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* SOLUTION

The University of Texas
ARLINGTON

EE5356 Digital Image Processing

Instructor: Dr. K.R. Rao

Spring 2016, Final

Tuesday, 10 May 2016

2:00 – 4:00 PM (1 hour ~~and 20 minutes~~) (2 Hours)

INSTRUCTIONS:

1. Closed books and closed notes.
2. Please show all the steps in your works.
3. You can work problems in any order.
4. At the end please rearrange in the correct order.
5. Please print your name and student ID.
6. No cheating, no talking.

Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	—
10	—
Total	

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(1) The output of a "binary source" (0/1) is to be coded in blocks of $M = 3$ samples. The successive outputs are independent and identically distributed (IID) with probability $p = 0.95$ (for a "0".) and 0.05 (for a "1").

Calculate:

(i) Entropy (DEVELOP THE HUFFMAN TREE)

(ii) Average "code length"

(iii) "Code efficiency"

generated by HUFFMAN code of the above Binary source.

HINT:-

$$H = -\sum_{i=1}^{2^M} P_i \cdot \log_2(P_i)$$

P_i = Probability of occurance of each Block.

Develop the Huffman Tree

For $M=3$

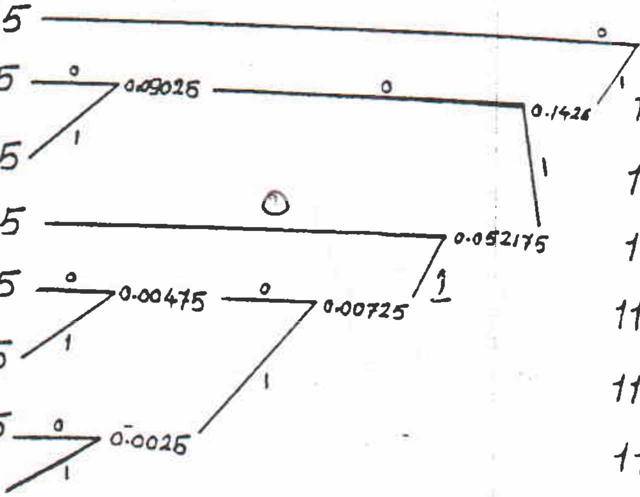
	Source	Probability	VLC
0	000		
1	001		
2	010		
3	011		
4	100		
5	110		
6	101		
7	111		

(EE 5356 Final exam KEY 5/10/16)

1. $\boxed{H = -\sum_{i=1}^{8} P_i \cdot \log_2(P_i)}$

$M = 3$; $N = 2^3 = 8$

Source	Probability	code
(1) 000	0.857375	0
(2) 001	0.045125	100
(3) 010	0.045125	101
(4) 100	0.045125	110
(5) 011	0.002375	11100
(6) 110	0.002375	11101
(7) 101	0.002375	11110
(8) 111	0.000125	11111



(a) Entropy $= H = 0.859$

(b) Average code length $= 1.3$

(c) Efficiency $= 66\%$

$$l = \underline{1 \times 0.857} + \underline{3 \times (0.045 \times 3)} + \underline{3 \times (0.002375 \times 5)} + \underline{0.000125 \times 1}$$

$$\boxed{l = 1.29975}$$

code efficiency of Huffman Code $= \dfrac{H}{l} \times 100$

$$= \frac{0.859}{1.29975} \times 100$$

$$\simeq 66\%$$

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2)

i. Which statement is correct for comparing scalar quantization and vector quantization?

a. By vector quantization we can always improve the rate-distortion performance relative to the best scalar quantizer.

b. Vector quantization improves the performance only for sources with memory. For IID Sources, the best scalar quantizer has the same efficiency as the best vector quantizer.

c. Vector quantization does not improve the rate-distortion performance relative to Scalar quantization, but it has a lower complexity.

ii. Why is vector quantization rarely used in practical applications?

a. The coding efficiency is the same as for scalar quantization

b. It requires block Huffman coding of quantization indexes, which is very complex

c. The computational complexity, in particular for the encoding, is much higher than in scalar quantization and a large codebook needs to be stored

iii. What characterizes a Vector Quantizer?

a. Multiple input symbols are represented by one quantization index

b. Multiple quantization indexes are represented by one codeword

c. Each input symbol is represented by a fixed-length codeword

iv. Let N represent the dimension of a vector in the VQ encoder. Which statement about the performance of the vector with dimension N is correct? $\underline{X} = \{X_1, X_2, \ldots\ldots\ldots\ldots, X_N\}$

a. The vector quantizer performance is independent of N

b. By doubling the dimension N, the bit rate for the same distortion is halved.

c. For N approaching infinity, the VQ performance asymptotically approaches the rate-distortion function ,theoretical

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3Q. Multiple Choice Questions (Only one answer is correct)

5X4 = 20 marks

[Write your answer in the boxes provided]

(i) In order to prove the power spectral density of the error of wiener filter to be,

$$S_e(\omega_1, \omega_2) = |1 - GH|^2 S_{ww} + |G|^2 S_{\eta\eta}$$

What definition of power spectral density is applied?
(S_e, S_{ww}, $S_{\eta\eta}$ are power spectral densities of the reconstruction error, original object and additive noise, respectively.)

A. Power spectral density of the error is the Fourier transform of the power of the error in the spatial domain.
B. Power spectral density of the error is the Fourier transform of the error.
C. Power spectral density of the error is the Fourier transform of autocorrelation function of the error.
D. Power spectral density of the error is the Fourier transform of the autocorrelation function of the mean square error.

C

(ii) Baud rate is defined as the number of bits transmitted per second. Generally, transmission is accomplished in packets consisting of a start bit, a byte (8 bits) of information, and a stop bit. Using these facts, how many minutes would it take to transmit a 512×512 image with 256 gray levels using a 36K modem? (1K = 1024)

A. 0.948 minutes
B. 36 seconds
C. 1.185 minutes
D. 2.56 seconds

C

(iii) Given two image compression systems:
#1 system can compress a 32×32 image into 960 bits, and achieve PSNR=38 dB;
#2 system can compress the same image into 720 bits, and achieve PSNR=33 dB;
Which system has more coding efficiency?

A. #1
B. #2
C. Both are the same
D. Cannot compare

D

(iv) Given a (4x4)-pixel image, A, 8 bpp (bits per pixel),

$$A = \begin{bmatrix} 200 & 200 & 200 & 34 \\ 200 & 5 & 200 & 34 \\ 200 & 200 & 200 & 99 \\ 34 & 34 & 99 & 99 \end{bmatrix}$$

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Calculate the Entropy of this image.

A. −0.51
B. 0.51
C. 1.70
D. Not enough information to calculate the entropy

$\boxed{C}$

(v) In run length coding, suppose the runs are coded in maximum lengths of M, then the probability distribution of the run lengths turns out to be the geometric distribution,

$$g(n) = \begin{cases} p^n(1-p), & 0 \le n \le M-1 \\ p^M & n = M \end{cases},$$

probability of a '0' is p, probability of a '1' is $1-p$.
Since a run length of $n \le M-1$ implies a sequence of n '0's followed by a '1', that is, $(n+1)$ symbols, the average number of symbols per run will be

A. $\mu = \dfrac{(1-p^M)}{1-p}$

B. $\mu = \dfrac{(1-p^{M-1})}{1+p}$

C. $\mu = \dfrac{(1-p^M)}{1+p}$

D. Cannot calculate.

$\boxed{A}$

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4)

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a) Hybrid coding is more sensitive to channel errors than DPCM.

☐ True ✓☐ False

b) In pseudo inverse filter the noise is amplified.

✓☐ True ☐ False

c) Constrained least square filter works like Wiener filter in low noise case.

✓☐ True ☐ False

d) Huffman coding, followed by transform coding can be adopted as a data compression system.

☐ True ✓☐ False

e) In Huffman coding, the size of the codebook and longest code word can be the same.

✓☐ True ☐ False

f) Quantizer should be designed to limit granularity and slope overload degradation.

✓☐ True ☐ False

g) Predictive coding schemes are not sensitive to changes in the statistics of data.

☐ True ✓☐ False

h) For the same number of transmitted samples, Threshold coding has more distortion compared to Geometrical zonal coding.

☐ True ✓☐ False

i) For the same number of transmitted samples, compared to Geometrical zonal coding, the threshold coding mask gives a better choice of transmission samples.

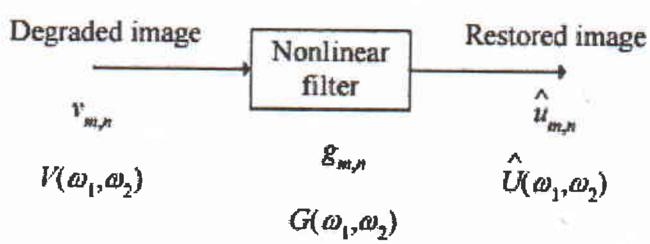
✓☐ True ☐ False

j) Huffman coding is a lossless coding.

✓☐ True ☐ False

k) A simple nonlinear filter called root filter is defined as

$$\hat{U}(w_1, w_2) = |V|^{\alpha} \exp(j\theta_v)$$
$$\text{where } V(w_1, w_2) = |V| \exp(j\theta_v)$$



u(m,n) in 2D spatial domain, U(w1,w2) original image in 2D frequency domain

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$v_{m,n}$, $g_{m,n}$, and $\hat{u}_{m,n}$ are in 2D-spatial domain.

$V(\omega_1,\omega_2)$, $G(\omega_1,\omega_2)$, and $\hat{U}(\omega_1,\omega_2)$ are in 2D-frequency domain.

For $\alpha \ll 1$,

The nonlinear filter acts as LPF

☐ True ☑ False

l) In DPCM codec, the difference between prediction value and original value needs to be quantized.

☑ True ☐ False

m) Inverse filter restores a blurred image perfectly from an output of a noiseless linear system.

☑ True ☐ False

n) When the ratio spectrum of N/H is small, both inverse filter and Wiener filter cannot give reconstruction. (N= Fourier transform of additive noise, H= Fourier transform of imaging system)

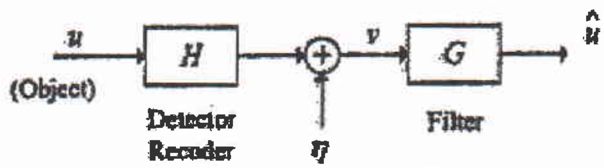

Figure 1.

η is stationary additive noise uncorrelated with u.
Also u and v are zero mean random sequences.

U^=Reconstructed image

☐ True ☑ False

o) Transform coding followed by DPCM coding cannot be adopted as a data compression system.

☐ True ☑ False

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Question 5: What can be described about Huffman coding??

A. A fixed-length coding technique.
B. A variable-length coding technique.
C. A and B are correct.
D. None of above is correct.

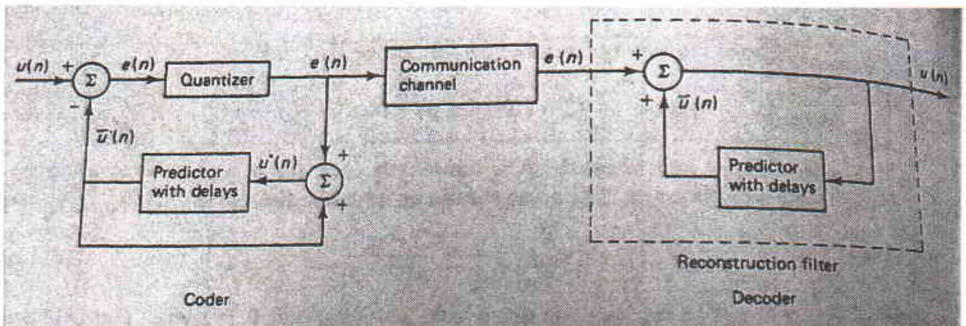

Figure 11 5 Differential pulse code modulation (DPCM) CODEC

Question 6: In Figure 11.5 in A.K. Jain Text. What is the purpose of the feedback path?

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A. Increase compression ratio.
B. Allow the decoder to be more efficient in decoding the encoded bitstream.
C. Prevent reconstruction error accumulation.
D. Feedback the good results to the quantizer so next process can be more accurate.

Question 7: Removing mutual redundancy between successive pixels and encoding only the new information are the underlying philosophy which belong to:

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A. Bit-Plane encoding technique.
B. Predictive coding techniques.
C. Arithmetic coding techniques.
D. Scalable video coding.

Question 8: What is the most used coding scheme in video encoding:

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A. Block-based coding.
B. Picture-based coding.
C. None of above.
D. Depending on application.