Video Compression Homework #1 – Color Transform

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I. Purpose

This script performs color space transformations on an input RGB image and saves the results as grayscale images for each channel/component. It supports RGB, YUV, and YCbCr (BT.601 full-range) color spaces.

II. Workflow

1. Input Handling
    i. Accepts an image file path and an output directory as command-line arguments.
    ii. Defaults to lena.png and outputs if not provided.
2. Image Loading
    i. Loads the image using PIL, converts it to RGB, and converts pixel data to a NumPy float32 array.
3. Channel Extraction
    i. Separates the image into R, G, B channels.
4. RGB Grayscale Output
    i. Saves each channel (R, G, B) as a separate grayscale image.
5. YUV Transformation (BT.601)
    i. Computes Y, U, V components using standard formulas.
    ii. U and V are offset by 128 for visualization.
    iii. Saves Y, U, V as grayscale images.
6. YCbCr Transformation (BT.601 full-range)
    i. Computes Cb and Cr components using standard formulas.
    ii. Saves Cb and Cr as grayscale images.
7. Data Type Conversion
    i. Uses to_uint8 to ensure all output images are in the 0–255 range and of type uint8.

III. Key Functions

1. **to_uint8(x):** Rounds, clips, and converts data to uint8 for image saving.
2. **main(in_path, out_dir):** Main processing function.

IV. Color Space Formulas

1. YUV (BT.601):
    i. Y = 0.299R + 0.587G + 0.114B
    ii. U = -0.169R - 0.331G + 0.5B + 128
    iii. V = 0.5R - 0.419G - 0.081B + 128
2. YCbCr (BT.601 full-range):
    i. Cb = 128 - 0.168736R - 0.331264G + 0.5B
    ii. Cr = 128 + 0.5R - 0.418688G - 0.081312B

V. Output

1. Grayscale images for each channel/component are saved in the specified output directory.