# NEWSLETTER

## Centre for Acoustic Signal Processing Research (CASPR)

**August 2021**

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.

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Department of Electronic Systems
Section on Artificial Intelligence & Sound
Aalborg University
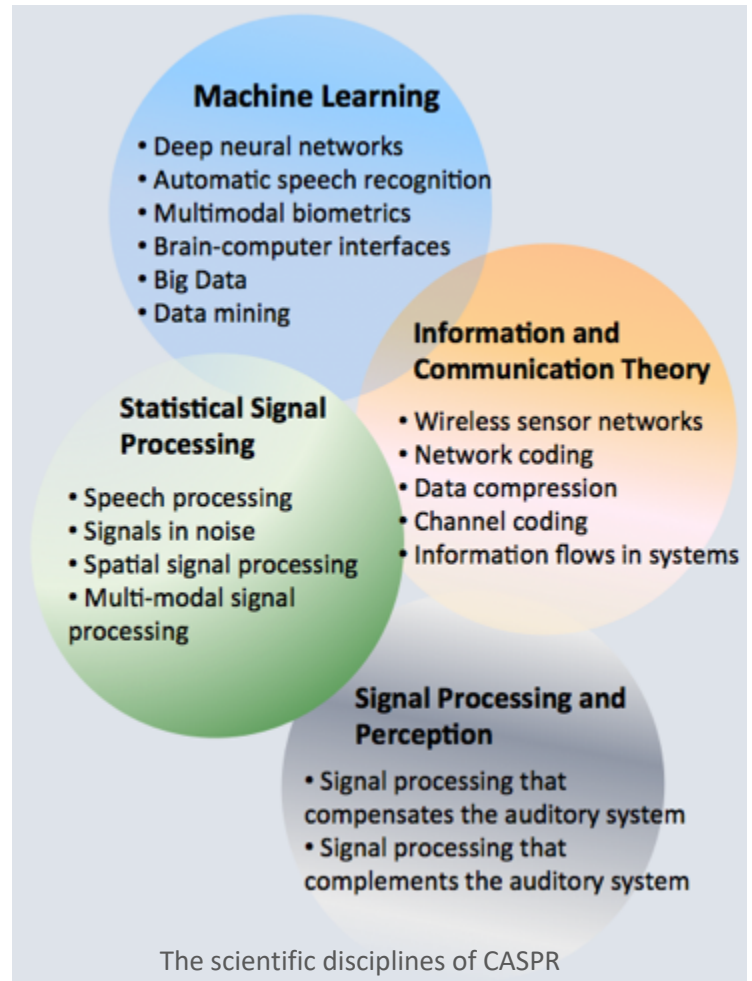
# Research in CASPR

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.

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.

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.



**Machine Learning**
- Deep neural networks
- Automatic speech recognition
- Multimodal biometrics
- Brain-computer interfaces
- Big Data
- Data mining

**Information and Communication Theory**
- Wireless sensor networks
- Network coding
- Data compression
- Channel coding
- Information flows in systems

**Statistical Signal Processing**
- Speech processing
- Signals in noise
- Spatial signal processing
- Multi-modal signal processing

**Signal Processing and Perception**
- Signal processing that compensates the auditory system
- Signal processing that complements the auditory system

The 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, PhD course.
- Deep learning, PhD course.
- CASPR Summer School on Signal Processing for Hearing Assistive Devices.

**CASPR is currently involved in 5 student projects:**

*Project 1*
Self-Supervised Deep Learning of Representations with Application to Speech Classification.
Signal Processing and Acoustics, long Master thesis project.
Bjørn Uttrup Dideriksen and Kristoffer Calundan Derosche

*Project 2*
Predictability-Based Objective Evaluation of Sound.
Mathematical Engineering, long thesis project with Oticon A/S.
Thor Pilgaard Knudsen

*Project 3*
Fourier Neural Operators for Virtual Microphones in the Time Domain.
Mathematical Engineering, 8th Semester project with B&O A/S.
Kristian Søgaard, Simone Birk Bols Thomsen, Martin Voigt Vejling.

*Project 4*
Bias-free DNNs for speech enhancement.
Signal Processing and Acoustics, thesis project with Oticon A/S.
James Peter Harris and Jakob Krarup Thomsen.

*Project 5*
Analysis of Scale-Invariance in EEG Microstates due to Acoustic Stimuli.
Mathematical Engineering, long thesis project.
Rasmus Lykke Vestergaard.

On May 17-21, 2021, CASPR organized the online CASPR Summer School on Signal Processing for Hearing Assistive Devices.

Around 38 participants were enrolled in the Summer School, with participant affiliations equally divided between industry (hearing aids, head sets, communication, etc) and university (Denmark, Czech Republic, Italy, The Netherlands, UK).

The Summer School consisted of lectures by invited experts, lectures by CASPR staff, and theoretical/practical exercises.

Lectures covered topics such as basic auditory perception, fundamental signal processing problems in hearing assistive devices and state-of-the-art solutions (hearing loss compensation, beamforming, feedback cancellation, etc.) and emerging topics (audio-visual methods, EEG-based methods, personalization, listening effort, etc.).
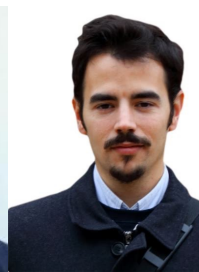
Dr. Carina Graversen, AAU.

Dr. Dorothea Wendt, Eriksholm / Oticon

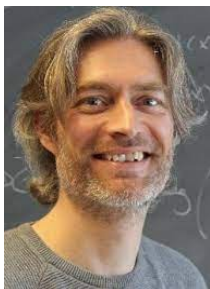Dr. Asger H. Andersen, Oticon

Poul Hoang, Oticon/AAU.

Dr. Iván López Espejo, AAU.

Payam Shahsavari, AAU.

Andreas Fuglsig, RTX/AAU
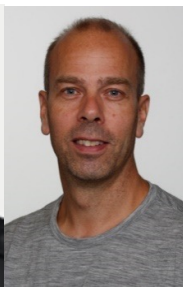
Prof. Jan Østergaard, AAU.

Dr. Johannes Zaar, Eriksholm /Oticon

Dr. Daniel Michelsanti, Oticon/AAU.

Dr. Meng Guo, Oticon.

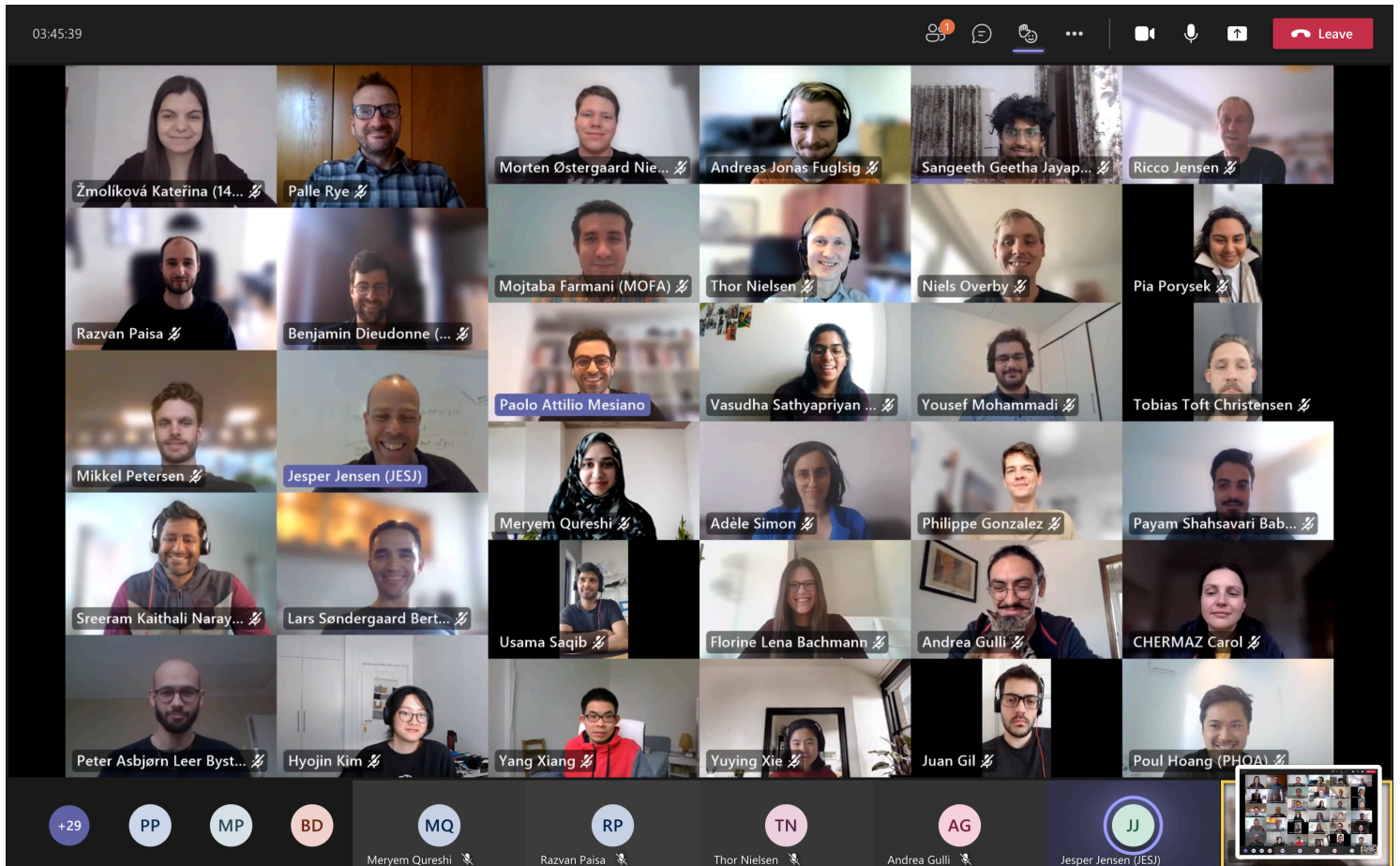Prof. Jesper Jensen, AAU / Oticon.

Prof. Zheng-Hua Tan, AAU.

Morten Østergaard Nielsen, AAU

Lecturers in the 2021 CASPR Summer School on Signal Processing for Hearing Assistive Devices.

# CASPR 2021 Summer School
## The Lecturers



Participants in the 2021 CASPR Summer School on Signal Processing for Hearing Assistive Devices.

# NEWS

Daniel Michelsanti, Dong Yu, Zheng-Hua Tan, and Jesper Jensen gave a tutorial lecture on Audio-Visual Speech Enhancement and Separation Based on Deep Learning at the International Conference on Acoustics, Speech, and Signal Processing (ICASSP), June 2021.

Prof. Zheng-Hua Tan becomes a Member of IEEE Signal Processing Society Technical Directions Board (https://signalprocessingsociety.org/our-story/technical-directions-board) and Chair of the Machine Learning for Signal Processing Technical Committee (https://signalprocessingsociety.org/community-involvement/machine-learning-signal-processing/mlsp-tc-home) for the term of 2021-2022.

Prof. Zheng-Hua Tan will participate in The Pioneer Center for Artificial Intelligence, a new large research centre in Denmark focusing on artificial intelligence. The Center is to launch by the end of 2021 with funding from five foundations and participation of five universities. For details refer to the news article (in Danish).

A new industrial Postdoc project was initiated with Oticon A/S. The project is supported by Innovation Fund Denmark and Oticon A/S.

- Title of postdoc project: Vision-assisted Hearing Aid System
- Company: Oticon A/S.
- Postdoctoral fellow: Daniel Michelsanti



- PhD researcher Payam S. Baboukani presented his paper entitled "Estimation of Directed Dependencies in Time Series Using Conditional Mutual Information and Non-linear Prediction" at the EURASIP European Signal Processing Conference (EUSIPCO), March 2021.
- PhD researcher Poul Hoang presented his paper entitled "Joint Maximum Likelihood Estimation of Power Spectral Densities and Relative Acoustic Transfer Functions for Acoustic Beamforming" at the IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP) conference in June 2021.
- Visiting PhD researcher Giovanni Morrone presented his paper entitled "Audio-Visual Speech Inpainting with Deep Learning" at the IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP) conference in June 2021.

# Recent CASPR Related Research

**Conference Papers**

**Journal papers**

1. Advanced Dropout: A Model-free Methodology for Bayesian Dropout Optimization. J. Xie, Z. Ma, G. Zhang, J.-H. Xue, Z.-H. Tan and J. Guo. Accepted by IEEE Transactions on Pattern Analysis and Machine Intelligence, 2021.

2. Self-Segmentation of Pass-Phrase Utterances for Deep Feature Learning in Text-Dependent Speaker Verification. A. k. Sarkar and Z.-H. Tan. Accepted by Computer Speech & Language, 2021.

3. Vocal Tract Length Perturbation for Text-Dependent Speaker Verification with Autoregressive Prediction Coding. A. k. Sarkar, Z.-H. Tan. Accepted by IEEE Signal Processing Letters, 2021.

4. A Family of Adaptive Volterra Filters Based on Maximum Correntropy Criterion for Improved Active Control of Impulse Noise. G. Guttikonda, S. Burra, A. Kar, J. Østergaard, P. Sooraksa, V. Mladenovics, D. Haddad. Accepted for publication in Elsevier Circuits, Systems, and Signal Processing, 2021.

5. Multiple Sub Filter Based Proportionate Filtering for Nonlinear Acoustic Echo Cancellation. V. Burra, A. Kar and J. Østergaard. Accepted for publication in Journal of Applied Acoustics, 2021.

6. An Overview of Deep-Learning-Based Audio-Visual Speech Enhancement and Separation, D. Michelsanti, Z.-H. Tan, S.-X. Zhang, Y. Xu, M. Yu, D. Yu, and J. Jensen. IEEE Trans. Audio, Speech, Language Process.Vol. 29, pp. 1368-1396, 2021.

7. Speech Intelligibility Prediction Using Spectro-Temporal Modulation Analysis, A. Edraki, W.-Y. Chan, J. Jensen, and D. Fogerty. IEEE Trans. Audio, Speech, Language Process. Vol. 29, pp. 210-225, 2021.

8. Directed Data-Processing Inequalities for Systems with Feedback. M. Derpich and J. Østergaard. Entropy, Vol.23., April 2021.

9. Minimum Processing Beamforming. A. Zahedi, M.S. Pedersen, J. Østergaard, T.U. Christiansen, L. Bramsløw, J. Jensen. IEEE Trans. Audio, Speech, Language Process., 2021.

1. A Spectro-Temporal Glimpsing Index (STGI) for Speech Intelligibility Prediction. A. Edraki, W.-Y. Chan, J. Jensen, and D. Fogherty, Proc. Interspeech, 2021, Accepted.

2. Audio-Visual Speech Inpainting with Deep Learning. G. Morrone, D. Michelsanti, Z.-H. Tan and J. Jensen. Proc. Int. Conf. Acoust., Speech, Signal Processing, June 2021.

3. Joint Maximum Likelihood Estimation Of Power Spectral Densities And Relative Acoustic Transfer Functions For Acoustic Beamforming. P. Hoang, Z.-H. Tan, J. M. de Haan, J. Jensen Proc. Int. Conf. Acoust., Speech, Signal Processing, 2021.

4. Auditory Attention Decoding During Naturalistic Music Listening: A Pilot Study. A. Simon, S. Bech, G. Loquet, J. Østergaard. Accepted for presentation at 16th International Conference on Music Perception and Cognition, 2021.

5. An Orthogonality Principle for Select-Maximum Estimation of Exponential Variables. U. Erez, J. Østergaard, R. Zamir. Accepted for presentation at IEEE International Conference on Information Theory (ISIT), 2021.

6. Low Delay Robust Audio Coding by Noise Shaping, Fractional Sampling, and Source Prediction. J. Østergaard. IEEE Data Compression Conference, March 2021.

7. UIAI System for Short-Duration Speaker Verification Challenge 2020. M. Sahidullah, A.K. Sarkar, V. Vestman, X. Liu, R. Serizel, T. Kinnunen, Z.-H. Tan, E. Vincent, Proc. of the 8th IEEE Spoken Language Technology Workshop (SLT 2021).