BENC 4173
MULTIMEDIA TECHNOLOGY & APPLICATION

Tutorial: Digital Data Representation & Communication

1. What is the cause of aliasing in digital media?
   a. a bit depth that is too small
   b. a frequency component that is an integer multiple of a second frequency component in the same complex wave
   c. a wavelength that is too long
   d. a sampling rate that is too low

2. Say that you want to digitally record a sound that has a highest frequency component of 650 Hz. According to the Nyquist theorem, what sampling rate do you have to use to be sure that you don't get sound aliasing?
   a. > 650 Hz
   b. > 1300 Hz
   c. > 325 Hz
   d. > 6500 Hz

3. What can you correctly say about a piece of music that has a wide dynamic range?
   a. it sounds very lively
   b. the difference between high pitched and low pitched sounds varies frequently
   c. there's a big difference between the highest note and the lowest note in the clip
   d. there's a big difference between the loudest and the softest part of the clip

4. How many bits or bytes of data are generated for one minute of uncompressed audio file with a sampling rate of 48 kHz and 32 bits per sample for each of two stereo channels?
   a. about 22 MB
   b. about 11 MB
   c. about 22 Mb
   d. about 11 Mb

5. If 16 different signal levels are possible for a data signal, how many bits can be communicated in each individual signal?
   a. 2
   b. 3
   c. 4
   d. 8

6. If a data signal has a bandwidth of 20 MHz, how many bits can it send per second, assuming there are eight signal levels?
   a. 20,000,000
   b. 120,000,000
   c. 40,000,000
   d. 160,000,000

7. You have a digital image in eight-bit color that has blocky areas of color, lacking the subtle gradations from one color to the next that you would like to see. Is this a matter of aliasing or quantization error? Explain.

8. If you are recording an audio file and you expect that the highest frequency in the file will be 10,00Hz, what is the minimum sampling rate you can use to ensure that you won't get audio aliasing?

9. What is data rate of a communication medium with a bandwidth of 3MHz using 4 different signal levels?

10. Do a run-length encoding of the following sequence grayscale values. Explain your encoding strategy, and compute the compression rate.

    240 240 240 240 240 240 240 238 238 238 238 238 230 230 230 230 229 228 228 227 227 277 227 227 227 227 277 227 227 227 227 277 227 227 227 277 227 227 227

11. Do a Shannon-Fano encoding of an image file on the basis of the frequency table below. Fill in the table below using Shannon's entropy equation. Then compare the average number of bits per color arising from your encoding with the minimum possible average number of bits derived from Shannon's entropy equation.

color	**frequency**	**optimum number of bits to encode this color**	**relative frequency of the color in the file**	**product of columns 3 and 4**
black	200			
white	175			
yellow	90			
orange	75			
red	70			
purple	35			
blue	20			
green	10			

12. Say that you have an image that has 100 pixels. The first six colors of the image are WKYBRY. Do the first six steps of arithmetic encoding based on the frequency table below:

Color	**Frequency out of total number of pixels in file**	**Probability interval assigned to symbol**
Black (K)	40/100 = 0.4	0 – 0.4
White (W)	30/100 = 0.3	0.4 – 0.7
Yellow (Y)	15/100 = 0.15	0.7 – 0.85
Red (R)	10/100 = 0.1	0.85 – 0.95
Blue (B)	5/100 = 0.05	0.95 – 1.0

13. Suppose you wish to transmit a stereo audio signal through a 1 mega-bit/s connection in real time. Consider the following scenarios:
    a) You are using a sampling frequency of 44.1 kHz. What is the maximum average number of bits can you use to represent an audio sample?
    b) You want to use 16 bit/sample/channel representation. What is the maximum sampling frequency? What will you need to do in order to avoid aliasing?
    c) You want to use a sampling frequency of 44.1 kHz, and also want to use 16 bit/sample/channel representation. What is the minimum compression ratio you need in order to transmit the audio signal?

14. Compute the number of bytes needed for one minute of uncompressed video that has 720 X 576 pixels per frame, 25 frames per second, three bytes per pixel, and CD-quality stereo audio.

15. Given the symbols with the characters in the word HELLO, perform:
    a) Shannon-Fano Algorithm
    b) Huffman coding.

What is the average number of bits used to code each character? Compare the answer with the calculation based on Shannon entropy theory.