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CSCI 576 – Assignment 1

Part 1:

Q.1. (a)
Lines per frame = 450
Pixels per line = 520
Frame rate = 25 Hz
Color sub sampling: 4:2:0
Pixel aspect ratio: 16:9
Each sample of Y, Cr, Cb is quantized with 8 bits

For every 4 pixels of Y,
Bits per pixel for Y = 4 * 8 = 32
Bits per pixel for U = 1 * 8 = 8
Bits per pixel for V = 1 * 8 = 8

Average bits/pixel = (32+8+8)/4 = 12

Therefore, bit-rate = sampling rate * quantization bits/sample
= 450 * 520 * 25 * 12
= 70200000 bits/s
= 70.2 Mbits/s

Q.1. (b)
The chrominance signals are re-quantized with 6 bits/sample.

For every 4 pixels of Y,
Bits per pixel for Y = 4 * 8 = 32
Bits per pixel for U = 1 * 6 = 6
Bits per pixel for V = 1 * 6 = 6

Average bits/pixel = (32+6+6)/4 = 11

Therefore, bit-rate = sampling rate * quantization bits/sample
= 450 * 520 * 25 * 11
= 64350000 bits/s
= 64.35 Mbits/s

To store 10 minutes = 10 * 60 = 600 s for video, we would require
64.35 * 600 = 38610 Mbits of space.

Q.2. (a) The given sequence:
1.8, 2.2, 2.2, 3.2, 3.3, 3.3, 2.5, 2.8, 2.8, 2.8, 1.5, 1.0, 1.2, 1.2, 1.8, 2.2, 2.2, 2.2, 1.9, 2.3, 1.2, 0.2, -1.2, -1.2, -1.7, -1.1, -2.2, -1.5, -1.5, -0.7, 0.1, 0.9

The quantized sequence:
1.75, 2.25, 2.25, 3.25, 3.25, 3.25, 2.5, 2.75, 2.75, 2.75, 1.5, 1.0, 1.25, 1.25, 1.75, 2.25, 2.25, 2.25, 2.0, 2.25, 1.25, 0.25, -1.25, -1.25, -1.75, -1.0, -2.25, -1.5, -1.5, -0.75, 0.1, 1

Q.2. (b) No. of levels, L = 32
Therefore, bits required to transmit = $\log_2 L = \log_2 32 = 5$

Q.3. (a) The diameter of the tire = 0.4244m
In 1 rotation it covers = pi * d = 3.14 * 0.4244 = 1.3326m
The speed of rotation = 36 km/hr = 36 * 1000/3600 = 10m/s
The tire covers 10 m in 1s.
It covers 1m in 0.1s.
Hence, it covers 1.3326 m in 0.13326s.
i.e. 1 rotation takes 0.13326s
Speed of rotation = 1/0.13326 = 7.5 rotations/s (approximately)

The Nyquist frequency = 2f = 2*7.5 = 15Hz
Since, 24 > 15, there is no aliasing and we perceive the wheel moving forward at the same speed of rotation of tires of 7.5 rotations/s.

Q.3. (b) Refresh rate of camcorder = 8fps
One rotation corresponds to a turn of 360 degrees.
In one frame, the wheel covers (7.5 * 360)/8 = 337.5 degrees.
i.e. Turn per frame 360 – 337.5 = 22.5 degrees
For 8 frames, wheel covers 8 * 22.5 = 180 degrees.
i.e. Number of rotations/s in the video recording = 180/360 = 0.5 rotations/s
The wheel appears to turn backward as 337.5 lies in between the 180 degree and 360 degree mark.
(The white mark will be 22.5 degrees away from the horizontal in the first frame in counter clockwise direction, 45 degrees away after the second frame, 67.5 degrees away and so on, giving the appearance of moving back)

Q.3. (c) Since the camera records at 30 fps, the maximum speed the car wheel can go without aliasing in the recording = 30/2 = 15 rotations/s. (By Nyquist's formula: f >= 2fmax)
From Q.3 (a), we have that one rotation covers 1.3326 m.
Hence, the maximum speed is 1.3326 * 15 = 19.989 m/s = 71.96 km/hr