CS 40 Arithmetic Design

Original Image

Image Handling - 1

Reads ppm file from command and ensures image width and height are even by trimming excess rows/columns if necessary

- Input: Original ppm image file name and commands
- Output: Trimmed ppm file
- Losses some information by trimming the dimensions potentially

Color Conversion - 2

Converts RGB pixel values to component video (Y, Pb, Pr) using linear transformations

- Input: RGB values $(0 - 255)$
- Output: Y $(0–1)$, Pb/Pr $(-0.5– 0.5)$
- No information lost

Chroma Subsampling and Quantization - 3

Averages Pb/Pr values for each 2x2 block and quantizes them to 4-bit indices.

- Input: Four Pb/Pr values per block
- Output: Two 4-bit indices $(Pb\ average\ ,\ Pr\ average)$
- Some information lost via spatial resolution reduced via averaging and quantization

Luminance DCT Transformation- 4

Applies DCT to four Y values in a block to compute coefficients

- Input: 4 Y values
- Output: Coefficients a, b, c, d

Coefficient Quantization - 5

Quantizes coefficients: a to 9-bit unsigned and b, c, d to 5-bit signed $(clamped\ to\ ±0.3)$.

- Input: Coefficients a $(0–1)$, b/c/d $(-0.5–0.5)$
- Output: Quantized integers $(9b, 5b, 5b, 5b)$

Bitpacking- 6

Applies DCT to four Y values in a block to compute coefficients

- Input: 4 Y values
- Output: Coefficients a, b, c, d

File Output - 7

Writes header $(width/height)$ and codewords in big-endian format.

- Input: Codewords, trimmed dimensions.
- Output: Binary compressed file

Compressed Image

File Output - 7

Clamps RGB values and writes PPM image

- Input: Reconstructed RGB pixels
- Output: PPM image file

RGB Conversion - 6

Converts YPbPr to RGB using inverse linear transformations

- Input: Y $(float)$, Pb_avg/Pr_avg $(float)$
- Output: RGB values $(float)$

Reverse DCT Transformation - 5

Reconstructs Y values from coefficients

- Input: Coefficients a, b, c, d
- Output: Four Y values $(float)$

Coefficient Dequantization - 4

Converts quantized coefficients back to floats.

- Input: Quantized a $(9b)$, b/c/d $(5b)$
- Output: Coefficients a, b, c, d $(float)$.

Chroma Dequantization - 3

Converts 4-bit indices back to Pb_avg/Pr_avg floats

- Input: Pb_index, Pr_index $(4b\ each)$
- Output: Pb_avg, Pr_avg $(float)$.

Data Unpacking - 2

Unpacks codeword into a, b, c, d, Pb_index, Pr_index

- Input: 32-bit codeword
- Output: Quantized coefficients and indices

Data Extraction - 1

Reads header to extract image dimensions and Reads 32-bit codewords from the file

- Input: Compressed file stream
- Output: Width, height $(unsigned\ integers)$ and array of codewords