Universidade do Minho
Escola de Engenharia
Departamento de Informática

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Study on FFT on the GPU

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ABSTRACT

Write abstract here (en) or import corresponding file

KEYWORDS keywords, here, comma, separated.

RESUMO

Escrever aqui resumo (pt) ou importar respectivo ficheiro

PALAVRAS-CHAVE palavras, chave, aqui, separadas, por, vírgulas

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INTRODUCTION

1.1 CONTEXTUALIZATION

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1.3 OBJECTIVES

The main objective of this dissertation is to provide efficient FFT alternatives in GLSL compared with dedicated tools for high performance of FFT computations like NVIDIA cuFFT library, while analysing the intrinsic of a good Fast Fourier Transform implementation on the GPU. To accomplish the main objective there are two stages taken in consideration, "*Analysis of CUDA and GLSL kernels*" to be well settled in their differences and to have a reference for the second stage "Analysis of cuFFT and GLSL FFT" which will cluster the study's main objective.

To compose a final verdict conclusion, we will use as case of study applications with implementation of the FFT in the field of Computer Graphics that require realtime performance.

1.4 DOCUMENT ORGANIZATION

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STATE OF THE ART

2.1 FOURIER TRANSFORM

2.1.1 *What is Fourier Transform*

The **Fourier Transform** is a mathematical method to transform the domain refered to as *time* of a function, to the *frequency* domain, intuitively the Inverse Fourier Transform is the corresponding method to reverse that process and reconstruct the original function from the one in *frequency* domain representation.

In general the Fourier Transform of a function is a complex-valued function of frequency.

Although there are many forms, the Fourier Transform key definition can be described as:

$$X(f) = \int_{-\infty}^{+\infty} x(t)e^{-ift}dt \qquad \text{Forward Fourier Transform}$$

$$x(t) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} X(f)e^{-ift}df \qquad \text{Inverse Fourier Transform}$$

- $x(t) \rightarrow$ function in *time* domain representation
- $X(f) \rightarrow$ function in *frequency* domain representation, also called the Fourier Transform of $x(t)$
- $i \rightarrow$ imaginary unit $i = \sqrt{-1}$

The above definition of the Fourier Integral can only be valid if the integral exists for every value of the parameter f. This model of the fourier transform applied to infinite domain functions is called **Continous Fourier Transform** and its targeted to the calculation of the this transform directly to functions with only finite discontinuities in $x(t)$.

2.1.2 *Where it is used*

It's noticieable the presence of Fourier Transforms in a great variety of apparent unrelated fields of application, even the FFT is often called ubiquitous[1] due to its effective nature of solving a great hand of problems for the most intended complexity time. Some of the fields of application include Applied Mechanics, Signal Processing, Sonics

1 present, appearing, or found everywhere.

and Acoustics, Biomedical Engineering, Instrumentation, Radar, Numerical Methods, Electromagnetics, Computer Graphics and more Brigham (1988).

One of the most well known cases of application is **Signal Analysis**, the Fourier Transform is probably the most important tool for analyzing signals, when representing a signal with amplitude as function of time, a signal can be translated to the frequency domain, a domain that consists of signals of sines and consines of varied frequencies, but to calculate the coefficients of those waves we need to use the Fourier Transform.

Figure 1: Example of a parametric plot $(\sin(x), \cos(x), x)$

And much more application such as polynomial multiplicationJia (2014), numerical integration, time-domain interpolation, x-ray diffracition, etc ...

2.1.3 *Discrete Fourier Transform*

The Fourier Transform of a finite sequence of equally-spaced samples of a function is the called the **Discrete Fourier Transform** (DFT), it converts a finite set of values in *time* domain to *frequency* domain representation. Its the most important type of transform since it deals with a discrete amount of data and has the popular algorithm in which is the center of attention of fourier transforms, which can be implemented in machines and be computed by specialized hardware.

$$X_k = \sum_{n=0}^{N-1} x_n \cdot e^{-\frac{i2\pi}{N}kn} \qquad \text{Forward Discrete Fourier Transform}$$

$$x_n = \frac{1}{N} \sum_{k=0}^{N-1} X_k \cdot e^{\frac{i2\pi}{N}kn} \qquad \text{Inverse Discrete Fourier Transform}$$

2.2 FAST FOURIER TRANSFORM

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2.2.1 *Computation of FFT*

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2.3 RELATED WORK

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E Oran Brigham. *The fast Fourier transform and its applications*. Prentice-Hall, Inc., 1988.

Yan-Bin Jia. Polynomial multiplication and fast fourier transform. *Com S*, 477:577, 2014.

NB: place here information about funding, FCT project, etc in which the work is framed. Leave empty otherwise.