High-Accuracy Parameter Estimation for Damped Signal via Three Weighted DFT Samples

Haitao Xu

Northwestern Polytechnical University

Ying Du

Northwestern Polytechnical University

Shengxi Zhou (✉ zhoushengxi@nwpu.edu.cn)

Research & Development Institute in Shenzhen, Northwestern Polytechnical University, Shenzhen, 518057, PR China <https://orcid.org/0000-0002-4034-193X>

Hongwei Fan

Xi'an University of Science and Technology

Xuhui Zhang

Xi'an University of Science and Technology

Original Article

Keywords: Parameter estimation, discrete Fourier transform, Crámer-Rao lower bound, symmetric windows, asymmetric windows

Posted Date: June 12th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-579724/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Recently, accurate parameter estimation of the damped complex exponential plays an increasingly important role in the field of precise measurement. However, the estimation variance of interpolation-based algorithms for the parameter estimation cannot be asymptotic to the Crámer-Rao lower bound (CRLB). This paper originally proposes a generalized, fast, and the accurate two-iteration estimator (TIE) based on the discrete Fourier transform (DFT). It can be operated by an arbitrary window (symmetric or asymmetric window). Theoretical estimation variances of the frequency and the damping factor for arbitrary windows are derived, respectively. Furthermore, extensive computer simulations are performed to compare the performance of the TIE with other state-of-the-art algorithms in the literature. The results support the theoretical findings and verify that high-accuracy parameter estimation can be ensured by the proposed algorithm. More importantly, the estimation variances returned by the TIE with the rectangle window exactly track the CRLB for a damped single tone.

Full-text

Due to technical limitations, full-text HTML conversion of this manuscript could not be completed. However, the manuscript can be downloaded and accessed as a PDF.

Figures

Figure 1

please see the manuscript file for the full caption

Figure 2

please see the manuscript file for the full caption

Figure 3

please see the manuscript file for the full caption

Figure 4

The curve of windows.

Figure 5

please see the manuscript file for the full caption

Figure 6

please see the manuscript file for the full caption

Figure 7

The expectation of the estimation error when the rectangle window is used: (a) Frequency estimation; (b) damping factor estimation.

Figure 8

The expectation of the estimation error when the Hann window is used: (a) Frequency estimation; (b) damping factor estimation.

Figure 9

please see the manuscript file for the full caption

Figure 10

The expectation of the estimation error when the Hann-T window is used: (a) Frequency estimation; (b) damping factor estimation.

Figure 11

The expectation of the estimation error when the Hamming-T window is used: (a) Frequency estimation; (b) damping factor estimation.

Figure 12

The expectation of the estimation error when the Blackman-T window is used: (a) Frequency estimation; (b) damping factor estimation.

Figure 13

please see the manuscript file for the full caption

Figure 14

The ratio of the MSE to the CRLB versus the damping factor for symmetric windows under SNR = 5 dB:
(a) Frequency estimation; (b) damping factor estimation.

Figure 15

please see the manuscript file for the full caption

Figure 16

please see the manuscript file for the full caption

Figure 17

The ratio of the MSE to the CRLB versus the damping factor for asymmetric windows under SNR = 5 dB:
(a) Frequency estimation; (b) damping factor estimation.

Figure 18

The ratio of the MSE to the CRLB versus the SNR : (a) Frequency estimation; (b) damping factor estimation.

Figure 19

The RMSE versus the frequency difference under SNR = 38 dB : (a) Frequency estimation; (b) damping factor estimation.

Figure 20

The RMSE versus the damping factor difference under SNR = 38 dB : (a) Frequency estimation; (b) damping factor estimation.

Figure 21

The RMSE versus the amplitude ratio under SNR = 38 dB : (a) Frequency estimation; (b) damping factor estimation.

Figure 22

The RMSE versus the SNR : (a) Frequency estimation; (b) damping factor estimation.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [S1.jpg](#)