Video Coding Research Seminar Project

Image Compression using MDCT

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1. Introduction:

Image compression refers to the process of minimizing the size of an image file without degrading its visual quality too much. This is important for saving, transmitting and handling digital images more efficiently. For this purpose, various methods have been used like discrete cosine transform (DCT), modified discrete cosine transform (MDCT) and many more.

Discrete cosines transform (DCT) converts an image to the frequency domain. The basic idea is that a considerable amount of energy of an image is usually present in its lowest frequencies. While modified discrete cosine transform (MDCT) is an extension of the discrete cosine transform with special properties which make it suitable for overlapping data blocks. This has particularly been helpful in audio compression but can also be useful in images.

1.1 Objective:

The objective of this project is to compress the image by using MDCT. It evaluates the performance of the proposed method in terms of compression ratio and image quality and compares the results with the image which is compressed by DCT to see which is better approach. It uses the JPEG algorithm for image compression which is a standard that relies on applying several mathematical transformations to the image data, which in turn helps achieve high compression ratios.

2. Methodology:

We have compressed images using DCT. So, for our project we'll replace the existing DCT function with MDCT implementation. The procedure to compress the image using MDCT is:

- First, import the required libraries like 'cv2', 'NumPy','matplot.lib','SciPy' which is used for image processing, numerical, plotting, MDCT and window respectively.
- To reduce the size, we'll create quantization matrix by using array. Also, we use some helping function to process the image by checking the quality by comparing the compressed image with the original one and counting the total no. of blocks of the image.
- In this, we do zigzag scanning of a block to convert the matrix into 1D array and group the low-frequency coefficients together. After grouping them, we need to restore the 2D matrix from the 1D array by using inverse zigzag scan.
- For MDCT, we are using 'Hann' window because it minimizes the spectral leakage and improves accuracy of frequency representation. Its smooth edge tapering reduces the discontinuity at segment boundaries.
- In this we are using JPEG encoder and decoder which takes color and grayscale image as input.
- For JPEG encoder, apply the following steps:
    1. Divide the image into blocks.
    2. Apply MDCT on each block.
    3. Quantizes the MDCT coefficients with the quantization matrix.
    4. Applies zigzag transformation to the quantized coefficients for efficient storage.
- For JPEG decoder, apply the following steps:
    1. Reverse the zigzag transformation.
    2. Dequantize the coefficients.
    3. Apply the inverse MDCT to transform back to the domain.
- We also have compressed the image using DCT to check which image is better.

- To compare the result of both compressed images we'll use Perceptual Similarity Metrics, compression ratio and bits per pixel. For this we need to install the library using! pip install long with the library name. After installing the library, import LPIPS model to calculate perceptual similarity which we have use 'alex' network.

3. Results:

For compressing the image, we have used the same block size and number of coefficients for DCT and MDCT techniques which are '12' and '16'. First, we did the compression using MDCT for grayscale and color images which results are shown in the figure below

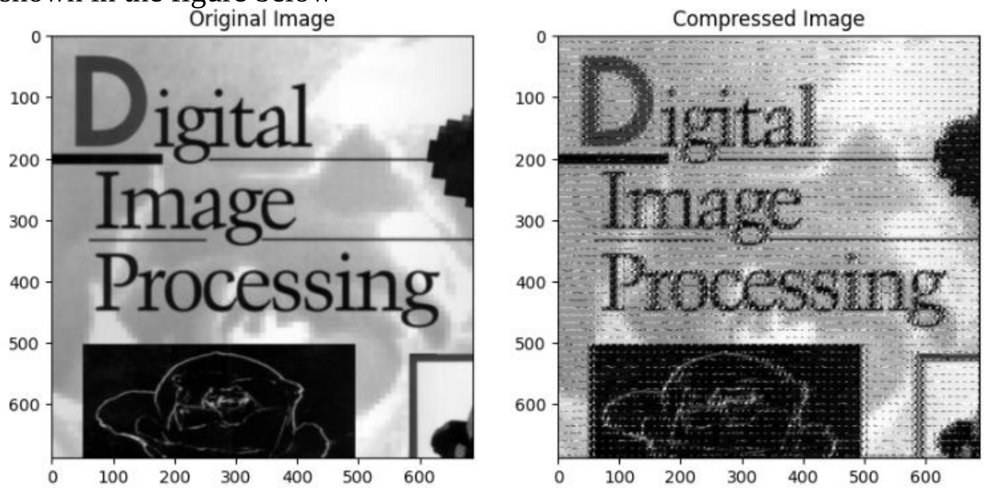

Fig.1

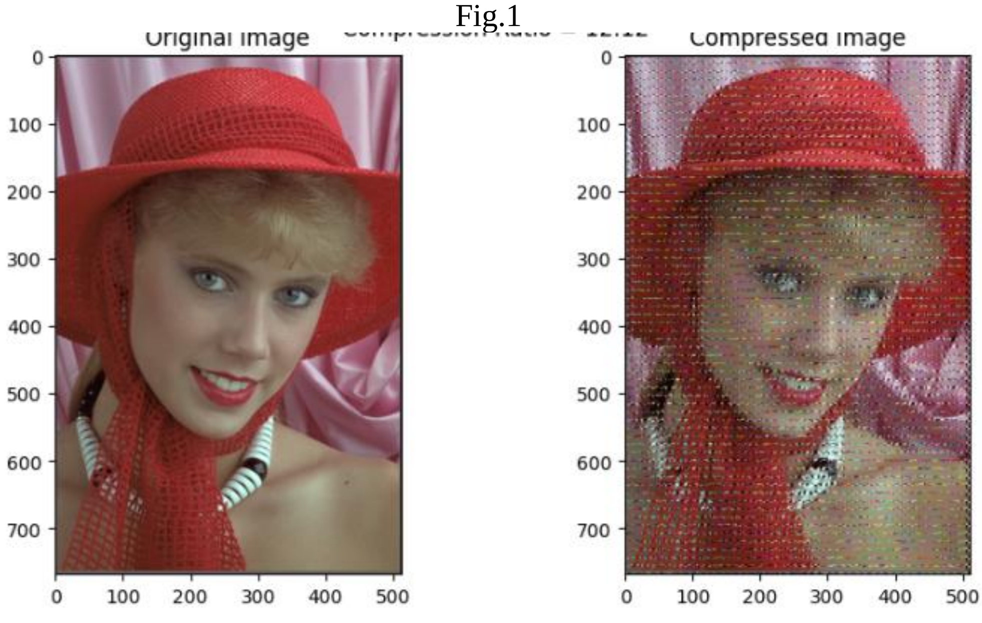

Fig.2

Then, we compressed the same images with DCT which the exact same block size and number of coefficients which results are shown below

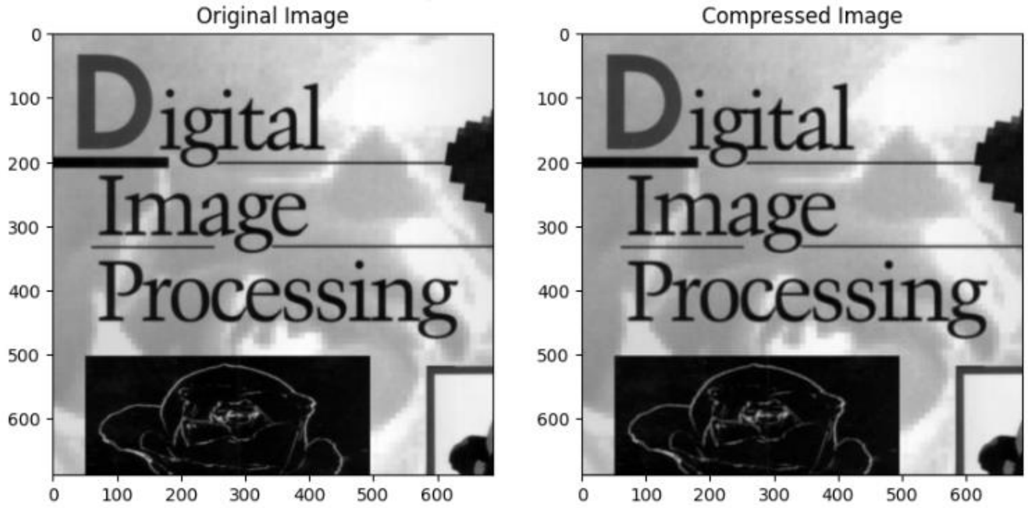

Fig.3

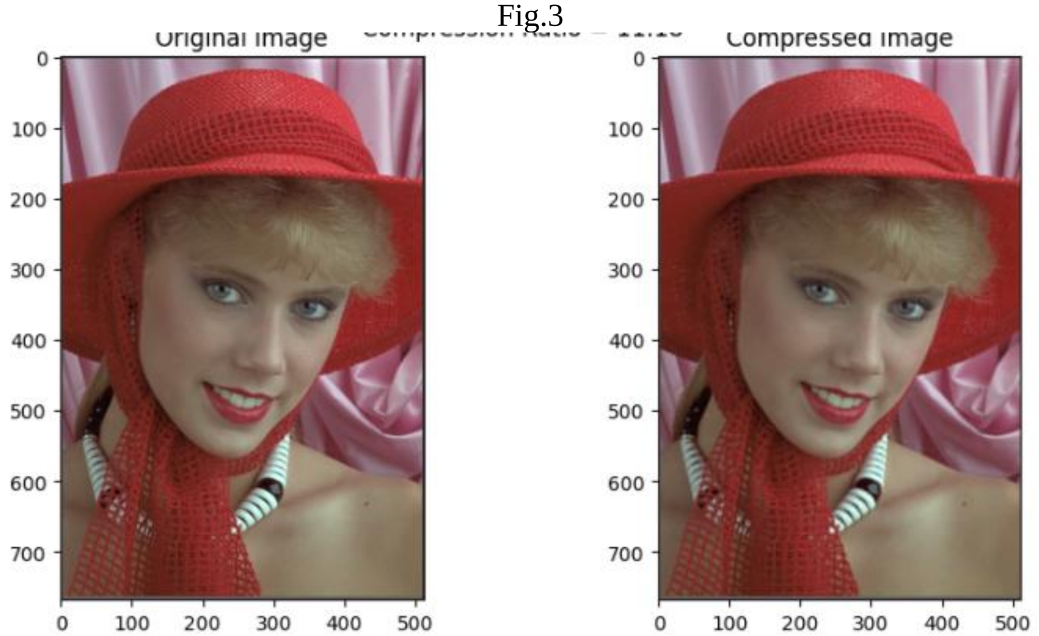

Fig.4

Then, we use perceptual similarity metric to compare the images to understood which compressing technique is better which is describe in the result analysis sections

4. Result Analysis:

The following is the description of results for Compression Ratio, Bits Per Pixel and Perceptual similarity for colored as well as grayscale image compared with the original image.

Color Image Results

Following are the results of color images

- **Compression Ratio:**

MDCT Compression Ratio: 1.92936119981234

DCT Compression Ratio: 6.482579070476965

The result shows that the DCT outperforms the MDCT in image compression as higher value indicates better compression ratio.

- **Bits Per Pixel:**

MDCT Bits Per Pixel: 6.721700032552083

DCT Bits Per Pixel: 2.0005289713541665

The result shows that the DCT outperforms the MDCT in compressing the image as lower value indicates better compression of image.

- **Perceptual Similarity:**

MDCT Perceptual Similarity: 0.7304627895355225

DCT Perceptual Similarity: 0.21777290105819702

The result shows that the DCT outperforms the MDCT in compressing the image as lower value indicates better perceptual similarity.

Grayscale Image Results

Following are the results of gray images

- **Compression Ratio:**

MDCT Compression Ratio: 1.3988771719826436

DCT Compression Ratio: 4.7954773533150465

The result shows that the DCT outperforms the MDCT in image compression as higher value indicates better compression ratio.

- **Bits Per Pixel:**

MDCT Bits Per Pixel: 5.196018117901568

DCT Bits Per Pixel: 1.5157179556517035

The result shows that the DCT outperforms the MDCT in compressing the image as lower value indicates better compression of image.

- **Perceptual Similarity:**

MDCT Perceptual Similarity: 0.6927622556686401

DCT Perceptual Similarity: 0.062057480216026306

The result shows that the DCT outperforms the MDCT in compressing the image as lower value indicates better perceptual similarity.

5. Conclusion:

After analyzing the results, we concluded that the DCT technique used for image compression is efficient and shows better results than MDCT techniques.