Program Documentation

1. RCAD_PCA.m

This script implements several image processing techniques, including image resizing, transformation using Haar wavelets, sub-band coding, principal component analysis (PCA), quantization, entropy calculation, and image reconstruction. Here's an overview of the steps:

Key Steps in the Code:

a. **Image Preprocessing:**
   i. Loads a color image (`kodim07.jpg`), resizes it to 512×512 and converts it to grayscale.

b. **Row and Column Differences:**
   i. Calculates first-order differences for rows and columns to form residual matrices.
   ii. Creates and visualizes a residual row image (`RRI`) and column image (`RCI`).

c. **Combination of Residuals:**
   i. Averages the residual row and column matrices to form a combined difference array (`CD`).

d. **Haar Wavelet Transform:**
   i. Applies Haar wavelet transform on `CD` to decompose it into four sub-bands (LL, HL, LH, HH).
   ii. Visualizes and processes each sub-band independently.

e. **Quantization:**
   i. Performs PCA on HH band and thresholds elements based on median eigenvalues to compress the data. Non-significant elements are set to zero.

f. **Reconstruction:**
   i. Combines quantized sub-bands and applies inverse RCAD and inverse Haar transform to reconstruct the original image.

g. **Entropy Calculation:**

i. Computes the entropy of the original image (`I1`), the reconstructed image (`I3`), and other intermediate arrays like `CD` and `A1`.

h. **Performance Metrics:**

i. Computes metrics such as Mean Squared Error (MSE), Peak Signal-to-Noise Ratio (PSNR), and Structural Similarity Index (SSIM) between the original and reconstructed images.

ii. Calculates the compression ratio based on file sizes before and after reconstruction.

2. RCAD_SVD.m

This MATLAB code is a complete workflow for compressing and reconstructing an image using wavelet transformation, sub-band coding, and Singular Value Decomposition (SVD). It includes preprocessing, entropy computation, and performance metrics such as PSNR (Peak Signal-to-Noise Ratio) and structural similarity (SSIM).

Key Steps in the Code:

a) Image Preprocessing:

i) Convert the input image to grayscale.

ii) Compute its histogram for visualization.

b) Difference Array Calculation:

i) Compute row and column differences to create a residual image representing changes between pixel intensities.

c) Haar Wavelet Transformation:

i) Apply Haar wavelet transformation to the residual difference array to separate the image into sub-bands (LL, HL, LH, HH).

ii) Analyze and manipulate each sub-band using Singular Value Decomposition (SVD).

d) Quantization and Reconstruction:

i) Quantize the transformed HH band and merge them to reconstruct the image.

ii) Perform inverse RCAD and inverse Haar wavelet transformation to reconstruct the original image.

e) Metrics Computation:

i) Calculate entropy of the original and reconstructed images.

ii) Compute PSNR and SSIM values to measure the quality of reconstruction.

f) Visual Outputs:

i) Display intermediate results such as residual images, wavelet-transformed bands, quantized arrays, and reconstructed images.

The code is modular and computes useful metrics like entropy and reconstruction quality, making it suitable for research on image compression methods.