

Homework 4 (Due: 5/29th)

(1) Write a Matlab or Python program to measure the structural similarity (SSIM) of two images A and B. The sizes of A and B are equivalent.

$$\text{SSIM}(A, B, c1, c2)$$

where c1 and c2 are some adjust constants.

The Matlab or Python code should be handed out by [NTUCool](#). (20 scores)

(2) Suppose that the probabilities of Chinese characters can be modeled as

$$P[n] = (\exp(0.002) - 1) \exp(-0.002n) \quad n = 1, 2, 3, \dots, 80000$$

(a) Determine the entropy of the Chinese characters. (b) Estimate the range of the coding length if we use the Huffman code to encode 10^5 Chinese characters using binary numbers. (c) Estimate the range of the coding length if we use the arithmetic code to encode 10^5 Chinese characters using binary numbers.

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(15 scores)

(3) Suppose that x is a complex number. What are the constraints of θ such that the multiplication of x and $\exp(j\theta)$ required only 2 real multiplications?

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(10 scores)

1D N-point DFT $O(N \log N)$

(4) What is the complexity of the $M \times N \times P$ -point 3D DFT? The deriving process should be given. (10 scores)

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(5) How do we implement the 4-point DST-I with the least number of nontrivial multiplications? The number of real multiplications should also be shown.

$$X[m] = \sum_{n=1}^4 \sin\left(\frac{\pi}{5} mn\right) x[n] \quad \begin{matrix} m = 1, 2, 3, 4 \\ n = 1, 2, 3, 4 \end{matrix} \quad (15 \text{ scores})$$

$$\begin{bmatrix} X[1] \\ X[2] \\ X[3] \\ X[4] \end{bmatrix} = \begin{bmatrix} a & b & b & a \\ b & a & -a & -b \\ b & -a & -a & b \\ a & -b & b & -a \end{bmatrix} \begin{bmatrix} x[1] \\ x[2] \\ x[3] \\ x[4] \end{bmatrix} \quad a = 0.5878, \quad b = 0.9511$$

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(Hint: we can convert it into two 2x2 matrices.)

(6) Determining the numbers of real multiplications for the (a) 143-point DFT, (b) 195-point DFT, and the (c) 196-point DFT. (15 scores)

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(7) Derive the transform matrices of the (a) forward and (b) inverse 5-point NTTs where the prime number M is 11 and the primitive root α should be as small as possible. (15 scores)

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

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