

THE HONG KONG POLYTECHNIC UNIVERSITY
DEPARTMENT OF COMPUTING
EXAMINATION

Course : MSc Scheme - 61030

Subject : COMP5422 Multimedia Computing, Systems and Applications

Group : 201, 202, 203, 204, 205, 2888

Session : 2010 / 2011 Semester II

Date : 11 May 2011

Time : 18:30-21:30

Time Allowed: 3 Hours

Subject Lecturer: Zhang Lei

This question paper has 5 pages.
(Some pages may be intentionally omitted.)

Instructions to Candidates:

The question paper has 4 sections.

Section A: True/False (20 points);

Section B: Multiple choices (15 points);

Section C: Short answers (25 points);

Section D: Long answers (40 points);

There are totally 100 points.

This is a closed book and closed notes examination.

Calculator is allowed.

Do not turn this page until you are told to do so!

Section C. Short Answers (25 points)

Question 16. Please explain why DCT is effective for image compression. (5 points)

Question 17. What are the main steps in JPEG image compression standard?
(5 points)

Question 18. Why could we do chroma subsampling for digital videos? Please show the 4:1:1 chroma subsampling scheme? (5 points)

Question 19. What is scalable coding in MPEG-2? Why scalable coding is especially useful for MPEG-2 video transmitted over networks?
(5 points)

Question 20. In MPEG, what types of image frames are defined for the video sequence? And what is the order of the frames in compression?
(5 points)

Section D. Long Answers (40 points)**Question 21. JPEG**

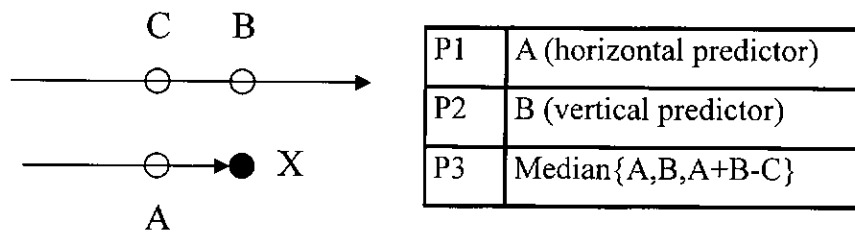
(10 points)

Suppose we have the following 4×4 image:

1	3	2	1
3	5	6	4
4	4	7	8
5	7	8	7

(a) What is the entropy of this image? (2 points)

(b) Three of the predictors used in JPEG-LS are listed in the following table.



We code the image as follows:

1. Code the first row using P1
2. Code the first column using P2
3. Code the other pixels using P3

Please calculate the prediction error image.

(6 points)

(c) What is the entropy of prediction error image?

(2 points)

Question 22. DCT

(9 points)

The signal $f = [45 \ 15 \ 5 \ -25 \ 50 \ -20 \ 90 \ 60]$. Please calculate its discrete cosine transform (DCT) coefficients $F(0)$ and $F(1)$.

Question 23. 1D Haar Wavelet Transform

(9 points)

Suppose the original signal is

$$f = [f_1, f_2, f_3, f_4, f_5, f_6, f_7, f_8]$$

We decompose it into 2 levels by using the Haar wavelet and the wavelet decomposition coefficients are

$$d = [9.5, 16.5, 0.5, -3.5, -2, 1, -2, 1]$$

Please reconstruct the wavelet coefficients at the first level and the original signal f .

Question 24. Image Quality Assessment

(12 points)

There are many image quality assessment (IQA) metrics, such as the mean squared error (MSE) and the structural similarity (SSIM). Compared with MSE, SSIM is a more effective modern full-reference IQA metric. For two image patches, \mathbf{x} and \mathbf{y} , there is

$$SSIM(\mathbf{x}, \mathbf{y}) = \frac{(2\mu_x\mu_y + C_1)(2\sigma_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)}$$

where μ_x (μ_y) is the intensity mean of the patch \mathbf{x} (\mathbf{y}), σ_x (σ_y) is the standard deviation of the patch \mathbf{x} (\mathbf{y}), and σ_{xy} is the covariance of the vectorized \mathbf{x} and \mathbf{y} . C_1 and C_2 are two constants.

Suppose that there is a 4×4 distortion-free reference image \mathbf{R} and its two distorted versions \mathbf{A} and \mathbf{B} as follows:

$$\mathbf{R}: \begin{bmatrix} 67 & 61 & 55 & 144 \\ 66 & 50 & 47 & 149 \\ 62 & 53 & 50 & 145 \\ 58 & 48 & 47 & 153 \end{bmatrix}; \quad \mathbf{A}: \begin{bmatrix} 65 & 59 & 54 & 142 \\ 63 & 48 & 44 & 146 \\ 59 & 49 & 49 & 142 \\ 57 & 48 & 45 & 150 \end{bmatrix}; \quad \mathbf{B}: \begin{bmatrix} 66 & 63 & 54 & 146 \\ 69 & 48 & 50 & 146 \\ 59 & 57 & 49 & 148 \\ 59 & 48 & 49 & 152 \end{bmatrix}.$$

(a) Please calculate the MSE of \mathbf{A} and \mathbf{B} . Based on the calculated results, which one has a better quality? (4 points)

(b) Please calculate the SSIM of \mathbf{A} and \mathbf{B} . We let $C_1 = 6.5$, $C_2 = 58.5$, and the size of the sliding window is 3×3 in SSIM. Based on the calculated results, which one has a better quality? (8 points)

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