

Student no:

Name:

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BLG 477E Multimedia Computing – Midterm 1

Answer all questions in the space provided. Open book, notes. Write your name

1. Let a mixture of two tones be expressed as $x(t) = 10 \cos(10\pi t) + 5 \cos(1000\pi t)$.
- a) Can both tones be heard by a human? (What are the frequencies of the tones? Ignore masking effect) (5 pts)

No, the first tone has frequency 5Hz, which is inaudible (below 20Hz)

- b) At what frequencies should we sample the analog waveform so that the waveform can be exactly reconstructed from its samples. (10 pts)

$\geq 2 \cdot \max_freq = 2 \cdot 500\text{Hz} = 1000\text{Hz}$

- c) Suppose we sample at the minimum frequency you found in part b). If we use a 256 level quantizer, what is the data rate of the digital representation of the analog waveform? (5 pts)

$1000\text{samples/sec} \cdot 8\text{bits/sample} = 8000\text{bits/sec.}$

- d) If we would like to increase the quality of the digital representation in part c) by approximately 12dB, how many levels should our quantizer have? (5 pts)

$12\text{dB} \cong 2\text{ bits}$. Therefore our quantizer should have 1024 levels which can be represented in binary by 10bits

2. Why do telephone systems use a nonlinearity to shape the probability density function of the input voice signal before quantization? Explain the psychoacoustic reasoning. (10 pts)

Human ear is sensitive to sounds with low amplitude. Therefore, high amplitude sounds could be quantized more coarsely than low amplitude sounds which is the net effect of preceeding a uniform quantizer by a log like nonlinearity.

3. How does MPEG audio encoder achieve compression by applying a filterbank? (What is the key algorithm for optimizing quality for a given number of bits? On which psychoacoustic principle(s) does this algorithm rely on?) (10 pts)

An incremental bit allocation algorithm is used to optimize the quality (minimize the noise-to-mask ratio). Frequency masking effect is modelled and a minimum masking threshold is computed for each subband

4. Is the following code uniquely decodable? Explain. $C = \{01,00,001,1\}$ (10 pts)

No, whether the sequence 001 is codeword3 or codeword2 followed by codeword4 is ambiguous to the decoder

5. For what kind of sources does entropy coding yield no compression gain with respect to binary coding of symbol indices. For what kind of sources does entropy coding yield good gain? Answer by referring to source statistics. (10 pts)

For sources with uniformly distributed symbol probabilities entropy coding yields no compression gain. If distribution is largely nonuniform entropy coding yields good gain.

6. Determine the triplets transmitted from encoder to decoder during the application of LZ77 algorithm for the sequence xyzxyxyzzyzx. Assume a search buffer of size 4 which is initially empty. What is the inherent problem here? Recommend a fix for this problem to increase the compression gain. (15 pts)

(0,0,x), (0,0,y), (0,0,z), (3,2,x), (2,1,z),(3,3,z),(3,1,x)

7. Why does the old JPEG standard not employ equal size quantization bins for the quantization of all DCT coefficients? (10 pts)

Human eye is less sensitive to high frequency coefficients and to chroma coefficients so these coefficients are assigned relatively larger quantization bins (less bits per coefficient)

8. A handheld device with limited display capability (resolution) decodes only a subset of the packets received for a JPEG2000 compressed image. Explain which packets are ignored and not decoded. (What kind of info do these packets contain?)(10 pts)

Packets containing high frequency subbands need not be decoded. For instance, to only get $(n/2) \times (n/2)$ resolution of a $n \times n$ picture the three high freq subbands (LH,HH,HL) at the lowest level of DWT need not be decoded.