MULTIMEDIA COMMUNICATION

INSTITUTO SUPERIOR TÉCNICO, Tagus

Academic Year 2023/2024 – 2nd Semester, Responsible: Prof. Fernando Pereira

1st Exam – 8th april 2024 (Monday), 3.30pm

The marks will be sent to the students by e-mail before **10th april (Wednesday), 7pm**. If needed, the exam scoring checking session will be on **11th May (Thursday) at 4pm**, room 0.15.

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 + 1.0 val. = 7.0 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, 2488320, 38880)

b) Determine the price in bits for a luminance and for a chrominance sample if the codec above is not used. (R: 8, 8)

c) Determine the price in bits per pixel if the codec above is not used. (R: 12 bpp)

d) 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: 0.5867 bpp)

e) 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)

f) 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: 9953280)

g) 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)

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 with lowest rate)

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

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 = 6.0 val.)

Consider the H.264/AVC video coding standard.

a) It is often said that the H.264/AVC standard may offer "*about 50% less rate for the same perceptual quality regarding existing standards*". Why is it important to include the term 'perceptual' in this claim ?

b) What is the relevance of using Variable Block-Size Motion Compensation for the more efficient coding of video content with rotational motion ?

c) What is the maximum number of motion vectors that may be used to code a P-MB if no blocks with size smaller than 8×8 are used ? In what conditions would it be convenient to use more than 1 motion vector ?

d) What would be the consequences (2) of using only full-sample motion estimation and not ½ and ¼-sample (luminance) motion estimation ?

e) What are the two types of information that may have to be coded when coding a MB using Intra coding tools (explain what they represent) ?

f) What is the offered compression factor if you use a H.264/AVC codec which spends around 3 Mbit/s to code video with a spatial resolution of 1152×1920, 4:2:2, 8 bit/sample at 25 Hz ? (R: 294.912)