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Image Compression Using Singular Value Decomposition (SVD) on Grayscale Images

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1 Introduction

Image compression is an important technique in digital image processing, allowing for efficient storage and transmission while keeping good image quality. Singular Value Decomposition (SVD) is a method that breaks an image matrix into three smaller matrices. By keeping only the most important singular values (from the matrix), we can compress the image. This method helps balance the compression ratio and image quality, making it useful in areas like medical imaging, multimedia, and remote sensing.

2 Objectives

- Understand how Singular Value Decomposition (SVD) works for image compression.
- Implement a basic SVD-based image compression algorithm.
- Test image quality using Peak Signal-to-Noise Ratio (PSNR) with different numbers of singular values.
- Observe the effect of compression on image size and quality.

3 Problem Statement

With the growing demand for high-resolution images across various fields, efficient image compression is crucial for reducing storage and transmission needs without sacrificing quality. Traditional methods like JPEG and PNG, though effective, may introduce artifacts or require significant computational resources. Singular Value Decomposition (SVD)

offers a promising approach for compressing images while retaining important visual details. However, finding the optimal balance between compression ratio and image quality remains a challenge, which this study aims to address.

4 Methodology

1. **Choose Images:** Select a few standard images (like "Lena" or "Cameraman") to work with.
2. **Convert to Grayscale:** Use Python libraries (e.g., OpenCV or PIL) to convert images to grayscale.
3. **Apply SVD:** Use Python (NumPy or SciPy) to perform Singular Value Decomposition on the grayscale images.
4. **Compress Images:** Keep only the top singular values (e.g., 10, 20, 50) to reconstruct smaller images.
5. **Evaluate Quality:** Calculate image quality metrics such as PSNR using Python.
6. **Measure Size:** Compare the original and compressed image file sizes.
7. **Compare with JPEG:** Optionally, compare your SVD compression results with JPEG compression in Python.
8. **Adjust Parameters:** Change the number of singular values kept to find the best balance between quality and compression.

5 Expected Outcomes

- A working Python program that compresses images using SVD.
- Results showing how image quality changes with different numbers of singular values.
- A basic comparison between SVD compression and JPEG compression.
- Understanding of how to choose the number of singular values for good compression and quality.