CSCI576 Homework#1

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Q.1 Suppose a camera has 450 lines per frame, 520 pixels per line, and 25 Hz frame rate. The color sub sampling scheme is 4:2:0, and the pixel aspect ratio is 16:9. The camera uses interlaced scanning, and each sample of Y, Cr, Cb is quantized with 8 bits

- What is the bit-rate produced by the camera? *(2 points)*
- Suppose we want to store the video signal on a hard disk, and, in order to save space, re-quantize each chrominance (Cr, Cb) signals with only 6 bits each for Y,Cr,Cb. What is the minimum size of the hard disk required to store 10 minutes of video *(3 points)*

(1)

$$bitrate = 450 * 520 * (1 + \frac{1}{4} + \frac{1}{4}) * 25 * 8 = 70200000bit/sec = 8775Kb/sec$$

(2)

$$OneFrameSize = 450 * 520 * (8 + \frac{6}{4} + \frac{6}{4}) = 2574000bits = 0.32175Mb$$
$$minSize = 0.32175 * 25 * 60 * 10 = 4826.24Mb$$

Q.2 The following sequence of real numbers has been obtained sampling an audio signal: 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 Quantize this sequence by dividing the interval [-4, 4] into 32 uniformly distributed levels (place the level 0 at -3.75, the level 1 at -3.5, and so on. This should simplify your calculations).

- Write down the quantized sequence. *(4 points)*
- How many bits do you need to transmit it? *(1 points)*

(1) After quantization

$$1.75, 2.25, 2.25, 3.25, 3.25, 3.25, 2.5, 2.75, 2.75, 2.75, 1.5, 1.0, 1.25, 1.25, 1.75, 2.25, 2.25, 2.25, 2.0, 2.25, 1.25, 0.25, -1.25, -1.25, -1.75, -1.0, -2.25, -1.5, -1.5, -0.75, 0.0, 1.0$$

convert to indes:

$$22, 24, 24, 28, 28, 28, 25, 26, 26, 26, 21, 19, 20, 20, 22, 24, 24, 24, 23, 24, 20, 16, 10, 10, 8, 11, 6, 9, 9, 13, 15, 19$$

(2)

$$32 \times 5 = 160bits$$

Q.3 Temporal aliasing can be observed when you attempt to record a rotating wheel with a video camera. In this problem, you will analyze such effects. Assume there is a car moving at 36 km/hr and you record the car using a film, which traditionally record at 24 frames per second. The tires have a diameter of 0.4244 meters. Each tire has a white mark to gauge the speed of rotation.

- If you are watching this projected movie in a theatre, what do you perceive the rate of tire rotation to be in rotations/sec? *(3 points)*
- If you use your camcorder to record the movie in the theater and your camcorder is recording at one third film rate (ie 8 fps), at what rate (rotations/sec) does the tire rotate in your video recording *(4 points)*
- If you use an NTSC camera with 30 fps, what is the maximum speed that the car can go at so that you see no aliasing in the recording *(3 points)*

(1) $36km/h = 10m/s$, perimeter of the tire is $\pi * 0.4244 = 1.33m$, which indicates the tire rotates $7.5rotation/sec$. Considering the sampling rate is 24, no aliasing would happen, we will see 7.5 rotation/sec.

(2) One frame at 24 fps rotates 0.3125 rotation. After downsampling, one frame roates $0.3125 \times 3 = 0.9375$, which indicates after each rotation, the mark will be $1 - 0.9375 = 0.0625rotation$ behind the previous point. We will see the mark rotates in an opposite direction to the acutal direction. At 8 fps it rotates $0.0625 \times 8 = 0.5rotation/sec$

(3) 30 fps which means we at most can see 15 rotation/sec. The maximum speed is $15 * \pi * 0.4244 = 20m/s = 72km/s$.