Coláiste na Tríonóide, Baile Átha Cliath
Trinity College Dublin
Ollscoil Átha Cliath | The University of Dublin

FACULTY OF ENGINEERING, MATHEMATICS & SCIENCE

SCHOOL OF ENGINEERING

Electronic & Electrical Engineering

Engineering

Senior Sophister

Annual Examinations

Digital Media Processing (EE4C08)

Sample Exam

Dr. F. Pitié

Instructions to candidates:

Answer FOUR (4) out of the FIVE (5) questions.

Please answer questions from each section in separate answer books.

Materials Permitted for this Examination:

New Formulae & Statistic Tables

Graph Paper

Non-programmable calculators

Question 1

1. The Haar Transform is a simple 2-point transform specified by the following transformation matrix:

$$T = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

Explain how the 1D Haar Transform is extended to 2D image matrices.

[5 marks]

2. Given an input 2x2 image with intensity values as follows:

$$\begin{bmatrix} 10 & 19 \\ 18 & 20 \end{bmatrix}$$

compute the Haar Transform coefficients for the 2×2 image and identify each of the subbands.

[5 marks]

3. The quantisation step matrix given to the encoder is as follows:

$$Q = \begin{bmatrix} 2 & 4 \\ 4 & 8 \end{bmatrix}$$

compute the quantised coefficients and compute the corresponding inverse image.

[5 marks]

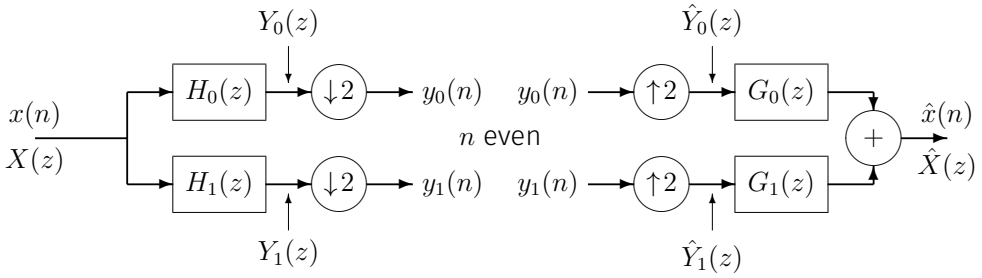
Compute the MSE between the original and quantised images.

4. Write down the code for the Matlab function that computes the entropy in bits/pixel of an 2d image with intensity range of 0:255.

[5 marks]

Question 2

Consider the two-band filter banks as follows:



(a) (b)

We choose the LeGall filters 3/5 for the analysis and reconstruction filters:

$$H_0(z) = \frac{1}{8}\left(-1 + 2z^{-1} + 6z^{-2} + 2z^{-3} - z^{-4}\right)$$

$$H_1(z) = \frac{1}{2}\left(1 - 2z^{-1} + z^{-2}\right)$$

$$G_0(z) = H_1(-z) = \frac{1}{2}\left(1 + 2z^{-1} + z^{-2}\right)$$

$$G_1(z) = -H_0(-z) = -\frac{1}{8}\left(-1 - 2z^{-1} + 6z^{-2} - 2z^{-3} - z^{-4}\right)$$

1. LeGall filters are used in JPEG2000 image compression standard. Are they used for lossy or lossless compression?

[3 marks]

2. What is Perfect Reconstruction and what are the conditions for H_0, H_1, G_0, G_1? Show that the LeGall filters meet the anti-aliasing condition.

[12 marks]

3. The filterbank is fully decimated and not shift invariant. Explain what decimated and shift invariance mean. Explain the importance of shift invariance in image processing.

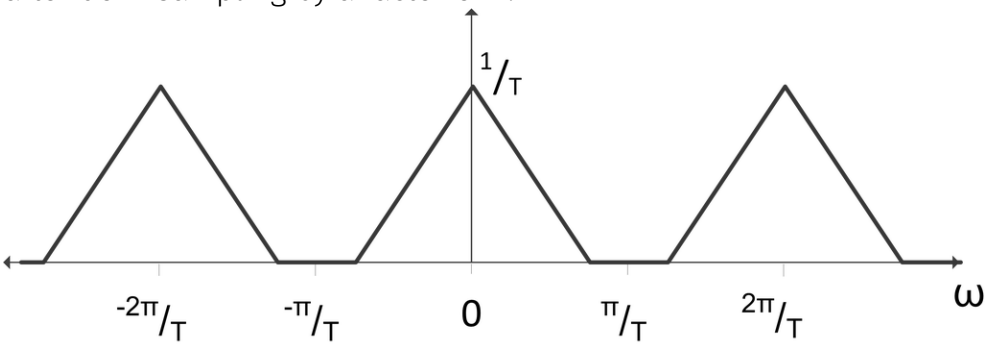
[10 marks]

Question 3

1. What is the necessary condition for the aliasing-free sampling of a 2D analogue signal?

[4 marks]

2. Below is the spectrum of a 1D digital signal, sampled at frequency $2\pi/T$: Draw the signal after downsampling by a factor of 2.



[5 marks]

3. The *sinc* filter can be used as an anti-aliasing filter before downsampling. What is effect of the *sinc* filter in the frequency domain? Explain why it is necessary to filter before resampling.

[10 marks]

4. What are the practical considerations to consider when implementing an FIR filter approximation of the sinc filter?

[6 marks]

Question 4

1. Explain in which ways the JPEG standard exploits the characteristics of the human visual system to colour and spatial contrast to improve the perceived quality of the compressed images.

[9 marks]

2. What is the computational complexity of the DCT

[2 marks]

3. How is the DCT computed on 2D images?

[2 marks]

4. Explain differential coding why and where it is used in JPEG.

[6 marks]

5. Explain the order in which the AC coefficients are read and why such an order is used.

[6 marks]

Question 5

1. Briefly explain the process of Full Search Block Matching and introduce block size, search width.

[5 marks]

2. Estimate the number of operations required to do full search block matching on a 4K resolution footage (3840×2160), with a Block Size of 16×16 pixels and a search size of ± 64 pixels.

[5 marks]

3. Explain the meaning of I-frame, B-frame, P-frame and GOP and explain their purpose in MPEG2.

[5 marks]

4. Consider video surveillance application of a static scene. We are only interested when there is activity in the video. Devise a simple and fast motion detection system that operates in the compressed stream.

[6 marks]

5. Explain how we could optimize the bandwidth by adapting the GOP structure to the presence or not of motion.

[5 marks]