

OLLSCOIL NA hÉIREANN, CORCAIGH
THE NATIONAL UNIVERSITY OF IRELAND, CORK
COLÁISTE NA hOLLSCOILE, CORCAIGH
UNIVERSITY COLLEGE, CORK

Summer Examination 2008

BSc in Computer Science

CS4405: Multimedia Compression and Delivery

Professor Susan Crow
Professor James Bowen
Dr Frank Böhme

Answer all questions.

90 minutes

1. These questions deal with the visualization of gray level pictures on monochrome devices with the help of *dithering algorithms*.
 - a) Briefly explain the term *ordered dither matrix*. (7 marks)
 - b) Consider a visualization algorithm that is based on a dither matrix with the dimensions $m \times n$. How many different gray levels are distinguished by this algorithm? (7 marks)

2. The questions below deal with mathematical transformations which are often part of algorithms for lossy compression of audio or video data.

a) Consider a set F of one dimensional functions, i.e. $F = \{f_0, f_1, f_2, \dots\}$. Under which condition is F a set of *orthogonal* functions? (9 marks)

b) In many algorithms for the compression of one-dimensional data (such as sound), the original sample data $y(t)$ are replaced by a *weighted sum* across a set of functions. This can be expressed by

$$y(t) \approx a_0 \cdot f_0(t) + a_1 \cdot f_1(t) + a_2 \cdot f_2(t) + \dots$$

Explain why in this formula the functions f_0, f_1, f_2, \dots are always chosen in such a way that they form a set of *orthogonal* functions. (9 marks)

c) There are many variants of RGB-YUV color space transformation. Consider a transformation with the following specification:

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} t_{11} & 0.4 & 0.3 \\ t_{21} & -0.3 & 0.8 \\ t_{31} & 0.5 & -0.2 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

The three coefficients t_{11} , t_{21} and t_{31} are not given. Calculate these three coefficients using the following reasonable assumptions:

- Y should represent the *actual luminance* (gray level) of the sample.
- U and V should represent *true chrominance* levels, i.e. they should assume zero for gray samples.

(7 marks)

3. Recall that *Huffman coding* is a lossless compression method that replaces each symbol in the original message with a binary code. Consider a message string s that consists of multiple occurrences of 3 different symbols A, B and C in no particular order. These questions deal with the application of Huffman coding to such a message.

a) Calculate the maximum possible value for the *information entropy* of s . Your answer may be a numerical expression that contains irrational functions such as $\sqrt{2}$. (7 marks)

b) In most cases, Huffman encoding of s will yield a sub-optimal compression factor. Give at least two reasons for this statement. (9 marks)

c) Under which exceptional circumstances will Huffman encoding of s yield the *optimal* compression factor? (9 marks)

4. These questions deal with general aspects of digital compression algorithms for still images and video.

a) JPEG is a standard for lossy compression of still images. Briefly explain the step where information is lost during the compression phase. (9 marks)

b) Name at least two advantages of *object based* video coding (as defined in MPEG-4) over *block based* video coding. (7 marks)