**MIT704 Imaging Applications III**

BM3MI331/P1

Bachelor of Applied Science

(Medical Imaging Technology)

Faculty of Applied Sciences

2023

**Digital Image Processing Lab**

**Answer Booklet**

**This Answer Booklet must be submitted no later than 5pm, Friday 9 June 2023.

Submission instructions can be found on the last page of this booklet.**

**Marks**

**Achieved Maximum**

**Exercise 1: 11**

**Exercise 2: 24**

**Exercise 3: 22**

**Exercise 4: 17**

**Exercise 5: 14**

**Exercise 6: 11**

**Presentation, Spelling and Grammar,
 Sentence Construction, APA-7 Referencing and In-text citation 5

 TOTAL: 103

 PERCENTAGE:**

**Before submitting please delete all questions (unless it’s a fill in question),**

**all unused lines**

**and empty spaces,**

**so that your submitted workbook will only contain**

 **your answers and screen shots.**

**Make sure to
number your answers correctly.**

***Remember to paste images to prove your progress***

***–
the more the better***

**Exercise 1 11 marks**

**PAINT**

**Question 1.1 Inverting grey scale 1 mark**

Explain one way in which this inversion might have been accomplished.

…

**Question 1.2 Image file size vs file storage size** **2 marks**

Give the width and height of the hand-xray image as shown at the base of the screen.

Width in pixels: ............ Height in pixels: ............

Bytes required to **store pixels only**: ................. bytes (w x h)

File size: ........................ bytes

Extra storage used: ............... bytes

When saved the image occupies more bytes. What additional data might be stored in the extra bytes?

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**Question 1.3 Zoom and spatial resolution 2 marks**

a) Describe what happens to the pixels in the image when zooming in.

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b) Explain the effect that zooming has on spatial resolution.

…………………………………………………………………………………………

**File Explorer**

**Question 1.4 BMP and Bit Depth 3 marks**

From the Details tab, record the pixel width and height:

Width: ............... pixels Height: .............. pixels

The File Item Type is bmp. What does “bmp” stand for? ..........................

Bit depth: ...........................

**Question 1.5 Combining red, blue and green to give a specific colour
 2 marks**

Explain why the intensity of the clouds do not appear to change.

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**Question 1.6 Measurement: calculating area 1 mark**

Area of the Arabian Peninsula: ............................................... sq km.

(Some allowance will be made for non-steady hand, but try to be it as accurate as possible)

**Exercise 2 24 marks**

**Question 2.1 Magnification and file size 2 marks**

For **fetal\_face\_1.bmp**, record the height and width in the table. Calculate the size by multiplying the height by width.

Repeat for the files **fetal\_face\_2.bmp**, **fetal\_face 4.bmp**, and **fetal\_face\_8.bmp.**

Complete the table:

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Height (pixels)** | **Width (pixels)** | **Size (H x W)** |
| Fetal\_face\_1 |  |  |  |
| Fetal\_face\_2 |  |  |  |
| Fetal\_face\_4 |  |  |  |
| Fetal\_face\_8 |  |  |  |

**Question 2.2 Detail and file size 4 marks**
For each of the above images, briefly comment on the detail observed.
*[Important note: the intrinsic resolution of the ultrasound machine is larger (more coarse) than the pixel size in fetal\_face\_1.bmp.* ***Use this information in your answer, where applicable.****]*

**Fetal\_face\_1:**

............................................................................................................................

**Fetal\_face\_2:**

............................................................................................................................

**Fetal\_face\_4:**

............................................................................................................................

**Fetal\_face\_ 8:**

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**Question 2.3 Detail and file size continued 2 marks**

Explain what the relationship between anatomical detail and file size is.

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**Question 2.4 Application of pixel size 1 mark**

Who is Tall Guy? ...................................

**Question 2.5 Useful pixelation 1 mark**

How would you optimize the pixelation used on television to adequately hide the identity of a person?

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**Question 2.6 Using colours to highlight various aspects of an image
 3 marks**

Apply each of the following three LUTs to ct\_head and critique each resulting image, stating areas of improvement and degradation for each LUT:

a) Greys

............................................................................................................................

b) 6 shades

............................................................................................................................

c) Fire

............................................................................................................................

**Question 2.7 Dissecting colours 5 marks**

Predicted values:

Red: ...................................................................................................................
Green: ...............................................................................................................
Blue: ..................................................................................................................

Actual values:

Red: ...................................................................................................................
Green: ...............................................................................................................
Blue: ..................................................................................................................

From https://www.colorhexa.com:

#xxxxxx of your chosen colour: .........................................................................

Name of your chosen colour: .........................................................................

**Question 2.8 Enhancing MRI Images Using Colour 4 marks**

Which LUT did you choose? ………………………………………………………..

Write down the frame number on which the following landmarks best seen:

(a) nasal cavities: .............................................................................................

(b) eye sockets: .................................................................................................

(c) ear canals: ....................................................................................................

**Colour Contrast Enhancement**

**Question 2.9 Can Colour Improve Contrast? 2 marks**

Comment on this resulting image

...........................................................................................................................

**Exercise 3 22 marks**

**Threshold and edge detection**

**Question 3.1 Diving Into Thresholds 3 marks**

REMEMBER to copy and paste your processed images for (a), (b) and (c).

Top: 92, Bottom: 134.
Comment on the image compared to what you saw when the limits were set to 0 and 255.

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Top: 92, bottom: 180.

**Explain** why the threshold selection generated the image you see.

........................................................................................................................…

Top: 128, bottom: 149.
How can these threshold selection be utilized in practice?

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**Question 3.2 1 mark**
Insert the screenshot of your *histogram*, that you’ve saved as Q3\_2 in your Results folder, in the space below.

 **Question 3.3** **3 marks**

Relate the shape of the histogram to the intensities seen in the image.

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**Threshold and counting objects
Question 3.4 Threshold Settings for Optimal Cell Count 1 mark**

Write down your threshold selection of the top and bottom adjustment bars for separating the blood cells from the background

Top adjustment bar: ………………………………………
Bottom adjustment bar: …………………………………..

**Question 3.5 Using Software to Count Cells** **3 marks**

Number of cells ImageJ found: …………………………..

Number of cells you can see ………………………………….

Explain the reason why the software count differs from the actual count.
………………………………………………………………………………………..

**Contrast Enhancement**
**Question 3.6 Histogram 1 mark**

Image of your histogram

**“Before”**

**Question 3.7 Apply LUT to Enhance Contrats** **1 mark**

Image of your enhanced histogram

Image of your enhanced histogram.

**“After”**

**Question 3.8 Analyzing Histograms** **2 marks**

By comparing the two **histograms**, explain how the contrast has been enhanced by relating the histogram to the changes in intensity levels.

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**Question 3.9 Contrast Enhancement by Histogram Equalization** **1 mark**

Paste the histogram of your processed image

**Question 3.10 Histogram Analysis** **3 marks**
Analyse your histogram to explain how the dramatic increase in overall brightness of the image increased dramatically.

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**Question 3.11 Contrast Enhancement by Histogram Equalization on Selected Region** **1 mark**

Paste your histogram here

**Question 3.12 Histogram Analysis** **2 marks**
Refer to histogram analysis to explain why equalisation, performed on a selected part of the image, give better results than on the whole image. You can use other arguments as well.

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**Exercise 4 17 marks**

**Question 4.1 Noise Reduction by Averaging** **2 marks**

Record the Standard Deviation:

chest\_a.tif σ = …………...

chest\_b.tif σ = ……………
result σ = …………...

**Question 4.2 Standard Deviation for Averaging Four and Eight Images
 2 marks**

Copy and paste your 3 images showing the regions

Record the σ values for chest\_ave\_4 and chest\_ave\_8
chest\_ave\_4.tif σ = …………… chest\_ave\_8.tif σ = ……………

**Question 4.3 Effectivity of Noise Reduction using Averaging of Images 3 marks**

Comment on the standard deviation in the averaged images of questions 4.1 and 4.2, compared to the two original images (chest\_a and chest\_b),

and compare the effect that the number of images averaged has on noise and detail visible in the averaged images, when compared to the original images
……………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………...…………………………………………………………………………………………

**Question 4.4 Noise Reduction by Smoothing** **2 marks**

Describe the influence of repeated smoothing on the noise and the detail in the image.

…………………………………………………………………………………………

**Question 4.5 Noise Reduction by Median Filtering; Comparison** **4 marks**

a) Name the specific type of noise in the image. …………………………………

b) Describe the effectivity of median filtering on a noisy image.
…………………………………………………………………………………………

…………………………………………………………………………………………

c) Out of these three methods (averaging, smoothing or median filtering) choose the one best suited for radiography, and validate your choice.
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**Spatial filtering**

**Question 4.6 Creating a shadow filter (to enhance either the negative diagonal, the vertical or the horizontal edges)** **2 marks**
Record your 5 x 5 **shadow** filter here:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**Question 4.7 Describe the Effect** **2 marks**

Describe the effect of the shadow filter on the hand xray image – remember to paste it as well..
…………………………………………………………………………………………

**Exercise 5** **14 marks**
Mask subtraction
**Question 5.1 Simple Subtraction** **2 marks**

**Copy and paste your processed image**

Comment on the effectivity of the removal of the mesh lines in the new file “Result”.

…………………………………………………………………………………………

**Question 5.2 Log Subtraction 1 mark**

**Copy and paste your processed image**

Compare this second Result image with the previous Result image.

…………………………………………………………………………………

**Intensity Uniformity Correction**
**Question 5.3 Horizontal Profile before Intensity Uniformity Correction**

 **1 mark**

Paste the profile of the plot graph of **mask**.bmp

**Question 5.4 Corrected Intensity Uniformity** **1 mark**

Paste the plot graph produced on the image uniformity.bmp

**Question 5.5 Horizontal Profile after Intensity Uniformity Correction**Paste the profile plot produced on the image Result **1 mark**

**Question 5.6 Outcome of Intensity Uniformity Correction 1 mark**Has the sensitivity non-uniformity been corrected? Explain how the profile plot confirms your answer. Give a reason for any unexpected results.

**………………………………………………………………………………………….**

**Frequency Filtering: High Pass Filtering
Question 5.7 Using a High Pass Filter in the Frequency Domain 2 marks**
Try to eliminate as much of this artefact as possible when answering
Copy and paste your processed image.

Describe the effect of applying a High Pass Filter on an image. (If you do not see a significant improvement in at least one aspect try increasing or decreasing your blocked out area.) **………………………………………………………………………………………….**

**Frequency Filtering: Low Pass Filtering
Question 5.8 Using a Low Pass Filter in the Frequency Domain
 2 marks**

Copy and paste your processed image

Describe the effect of applying a Low Pass Filter on the FFT has on the filter (If you do not see a significant difference increase or decrease your blocked out area.)

…………………………………………………………………………………………

Describe the effect of applying a Low Pass Filter on the FFT has on the image.

**………………………………………………………………………………………….**

**Question 5.9 Removing a High Percentage of High Frequencies 1 mark**

Approximately what percentage of the high frequency spectrum, i.e. the gray area of the transform around the edges, has to be removed before the ape’s whiskers appear to fade / disappear?

……………………………...

Paste your filter and the Inverse Fourier Transform.

**Question 5.10 Removing Specific Features by Applying Filters in the Frequency Domain 2 marks**

a) Copy and paste your Fourier Transform, showing which frequencies you’ve filtered out.

b) Copy and paste the altered image of the house (i.e. the inverse Fourier transform)

**Exercise 6 11 marks**

**Lossy Compression

Queston 6.1 File sizes and Compression Ratios for JPEG storage (lossy)** **4 marks**

Complete the table:

|  |  |  |
| --- | --- | --- |
| **Image** | **File size (kB)** | **Compression ratio** |
| Original image**lp\_phantom.bmp** |  | - |
| JPEG Quality factor 100**lp\_phantom\_100** |  |  |
| JPEG Quality factor 80**lp\_phantom\_80** |  |  |
| JPEG Quality factor 40**lp\_phantom\_40** |  |  |
| JPEG Quality factor 10**lp\_phantom\_10** |  |  |
| JPEG Quality factor 1**lp\_phantom\_1** |  |  |

Compression ratio = Original Image file size / JPEG compressed file size

**Question 6.2 Compression of JPEG (continued)** **1 mark**
At what JPEG Quality Factor do you feel that the loss of image data becomes obvious? ………………...

**Question 6.3 Compression of JPEG (continued)** **1 mark**
As the JPEG Quality Factor decreases, which components of the image are the first to be affected? ……………..

**Question 6.4 File Sizes and Compression Ratios for LZW storage (lossless)** **2 marks**
Complete the table: Then calculate the compression ratios.

|  |  |  |
| --- | --- | --- |
| **Image** | **File size (kB)** | **Compression Ratio** |
| Original image**lp\_phantom\_LWZ.bmp** |  | - |
| LWZ compression**lp\_phantom\_LWZ.tif** |  |  |
| LWZ & differencing compression**lp\_phantom\_LWZ+differencing.tif** |  |  |

**Question 6.5 Compare lossy and lossless compression ratios and corresponding image quality.** **1 mark**
Compare and comment on the compression ratios for lossless and lossy compression, and the corresponding image quality.

…………………………………………………………………………………………

**Question 6.6 Compression algorithms applied to radiography** **2 marks**
Suggest suitable applications for each of lossy and lossless compression in Radiography specifically. Comment of the type of files that could be stored using lossy compression, and which types should be stored using lossless compression.

…………………………………………………………………………………………

Have you added proof of your progress for every question, whether it was specifically asked or not?

Do so now if your answer is no.

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**Submission instructions:**

A drop box has been created on Moodle for your Answer Booklet.

**If your file is too large and you need to zip or compress it (especially for MacBook users:**

* Right click on the file name
* Hover over “Send to”
* Left click on “Compressed (zipped) folder”

**Use your name as file / folder name**

Closing time and date for submissions: **5 pm on 9 June 2023.**

**Kia Ora**