Homework 1

CS 414, Spring 2011
Instructor: Klara Nahrstedt

Note: Homework is an individual effort, i.e**., no working in groups.** Consider the homework as a preparation for your midterm. The deadline for HW1 is **Wednesday, March 2, midnight**. You can submit your solutions through Compass in **pdf** format or you can slide the homework solutions in **paper form** under the door of the office 3104 Siebel Center. The homework has 100 points together.

Problem 1: Multimedia Stream Characteristics (6 Points)

Let us consider digital uncompressed audio stream and MPEG-1 with GOP= IPBBPBBI compressed video stream. Imagine that the audio and video streams are being exchanged in a tele-conferencing application between two users over a network. Provide the following information:

a. (3 Points) Characterize the audio stream in the tele-conferencing session, i.e., if the audio stream is strongly or weakly periodic stream; what network transmission mode is desirable for this audio stream - synchronous, asynchronous, isochronous mode; if the audio stream is strongly or weakly regular stream and explain why you choose the characteristics.

b. (3 Points) Characterize the video stream in the tele-conferencing session (as in case of audio) and explain why you choose the characteristics.

Problem 2: Audio Processing (10 Points)

1. (2 Points) What is the Intensity (in W/m^2) for Whisper with 30 dB when compared to the Threshold of Hearing (TOH) intensity? Show the work.
2. (2 Points) One guitar produces 40 dB while another produces 50 dB. What is the dB reading when both are played? Show the work.
3. (2 Points) If you increase sound intensity 10000 times than TOH, by how much do you increase the loudness (in dB)? Show the work.
4. (2 Points) If two people talk in a noisy restaurant, why are they speaking louder than usual? Explain briefly.
5. (2 Points) Why are Fletcher-Munson Contours not linear? Explain briefly.

Problem 3: Digital Audio (14 points)

1. (7 Points) Explain clearly **how** does **analog audio** get digitized and **what** concepts are of importance. Explain clearly how you get from a sinus-like analog signal to a stream of bits that will be used in the computer or transmitted over the network.

2. (8 Points) Show why adding one bit for signal quantization increases SNR (signal-to-noise ratio) approximately by 6 decibels?

Problem 4 Video (15 Points)

1. (5 Points) 24 is the standard frame rate for film production and projection. Why does the current refreshing rate of TV keep increasing to 120Hz, 240Hz, or even higher?

2. (5 Points) Which HDTV requires more bandwidth to transmit signal fully, 1080i (16:9 aspect ratio, 60Hz) or 720p (16:9 aspect ratio, 60Hz)? Show your work.

3. (5 Points) Cameras usually code captured video in the RGB (Red-Green-Blue) format. Why do we often convert RGB signal into luminance and chrominance signals and why do our computers and networks still work with luminance and chrominance signals? Give at least one reason and brief explanation.

Problem 5: Entropy Coding (15 Points)

1. (5 Points) Let us consider uncompressed sequence of character bytes (**Case 1**): **AAAABBAAAAACCCCCAAAAABBBBBBDDDDD**
   a. Encode this sequence with Run-Length Coding

   b. Specify the compression ratio when compressing the sequence with Run-Lenth Coding

2. (10 Points) Consider the following two coding tables for the alphabet {A, B, C, D} :

Block-Block coding table for the alphabet {A, B, C, D}:

Symbol	Code word
A	00
B	01
C	10
D	11

Block-Variable coding table for the alphabet {A,B,C,D}

symbol	Code word
A	1
B	01
C	000
D	001

Consider encoding the **sequence Case 1** above and encode it with **Block-Block** coding table and **Block-Variable** coding table. Show:

a. The encoded sequence **Case 1** for both coding tables

b. Which coding scheme compresses the **Case 1** sequence more and by how much.

Problem 6: Huffman Coding and Arithmetic Coding (30 Points)

Consider the following alphabet {e, m, n, o, t} with probabilities as follows:
p(e) = 0.6; p(m) = 0.2, p(n) = 0.1, p(o) = 0.05, p(t) = 0.05.

1. (10 Points) Construct the Huffman tree, the coding table, and encode the word "***monet***".

2. (10 Points) Based on the occurrence of letters in the word ***momento*** what is the new occurrence probability for the above alphabet {e, m, n, o, t} and how does the Huffman encoding table changes based on the new probabilities?

3. (10 Points) Encode the word "**emo**" with arithmetic encoding and compare which encoding (Huffman or Arithmetic) is more efficient. Use the original probabilities for the alphabet (p(e) = 0.6, ….).

Problem 7 JPEG/MPEG Coding (10 Points)

Consider JPEG Encoding Process and explain the following:

1. (2 Points) Why does JPEG coding transform light intensity values of an image into Forward DCT values? Explain briefly.

2. (2 Points) Explain how does quantization on AC coefficients happen in JPEG?

3. (2 Points) What is the difference between quantization process in JPEG and MPEG-1?

4. (2 Points) Give three reasons why JPEG-2000 was introduced.

5. (2 Points) How is psychoacoustic effect used in MPEG-1 audio encoding? Explain briefly.