Cost-Optimized FFT Algorithm Selection for Variable-Length Input in Low-Power Signal Processing Systems

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Abstract

This paper introduces an adaptive fast Fourier transform (FFT) algorithm selection framework tailored for input signals with variable lengths. The framework addresses the algorithmic rigidity of traditional FFT implementations by incorporating a dynamic zero-padding policy and a unified cost evaluation model that quantifies the trade-offs between computational complexity, memory usage, padding overhead, and transform fidelity. By integrating Radix-2, Radix-4, and Mixed-Radix implementations under a common selection scheme, the system enables flexible adaptation to diverse point sizes without compromising spectral accuracy. Furthermore, the framework supports a dual-mode operation: one targeting minimum padding overhead, and the other optimizing based on a weighted cost function. This dual-mode architecture allows system designers to prioritize either structure-constrained compatibility or holistic performance, thus making the proposed approach broadly applicable to scenarios where transform efficiency and numerical precision must be jointly considered across a wide range of signal lengths.

Keywords

Fast Fourier Transform, Cost Model, Algorithm Selection, Signal Processing.