PROCEEDINGS of the
23rd International Congress on Acoustics
9 to 13 September 2019 in Aachen, Germany

Phase-magnitude relations and phaseless reconstruction for time-frequency and time-scale representations

Nicki Holighaus[(1)], Zdeněk Průša[(2)], Günther Koliander[(1)]

[(1)]Acoustics Research Institute, Austrian Academy of Sciences, Austria, {nicki.holighaus,guenther.koliander}@oeaw.ac.at
[(2)]Lewitt GmbH, Austria, zdenek.prusa@oeaw.ac.at

Abstract

It is widely accepted that the phase and magnitude components of redundant time-frequency and time-scale representations are not independent and carry equally important information. For the short-time Fourier and wavelet transforms with an appropriate mother wavelet, this dependence can be made explicit in the so-called phase-magnitude (PM) relations. More explicitly, the PM relations establish a one-to-one mapping from the gradient of the logarithmic magnitude of the transform to the gradient of its phase. The PM relations for the short-time Fourier transform were previously studied by Portnoff and later rediscovered by Auger et al. Recently, we showed that similar relations hold for wavelet transforms as well. In both cases, the PM relations can be employed to enable signal reconstruction from magnitude-only transform coefficients by combining them with an adaptive integration scheme. The resulting algorithms often perform on par or better than more expensive, iterative algorithms for phaseless reconstruction. We demonstrate their application in the audio domain. Based on joint work with Luis Daniel Abreu, Peter Balazs, Pavel Rajmic and Peter L. Søndergaard

Keywords: audio processing, phaseless reconstruction, time-frequency

ACKNOWLEDGEMENTS

This work was supported by the Austrian Science Fund (FWF): Y 551-N13, I 3067-N30, and P 31225-N32 and the Vienna Science and Technology Fund (WWTF): MA16-053.

REFERENCES

[1] R. Alaifari, I. Daubechies, P. Grohs, and G. Thakur. Reconstructing real-valued functions from unsigned coefficients with respect to wavelet and other frames. *J. Fourier Anal. Appl.*, 23(6):1480–1494, Dec. 2017.

[2] G. Ascensi and J. Bruna. Model space results for the Gabor and wavelet transforms. *IEEE Trans. Inf. Theory*, 55(5):2250–2259, May 2009.

[3] F. Auger, E. Chassande-Mottin, and P. Flandrin. On phase-magnitude relationships in the short-time Fourier transform. *IEEE Signal Process. Lett.*, 19(5):267–270, May 2012.

[4] D. Griffin and J. Lim. Signal estimation from modified short-time Fourier transform. *IEEE Trans. Acoust., Speech, Signal Process.*, 32(2):236–243, Apr. 1984.

[5] N. Holighaus, G. Koliander, Z. Pruša, and L. D. Abreu. Characterization of analytic wavelet transforms and a new phaseless reconstruction algorithm. *to appear in IEEE Trans. Sig. Proc*, 2019.

[6] J. Le Roux, H. Kameoka, N. Ono, and S. Sagayama. Fast signal reconstruction from magnitude STFT spectrogram based on spectrogram consistency. In *Proc. 13th Int. Conf. on Digital Audio Effects (DAFx-10)*, pages 397–403, Sept. 2010.

[7] S. Mallat and I. Waldspurger. Phase retrieval for the Cauchy wavelet transform. *J. Fourier Anal. Appl.*, 21(6):1251–1309, Dec. 2015.

[8] A. Marafioti, N. Holighaus, N. Perraudin, and P. Majdak. Adversarial generation of time-frequency features with application in audio synthesis. In *Proceedings of the International Conference on Machine Learning (ICML, to appear); arXiv preprint arXiv:1902.04072*, Long Beach, USA, 2019.

[9] N. Perraudin, P. Balazs, and P. L. Sondergaard. A fast Griffin-Lim algorithm. In *Proc. IEEE Appl. Sig. Process. Audio Acoustics*, New Paltz, NY, USA, Oct. 2013.

[10] M. R. Portnoff. Magnitude-phase relationships for short-time Fourier transforms based on Gaussian analysis windows. In *Proc. IEEE Int. Conf. Acoust. Speech Signal Process.*, volume 4, pages 186–189, Washington, D. C., USA, Apr 1979.

[11] Z. Průša. The Phase Retrieval Toolbox. In *AES International Conference On Semantic Audio*, Erlangen, Germany, June 2017.

[12] Z. Průša, P. Balazs, and P. L. Søndergaard. A noniterative method for reconstruction of phase from STFT magnitude. *IEEE Audio, Speech, Language Process.*, 25(5), May 2017.

[13] Z. Průša and N. Holighaus. Non-iterative filter bank phase (re)construction. In *Proc. Eur. Signal Process. Conf. EUSIPCO*, pages 952–956, Kos island, Greece, Aug. 2017.

[14] Z. Průša and N. Holighaus. Phase vocoder done right. In *Proc. Eur. Signal Process. Conf. EUSIPCO*, pages 1006–1010, Kos island, Greece, Aug. 2017.

[15] Z. Průša and P. Rajmic. Toward high-quality real-time signal reconstruction from STFT magnitude. *IEEE Signal Process. Lett.*, 24(6):892–896, June 2017.

[16] Z. Průša and P. L. Søndergaard. Real-time spectrogram inversion using phase gradient heap integration. In *Proc. Int. Conf. Digital Audio Effects*, Brno, Czech Republic, Sept. 2016.

[17] Z. Průša and N. Holighaus. Phase vocoder done right. In *Proc. Eur. Signal Process. Conf. EUSIPCO*, pages 976–980, Kos island, Greece, Aug. 2017.

[18] N. Sturmel and L. Daudet. Signal reconstruction from STFT magnitude: A state of the art. In *Proc. Int. Conf. Digital Audio Effects*, pages 375–386, Paris, France, Sept. 2011.

[19] I. Waldspurger. Phase retrieval for wavelet transforms. *IEEE Trans. Inf. Theory*, 63(5):2993–3009, May 2017.