Lebanese University Faculty of Science Section 5	M1- Computer Science Info449-E: Image, Video and Audio Final Exam – English version	Duration: 90 minutes Date: 25/06/2025 Instructor: M. Haydar

Problem #1: [20 pts]

A given colored image has 600-pixel width and 500-pixel height. The image is coded in RGBA where each component is coded using 8-bits.

1. Compute the number of pixels in the image **[2 pts]**. Compute the pixel size in bits **[2 pts]**, the image size in bytes **[2 pts]** and the number of possible colors **[2 pts]**.
2. If the image is quantized by using 5 bits for the red component, 5 bits for the green component, 5 bits for the blue component and 1 bit for transparency. Compute the new pixel size **[2 pts]**, the new image size **[2 pts]** and the new number of possible colors **[2 pt]**. Is this transformation loosely or lossless, justify! **[2pts]**.
3. The original image is sub-sampled by taking the average of each 4x4 pixels. Compute the new width and height of the image **[2 pts]**. Deduce the new image size in bytes **[2 pts]**.

Problem #2: [10 pts]

A temperature sensor reads and sends temperature data (8-bit values) to a device at a rate of 100 values per second. The device classifies and stores the values for further analysis based on the following classification:

- $T \leq 30 \rightarrow$ Cold
- $30 < T \leq 80 \rightarrow$ Warm
- $80 < T \leq 120 \rightarrow$ Hot
- $T > 120 \rightarrow$ Dangerous

For the Cold, Warm, and Dangerous categories, there is no need to store the temperature values. However, for Hot temperatures, the exact value must be stored.

a) Propose a storage format that minimizes the number of bits needed **[5 pts]**.
b) Assuming that 20% of the values are Hot, calculate the total storage size (in bytes) for one hour of data using both approaches:
   - Storing the exact value for all readings **[3 pts]**
   - Using your proposed optimized format **[3 pts]**

Problem #3: [10 pts]

A video source produces 400x500 images, interlaced at a field rate of 60Hz, and full color (24 bpp). You first convert the video to 4:2:1 color format representation. The component Y of the pixel is quantized using 8 bits and Cr , Cb using 3 bits each.

1. **[7 pts]** Compute the bit rate of the video source.
2. **[3 pts]** Compute the size in bytes for a minute of video.

Problem #4: [14 pts]

The enclosed 4x4 matrix represent a 256 level gray scale image. Convert it to binary image by applying the following methods:

120	80	120	130
200	110	95	180
90	10	60	20
120	150	70	45

1. **[3 pts]** The naive conversion
2. **[3 pts]** The average dithering
3. **[4 pts]** The **local median** cut dithering (convert only the 4 internal pixels), in the local median we use the median of the pixel and its 8 neighbors as threshold.
4. **[4 pts]** Error diffusion using threshold = 127 and the below diffusion matrix. Show conversion for first row only and error diffusion for first and second row.

P	4 / 8
3 / 8	1 / 8

Problem #5: [12 pts]

A message contains three symbols (x, y and z) with the distribution probabilities 10%, 80% and 10% respectively.

1. **[6 pts]** Encode the message yyz using arithmetic coding (show all calculation steps)
2. **[6 pts]** Decode the number 0.915 to obtain a 3 symbols length message (show all calculation steps)

Problem #6: [18 pts]

A message contains 6 symbols with the following distribution probabilities :

A	B	C	D	E	F
0.3	0.2	0.17	0.03	0.25	0.05

1. **[8 pts]** Apply the Shanon-Fano coding to obtain symbols' codes (show your work)
2. **[2 pts]** Compute the average symbol length
3. **[4 pts]** Compute the entropy and the compression efficiency
4. **[2 pts]** Encode the word : FADE
5. **[2 pts]** Decode the message: 11100100000001001

Problem #7: [16 pts]

Consider the encoding of a 640x480 video at 30 fps using I and P frames. To encode the P frames, we consider 8x8 macroblocks and use sequential (brute force) search to find the best motion vector. Assume that the search area parameter k is equal to 8.

a. **[4 pts]** Calculate the number of candidate blocks to be matched against a target macroblock.
b. **[4 pts]** Calculate the number of MAD evaluations per frame (assume that all target macroblocks, including the boundary ones, have the same number of candidates).
c. Consider now 10 minutes of video knowing that one I frame is inserted after every 4 consecutive P frames as follows:
   I PPPP I PPPP I … . Assume that 1 MAD evaluation takes 0.1 ms.
   1. **[3 pts]** What is the Total number of frames? I frames? P frames?
   2. **[3 pts]** Deduce the time spent on motion vector computation for these 10 minutes of video.
   3. **[2 pts]** Can this be used for real-time encoding and distribution setup? Justify.

Good Work