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MITIGATING THE GIBBS PHENOMENON IN SIGNAL APPROXIMATION VIA DEFERRED EULER SUMMABILITY

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Abstract. The Gibbs phenomenon, characterized by persistent overshoots near points of discontinuity in Fourier series approximations, poses a significant challenge in signal reconstruction and spectral analysis. Classical summability methods such as Cesàro and Euler means provide partial remedies by improving convergence behavior, but they often fail to fully suppress oscillations near sharp transitions. In this paper, we propose a novel summation approach termed deferred Euler summability, which introduces a delay parameter into the traditional Euler mean to enhance smoothing near discontinuities. We define the deferred Euler mean and establish its theoretical convergence properties for functions of bounded variation. Specifically, we prove pointwise and uniform convergence theorems and derive quantitative error bounds demonstrating superior mitigation of the Gibbs phenomenon. Numerical experiments on piecewise continuous signals, including the square wave function, illustrate the effectiveness of the proposed method in reducing overshoot and improving approximation fidelity. This framework offers a robust tool for high-precision signal processing applications where minimizing oscillatory artifacts is essential.

1. Introduction

Fourier series are widely used in mathematics, physics, and signal processing to represent periodic functions and approximate signals. However, when a function has jump discontinuities, the Fourier partial sums exhibit persistent oscillations near such points. This behavior, known as the *Gibbs phenomenon*, does not disappear even as the number of terms increases, leading to the failure of uniform convergence [1, 4, 9].

To reduce these oscillations, various summability methods have been developed. In particular, the Cesàro summation method replaces partial sums by their averages, while the Euler summation method uses weighted means to control oscillatory behavior [4]. These classical techniques significantly improve approximation near discontinuities.

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