Ukrainian Catholic University

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Data Science Master Programme

# Discrete Wavelet Transform for Image Compression

## Interim Report

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# 1 Introduction

Our project focuses on investigating the wavelet transform, specifically the multidimensional discrete wavelet transform (DWT), and its application in image compression. The aim is to understand the principles of DWT, explore its effectiveness in compressing images while preserving essential information, and compare it with other compression techniques such as Fractal Compression and Discrete Cosine Transform (DCT).

# 2 Problem

Image compression is crucial in various fields, including telecommunications, medical imaging, and multimedia applications, as it helps reduce storage space and transmission bandwidth requirements while maintaining image quality. Traditional methods like the classical Fourier transform have been widely used, but newer techniques like the wavelet transform offer potential advantages in terms of compression efficiency and preservation of image details.

# 3 Existing Approaches

## 3.1 Fractal Compression

Fractal compression is a technique based on the concept of iterated function systems (IFS), where self-similarities within an image are exploited to achieve compression. It involves partitioning an image into smaller blocks, called domain blocks, and finding a mapping (fractal transform) to represent each block in terms of another block in the image. Fractal compression can offer high compression ratios, especially for natural images with fractal-like properties. However, it typically involves computationally intensive search algorithms to find optimal mappings, and the reconstruction process may introduce artifacts.

## 3.2 Discrete Cosine Transform (DCT)

DCT is a widely used method for image compression, particularly in standards like JPEG. It involves transforming image data from the spatial domain to the frequency domain using cosine functions. DCT concentrates most of the image energy into a small number of low-frequency coefficients, which can be quantized and encoded more efficiently. While DCT-based compression provides good compression ratios and is computationally efficient, it may not preserve fine image details as effectively as other methods, leading to loss of quality, especially at higher compression levels.

# 4 Method

The Discrete Wavelet Transform (DWT) is a technique used for signal and image processing. Is is widely used for image compression in such formats as JPEG2000. Wavelet is simmilar to Fourier transform in that it represents signal in frequency domain but also preserve information about time domain, effectively localizing influence of particular frequency in particular moment in signal. The DWT although comes with tradeof, to achieve localization of frequency it is nessesary to sacrifice some of both. But nevertheless,

DWT is currently one of the best methods that provides representation in time-frequency domain.

Pros:

- DWT offers multi-resolution analysis, allowing for efficient representation of both low and high-frequency components in an image.
- It can achieve high compression ratios while preserving important image features.
- DWT-based compression can be adapted to various image types and sizes.

Cons:

- DWT is computationaly demanding and usualy runs slower than FFT.
- The choice of wavelet basis and decomposition levels can significantly affect the compression performance and image quality.
- DWT may not always outperform other compression techniques in all scenarios.

# 5 Further Work

- Define key metrics for algorithms evaluation and comparison
- Implement DWT-based compression algorithm
- Benchmark our DWT implementation and comprate it on the training dataset to other approaches such as Fractal Compression and DCT.
- Analyze the results to identify strengths and weaknesses of each approach and draw conclusions about their suitability for different applications.