LEARNING MODULE DESCRIPTION

GENERAL INFORMATION

1. Module title: Active methods of noise reduction
2. USOS code: 04-S2AKas02-P07061
3. Term: winter
4. Duration:10 h
5. ECTS: 1
6. Module lecturer: Assoc. Prof. dr. (hab.) Jedrzej Kociński
7. E-mail: jedrzej.kocinski@amu.edu.pl
8. Language: English

DETAILED INFORMATION

1. Module aim (aims)
   This module aims to explore novel techniques in noise reduction, with a focus on digital signal processing. Students will gain an understanding of both classical and modern approaches, starting with single-sensor methods like spectral subtraction. The course will then progress to advanced multi-sensor techniques, including spatial filtering (beamforming), blind source separation, and cutting-edge methods utilizing machine learning. Through theoretical discussions and practical applications, students will develop the skills needed to address real-world challenges in noise reduction.

2. Pre-requisites in terms of knowledge, skills and social competences (where relevant)
   Signal processing methods (Fourier transform, impulse response, analog-to-digital conversion, etc.), mathematical methods (differentiation, integration, basics of statistics).

READING LIST

Aichner, R., H. Buchner, F. Yan i W. Kellermann (2006a). "A real-time blind source separation scheme and its application to reverberant and noisy acoustic environments." Signal Processing 86(6): 1260-1277.
Aichner, R., M. Zourub, H. Buchner i W. Kellermann (2006b). Residual Cross-talk and Noise Suppression for Convolutive Blind Source Separation. 32nd Annual German Conf. on Acoustics (DAGA), Braunschweig, Germany.
Amin, M. G. i Y. Zhang (2006). "Blind Separation of Nonstationary Sources Based on Spatial Time-Frequency Distributions." EURASIP Journal on Applied Signal Processing in press.
Back, A. D. i T. P. Trappenberg (2001). "Selecting Inputs for Modeling Using Normalized Higher Order Statistics and Independent Component Analysis." IEEE Trans. on Neural Networks 12(3).
Berouti, M., R. Schwartz i J. Makhcul (1979). Enhancement of Speech Corrupted by Acoustic Noise. IEEE Int. Conf. Acoust., Speech, Signal Process.
Boll, S. F. (1979). "Suppression of Acoustic Noise in Speech Using Spectral Substraction." IEEE Trans. Acoust. Speech Signal Process. ASSP-27(2): 113-120.
Choi, S., A. Cichocki i A. Belouchrani (2001). Blind separation of second-order nonstationary and temporallycolored sources. Statistical Signal Processing, 2001. The 11th IEEE Signal Processing Workshop.
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Ephraim, E. i D. Malah (1984). "Speech Enhancement Using a Minimum Mean-Square Error Short-Time Spectral Amplitude Estimator." IEEE Trans. Acoust., Speech, Signal Processing ASSP-32(6): 1109-1121.
Ephraim, E. i D. Malah (1985). "Speech Enhancement Using a Minimum Mean-Square Error Log-Spectral Amplitude Estimator." IEEE Trans. on Speech and Audio Processing. ASSP-33(2): 443-445.
Gävert, H., J. Hurri, J. Särelä i A. Hyvärinen (2001). FastICA.
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Parra, L. (1998). Temporal Models in blind source separation. Adaptive Processing of Sequences and Data Structure. L. Giles i M. Gori. Berili, Germany, Springer: 229-247.
Parra, L. i C. Spence (2000a). "Convolutive blind source separation of non-stationary sources. US Patent US6167417." IEEE Trans. on Speech and Audio Processing. 8(3): 320-327.
Parra, L. i C. Spence (2000b). "On-line Blind Source Separation of Non-Stationary Signals." Journal of VLSI Signal Processing 26(1/2): 39-46.
Pham, D. T., P. Garrat i C. Jutten (1992). Separation of a mixture of independent sources through a maximum likehood approach. EUSIPCO.

Pham, D.-T. (2001). "Joint Approximate diagonalization of positive definite matrices." SIAM J. on Matrix Anal. and Appl. 22(4): 1136-1152.
Pham, D.-T., C. Serviere i H. Boumaraf (2003). Blind separation of convolutive audio mixtures using nonstationarity. ICA 2003, Nara, Japan.
Saruwatari, H., K. Sawai, A. Lee, K. Shikano, A. Kaminuma i M. Sakata (2003). Speech enhancement and recognition in car environment using blind source separation and sobband elimination processiong. $th International Symposium an Independent Component and Blind Source Separation (ICA), Japan, Nara.
Scalart, P. i J. V. Filho (1996). "Speech enhancement based on a priori signal to noise estimation." IEEE International Conference on Acoustics, Speech, and Signal Processing 1: 629-632.
Wienstein, E., M. Feder i A. V. Oppenheim (1993). "Multi-channel signal separation by decorrelation." IEEE Trans. Speech Audio Proc. 1: 405-413.
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Zavarehei, E. (2005a). WienerScalart96.m.
Zavarehei, E. (2005b). MMSESTSA85.m.
Zavarehei, E. (2005c). SSBerouti79.m.
Zavarehei, E. (2005d). SSBoll79.m.
Zhang, X. i C. H. Chen (2002). "New independent component analysis method using higher order statistics with application to remote sensing images." Optical Engineering 41(7): 1717-1728.

SYLLABUS:
Week 1: Methods for Improving a Signal-to-Noise Ratio (SNR)
Week 2: "Classical" Noise Reduction (denoising) part 1
Week 3: "Classical" Noise Reduction (denoising) part 2
Week 4: Beamforming and Blind Source Separation
Week 5: Machine Learning and AI in signal processing, noise reduction and signal detection