# *University of KwaZulu-Natal*

# *School of Engineering*

Examinations: October 2013

Image Processing: ENEL4IPH2

Duration: **2 Hours** Marks: 100

Examiners : Prof. H. Xu (Internal)

 : Dr. Fred Nicholls (External)

Instructions : 1. Answer all questions.

 2. This is not an open book exam and no notes may be used, either electronic or handwritten.

**Question 1: (10 marks) Concepts: true or false**

1. The bit planes corresponding to least significant bits have the details of an image.
2. The shape of the histogram of an image does in general give us useful information about the possibility of contrast enhancement.
3. Increasing the cut-off frequency in an ideal 2-D lowpass filter results in more blurring in the filtered image.
4. The directional filter implemented using the following  mask highlight horizontal edges in an image.

-1

0

1

-1

0

1

-1

0

1

1. By default, Matlab stores most data in arrays of class uint8.
2. Applying histogram equalization to an image a second time will not improve the contrast in the image.
3. Transform coefficients with small variance carry most of the information about the image.
4. Average or mean filtering is equivalent to lowpass filter.
5. The 2D DFT of a symmetric matrix results in real coefficients only.

(10) Transforming the pixel values of an image using the **log ( )** transformation is an

 example of contrast compression of the dark pixels.

**Question 2: (17 marks) Image Enhancement**

1. (**9 marks**) An image contrast stretching is used in an image enhancement which is shown in Fig. 1.

20

35

42

0

10

30

42

*r*

*s*

Fig. 1

Compute the following outputs:

* 1. The output $s$ for input $r=15$;
	2. The output $s$ for input $r=25$;
	3. The output $s$ for input $r=40$.
1. **(8 marks)** In Fig. 2, a $6×6$ image contains three bright pixels which gray values are 15. Design a filter to remove these three bright pixels, keep all pixels with gray value 4 unchanged, and write the filtered image in matrix (do not process boundary pixels).

$$\begin{matrix}\begin{matrix}1&3\\0&5\end{matrix}&\begin{matrix}6&9\\15&9\end{matrix}&\begin{matrix}6&3\\10&1\end{matrix}\\\begin{matrix}2&0\\3&4\end{matrix}&\begin{matrix}1&5\\15&15\end{matrix}&\begin{matrix}7&5\\2&9\end{matrix}\\\begin{matrix}3&4\\2&3\end{matrix}&\begin{matrix}4&6\\3&10\end{matrix}&\begin{matrix}9&7\\1&3\end{matrix}\end{matrix}$$

Fig. 2

**Question 3: (20 marks) Histogram Equalization**

 A 64 x 64 image with seven gray levels (0,1, …, 6) has a histogram given by:

|  |  |  |
| --- | --- | --- |
| *k* |  | $$p\left(r\_{k}\right)=n\_{k}/n$$ |
| 0123456 | 01/62/63/64/65/61 | 0.190.250.210.160.080.060.05 |

where is the gray level. is number of pixels with gray value . $n$ is the total number of pixels.

It is desired to transform the above image into a new image, using a transform $Z=H\left(r\right)$, with histogram as specified below:

|  |  |  |
| --- | --- | --- |
| *k* |  | $$p\left(r\_{k}\right)=n\_{k}/n$$ |
| 0123456 | 01/62/63/64/65/61 | 0.000.000.150.200.300.200.15 |

Find the transform $Z=H\left(r\right)$.

**Question 4: (15 marks) Image Segmentation**

There are two masks,$ \left[\begin{matrix}-1&-1&-1\\0&0&0\\1&1&1\end{matrix}\right]$ and $\left[\begin{matrix}-1&-2&-1\\0&0&0\\1&2&1\end{matrix}\right]$.

1. From the frequency response show that the mask $ \left[\begin{matrix}-1&-1&-1\\0&0&0\\1&1&1\end{matrix}\right]$ is a highpass filter.
2. If the above two masks are used to detect lines in images, what kind of lines can the above two masks detect?
3. Which mask can remove more noise?

**Question 5: (15 marks) Image Compression**

1. (**2 marks**) Explain why $8×8 $block size, not $16×16$ or $32×32$, is chosen in the JPEG algorithm.
2. (**1 marks**) What is the block artifact in JPEG algorithm?.
3. (**4 marks**) Fig. 3 is a block of DCT coefficients which have already undergone quantization. Ignoring the DC value, what are the actual symbols that the JPEG Huffman coder will have to encode for this particular block? With the default Huffman tables, how many bits will be needed? (You are not required to write out the actual bit sequence.).

 

 Fig. 3

1. (**8 marks**) Consider an information source emitting the symbols . Let  be the corresponding probabilities associated with the symbols. Show the Huffman code scheme that you have come up and compare the expected code word length to the entropy of the code. (Bit 1 is assigned to larger probability and bit 0 is assigned to smaller probability).

**Question 6: (15 marks) Image restoration**

1. (**1 mark**) What is the ring effect?
2. (**1 mark**) What is periodic noise or interference?
3. (**13 marks**) Consider a variety of different kinds of images which are degraded by different kinds of point spread function or corrupted by different kinds of noise. Given the following filters: max filter, min filter, inverse filter, low pass filter, high pass filter, contraharmonic mean filter (), band reject filter and Wiener filter which one(s) would you use to improve the appearance of images that have been corrupted by the following kinds of processes? Explain your choice.
	1. Image corrupted by pepper noise.
	2. Image corrupted by salt noise.
	3. Image corrupted by low pass filter (convolution with white Gaussian noise).
	4. Image with known power spectrum corrupted by low pass filter (convolution with known white Gaussian noise).
	5. Image corrupted by periodic interference.

**Question 7:** (**8 marks**) **Binary Morphological Operation**

An original image and a structuring element are shown in Fig. 4. Describe which morphological operator (erode, dilate, open, close) has been used to create the two images shown in Fig. 5.

Original image

$$\left[\begin{matrix}0&1&0\\1&1&1\\0&1&0\end{matrix}\right]$$

Structuring element

Fig. 4



Fig.5