User Manual for Image Compression and Reconstruction Using Wavelet Transform and SVD (RCAD_SVD.m)

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1. Introduction

This manual guides users on how to execute the MATLAB script for image compression and reconstruction using techniques such as Haar wavelet transform and Principal Component Analysis (SVD). The script processes an input image to compress it while maintaining quality and calculates various metrics to evaluate the compression performance.

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2. Prerequisites

- MATLAB (R2021b or later recommended).
- Image Processing Toolbox.
- A grayscale or color image file (e.g., `kodim07.jpg`).
- Basic understanding of MATLAB operations and image processing.

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3. Running the MATLAB Script

1. Open MATLAB.
2. Copy and paste the provided script into a new MATLAB `.m` file (e.g., `image_compression.m`).
3. Place the input image (`kodim07.jpg`) in the same directory as the script.
4. Run the script by typing `image_compression` in the MATLAB Command Window.

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4. Overview of the Code

Input Image Preprocessing

- The script reads the input image using `imread` and resizes it to 512x512 pixels.
- The image is converted to grayscale if it is in RGB format.
- The histogram of the original image is displayed.

Residual Calculations

- The script calculates row-wise and column-wise differences to obtain residual matrices.
- A combined residual matrix is computed by averaging the row and column differences.

Haar Wavelet Transform

- A Haar wavelet transformation is applied to the combined residual matrix.
- The transformed image is separated into four sub-bands: LL, HL, LH, and HH.
- The LL band captures low-frequency components, while HL, LH, and HH capture high-frequency details.

SVD Implementation

- SVD is applied to the sub-bands to reduce dimensionality.
- A reduced image is reconstructed using the principal components.

Quantization

- The HH band is quantized using thresholds derived from SVD variance analysis.
- Non-zero elements in the sub-bands are retained for reconstruction.

Image Reconstruction

- The quantized sub-bands are merged.
- An inverse wavelet transform reconstructs the compressed image.
- The reconstructed image is compared with the original image.

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5. Performance Metrics

- **Entropy**: Computed for the original image, residual matrix, and reconstructed image.
- **Peak Signal-to-Noise Ratio (PSNR)**: Measures the quality of the reconstructed image.
- **Compression Ratio (CR)**: Indicates the efficiency of compression.

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6. Output Files

- `I1.jpg`: Original grayscale image.
- `RRI.jpg`: Residual row image.
- `RCI.jpg`: Residual column image.
- `SA.jpg`: Haar transformed band-separated array.
- `HH_Quantized.jpg`: Quantized HH band.
- `quantized_CD.jpg`: Quantized combined residual image.
- `ISB.jpg`: Inverse sub-band transformed image.
- `I33.jpg`: Final reconstructed image.

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7. Troubleshooting

- **Error: File not found.**
  - Ensure the input image (`kodim07.jpg`) is in the same directory as the script.
- **Incorrect output size.**
  - Check the input image dimensions; ensure the resizing operation is applied correctly.
- **Low PSNR.**
  - Verify the thresholds used for quantization.

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8. Summary

This script demonstrates an effective method for compressing and reconstructing images using wavelet transform and SVD. The method achieves a balance between compression and image quality, making it suitable for various applications in image processing.