

Name:
Student number:

University of Toronto
Faculty of Applied Science and Engineering

MIDTERM EXAMINATION 1
ECE462H1S, Multimedia Systems

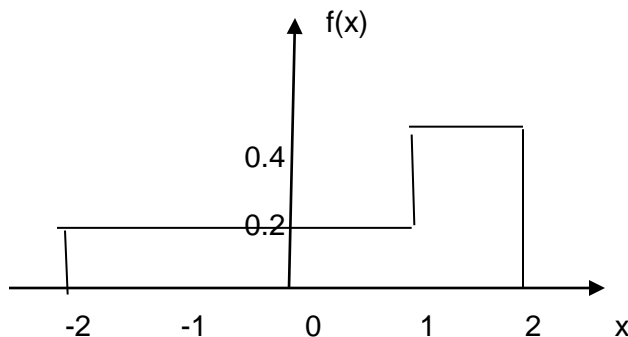
February 17, 2022, 5:00 - 6 pm
Instructor: D. Hatzinakos

Instructions:

1. The exam counts for 15% of overall mark.
2. Please solve all problems. Do not show only final answers. You should demonstrate how the answer has been obtained by including intermediate results and explanations wherever needed.
3. Use the blank space provided in this handout to record your answers.
4. Write your name and/or student number on top of all submitted pages.

QUESTIONS.

1. A signal x has the following pdf $f(x)$.



Use the Max-Lloyd algorithm to design a 2-bit non-uniform quantizer. Use the settings for a uniform quantizer to initialize the algorithm. What are the decision boundaries and reconstruction levels at the end of recursion (iteration) 1. What is the corresponding MSE distortion for this quantizer?

(3 points)

2. How many bits will you assign to two values A and B so that the average distortion (MSE of quantization error) is at maximum $MSE=0.01$? Describe a procedure to achieve this if you know that the variances of the values A and B are $Var(A)=3.5$ and $Var(B)=1.5$. How many bits will you assign to A and how many bits will you assign to B? (3 points)
3. Consider compressing the following 4x4 image using JPEG (2 points)

```

1  1  1  1
1  0  0  0
1  0  0  0
1  0  0  0

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Assuming equal size blocks how will you segment the image for best performance? Why?

Assuming non equal size blocks how will you segment the image for best performance?

Why?

Is JPEG the best choice for compression?

4. An alien species has a different colour visual spectrum than the human range. Can they still perceive human generated images generated by JPEG encoding? (1 point)
5. Given the sequence of 8 values for a signal $x(n)$, $n=0,\dots,7$, that is 1, 1.2, 1.4, 1.2, 1.4, 1.6, 1.4, 1.6 design a MSE predictor of length 1 and estimate the value of $x(8)$. (2 points)
6. Now many different Huffman codes can you design for the word TAKATAKA. What is the rate for these codes? (2 points)
7. A signal $x(n)$ is uniformly distributed between -0.5 and 0.5 and is uniformly quantized using 8 bits/sample. A second signal $y(n)$ uniformly distributed between -1 and 1 is also uniformly

quantized using b bits /sample. Find b so that the Signal to Quantization noise ratio (SQNR) is the same in both cases. (2 points)

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Aid sheet (Useful relations)

- 4-DCT Matrix

$$T = \begin{pmatrix} 0.25 & 0.25 & 0.25 & 0.25 \\ 0.4 & 0.2 & -0.2 & -0.4 \\ 0.25 & -0.25 & -0.25 & 0.25 \\ 0.2 & -0.4 & 0.4 & -0.2 \end{pmatrix},$$

- 2-DCT matrix

$$T = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

- MSE prediction optimization : $\begin{pmatrix} R(0) & R(1) & R(2) \\ R(1) & R(0) & R(1) \\ R(2) & R(1) & R(0) \end{pmatrix} \begin{pmatrix} a1 \\ a2 \\ a3 \end{pmatrix} = \begin{pmatrix} R(1) \\ R(2) \\ R(3) \end{pmatrix}$

- Distortion $D \sim \sigma^2 2^{-2R}$

- Max-Lloyd relations:

$$b_i = \frac{\hat{x}_{i-1} + \hat{x}_i}{2},$$

$$\hat{x}_i = \frac{\int_{b_i}^{b_{i+1}} x f_X(x) dx}{\int_{b_i}^{b_{i+1}} f_X(x) dx}$$