

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 rotates $0.3125 \times 3 = 0.9375$, 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 actual 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 $15 * \pi * 0.4244 = 20m/s = 72km/s$.