MULTIMEDIA COMMUNICATION

INSTITUTO SUPERIOR TÉCNICO

Academic Year 2016/2017 – 2nd Semester, Responsible: Prof. Fernando Pereira

2nd Exam – 4th July 2017 (Tuesday), 8am

The marks should be out before **5th July (Wednesday), 2pm** at the CMul Web page and the exam checking session will on the **6th July (Thursday), 5pm** in room 0.17.

The exam is **3 hours long**. Answer all the questions in a detailed way, including all the computations performed and justifying well your answers.

Don't get 'trapped' by any question; move forward to another question and return later. ***Good luck !***

I (0.5 + 0.5 + 0.5 + 1.0 + 0.5 val. = 3.0 val.)

a) How many signal components are needed to see a gray image in a black and white television ? Which ones ? (R: 1, luminance)
b) How many signal components are needed to see a gray image in a colour television ? Which ones ? (R: 3, luminance and chrominances)
c) How many signal components are needed to see a colour image in a colour television ? Which ones ? (R: 3, luminance and chrominances)
d) Are there more samples or pixels in a black and white image ? And in a colour image ? Why ? (R: The same, more samples)
e) Are there more luminance samples or chrominance samples in a 4:2:2 colour image ? Why ? (R: The same)

II (0.5 + 0.5 + 0.5 + 0.5 + 0.5 + 1.0 val. = 3.5 val.)

Consider a videotelephony communication using Recommendation ITU-T H.261. The video sequence is coded with a CIF spatial resolution (352×288 samples for the luminance, 4:2:0), a frame rate of 10 Hz and a constant bitrate channel of 64 kbit/s. The output buffer has a size of 12800 bits. The bits for each coded image are uniformly generated in the time between the acquisition of two images.

a) What is the average number of bits that a single image may spend ? (R: 6400 bit)
b) What is the maximum number of bits that a single image may spend ? (R: 19200 bit)
c) What is the maximum number of bits that the third image may spend ? (R: 19200 bit)
d) What is the maximum number of bits that a single image may spend if the buffer is full when the image is acquired ? (R: 6400 bit)
e) What is the maximum number of motion vectors that may be used to code a single image ? (R: 396)
f) Considering that a constant bitrate channel is used, what architectural element mostly allows the encoder directly controlling the number of bits spent per frame ? Why ? (R: Quantizer)

III (0.5 + 0.5 + 2.0 + 0.5 = 3.5 val.)

Suppose that you are contacted by an advertising company to design a multimedia digital storage system. The company requires editing flexibility with a maximum access time per image below 400 ms and needs to store the largest number of 3.8 minutes clips in a disk with 500 TBytes of capacity. The maximum access speed to the disk is 30 Mbit/s. The clips have HDTV resolution, this means 1920×1152 (Y) and 960×1152 (Cr, Cb) at 25 Hz. Assuming that you have at your disposal providing the required video quality:

1. a JPEG coding solution with a compression factor of 30 for both the luminance and chrominances
2. a MPEG-2 Video coding solution with the following compression factors when M=2 is used:

- I frames: 20 and 25 for the luminance and chrominances, respectively
- P frames: 40 and 50 for the luminance and chrominances, respectively
- B frames: 50 and 60 for the luminance and chrominances, respectively

a) Considering its native features, which of these two coding solutions is more suitable for editing purposes? Why ? (R: JPEG)

b) Considering its native features, which of these two coding solutions is more suitable for compression purposes? Why ? (MPEG-2 Video)

c) Considering the requirements defined above, determine, justifying, which coding solution should be proposed to your client ? Do NOT directly base your answer on the number of clips that may be stored in the disk. (R: MPEG-2 Video)

d) If you could consider a third coding solution, notably to increase the compression efficiency, which solution would you like to have at your disposal ? Why ? (R: H.264/AVC)

IV (1.0 + 1.5 + 1.0 = 3.5 val.)

Consider that your company is contacted to design a videoconference system between the various main locations of a bank. The spatial resolution is CIF (352×288 luminance samples), 4:2:0, at 12.5 Hz, with the usual number of bits per sample. Assume that you have available, offering the target video quality, two solutions:

1. **H.261 based solution** with average compression factors of 25 and 35 for the luminance and chrominance, respectively; the critical compression factors (for the images spending more bits) are 20 and 25 for the luminance and chrominances, respectively.
2. **MPEG-2 Video based solution** with N = M = 3 with average compression factors of 25 and 35 for the luminance and chrominance, respectively, for the I frames, and 30 and 45 for the luminance and chrominances, respectively, for the P and B frames. The critical compression factors are 75% of the average compression factors.

Assume that the transmission rate is always the same as the coding rate.

a) Determine the bitrate and acquisition-visualization delay for the H.261 based solution. (R: 550.3 kbit/s and 103 ms)

b) Determine the bitrate and acquisition-visualization delay for the MPEG-2 Video based solution. (R: 483.8 kbit/s and 400 ms)

c) Assuming that your client always pretends to minimize the transmission rate, what solution from above would you select depending on the acquisition-visualization delay requirement defined by the client?

V (0.5 + 0.5 + 1.0 + 0.5 + 0.5 = 3.0 val.)

Consider the audio codec specified in MPEG-1 Audio Part 3.

a) What is a reasonable rate required to code a stereo signal with 44kHz sampling rate ? (R: 117.333 kbit/s)

b) What does it happen if the 'spatial integrity' is lost when coding a stereo audio signal ?

c) Indicate two coding effects that may happen if the audio encoder includes a psychoacoustic model which is conservative in the sense of exaggeratedly lowering the hearing thresholds associated to the audio masking effects ?

d) Considering the varied composition of a symphonic orchestra, how would change the subjective quality assessment associated to the music if the full bandwidth is kept while successively reducing the initial sampling rate from a value which starts being 2.5 times the full bandwidth and ends being the same as the full bandwidth?

e) What would happen in terms of subjective quality assessment if the full bandwidth is now reduced in the same proportion as the sampling rate starting from the same initial values as in d) ?

VI (1.0 + 0.5 + 0.5 + 0.5 + 0.5 + 0.5 = 3.5 val.)

Consider a digital TV system for terrestrial broadcasting.

a) Why is it essential that all the transmitters are synchronized to transmit the same symbol at the same time to properly operate in a Single Frequency Network ?

b) Why is it useful to have longer modulated symbols to be able to deal with the multipath effect ?

c) What key feature does OFDM have regarding FDM that allows it to become more bandwidth efficient ?

d) Why is the 8k mode more robust than the 2k mode to the multipath effect ?

e) What good and bad may happen if the modulation efficiency of each carrier is increased for the same total number of carriers ?

f) What good and bad may happen if the total number of carriers is increased for the same bandwidth and rate ?