Homework Report: DCT and Wavelet Transforms

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1. Introduction

This project investigates the use of Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) for image analysis in the frequency domain. The two transforms have numerous applications in image compression, denoising, and feature extraction. The objective is to apply both transforms and display their impact on an image.

2. Methodology

2.1 Discrete Cosine Transform (DCT)

- Converts the image to a floating-point format and normalizes it.
- Computes the 2D DCT using OpenCV's *cv2.dct()*.
- Displays both raw and log-normalized DCT spectra for better interpretation.

2.2 Discrete Wavelet Transform (DWT)

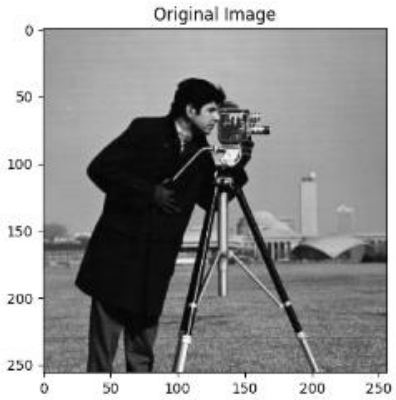
- Uses Haar wavelet to decompose the image into four sub-bands:
    - Approximation (cA): Main structure (low frequencies).
    - Horizontal (cH), Vertical (cV), and Diagonal (cD): Detail components.

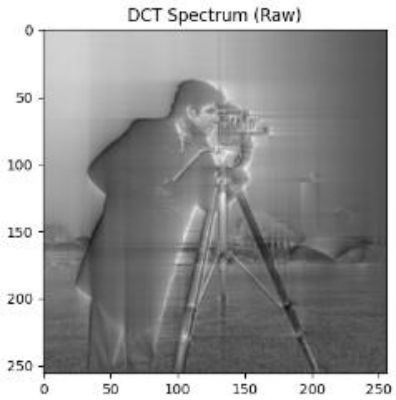
3. Implementation

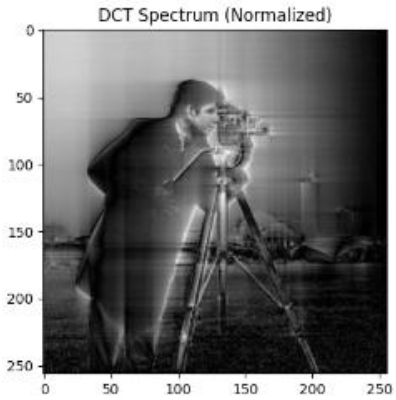
- The program is implemented in Python using OpenCV, NumPy, PyWavelets, and Matplotlib.
- Steps:
    1. Read the input grayscale image.
    2. Compute DCT and visualize its spectrum.
    3. Apply DWT and display the sub-bands.
    4. Present all results in a structured layout.

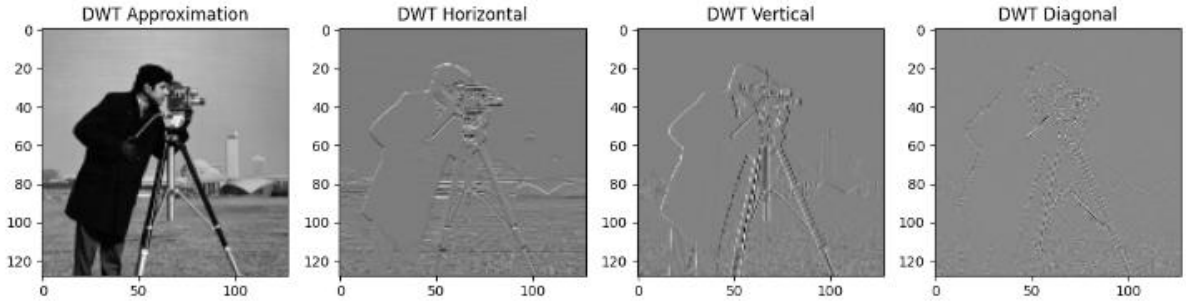
4. Results and Observations

- The DCT spectrum shows that most of the image energy is concentrated in low frequencies, supporting its role in compression.
- The DWT decomposition effectively highlights edges and textures in the image, separating different frequency components.









5. Conclusion

This project clearly shows the application of DCT and DWT to frequency domain analysis of images. The DCT concentrates most of the energy of the image into the lower frequencies, which is useful for compression and filtering. Meanwhile, the DWT decomposes the image into different sub-bands effectively, highlighting the edges and texture. The results provide information about how these transforms represent image data, making them valuable tools for a wide variety of image processing tasks.