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Generalization of the Wigner Distribution Function: Sampling Analysis, Numerical Computation, and Applications

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摘 要: The Wigner distribution function (WDF) is a well-established time–frequency analysis tool widely used in the areas of signal processing and optics. It can interpret diverse systems geometrically such as the Fourier, fractional Fourier or linear canonical transforms. It is also important for analyzing non-stationary signals such as linear frequency modulated (LFM) signals and Newton’s rings in optics. In recent years, to extend its applications, numerous novel time-frequency distributions have been proposed by combining the WDF and linear canonical transform. Among them, the Bai distribution function (BDF) and its generalized form are notable. The BDF can interpolate between the instantaneous auto-correlation function and the WDF, and its generalized form can provide improved resilience to noise in LFM signal detection. However, these two transformations are currently defined only for continuous signals, and the signals in simulations and experiments are discrete. Therefore, to enable their practical applications, their discrete formulations, numerical calculation algorithms and corresponding sampling analysis are investigated using phase space diagrams (PSDs). Based on these results, the BDF and its generalization are applied to estimate the Newton’s ring’s parameter in optical experiment, which can be applied in applications such as lens curvature measurement.

个人简介: Yushi Zheng was born in Tianjin, China in 1997. He was awarded the bachelor’s and master’s degrees in Electrical and Electronic Engineering from the Liverpool University and University College London in 2020 and 2021. He has been an PhD student in the Electrical and Electronic Engineering in UCD since 2022. He is the president of the SPIE UCD student Chapter and a member of the Optica UCD student chapter. His work is the area of computational optics, phase space analysis and time-frequency distributions.