithms for Nonlinear Stereophonic Acoustic Echo Cancellation. S. Burra, S. Sankar, A. Kar, J. Østergaard. Journal of Ambient Intelligence and Humanized Computing, 2022. 41, 2, pp. 1019–1037.
7. A Family of Adaptive Volterra Filters Based on Maximum Correntropy Criterion for Improved Active Control of Impulsive Noise. G. Guttikonda, S. Burra, A. Kar, J. Østergaard, P. Sooraksa, V. Mladenovic, B.D. Haddad. Systems and Signal Processing, 2022, 41, 2, pp. 1019 – 1037.
8. Performance of Low Complexity Fully Connected Neural Networks for Monoaural Speech Enhancement. H. Reddy, A. Kar, J. Østergaard. Applied Acoustics, 2022. Accepted.
9. Training Data-Driven Speech Intelligibility Predictors on Heterogeneous Listening Test Data. M. B. Pedersen, A. H. Andersen, S. H. Jensen, Z.-H. Tan and J. Jensen. IEEE Access, vol. 10, pp. 66175-66189, 2022.
10. iVAE-GAN: Identifiable VAE-GAN Models for Latent Representation Learning. *IEEE Access*, vol. 10, pp. 48405-48418, 2022.

Conference Papers

1. Model-Based Estimation of In-Car-Communication Feedback Applied to Speech Zone Detection. K. Müller, S. Doclo, J. Østergaard and T. Wolff. Accepted for IWAENC 2022.
2. A linear MMSE filter using delayed remote microphone signals for speech enhancement in hearing aid applications. V. Sathyapriyan, M.S. Pedersen, J. Østergaard, M. Brookes, P.A. Naylor and J. Jensen. Accepted for IWAENC 2022.
3. Distributed Cross-Relation-Based Frequency-Domain Blind System Identification using Online-ADMM. M. Blochberger, F. Elvander, R. A., M. Moonen, J. Østergaard, J. Jensen and T. Waterschoot. Accepted for IWAENC 2022.
4. Performance of Low Frequency Sound Zones Based on Truncated Room Impulse Responses. J. Cadavid, M.B. Møller, S. Bech, T. Waterschoot and J. Østergaard. Accepted for Audio Mostly 2022.
5. A neural network framework for modelling parameterized auditory models, P. A. L. Bysted, J. Jensen, Z.-H. Tan, J. Østergaard, L. Bramsløw, Proc. Baltic Nordic Acoustic Meeting (BNAM) 2022 – Joint Acoustics Conference, May 2022.
6. Effect of Wireless Transmission Errors on Sound Zone Performance at Low Frequencies. Pedersen, C. S., Møller, M. B. & Østergaard, J. Presented at EUROREGIO BNAM2022 Joint Acoustic Conference.
7. Electrodes selection for cortical auditory attention decoding during speech and music listening. Simon, A. M. D., Bech, S., Loquet, G. S. J. M. & Østergaard, J., 2022, Proceedings Fusion Conference. (International Conference on Information Fusion Proceedings).
8. Optimal time lags for linear cortical auditory attention detection: differences between speech and music listening. Simon, A. M. D., Østergaard, J., Bech, S. & Loquet, G. S. J. M., 2022, Proceedings International Symposium on Hearing.
9. The Effect of Fixed-point Arithmetic on Low Frequency Sound Zone Control. Koch, P. & Østergaard, J., maj 2022, EUROREGIO BNAM2022 Joint Acoustics Conference. s. 125-134 10 s.
10. Joint Far- and Near-End Speech Intelligibility Enhancement based on the Approximated Speech Intelligibility Index. A.J. Fuglsig, J. Østergaard, J. Jensen, L.S. Bertelsen, P. Mariager, Z.-H. Tan. IEEE International Conference on Acoustics, Speech, & Signal Processing (ICASSP), 2022.
11. A Stimuli-Relevant Directed Dependency Index for Time Series. P.S. Baboukani, S. Theodoridis, J. Østergaard. IEEE International Conference on Acoustics, Speech, & Signal Processing (ICASSP), 2022.
12. Sensory Evaluation of Spatially Dynamic Audiovisual Soundscenes: A review. P. Porysek, S. Bech, J. Francombe, J. Østergaard, S. Par. In Proc. 152nd AES Convention, 2022.
13. Adversarial Multi-Task Deep Learning for Noise-Robust Voice Activity Detection with Low Algorithmic Delay. C. M. Larsen, P. Koch and Z.-H. Tan. Interspeech 2022, Sept. 18-22, Incheon, Korea.

Contact CASPR

If you are interested in learning more about the research and teaching taking place in CASPR:

Check our webpage at: http://caspr.es.aau.dk

Reach out to Professor Jan Østergaard (jo@es.aau.dk), Professor Zheng-Hua Tan (zt@es.aau.dk), or Professor Jesper Jensen (jje@es.aau.dk).

Aalborg University (http://www.en.aau.dk/) is one of the leading Danish universities with campuses in Aalborg, Esbjerg and Copenhagen. The student population of AAU comprises of around 20.000 regular (both undergraduate and postgraduate) students and 900 PhD students. AAU is famous for its innovative problem and project based learning approach (PBL) where students work on team-based projects solving 'real-life' problems in collaboration with organisations or companies. Aalborg University is acknowledged for collaboration with industry and according to U.S. News & World Report, Aalborg University is the best Engineering University in Europe and the fourth best worldwide.