University of Toronto Faculty of Applied Science and Engineering

FINAL EXAMINATION ECE462H1S, Multimedia Systems

April 29, 2024, 6:30 – 9:00 pm Instructor: D. Hatzinakos

Instructions:

- 1. This is a type C1 exam. All non-programmable calculators are allowed (type 2).
- 2. The exam counts for 50% of the overall mark.
- 3. Please, answer all question. Do not show only final answers. You should demonstrate how the answer has been obtained by including intermediate results and explanations wherever needed.
- 4. Please use the provided exam books to write your answers. Please, use a dark ink pen or pencil so that the writing is clear.

QUESTIONS (All questions are equally weighted each counting for 2.5 points)

1. Assume that in an EZW based compression of a 4x4 image f(x,y), the decoder receives the following information:

2 level Haar wavelet transform To=16 Do=11000000 So=1 D1=10000011110000 S1=010

Assuming that the following codes have been used

| Zerotree root Significant positive Significant negative Isolated zero | t | 00 |
|--|-------------|----------------|
| | p n z | 11 01 10 |

What is the reconstructed 2-pass wavelet transform?

- 2. In question 1, what is the reconstructed image? How many bits have been used for encoding? Is the algorithm more sensitive to errors in the transmission of To or errors in the transmission of Do or So?
- 3. What is the motivating principle behind transform based coding (for compression). What will be the criteria for choosing between two different transforms ?
- 4. The autocorrelation sequence of a short voiced speech signal takes the values R(0)=1, R(1)=0.5, R(2)=0.3, R(3)=0.15, R(4)=0.8, R(5)=0.4, R(6)=0.3, R(7)=0.1 An LPC coder uses this information to generate the excitation signal e(n)=δ(n)+δ(n-P)+δ(n-2P)+... where P is the pitch period in samples and δ(n) is the delta function. Estimate the value P.
- 5. Given that singing has characteristics of both speech and music which compression algorithms would you expect to be more successful on songs?
- 6. The display order in a GOP is I1P2P3P4B5P6B7P8. What will be the transmission order?
- 7. Provide an example of an image with entropy equal to 0. What this implies in compression terms?
- 8. Given the sequence x(n): ..., 1, 0.9, 1, 0.9, 1, 0.9, design a length 2 linear predictor based on the MSE criterion. Then design a length 2 predictor by inspection. Comment on your results.

 Consider the two video frames shown below. Apply a logarithmic search process with area size (2p+1)x(2p+1) and p=4 using the SAD criterion in order to estimate the motion vector for the 4x4 macroblock indicated in the target frame



Note: the "dots" and the dashed box in the reference frame are aids to show the relative position of the target frame content.

- 10. An engineer is told that a digital image must be compressed by a factor of 4. After carefully examining the image the engineer considers two possible approaches: a) down-sample the image by deleting every-other row and column. b) Keeping every -forth column of the image. Which one of this approaches (if any) makes sense. Please, explain.
- 11. What are different forms of redundancies used in video compression?
- 12. A signal -2 < x < 2 has the following pdf f(x)



Design a 1 bit Max-Loyd non-uniform quantizer. Provide 2 iterations of the algorithm and calculate the MSE in both iterations.

- 13. Given the sequence 31.5, 16.2, 5.6, 3.1, 1.1 and a quantizer round(x/q) where x is the signal value and q is a constant scale, describe a two level scalable-SNR using first q=16 and later q=2.
- 14. Which compression scheme uses modified DCT? What is the benefit compared to classical DCT?
- 15. How many LPC-10 compressed 3 minute long conversations can be stored in a 512 Mbyte hard disk?
- 16. Mention similarities and differences between H.261 and MPEG-2 coders.
- 17. In an audio compression scheme we find at a particular frequency that the Mask to Noise Ratio MNR=-8 dB. What does this imply in terms of allocated bits at that frequency?
- 18. A quantizer uses 8 bits to process a signal. What is the QSNR in dB scale at the output of the quantizer? Make all necessary assumptions.
- 19. Given the signal x(n), n=0,1,2,..., 8 with values 2.3, 2.1, 3.2, 1.2, 1.5, 4.2, 0.6, 1.5and a 4 bit quantizer design explicitly a DPCM encoder-decoder. What is the MSE between the original and reconstructed signals?
- 20. Assume that you want to design a new video codec standard. Which ones of the units and properties used in existing standards will you preserve or improve?