Fourier Analysis in Optical Coherence Tomography

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Fourier analysis is a powerful Linear operator used to analyze signals and extract valuable information within physics. We use it in almost every branch of Physics, such as in Optical coherence tomography (OCT). In this study, we take four different approaches and compare them to find a more accurate peak than originally given with the Discrete Fast Fourier Transorm (DFFT) . We simulate discrete input signals and employ the DFFT to transform them into the frequency domain. To accurately identify the true peak of the signal, we explore four interpolation methods, namely: quadratic, barycentric, Quinn's 2nd method, and Jain's method. Our findings reveal that while quadratic and barycentric methods are straightforward, they are less precise compared to the other two techniques. We also find that all methods except for the Quadratic are discontinuous . These results underscore the importance of selecting appropriate interpolation methods to achieve accurate peak estimation in Fourier analysis.

I. INTRODUCTION

OCT has revolutionized imaging in the field of nanomaterials. By employing low-coherence light on a surface which after modulation provides high-resolution cross-sectional imaging. This Enables detailed visualization of microstructures. One of the key components of OCT signal processing is the application of the Fourier Transform. [1]

The Fourier Transform allows us to decompose complex signals into their frequency components, providing valuable information about the depth-resolved structural characteristics of the imaged tissue. In OCT, the FFT is employed to extract the spectral interference information, which is then transformed back into the spatial domain for image reconstruction.

However, a critical challenge in Fourier analysis within OCT lies in accurately estimating the peaks obtained from the FFT. These peaks represent the specific frequencies corresponding to the scattering events within the tissue. Estimating these peaks with high precision is essential for quantitative analysis, such as measuring tissue thickness, identifying pathological features, and monitoring dynamic processes.

In this study, we focus on the interpolation methods employed to determine the true peaks in the FFT of OCT signals. Specifically, we compare four interpolation techniques: quadratic, barycentric, Quinn's 2nd method, and Jain's method. By evaluating the performance of these methods, we aim to identify the most accurate and reliable approach for peak estimation.

The significance of this research lies in its potential impact on enhancing the accuracy and reliability of OCT imaging. Accurate peak estimation can provide valuable insights into tissue properties, and dynamic processes. Furthermore, understanding the strengths and limitations of different interpolation methods can guide researchers in choosing appropriate techniques for their specific OCT applications.

II. THEORY

III. SETUP AND METHOD

IV. RESULTS

V. DISCUSSION

VI. CONCLUSIONS

[1] Pegah Asgari, Itir Bakiş Doğru Yüksel, Gerhard A. Blab, Hans C. Gerritsen, and Allard P. Mosk Sub-nanometer measurement of transient structural changes in dye-doped polystyrene microspheres https://arxiv.org/pdf/2209.00356.pdf **93**, 1 Sep (2022).