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Passive amplification approach to real-time recovery of noise-dominated isolated signals

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We present a comprehensive technique for single-shot recovery of arbitrary signals corrupted by noise. The concept relies on temporal and spectral phase manipulations derived from the Talbot effect, namely discrete level temporal phase modulation and group velocity dispersion. The process transforms an isolated waveform into a series of peaks which follow the envelope of the input waveform amplified by a designed integer amount, either in its time domain or frequency domain representation. It is akin to the Talbot Array Illuminator (TAI), which was first used in the spatial domain to transform a uniform wavefront into an array of bright spots [1], with applications such as for power supply in optical parallel processor or for integrated circuit illumination. Recently, these concepts have been brought to the temporal domain (Temporal Talbot Array Illuminator, T-TAI) for CW-to-pulse conversion [2] and temporal cloaking [3], as well as in the spectral domain (Spectral Talbot Array Illuminator, S-TAI) for broadband invisibility cloaking [4].

In this work, we exploit the particularity that the TAI process preserves the shape of a varying signal. Additionally, since it heavily relies on the phase coherence of the signal of interest, the coherent signal is effectively amplified, while the incoherent, stochastic noise is left virtually untouched. This denoising effect can be implemented either in the temporal domain or in the spectral domain. When implemented in the temporal domain, the T-TAI effectively implements a loss-less temporal sampling process, focusing the energy of the input waveform into peaks with an envelope that follows the input waveform. It can be interpreted as a sliding average process, and as such, has proven impressive performance for ultra-narrowband (down to 200 kHz) waveform recovery [5]. In its spectral implementation, it performs a similar process, but in the spectral domain. Thus, the spectral representation of the waveform is reshaped into a series of peaks, and this implementation has shown to be a unique approach for in-band noise mitigation [6] (e.g., noise that is within the bandwidth of the signal itself). The S-TAI and T-TAI methods thus represent a generalized approach for the recovery of weak noisy signals.

References

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