JPEG Compression

JPEG File format

- Joint Photographic Experts Group (JPEG)
  - Aimed at reducing redundancy in most image data
  - Widely used
- Better representation
- Observations
  - Brightness is similar for neighbouring pixels
  - Human eye is easy to fool
  - Psycho-visual redundancy

(a)   (b)

JPEG Steps
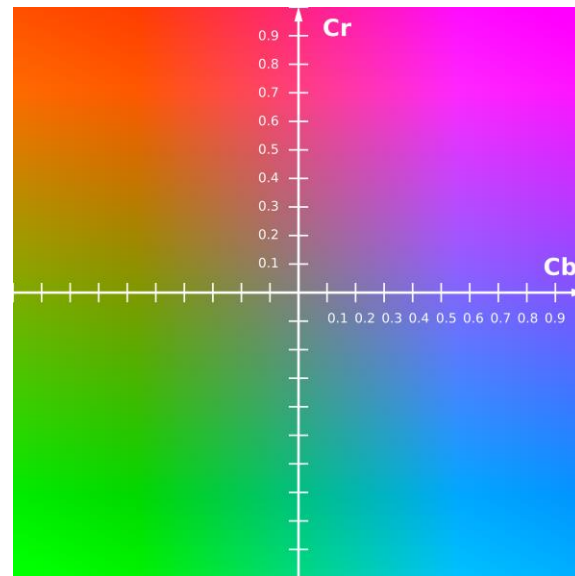
- The JPEG image compression technique consists of 5 functional stages

  - 1: RGB to YCC color space conversion

  - 2: a spatial subsampling of the chrominance channels in YCC space

  - 3: the transformation of a blocked representation of the YCC spatial image data to a frequency domain representation using the discrete cosine transform

    - inter-pixel redundancy

    - Low frequency information

  - 4: a quantization of the blocked frequency domain data according to a user-defined quality factor

  - 5: the coding of the frequency domain data, for storage, using Huffman coding

YCC color space

$$Y = 0.2990R + 0.5870G + 0.1140B$$

$$C_b = -0.1687R - 0.3313G + 0.5B + 2^{Bit\,Depth-1}$$

$$C_r = 0.5R - 0.4187G - 0.0813B + 2^{Bit\,Depth-1}$$

RGB   Y   Cb   Cr

JPEG Subsampling

Y　Cb　Cr　(a)

(b)

(c)

Discreet Cosine Transform

- First 2 steps: take advantage of human perception
- Step 3: Exploit inter-pixel redundancy
  - Performed in small blocks
- DCT Transform

$$F(u) = c(u) \sum_{x=0}^{M-1} f(x) \cos \frac{(2x+1)u\pi}{2M} \quad \text{for} \quad u = 0,1,2,\ldots,M-1$$

$$c(u) = \begin{cases} \sqrt{\dfrac{1}{M}} & \text{where } u = 0 \\ \sqrt{\dfrac{2}{M}} & \text{otherwise} \end{cases}$$

- DCT Inverse Transform

$$f(x) = \sum_{u=0}^{M-1} c(u) F(u) \cos \frac{(2u+1)x\pi}{2M} \quad \text{for} \quad x = 0,1,2,\ldots,M-1$$
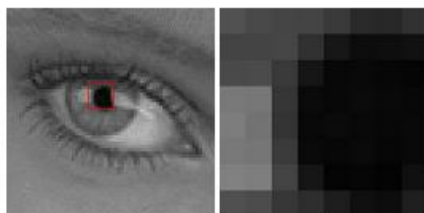
$$c(u) = \begin{cases} \sqrt{\dfrac{1}{M}} & \text{where } u = 0 \\ \sqrt{\dfrac{2}{M}} & \text{otherwise} \end{cases}$$

- DCT coefficients are scaled, quantized, and converted to integer values

(a)

925.5	-11.1	4.4	-1.8	-1.0	1.9	1.4	-0.3
4.3	-1.3	4.4	2.5	2.6	1.0	-0.7	0.6
4.0	-3.6	-0.7	3.5	1.7	-0.2	-1.6	1.0
-2.1	0.3	-0.1	-3.5	1.7	0.6	0.6	-0.6
-1.2	-0.6	0.2	3.3	1.3	-3.6	1.3	-0.8
-0.9	1.2	3.8	2.0	3.5	0.7	-0.9	-0.6
1.9	-1.0	-0.9	-1.3	0.1	0.9	1.4	1.2
-0.9	1.0	-0.8	-3.0	0.3	1.3	0.0	-0.4

350.5	251.0	109.0	0.8	-17.7	-26.1	-6.7	-3.7
7.0	-47.2	-43.6	-11.3	4.5	15.1	5.1	5.1
30.8	-58.4	-52.0	-26.3	25.0	14.2	6.4	-1.7
35.7	14.0	17.1	12.4	0.3	-6.1	-3.0	1.4
26.0	-19.7	-3.5	10.7	13.7	-3.1	-5.1	-1.1
20.0	18.6	20.0	7.5	-5.7	-6.5	-2.5	-3.1
-6.0	-23.6	-12.4	2.4	1.6	0.5	1.7	2.2
-3.0	-1.8	0.3	0.0	1.3	1.2	1.9	1.2

(b)