# ADSP HW4 r12631055 林東甫

1.

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img_y*0.5 + 255.5*0.5
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SSIM = 0.7494340923996867

2. 3.

2. (a) entropy H: $H = -\sum_{n=1}^{40000} P[n] \log P[n]$

$P[n] = (e^{0.002}-1)\, e^{-0.002n}$ $\approx 10.408479566\cdots$

$\approx 10.41$ bit

(b) the Huffman code

$$N\frac{H}{\ln k} \le b \le N\frac{H}{\ln k} + N \quad \text{(bits)}$$

$$\Rightarrow 10^5 \cdot \overset{10.40848}{\cancel{15.01626}} \le b \le 10^5 \cdot \overset{10.40848}{\cancel{15.01626}} + 10^5$$

$$\Rightarrow \overset{1040848}{\cancel{1501626}} \le b \le \cancel{1601626}\ 1140848$$

(c) the Arithmetic code

$$\left\lceil N\frac{H}{\ln k} \right\rceil \le b \le \left\lceil N\frac{H}{\ln k} + \ln 2 \right\rceil + 1 \quad \text{(bits)}$$

$$\Rightarrow 1040848 \le b \le 1040850$$

3. $\exp(j\theta) = c + jd$, where $c = \cos\theta$, $d = \sin\theta$

$$\begin{bmatrix} c & -d \\ d & c \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}, \quad \begin{bmatrix} z_0 \\ z_1 \end{bmatrix} = \begin{bmatrix} c & -d \\ d & c \end{bmatrix} \begin{bmatrix} a \\ b \end{bmatrix} \text{ need 3 multip.}$$

If $\theta = n\frac{\pi}{2}$, $n \in \mathbb{Z}$ : 0 or 1 or $-1$ or $j$ or $-j$ no need multiplication

If $\theta = n\frac{\pi}{4}$, $n \in \mathbb{Z}$ : $\sin(\theta) = \cos\theta$ or $\sin\theta = -\cos\theta$, need 2 multiplication

If $\theta = n\frac{\pi}{6}$, $n \in \mathbb{Z}$ : $\sin\theta = \frac{1}{2}$ or $\cos\theta = \frac{1}{2}$, need 2 multipliction

Ans: $n\frac{\pi}{4}$ or $n\frac{\pi}{6}$ $n \in \mathbb{Z}$

4. 5.

4、

1-D DFT $= O(n \log n)$

$M: N \times P,\ N: M \times P,\ P: M \times N.$

$M: M \log M \times N \times P = MNP \log M$

$N: N \log N \times M \times P = MNP \log N$

$P: P \log P \times M \times N = MNP \log P$

$M \times N \times P$-point 3D:

$$O(MNP \log M + MNP \log N + MNP \log P)$$

$$= O(MNP(\log M + \log N + \log P))$$

$$= O(MNP \log(MNP))$$

5、Convert it into two $2\times 2$ matrices:

$$\begin{bmatrix} a & b \\ b & a \end{bmatrix},\quad \begin{bmatrix} b & a \\ -a & -b \end{bmatrix}$$

Case 3. MUL 2:

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} a & b \\ b & a \end{bmatrix} \begin{bmatrix} x[1] \\ x[4] \end{bmatrix} = \begin{bmatrix} a x[1] + b x[4] \\ b x[1] + a x[4] \end{bmatrix} = \begin{bmatrix} X[1] \\ X[2] \end{bmatrix}$$

Case 3. MUL 2:

$$\begin{bmatrix} y_3 \\ y_4 \end{bmatrix} = \begin{bmatrix} b & a \\ -a & -b \end{bmatrix} \begin{bmatrix} x[2] \\ x[3] \end{bmatrix} = \begin{bmatrix} b x[2] + a x[3] \\ -a x[2] - b x[3] \end{bmatrix} = \begin{bmatrix} X[3] \\ X[4] \end{bmatrix}$$

$$2\text{MUL} + 2\text{MUL} = \underline{4\text{MUL}}\ \#$$

6. 7. Ex.

6. (a) $143 = 11 \cdot MUL_{13} + 13 \cdot MUL_{11}$

$= 11 \cdot \cancel{4}52 + 13 \cdot 40 = \underline{1092}$ #

(b) $MUL_{195} = 13 \cdot MUL_{15} + 15 \cdot MUL_{13}$

$= 13 \cdot 40 + 15 \cdot 52 = \underline{1300}$ #

(c) $MUL_{196} = 4 \cdot MUL_{49} + 49 \cdot MUL_{4}$ $\cancel{14 \cdot MUL_{14} + 14 \cdot MUL_{14} + 3 \times (14-1) \times (14-1)}$

$= 4 \cdot 332 + 49 \cdot 0 = 1328$ #

$= \cancel{14 \cdot 32 + 14 \cdot 32 + 3 \cdot 13 \cdot 13 = 1403}$ #

Ex. (學號尾數為 0, 5)

$MUL_{400} = 25 \cdot MUL_{16} + 16 \cdot MUL_{25}$

$= 25 \cdot 20 + 16 \cdot 148 = \underline{2868}$ #

7 (a) forward:

$M = 11, \ \alpha = 2, \ W_{jk} = \alpha^{jk} \bmod M$

$$W = \begin{bmatrix} \alpha^{00} & \alpha^{01} & \alpha^{02} & \alpha^{03} & \alpha^{04} \\ \alpha^{10} & \alpha^{11} & \alpha^{12} & \alpha^{13} & \alpha^{14} \\ \alpha^{20} & \alpha^{21} & \alpha^{22} & \alpha^{23} & \alpha^{24} \\ \alpha^{30} & \alpha^{31} & \alpha^{32} & \alpha^{33} & \alpha^{34} \\ \alpha^{40} & \alpha^{41} & \alpha^{42} & \alpha^{43} & \alpha^{44} \end{bmatrix} \bmod 11 \Rightarrow W = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 2 & 4 & 8 & 5 \\ 1 & 4 & 5 & 9 & 3 \\ 1 & 8 & 9 & 6 & 4 \\ 1 & 5 & 3 & 4 & 9 \end{bmatrix}$$ #

(b) inverse

$W^{-1}_{jk} = \alpha^{-jk} \bmod M \quad \because \alpha^{-1} \equiv \alpha^{M-2} \bmod$

$$W^{-1} = \begin{bmatrix} \alpha^{-00} & \alpha^{-01} & \alpha^{-02} & \alpha^{-03} & \alpha^{-04} \\ \alpha^{-10} & \alpha^{-11} & \alpha^{-12} & \alpha^{-13} & \alpha^{-14} \\ \alpha^{-20} & \alpha^{-21} & \alpha^{-22} & \alpha^{-23} & \alpha^{-24} \\ \alpha^{-30} & \alpha^{-31} & \alpha^{-32} & \alpha^{-33} & \alpha^{-34} \\ \alpha^{-40} & \alpha^{-41} & \alpha^{-42} & \alpha^{-43} & \alpha^{-44} \end{bmatrix} \quad \alpha^{-1} = 6 \Rightarrow W^{-1} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 6 & 3 & 7 & 5 \\ 1 & 3 & 9 & 10 & 4 \\ 1 & 7 & 10 & 5 & 2 \\ 1 & 5 & 4 & 2 & 8 \end{bmatrix}$$ #