Midterm exam 2022, Solutions

Student name:
Student number:

bit budget = 35 bits

(1)

20 10	16 7
-10 5	4 3
17 6	3 -1
-2 0	2 0

Note: This is a 1 level WT. Therefore there are no parents pixel and descendants pixel

$T_0 = 16 = 2^4$

first pass: sp iz iz iz spiz iz iz spiz iz iz iz iz iz iz 32 bits

$1.5\ T_0 = 24$

24 0 0 0	24 0 0 0
24 0 0 0	0 0 0 0

→ Correction: $\frac{T_0}{4} = 4$

20 − 24 < 0
16 − 24 < 0
17 − 24 < 0

$-\frac{T_0}{4}$ =

20 0 0 0	20 0 0 0
20 0 0 0	20 0 0 0

3 bits

total of 35 bits stop here.

Full bit stream: 11 01 01 01 11 01 01 01 11 01 01 01 01 01 01 01 or/a

(2) $G = A^H F A$

original image

$$\frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 0 & 1 & 0 \\ 0 & -1 & 0 & 1 \\ 1 & 0 & -1 & 0 \\ 0 & 1 & 0 & -1 \end{bmatrix}\begin{bmatrix} 20 & 10 & 16 & 7 \\ -10 & 5 & 4 & 3 \\ 17 & 6 & 3 & -1 \\ -2 & 0 & 2 & 0 \end{bmatrix}\frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 \\ 1 & -1 & 0 & 0 \\ 0 & 0 & 1 & -1 \end{bmatrix} = \frac{1}{2}\begin{bmatrix} 56 & 18 & 22 & 10 \\ 10 & -10 & 12 & -4 \\ -6 & 18 & 0 & 22 \\ -6 & -10 & 8 & 2 \end{bmatrix}$$

reconstructed as

$$A^H \begin{bmatrix} 20 & 0 & 20 & 0 \\ 0 & 0 & 0 & 0 \\ 20 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} A = \cdots = \begin{bmatrix} 10 & 10 & 0 & 0 \\ 10 & -10 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

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(3) R=1 $\quad b_k = R + \log_2 \dfrac{w_k \sigma_k^2}{\prod_{i=1}^{4} (w_k \sigma_k^2)^{a_k}}$

Here $a_1 = a_2 = a_3 = a_4 = \frac{1}{4}$, $w_k = 1$ all k

So we need to calculate σ_k^2, $k = 1, 2, 3, 4$

from each subband $\sigma_k^2 = E\{x^2\} - (E\{x\})^2 = \frac{1}{4}\sum_{i=1}^{4} x_i^2 - \left(\frac{1}{4}\sum_{i=1}^{4} x_i\right)^2$

So for $\sigma_1^2 = \frac{1}{4}\left(20^2 + 10^2 + (-10)^2 + 5^2\right) - \left(\frac{1}{4}(20 + 10 - 10 + 5)\right)^2$

$= 117.14$

Similarly $\sigma_2^2 = 26.25$

$\sigma_3^2 = 54.7$

$\sigma_4^2 = 2.5$

Then $b_1 \approx 3$ bits

$b_2 = 0.276$ bit

$b_3 = 0.376$

$b_4 = 1 + \log_2 0.1 < 0 = 0$

$\Rightarrow R = \frac{1}{4}(3 + 0.276 + 0.376) = 1$

(4) H.261 uses I and P frames
H.263 uses I, P, B frames, ——— ——

(5) Video coding exploits both spatial and temporal redundancy

(6) $\frac{N}{2} \times \frac{N}{2}$ largest subband

$\frac{N}{2^5} \times \frac{N}{2^5}$ smallest subband

$3 \times 5 + 1 = 16$ total # of subbands

(7) In Assymetrical coding the decoder is well defined while the encoder can have arbitrarily high sophistication and complexity

MPEG is assymetrical
H.261 is symmetrical

(8) Assume 30 frames/sec $N \times N$ pixels

Then bit rate is $30 \times 3 \times N \times N \times 8 =$ ———