University Kasdi Merbah - Ouargla

Department of Computer Science and Information Technology

Master Artificial Intelligence and Data Science

Module: Image Processing and Computer Vision

TD N°1

Exercise 1

Given the following Cb channel of an 8x8 image that is represented in YCbCr color space.

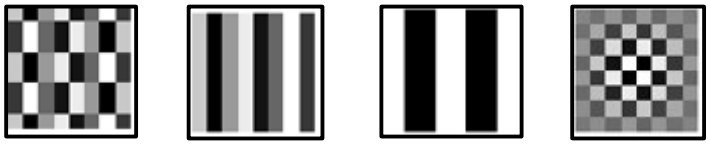
9	12	2	11	0	2	8	166
9	0	8	3	3	0	2	215
2	1	255	2	215	1	1	102
7	1	5	4	4	2	1	0
189	4	5	5	7	2	5	1
1	2	0	5	12	2	5	1
4	3	1	6	3	5	101	0
4	7	6	4	9	0	1	0

1. Calculate the compression ratio when applying the 4:1:1, 4:2:2 sub-sampling on this channel of the image?

2. What would be the effect on the image if the size of the conceptual region is 2x2 and we apply 2:1:1 sub-sampling on this image (without calculations)?

Exercise 2

Order the following bases functions according to their frequency from high to low level frequency



1. Is it possible to generate 4x4 bases functions and use them with JPEG?
2. Give the mathematical formula that allow to generate these bases?
3. Consider an MxN image, write the mathematical formula to calculate the DCT of this image?

Exercise 3

Given the following image denoted as *I*

5	3	2	11	1	9	8	6
9	1	8	3	3	0	2	3
2	1	5	2	4	1	1	5
7	1	5	4	4	2	1	0
1	4	5	5	7	2	5	1
1	2	0	5	12	2	5	1
4	3	1	6	3	0	10	0
4	7	2	7	5	0	10	0

1. Calculate the base function for vertical frequency V= 0, and horizontal frequency U=3?
2. Calculate the DCT matrix of *I* ?
3. Determine for *I* the top 5 bases functions (in terms of U and V) that have more effect on the image construction?
4. What is the closest statistical measure to the calculation of the base function (U=0, V=0)?
5. Apply the quantization matrix Q50 on the DCT matrix of *I* ?
6. Calculate the quantization matrix Q80 and apply it on the DCT matrix?
7. Calculate the reconstructed image by applying the inverse DCT if we keep only 49% from the energy of the quantized DCT matrix?
8. Apply the zig-zag ordering to vectorize the DCT quantized matrix?
9. Encode the DC and AC coefficients of the resulting matrix using DPCM and run-length encoding, respectively?
10. Enumerate all the compression acts that participate in decreasing the image size in JPEG?

Exercise 4

Verify that the 2D DCT can be written in terms of 1D DCT as $C.X.X^T$, where X is the input image, and C is the matrix of 1D DCT (use an example of 2x2 image for verification)? C is given by

$$C_{ux} = \frac{\sqrt{2}}{n}.a_u.cos\left(\frac{u(2x+1)\pi}{2n}\right)$$

$$a_u = \begin{cases} 1/\sqrt{2} & if\ u = 0 \\ 1 & otherwise \end{cases}$$

Exercise 5

Suppose we are given a file that contains letters with the following occurrence frequency: A(25), B(21), C(15), D(10), E(6), F(2).

1. Calculate the number of bits required to store this file using the fixed-length encoding?

2. Calculate the number of bits required to store this file using the Huffman encoding?
3. Is there any further optimization technique to reduce the required number of bits?

Exercise 6

Which text from the following list (ABBCD, DBACCDB, AABBCCDD, DBAACBB) corresponds to the following Huffman code 111100110111011110, if you know that letters frequency is as follow A(9), B(6), C(3), D(1).

Exercise 7

Given the following quantized DCT matrix

25	-9	2	0	1	0	0	0
0	4	3	3	1	0	0	0
-9	4	-3	2	0	0	0	0
-6	0	2	0	0	0	0	0
2	-4	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

1. Vectorize this matrix using the zig-zag ordering?
2. Encode the AC coefficients using run-length encoding?
3. Encode the encoded AC coefficients using data-driven Huffman codes, then using standard Huffman tables, and compare the two schemes?
4. By considering the left-right-top-down image browsing fashion (instead of zig-zag), what is the effect of such fashion on the compression ratio? Give a simple example?

SIZE	Value	Code
0	0	---
1	-1,1	0,1
2	-3, -2, 2,3	00,01,10,11
3	-7,..., -4, 4,..., 7	000,..., 011, 100,...111
4	-15,..., -8, 8,..., 15	0000,..., 0111, 1000,..., 1111
.		.
.		.
11	-2047,..., -1024, 1024,... 2047	...

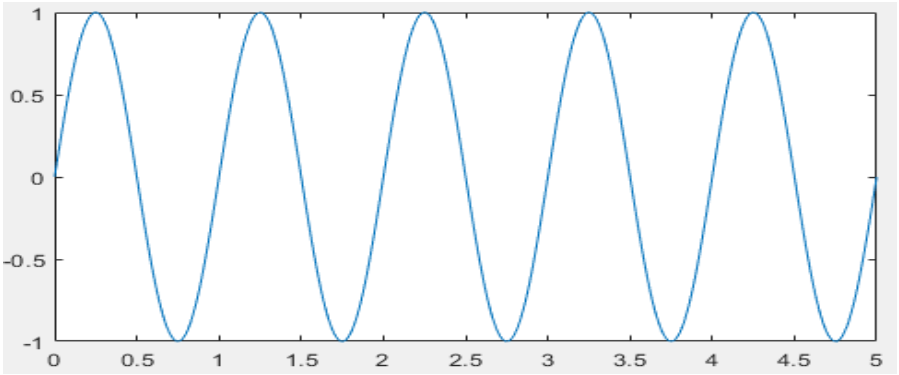
Run/ SIZE	Code Length	Code
0/0	4	1010
0/1	2	00
0/2	2	01
0/3	3	100
0/4	4	1011
0/5	5	11010
0/6	7	1111000
0/7	8	11111000
0/8	10	1111110110
0/9	16	1111111110000010
0/A	16	1111111110000011

Run/ SIZE	Code Length	Code
1/1	4	1100
1/2	5	11011
1/3	7	1111001
1/4	9	111110110
1/5	11	11111110110
1/6	16	1111111110000100
1/7	16	1111111110000101
1/8	16	1111111110000110
1/9	16	1111111110000111
1/A	16	1111111110001000
... 15/A	More	Such rows

Partial Huffman Table for AC Run/Size Pairs

Exercise 8

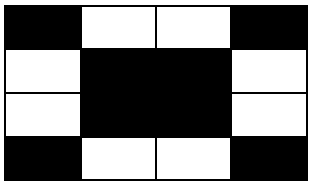
Given the following sinusoids signal



1. Determine the amplitude, period and frequency of this signal?
2. Calculate the output of a sinusoid function with period equals to 3 if the input is $x = 1.2$?

Exercise 9

Given the following 4x4 image (black = 0, white = 255)



1. Calculate the 2D discrete Fourier transform of this image (16 coefficients)?
2. Reconstruct the images based on Fourier coefficients and the inverse 2D Fourier transform? Consider the first 5, 8, 12 coefficients (set the rest to zero), respectively? What do you notice?
3. If we apply the 2D DCT for reconstructing this image, what would be the difference compared to 2D DFT? (without calculations)