MULTIMEDIA COMMUNICATION

INSTITUTO SUPERIOR TÉCNICO, Alameda

Academic Year 2023/2024 – 1st Semester, Responsible: Prof. Fernando Pereira

2nd Exam – 30th January 2024 (Tuesday), 1pm

The marks should be out before **30th January (Tuesday), 7pm** at the CMul Web page. The exam scoring checking session will be on **31th January (Wednesday) at 4pm**, room 10.14, floor 10, North Tower, IST.

The exam is **90 minutes 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. ***Boa sorte !***

I (1.0 + 1.0 + 1.0 + 1.0 + 1.0 + 1.0 val. = 6.0 val.)

Consider the JPEG standard to code photographic images with a 1152×1440 luminance resolution, 4:2:0 color subsampling and 8 bit/sample.

a) How many total pixels, samples and blocks exist in this type of image. (R: 1658880 pixels, 2488320 samples, 38880 blocks)

b) State the price in bits for a luminance and for a chrominance sample. (R: 8 bit, 8 bit)

c) Determine the price in bits per pixel if a codec with a luminance compression factor of 25 and a chrominances compression factor of 15 is used. (R: 0.587 bit/pixel)

d) Determine the price in bits for a full image if a codec with a luminance compression factor of 25 and a chrominances compression factor of 15 is used. (R: 973209.6 bit)

e) Determine the price in bits to code a gray scale version of a full image with only 64 levels of gray if the same codec as in c) is used. (R: 398131.2 bit)

f) Determine the total number of bits that have to be spent to code the 2 chrominance components of an image if an average number of 5 DCT coefficients are coded per block and each coefficient costs, on average, 3 bits; additionally consider that the EOB (End of Block) word costs 4 bits. (R: 246240 bit)

II (2.0 + 2.0 + 1.0 + 1.0 + 1.0 = 7.0 val.)

Assume that you are contacted by a company to design a digital storage system for video clips. The company requires some editing flexibility and needs to store the largest number of 4 minutes clips in a disk. The maximum access speed to the disk is 80 Mbit/s. The clips have 4K resolution with the following characteristics: 3840×2160 (Y), 4:2:2, 10 bit/sample at 25 Hz.

a) Assuming that you have at your disposal, providing the required video quality, a JPEG coding solution with average compression factors of 40 and 45 for the luminance and chrominances,

respectively, determine the maximum access time for an image knowing that the compression factors for critical frames are 20% lower than average. (R: 61.12 ms)

b) Assuming now that you have at your disposal, providing the required video quality, a MPEG-2 Video coding solution with

N=12 and M=4 with the following average compression factors:

- I frames: 30 and 35 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

Determine the maximum access time for an image knowing that the compression factors for critical frames are 25% lower than average. (R: 346.26 ms)

c) Determine, justifying, which coding solution would you propose to your client if the target is only to maximize the number of clips stored in the disk. (R: MPEG-2 Video)

d) Determine, justifying, which coding solution would you propose to your client if a maximum random access requirement of 100 ms is put forward together with the requirement of maximizing the number of clips stored in the disk. (R: JPEG)

e) How many full video clips would you be able to store in the disk for the JPEG solution if the disk has a capacity of 10 TByte (10^{12}). (R: 3404 full clips)

III (1.0 + 1.0 + 1.0 + 1.0 + 1.0 + 1.0 + 1.0 = 7.0 val.)

Consider the currently very popular H.264/AVC video coding standard.

a) What may be real-world service implications of the fact that H.264/AVC spends “about 50% less rate for the same perceptual quality regarding previous existing standards” (2 implications) ?

b) Indicate a major difference between the coding of a B-macroblock in H.264/AVC versus MPEG-2 Video.

c) What is the purpose of H.264/AVC defining a lossless coding mode considering that it also defines a PCM coding mode ?

d) In what way does H.264/AVC try to not represent better non-translational motion, notably rotational motion ?

e) Why is it important to define good interpolation filters for the half and quarter sample positions ?

f) Why are the motion vectors coded using a prediction made based on the motion vectors for neighboring partitions?

g) What are the main positive and negative impacts of using multiple reference frames ?