

CMPT 365 Final Examination
Spring 2006

(Please answer all questions for a total of 100 points)

1. (15 points) [Short Answer Questions]

- (a) (1 point) In your opinion, what is the topic that we should have spent more time to discuss this semester?
- (b) (4 points) Name at least 4 factors that affect the quality of *Digital video*.
- (c) (4 points) Name two major improvements (not including support of more frame resolutions) that H.263 has over H.261.
- (d) (6 points) *Arithmetic coding* is used in modern image and video compression standards such as JPEG-2000 and MPEG-4/H.264. Very briefly describe how Arithmetic coding works and what is the main advantage of Arithmetic coding over Huffman coding.

2. (10 points) [Audio]

Human perception to multimedia stimuli is known to be non-uniform. Describe 3 types of *perceptual non-uniformity* in auditory perception.

3. (15 points) [JPEG]

JPEG image compression is based on *Transform Coding*.

- (a) State at least 2 reasons why it is a good idea to use Transform Coding.
- (b) Outline all major steps in JPEG encoding.
- (c) When *bbp (bits per pixel)* is low, we start to see blurred edges and blocky images. Explain why for each of these artifacts.

4. (15 points) [Color]

- (a) In the *YUV* color scheme, $U = B - Y$, $V = R - Y$, and $Y = 0.3R + 0.6G + 0.1B$. Use the above formula to show (prove) that the color differences $U = 0$ and $V = 0$ for all gray-level color intensities.
- (b) Given that values of R , G , B in the color cube all have range of $[0, 1]$, what are the ranges of U and V ? Show your derivation.
- (c) YC_bC_r is a color scheme similar to *YUV*. C_b and C_r are defined as:
 $C_b = [(B - Y)/1.772] + 0.5$, and $C_r = [(R - Y)/1.402] + 0.5$.
What is the advantage of YC_bC_r over *YUV* ?

5. (20 points) [Video Compression]

- (a) Describe how MPEG deals with *spatial* and *temporal* redundancies in video.
- (b) Given the following two consecutive frames in an MPEG-1 video, if the first is an I-frame and the second a P-frame, show **in detail** how the P-frame is encoded in MPEG. (Work out the numbers at each step. You can skip the step of Huffman Coding.)
 [Hint: (i) To simplify the data, we assume that the size of macroblocks is 8×8 instead of 16×16 .
 (ii) The formula for DCT can be found on the next page.
 (iii) State clearly if you made some of your own assumptions.]

Intensity Values of the I-frame:

110	110	110	110	110	110	110	110	50	50	50	50	50	50	50
110	110	110	110	110	110	110	110	50	50	50	50	50	50	50
110	110	110	110	110	110	110	110	50	50	50	50	50	50	50
110	110	110	110	110	110	110	110	50	50	50	50	50	50	50
110	110	110	110	110	110	110	110	195	195	195	195	195	195	195
110	110	110	110	110	110	110	110	195	195	195	195	195	195	195
110	110	110	110	110	110	110	110	195	195	195	195	195	195	195
110	110	110	110	110	110	110	110	195	195	195	195	195	195	195
50	50	50	50	50	50	50	50	195	195	195	195	195	195	195
50	50	50	50	50	50	50	50	195	195	195	195	195	195	195
50	50	50	50	50	50	50	50	195	195	195	195	195	195	195
50	50	50	50	50	50	50	50	195	195	195	195	195	195	195
50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

Intensity Values of the P-frame:

200	200	200	200	200	200	200	200	100	100	100	100	100	100	100
200	200	200	200	200	200	200	200	100	100	100	100	100	100	100
200	200	200	200	200	200	200	200	100	100	100	100	100	100	100
200	200	200	200	200	200	200	200	100	100	100	100	100	100	100
200	200	200	200	200	200	200	200	100	100	100	100	100	100	100
200	200	200	200	200	200	200	200	100	100	100	100	100	100	100
200	200	200	200	200	200	200	200	100	100	100	100	100	100	100
50	50	50	50	50	50	50	50	100	100	100	100	100	100	100
50	50	50	50	50	50	50	50	100	100	100	100	100	100	100
50	50	50	50	50	50	50	50	100	100	100	100	100	100	100
50	50	50	50	50	50	50	50	100	100	100	100	100	100	100
50	50	50	50	50	50	50	50	40	40	40	40	40	40	40
50	50	50	50	50	50	50	50	40	40	40	40	40	40	40
50	50	50	50	50	50	50	50	40	40	40	40	40	40	40
50	50	50	50	50	50	50	50	40	40	40	40	40	40	40

6. (25 points) [JPEG and Hierarchical JPEG]

(a) The Discrete Cosine Transform (DCT) is used in JPEG for image compression.

$$F(u, v) = \frac{\Lambda(u)\Lambda(v)}{4} \sum_{i=0}^7 \sum_{j=0}^7 \cos \frac{(2i+1) \cdot u\pi}{16} \cdot \cos \frac{(2j+1) \cdot v\pi}{16} \cdot f(i, j)$$

$$\Lambda(\xi) = \begin{cases} \frac{1}{\sqrt{2}} & \text{for } \xi = 0 \\ 1 & \text{otherwise} \end{cases}$$

- i. What is the value of $F(0, 0)$ if the image $f(i, j)$ is as below?
- ii. Which AC coefficient $|F(u, v)|$ is the largest for this $f(i, j)$, why? Is this $F(u, v)$ positive or negative, why?

20	20	80	80	140	140	200	200
20	20	80	80	140	140	200	200
20	20	80	80	140	140	200	200
20	20	80	80	140	140	200	200
20	20	80	80	140	140	200	200
20	20	80	80	140	140	200	200
20	20	80	80	140	140	200	200
20	20	80	80	140	140	200	200

(b) Show **in detail** how a 3-level hierarchical JPEG will encode the image above. Assuming:

- i. the encoder/decoder at all three levels use *Lossless JPEG*
- ii. *reduction* is done by averaging each 2×2 block into a parent pixel value
- iii. *expansion* is by simply duplicating the single pixel value four times at the next level.

