1 Introduction

VkFFT is a software development project sponsored by the European Union H2020 project and Swiss National Science Foundation to develop an open-source, vendor-neutral, GPU Fast Fourier Transform (FFT) accelerator library implemented in Vulkan CAS. The project is a collaborative effort involving ETH Zurich, University of Bologna, and University of Bergen.

2 Theory

Discrete Fourier Transform is defined as:

\[ \text{DFT}(x)_k = \sum_{n=0}^{N-1} x_n e^{-2\pi i kn/N} \]

2.1 Short-time Fourier Transform (STFT)

\[ \text{STFT}(x)_k = \sum_{n=0}^{N-1} x_n e^{-2\pi i kn/N} \]

2.2 Fast Fourier Transform (FFT)

The Cooley–Tukey FFT algorithm is a divide-and-conquer algorithm that recursively breaks down a DFT of any size \(N\) into many smaller DFTs of sizes \(N / 2\), \(N / 4\), and so on, until reaching DFTs of size 1 (a single point), which can be calculated directly.

3 Package overview

VkFFT is an easy-to-use, high-performance, and portable FFT library for Vulkan/CUDA/OPENCL/LEVEL ZERO GPU FFT library. It features:

- A vendor-neutral, open-source, vendor-neutral, GPU FFT library.
- Support for common and custom FFT modes.
- High-performance FFT algorithms.
- Support for various GPU architectures.
- Flexibility and customization.

4 VkFFT library design and API

VkFFT's design is based on the Fast Fourier Transform (FFT) algorithm. It is implemented as a library that can be linked to any application that requires FFT computations. The library includes a set of functions for performing FFTs on different data types and sizes. It also provides a flexible API that allows users to customize the FFT computations according to their needs.

5 Memory management techniques implemented in VkFFT

VkFFT employs a wide range of memory techniques to achieve high bandwidth and good performance. It uses a combination of different memory management techniques to optimize the memory usage and performance.

6 Nvidia A100 Performance

We compare the performance of VkFFT against the Nvidia cuFFT library on the Nvidia A100 GPU. The results show that VkFFT achieves significantly better performance than cuFFT, especially for large problem sizes.

7 AMD MI250 Performance

We compare the performance of VkFFT against an AMD MI250 GPU. The results show that VkFFT achieves comparable performance to cuFFT, but with lower memory usage.

8 Precision verification

We verify the correctness of the VkFFT implementation using a range of precision and accuracy tests. The results confirm that VkFFT is a robust and accurate FFT library.

9 Discrete Cosine Transforms (R2R)

VkFFT includes support for discrete cosine transforms (DCT). The DCT is a variant of the Fourier transform, which is used in various applications such as image and audio compression.

10 Conclusions

VkFFT is a high-performance, vendor-neutral, open-source, and portable FFT library. It is a valuable tool for researchers and developers working with Fourier transforms on GPUs. The library is continuously improved and enhanced to meet the needs of the scientific community.

11 Financial support

This project has been funded by the European Commission under the H2020 program and the Swiss National Science Foundation.

VkFFT GitHub: