

## Homework 4 (Due: 5/28<sup>th</sup>)

- (1) Write a Matlab or Python code for the 4:2:0 image compression technique.  
B = C420(A), where A is the input color image and B is the reconstructed image. Just use the interpolation method for reconstruction. The code should be handed out by NTUCool. (Note: The command `rgb2ycbcr` cannot be used).  
Moreover, please use the PSNR to compute the difference between A and B).  
(25 scores)
- (2) In the JPEG process, (a) why the DCT is used instead of the DFT for transformation? Write at least two reasons. (b) Why the input image is separated into several 8x8 blocks before using the DCT? Write at least two reasons.  
(10 scores)
- (3) (a) Give at least three conditions where the two images look similar but the NRMSE is large. (b) Give at least two conditions where the two vocal signals sound similar but the NRMSE is large.  
(10 scores)

- (4) Suppose that  $P(x = n) = (1 - e^{-\lambda}) \exp(-\lambda n)$  for  $n = 0, 1, 2, 3, \dots, 5000$  where  $\lambda = 0.015$ . Also suppose that  $\text{length}(x) = 50000$ . Estimate the range of the total coding lengths in the binary system when using (i) the Huffman code and (ii) the arithmetic code. (15 scores)

- (5) How do we implement the following matrix operation with the least number of multiplications? (10 scores)

$$\begin{bmatrix} y_0 \\ y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} 0.7010 & 0.7010 & 0.7010 & 0.7010 \\ 0.9239 & 0.3827 & -0.3827 & -0.9239 \\ 0.7010 & -0.7010 & -0.7010 & 0.7010 \\ 0.3827 & -0.9239 & 0.9239 & -0.3827 \end{bmatrix} \begin{bmatrix} x_0 \\ x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

- (6) For the rotation operation as follows:

$$\begin{bmatrix} y_0 \\ y_1 \end{bmatrix} = \begin{bmatrix} \cos \theta & \sin \theta \\ -\sin \theta & \cos \theta \end{bmatrix} \begin{bmatrix} x_0 \\ x_1 \end{bmatrix}$$

In what conditions we can implement it with only two multiplications? Express the solutions in terms of  $\theta$ . (10 scores)

(7) Consider the implementation efficiency, what is the optimal number of points of the DFTs if we want to implement the convolution of  $x[n]$  and  $h[n]$  when  $\text{length}(x[n]) = 63$  and  $\text{length}(h[n]) = 35$ ? (5 scores)

(8) Determine the number of real multiplications for (a) the 154-point DFT, (b) the 165-point DFT, and (c) the 242-point DFT. (15 scores)

(Extra): Answer the questions according to your student ID number.

(ended with 0, 2, 3, 4, 5, 7, 8, 9)