ECE 462, ~~Fall 2007~~ Solutions Final 2018

Q.1

a)

54	-22	21	-9
14	-12	13	-11
15	-8	9	7
34	-2	-6	10

First Pass

$T_0 = 32$

54 -22 14 -12 15 -8 34 -2

↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓

sp zt iz zt zt zt sp zt

$T_0 + \frac{T_0}{2}$

48	0	0	0
0	0	0	0
0	0	0	0
48	0	0	0

Correction:

$54 - 48 > 0 \rightarrow 48 + \frac{32}{4}$

$34 - 48 < 0 \rightarrow 48 - \frac{32}{4}$

56	0	0	0
0	0	0	0
0	0	0	0
40	0	0	0

So after first pass the bitstream is

11 00 10 00 00 00 11 00 / 1 0 = 18 bits

Second pass: $T_1 = \frac{T_0}{2} = 16$

... Continue process.

b) If only 16 bits are allowed then the process must stop just before correction in the first pass. Then the reconstructed image will be

48	0	0	0
0	0	0	0
0	0	0	0
48	0	0	0

Inverse wavelet transform (Haar)

$$\begin{bmatrix} 12 & 12 & 12 & 12 \\ 12 & 12 & 12 & 12 \\ 36 & 36 & 12 & 12 \\ -12 & -12 & 12 & 12 \end{bmatrix}$$ Reconstructed image

We have $A_1 = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$, $A_2 = \frac{1}{2}\begin{bmatrix} 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 \\ 1 & -1 & 0 & 0 \\ 0 & 0 & 1 & -1 \end{bmatrix}$

First $A_1^T \begin{bmatrix} 48 & 0 \\ 0 & 0 \end{bmatrix} A_1 = f_1$ → then $A_2^T \begin{bmatrix} f_1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} A_2 = f_2$

Q.2

a)

odd sequence :	2.3	3.2	1.3	2.5	3.8	2	1	0	-0.5	-1.2
error (odd) sequence	2.3	0.9	-1.9	1.2	1.3	-1.8	-1	-1	-0.5	-0.7
Quantized error sequence 16 levels, $\Delta = 0.3$	2.4	0.9	-1.8	1.2	1.2	-1.8	-0.9	-0.9	-0.6	-0.6

even sequence :	2.1	1.2	2.3	3.8	2.5	1.4	0.6	-0.3	-0.8	-1.4
error sequence :	2.1	-0.9	1.1	1.5	-1.3	-1.1	-0.8	-0.9	-0.5	-0.6
Quantized error seq. 16 levels, $\Delta = 0.3$	2.1	-0.9	1.2	1.5	-1.2	-1.2	-0.9	-0.9	-0.6	-0.6

Reconstructed Full rate :

2.4 2.1 3.3 1.2 1.5 2.4 3.1 (3.7) 3.9 2.7 2.1 1.5 1.2 0.6 . . . .

Reconstructed Half rate (odd)

2.4 2.85 3.3 2.4 1.5 2.1 2.7 3.1 3.9 3 2.1 . . . .

Recon Half rate (even)

2.4 2.7 3.0 . . . .

$MSE_{Full\ rate} = 0.02325$ (only quantization errors)

$MSE_{HR\ even} = 0.152$, $MSE_{HR\ odd} = 0.221$

$\therefore MSE_{HR} = \frac{0.152 + 0.221}{2} = 0.197$

Higher due to quantization + interpolation error

Q.3

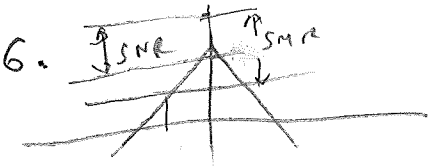
1. All 3 layers employ the masking properties of the Human ear to effectively reduce bit count.

2. It is a perceptual approach where a group of ~~listeners~~ listeners rank the audio sample on a scale from 1 → 5

3. $H = \sum_{i=1}^{6} p_i \log_2 \frac{1}{p_i} = \dots = 2.41$ $\left(\log_2 x = \frac{\log_{10} x}{\log_{10} 2}\right)$

4. By assuming (1) uniform quantization (step size Δ = constant = $\frac{2-0}{2} = 1$ then the values between $(0,1) \to +\frac{1}{2}$ and values between $(1,2) \to \frac{3}{2}$

(2) constant pdf over input intervals (as is)

6. 

We must have SNR = SMR

→ increase the number of bits until this is achieved

5. Due to the strong correlation between samples, a differential predictive compression approach is recommended. By downsampling by M correlation decreases between samples → this strategy may not be the best.

(6) ~~There is too much noise in the system. → So use more bits to decrease the noise and bring the SNR to the same level as SMR~~

6. The level of some bits are much smaller than SMR. This means that bits are wasted. Decrease # of bits to bring the SMR to the same level as SMR.

7. Equiprobable input signal values.

8. Energy compaction, 9. IBBPBBIBBPBBI 10. MP3

Q.4 · MV = $(1,-2) = (\Delta x, \Delta y)$