



Discrete Quaternion Quadratic Phase Fourier Transform

Mohra Zayed¹ · Aamir H. Dar^{2,3} · M. Younus Bhat³

Received: 12 August 2024 / Accepted: 24 February 2025

© The Author(s), under exclusive licence to Springer Nature Switzerland AG 2025

Abstract

As a novel addition to the family of integral transforms, the quadratic phase Fourier transform (QPFT) embodies a variety of signal processing tools, including the Fourier transform (FT), fractional Fourier transform (FRFT), linear canonical transform (LCT), and special affine Fourier transforms. Due to its additional degrees of freedom, QPFT performs better in applications than other time-frequency analysis methods. Recently, quaternion quadratic phase Fourier (QQPFT), an extension of the QPFT in quaternion algebra, has been derived and since received noticeable attention because of its expressiveness and grace in the analysis of multi-dimensional quaternion-valued signals and visuals. To the best of our knowledge, the discrete form of the QQPFT is undefined, making it impossible to compute the QQPFT using digital techniques. It initiated us to introduce the two-dimensional (2D) discrete quaternion quadratic phase Fourier (DQQPFT) that is analogous to the 2D discrete quaternion Fourier transform (DQFT). Some fundamental properties are obtained, including Modulation, the reconstruction formula, and the Plancherel theorem of the 2D DQQPFT. Crucially, the fast computation algorithm and convolution theorem of 2D DQQPFT, which are essential for engineering applications, are also considered. Finally, we present an application of the DQQPFT to study the two-dimensional discrete linear time-varying systems.

Communicated by Tao Qian.

✉ Aamir H. Dar
ahdkul740@gmail.com

Mohra Zayed
mzayed@kku.edu.sa

M. Younus Bhat
gyounusg@gmail.com

¹ Mathematics Department, College of Science, King Khalid University, 61413 Abha, Saudi Arabia

² Mehta Family School of Data Science & Artificial Intelligence Indian Institute of Technology Guwahati, 781039 Guwahati, India

³ Department of Mathematical Sciences, Islamic University of Science and Technology, 192122 Kashmir, India