A Parallel Application of the Fourier Transformation

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Abstract

A Fourier transform is a mathematical transform decomposing functions based on space and time into functions based on spatial or temporal frequency. The Fourier transform is denoted by adding a circumflex to the symbol of a function:

$$f \to \hat{f}$$

The Fourier transform is defined as:

$$\hat{f}(\xi) = \int_{-\infty}^{\infty} f(x) e^{-2\pi i x \xi} dx \tag{1}$$

Whereas the inverse Fourier transform is denoted as:

$$f(x) = \int_{-\infty}^{\infty} \hat{f}(\xi) e^{2\pi i x \xi} d\xi \tag{2}$$

Introduction

The Fourier Transform is an important mathematical concept. It has applications in digital signal processing, convolution in neural networks, image recognition and even speech processing. The main idea behind the Fourier Transform is that it is a "mathematical operation that changes the domain (x-axis) of a signal from time to frequency," [4].

Parallelization

There are a few different directions to explore when developing a more parallized implementation of the Fourier Transform. According to Anthony Blake in his thesis paper titled "Computing the Fast Fourier Transform on SIMD Microprocessors", use of the FFT algorithm is extremely widespread in multiple disciplines. He goes on to state that "use of the FFT is even more pervasive, and it is counted among the 10 algorithms that have had the greatest influence on the development and practice of science and engineering in the 20th century," [1]. Two methods of Parallelization that stand out in particular are SIMD, and multithreading.

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SIMD

Multithreading

References

[1] Anthony Blake. Computing the fast fourier transform on simd microprocessors, 2012.

[2] Donald E. Knuth. Literate programming. *The Computer Journal*, 27(2):97–111, 1984.

[3] Bo Liu. Parallel fast fourier transform, N/A.

[4] Cory Maklin. Fast fourier transform, 2019.