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Reconstruction of Noisy Superoscillations Based on Machine Learning

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Superoscillations are band-limited signals with a counterintuitive property. Superoscillating signals can vary arbitrarily faster than their fastest spectral component [1]. Superoscillations exist during limited time intervals, and their amplitude is small compared to the signal components with the frequencies inside the bandwidth [2],[3]. Superoscillations attract high interest in various scientific and engineering areas: quantum mechanics, signal processing, subwavelength imaging, and optics (see, for instance, [1] and references therein).
However, the superoscillation amplitude is usually tiny compared to the typical amplitude values in non-super oscillating regions.
The near-perfect coherent destructive interference constructs such small values among the function's spectral components. For large superoscillations, persisting over a vast region requires an exact relationship of phases. Such interference is noise-sensitive, especially in the form of random phases in the Fourier components [4].
In this work, we applied machine learning algorithms such as Gaussian process regression(GPR) and Recursive Neural Networks to reconstruct the noised superoscillatory signals. We have shown that noisy superoscillatory signals can be perfectly reconstructed by using these algorithms. In addition, the same algorithms can be used to generate various superoscillatory signals.

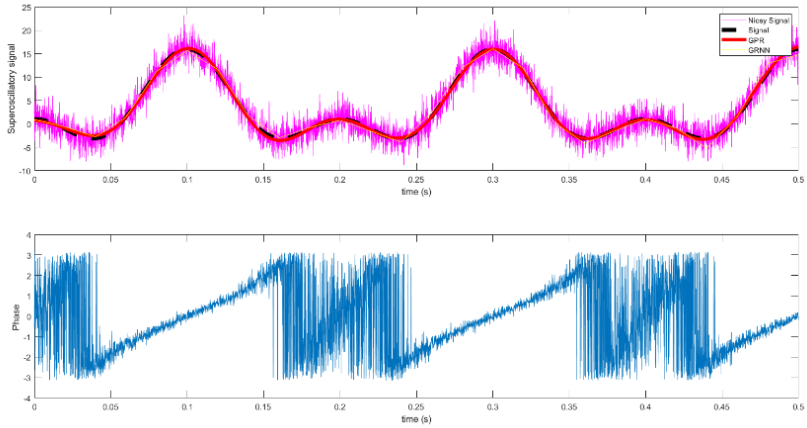

Figure 1. Upper box – original noisy and reconstructed signals based on GPR and RNN, lower box – the phase of the noisy signal

Original, noisy and reconstructed superoscillatory signals are presented in the upper box of Figure 1. The lower box presents the noisy phase of the superoscillatory signal.

Keywords: superoscillation, optical communication, digital signal processing, machine learning, Gaussian process regression, Recursive Neural Networks

References

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