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MULTIMEDIA CODING

Final Project:
A JPEG-like coding system for color images

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A JPEG-like coding system for color images

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OBJECTIVES:

- Build a JPEG-like coding system
- Compare the results

STRUCTURE OF THE PRESENTATION:

- Introduction to JPEG
- Technical approach to the problem
- Discussion of the results

JPEG standard

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- Introduced in 1992
- Lossy type of compression
- Basic idea: concentrate information in few samples

PROS	CONS
Amount of compression ⟷ Loss in details	Not suitable for multiple edits
Tunable quality of the compressed image	No transparency allowed
Good for high-quality phorographs	Not good for sharp lines and shapes

JPEG standard

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PROCEDURE:

- Pre-processing
- Discrete Cosine Transform (DCT) on 8x8 blocks
- Quantization of the DCT coefficients
- Huffman coding on the quantized coefficients

Preprocessing

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IMAGE PADDING:

- Number of rows and columns must be multiple of 8

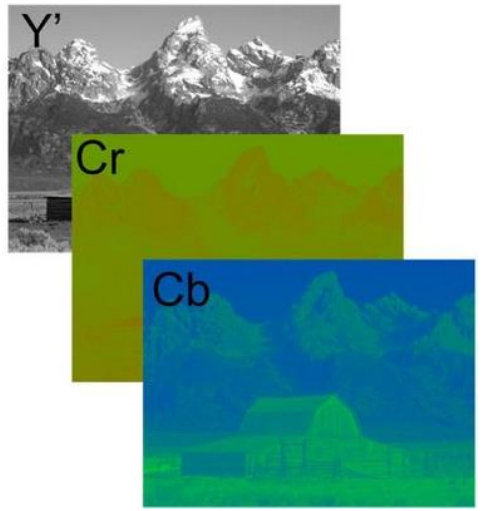
COLOR SPACE CONVERSION:

- Convert from RGB to YCbCr: linear operation

$$\begin{bmatrix} Y \\ C_b \\ C_r \end{bmatrix} = \begin{bmatrix} 0 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 0,299 & 0,587 & 0,114 \\ 0,169 & 0,331 & 0,5 \\ 0,5 & 0,419 & 0,081 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Y	Luminance
Cb	Blue difference
Cr	Red difference

Chroma components



- Y component -> most perceived by the human eye

-> more compact representation

Chroma subsampling

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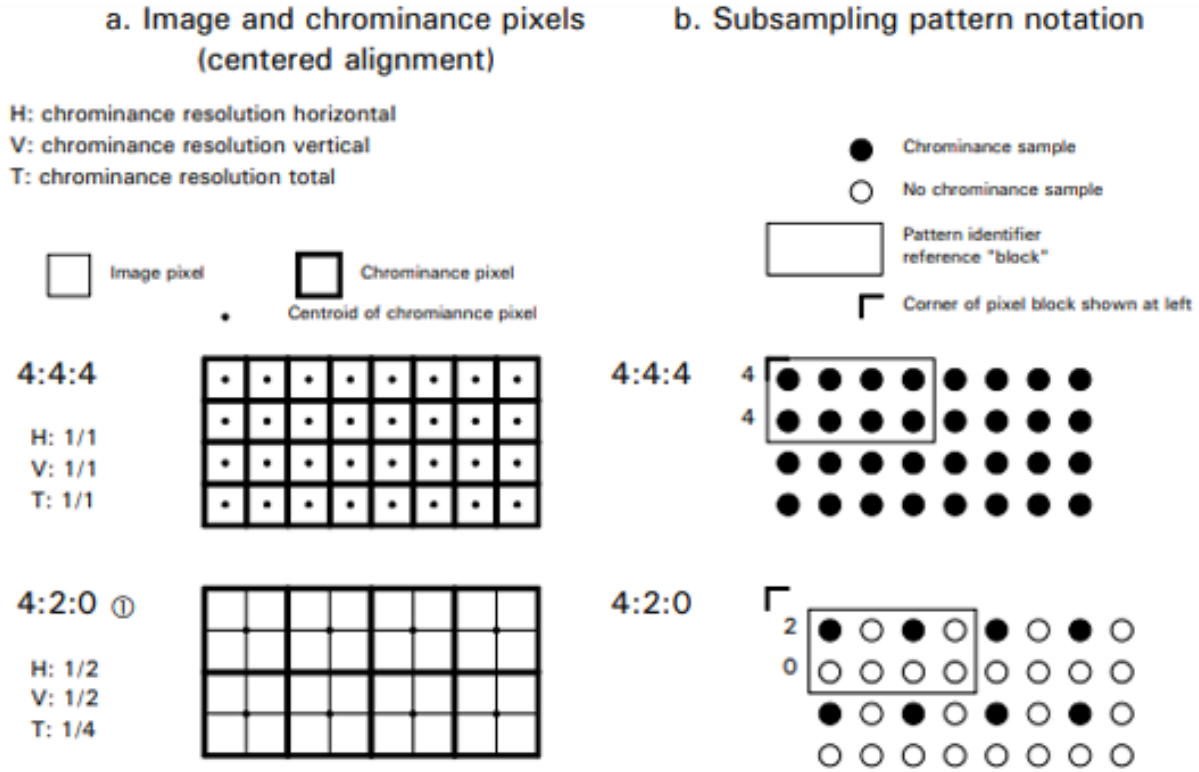
- Chroma components can be downsampled
- Quality of the final result not too affected



Discrete Cosine Transform

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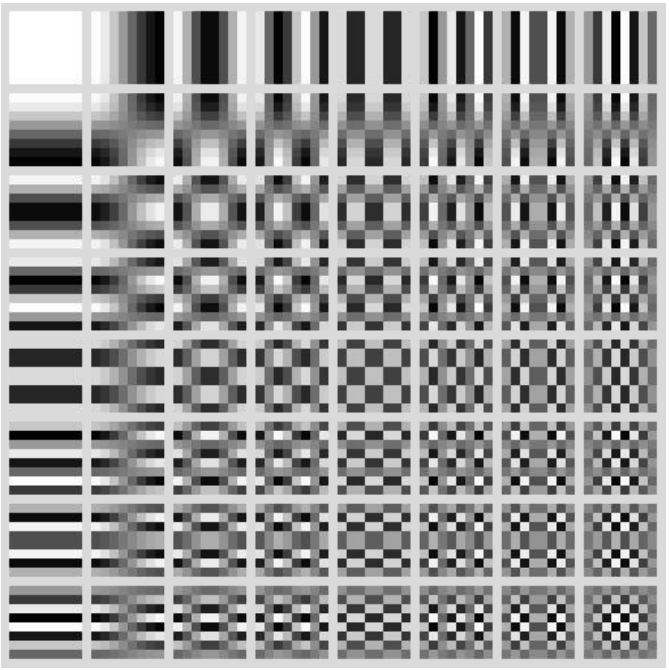
- Partition the image into blocks of 8x8 pixels
- Apply DCT to each block -> more compact representation

$$t_{kl} = \begin{cases} \sqrt{\frac{1}{N}} cos(\frac{\Pi}{2N}(k-1)(2l-1)), & k = 1 \\ \sqrt{\frac{2}{N}} cos(\frac{\Pi}{2N}(k-1)(2l-1)), & k = 2, 3...N \end{cases}$$

- 64 patterns -> basis functions
- Top left corner -> DC coefficient
  - Low-frequency, better perceived by human eye
- Other 63 coefficients -> AC coefficients



Quantization

- Use of quantization tables
- Result given by a rounding

$$F_{i,j} = \left\lfloor \frac{D_{i,j}}{Q_{i,j}} + 0.5 \right\rfloor$$

$$\begin{bmatrix} 16 & 11 & 10 & 16 & 24 & 40 & 51 & 61 \\ 12 & 12 & 14 & 19 & 26 & 58 & 60 & 55 \\ 14 & 13 & 16 & 24 & 40 & 57 & 69 & 56 \\ 14 & 17 & 22 & 29 & 51 & 87 & 80 & 62 \\ 18 & 22 & 37 & 56 & 68 & 109 & 103 & 77 \\ 24 & 35 & 55 & 64 & 81 & 104 & 113 & 92 \\ 49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\ 72 & 92 & 95 & 98 & 112 & 100 & 103 & 99 \end{bmatrix} \quad (5a)$$

$$\begin{bmatrix} 17 & 18 & 24 & 47 & 99 & 99 & 99 & 99 \\ 18 & 21 & 26 & 66 & 99 & 99 & 99 & 99 \\ 24 & 26 & 56 & 99 & 99 & 99 & 99 & 99 \\ 47 & 66 & 99 & 99 & 99 & 99 & 99 & 99 \\ 99 & 99 & 99 & 99 & 99 & 99 & 99 & 99 \\ 99 & 99 & 99 & 99 & 99 & 99 & 99 & 99 \\ 99 & 99 & 99 & 99 & 99 & 99 & 99 & 99 \\ 99 & 99 & 99 & 99 & 99 & 99 & 99 & 99 \end{bmatrix} \quad (5b)$$

- Possibility of tuning the amount of quantization -> quality factor (default = 50)

$$Q'_{i,j} = Q_{i,j} \cdot \frac{1}{q_f} \cdot 50$$

- Finer quantization step size for low frequency coefficients -> more compact representation

Encoding

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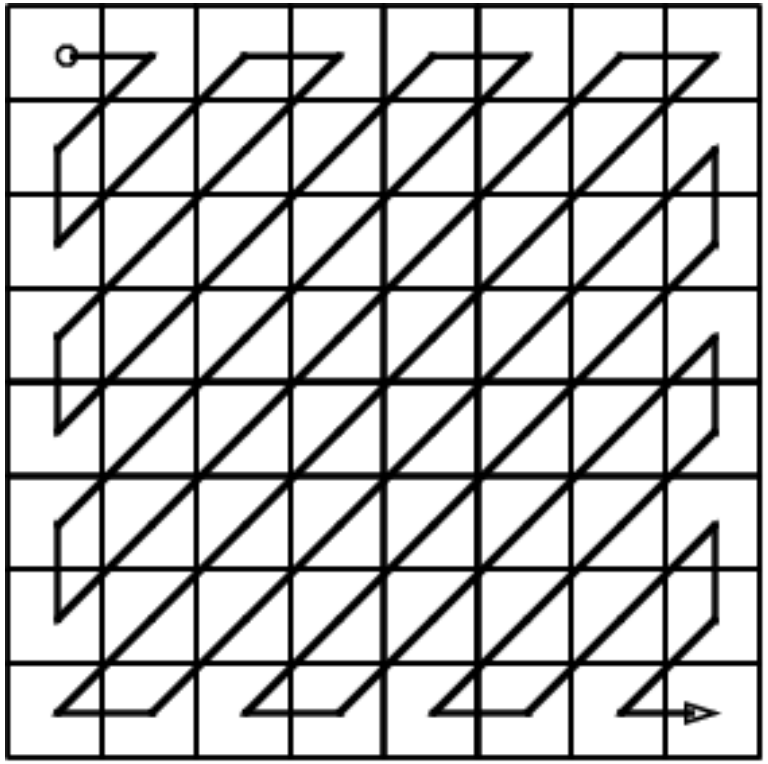
- AC and DC disposed using a zigzag scan

Different encoding for DC and AC coefficients:

- AC -> defined by the pair {size, skip}
- DC -> delta measure between adjacent blocks
- Both encoded using Huffman coding



Results

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Measures to evaluate the performace:

- Size of the encoded image [kB]
- Compression ratio = $\frac{\text{Original image size}}{\text{Compressed image size}}$
- Computational complexity [seconds]
- bpp = $\frac{\text{Compressed image size}}{\text{Number of pixels}}$
- PSNR [dB]

$$PSNR = 10log_{10}\frac{255^2}{MSE} \quad \text{where} \quad MSE = \frac{\sum_{M,N}[I_{original}(m,n) - I_{compressed}(m,n)]^2}{MN}$$

Results

Original image

Compressed with quality = 5

Results

Original image

Compressed with quality = 15

Results

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Original image

Compressed with quality = 30

Results

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Original image

Compressed with quality = 50

Results

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Original image

Compressed with quality = 80

Results

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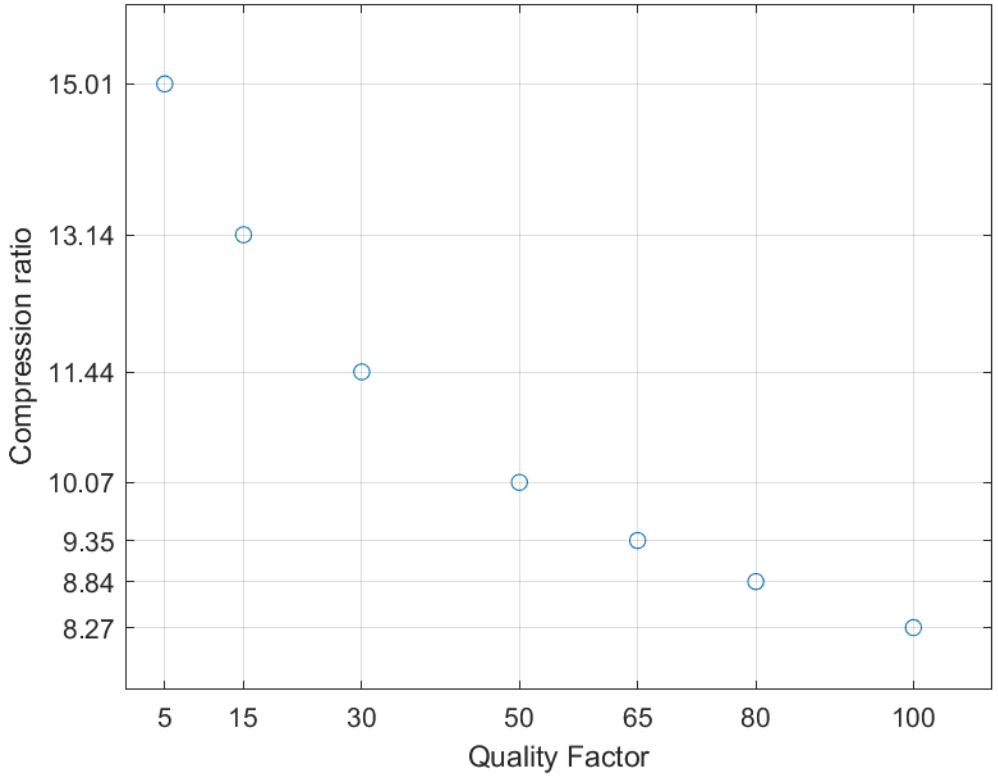
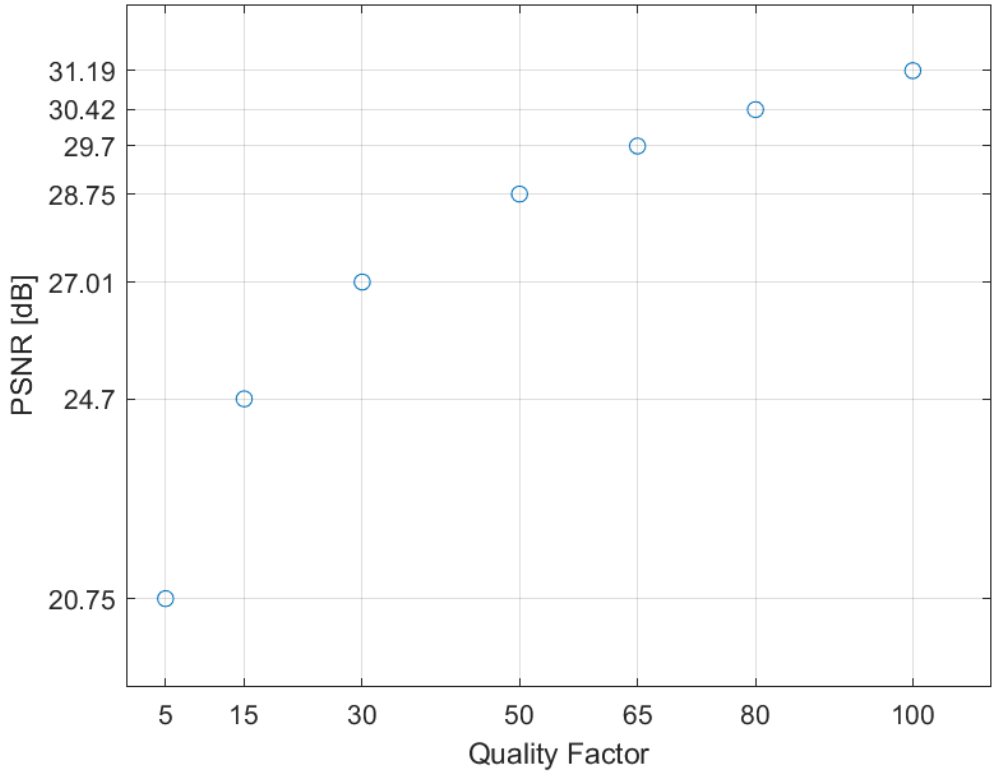
Image	Quality	Enc. Size [kB]	C. Ratio	Time [s]	bpp	PSNR [dB]
Motocross	5	78.55	15.01	3.40	1.59	20.75
(Original	15	89.76	13.14	3.66	1.83	24.70
Size:	30	103.13	11.44	4.18	2.10	27.01
1179.64	50	117.14	10.07	4.63	2.38	28.75
kB)	65	126.18	9.35	5.21	2.57	29.70
	80	133.44	8.84	5.45	2.71	30.42
	100	142.56	8.27	6.18	2.90	31.19





Results

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Chroma Sub.	Enc. Size [kB]	C. Ratio	Time [s]	bpp	PSNR [dB]
Yes	117.14	10.07	4.63	2.38	28.75
No	197.37	5.97	12.26	4.01	29.52

With chroma subsampling (Quality = 50)

Without chroma subsampling (Quality = 50)

Results

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JPEG-like approach (Quality = 5)

Standard JPEG (Quality = 5)

Results

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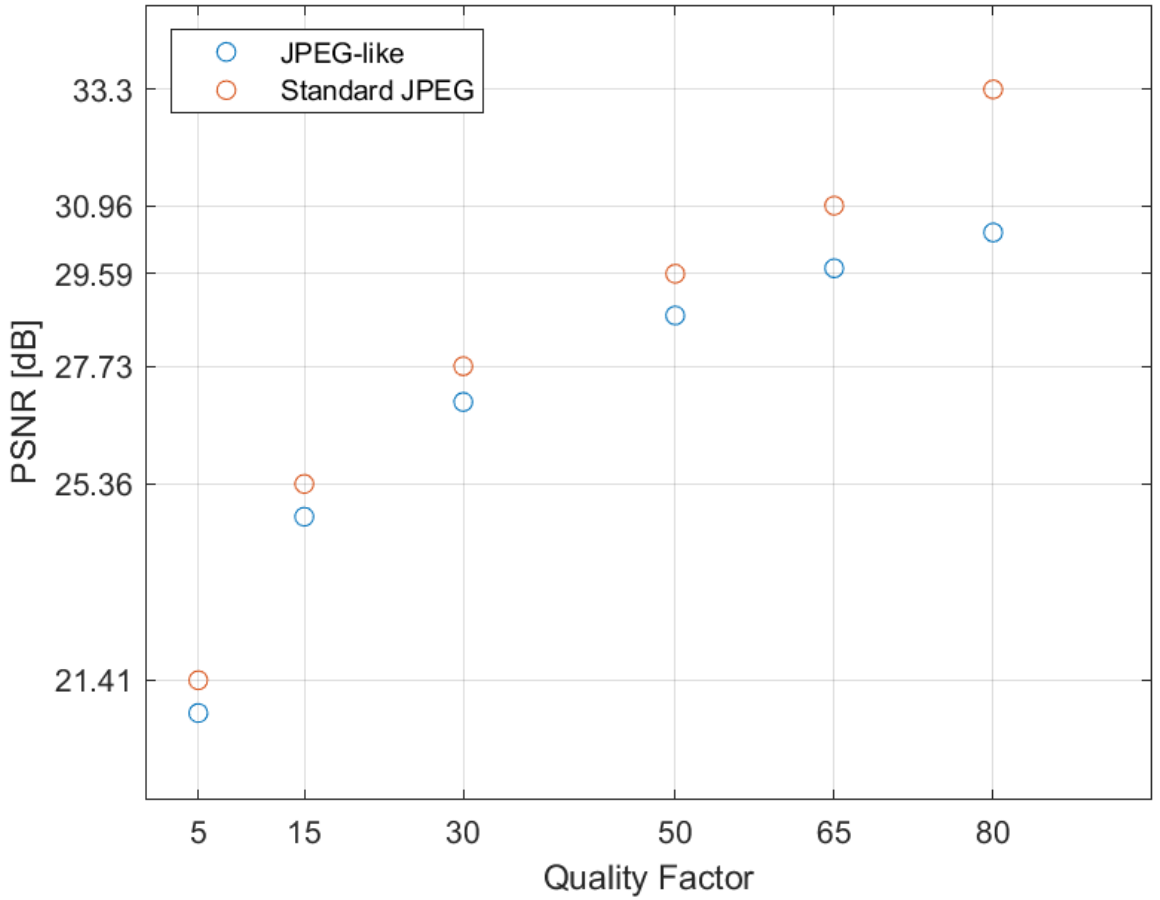
Image	Quality	Enc. Size [kB]	Time [s]	PSNR [dB]
Standard JPEG	5	14.9	0.02	21.41
	15	31.8	0.04	25.36
	30	49.7	0.04	27.73
	50	67.4	0.04	29.59
	65	82.7	0.06	30.96
	80	112	0.06	33.30
JPEG-like	5	78.55	3.40	20.75
	15	89.76	3.66	24.70
	30	103.13	4.18	27.01
	50	117.14	4.63	28.75
	65	126.18	5.21	29.70
	80	133.44	5.45	30.42



Results

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JPEG-like approach (Quality = 15)

Standard JPEG (Quality = 15)

Results

JPEG-like approach (Quality = 50)

Standard JPEG (Quality = 50)

Results

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JPEG-like approach (Quality = 80)

Standard JPEG (Quality = 80)

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Thank you for your attention