RHODES UNIVERSITY
DEPARTMENT OF COMPUTER SCIENCE

EXAMINATION: NOVEMBER 2018

COMPUTER SCIENCE HONOURS
PAPER 2 – IMAGE PROCESSING

Internal Examiner: Mr. J Connan
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MARKS: 120
DURATION: 4 hours

External Examiners: Prof. M Kuttel

GENERAL INSTRUCTIONS TO CANDIDATES

1. This paper consists of 8 questions and 7 pages. ***Please ensure that you have a complete paper.***
2. State any assumptions and show all workings.
3. Diagrams are encouraged and should be labelled.
4. Provide answers that are concise, legible and clearly numbered.
5. Use the mark allocation as a guide to the depth of your answer.
6. The Concise Oxford English Dictionary may be used during this examination.
7. You may use a calculator (though it should not be needed).

My castle is under siege. The raiding party is at the gate. You have come to steal my marks and all I have left for protection are these 10 questions. Luckily, you can each carry a maximum of 120 away with you. Prepare for a fight to the bitter end ...

FOR GLORY!!!!!

PLEASE DO NOT TURN OVER THIS PAGE UNTIL TOLD TO DO SO.

Section A Theory [62 Marks]

Question 1 **(6+4+2+4+2=18 marks)**

A digital image is a representation of a physical phenomenon. It is normally stored in a specific file format. The Netpbm image formats were widely used during this course.

a. Provide a brief description of the structure of these files and how the image data is stored in them.
b. Briefly explain how Bilinear Interpolation can be used to scale images.
c. Image rotation can lead to noisy and distorted images. What can be done to ensure good results when rotating images?
d. Briefly explain the difference between background subtraction and frame differencing, giving examples of when you would use each.
e. Sometimes it is desirable to remove colour information from images. Provide two reasons why this might be desirable.

Question 2 **(3+3+6+4+4=20 marks)**

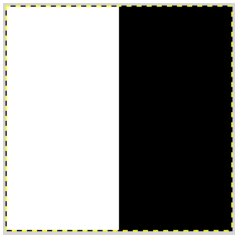


Figure 1

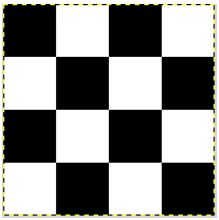


Figure 2

Refer to Figure 1 and Figure 2. Assume each is a 4x4 pixel image and the maximum pixel value is 255:

a. Draw and label the histogram for Figure 1.
b. Draw and label the histogram for Figure 2.

Assume that the filter *h* is applied to the image in Figure 1. Pad the image with zeros where necessary.

$$h=\frac{1}{9}\begin{pmatrix}1 & 1 & 1\\ 1 & 1 & 1\\ 1 & 1 & 1\end{pmatrix}$$

c. Write down the pixel values for Figure 1 after the filter *h* has been applied to it.
d. Assume that the image, as originally depicted in Figure 1, is scaled to twice its size using Bilinear Interpolation. Make a sketch of the resultant image (this is not an art class, so it must be legible but does not have to be a work of art).
e. Assume that the image, as originally depicted in Figure 2, is scaled to twice its size using the Nearest Neighbour method. Make a sketch of the resultant image (this is not an art class, so it must be legible but does not have to be a work of art).

Question 3 **(12+6=18 marks)**

a. Use the following data to create a Huffman tree and to determine an appropriate code for each symbol.

Symbol	a_1	a_2	a_3	a_4	a_5	a_6
Probability	0.1	0.4	0.06	0.1	0.04	0.3
Code						

b. Use your codes from *part a* to illustrate how an instantaneous block code works.

Question 4 **(6 marks)**

Explain how image compression differs from compressing other data.

Section B Practical [58 Marks]

All resources for this section can be found in your exam folder.

Question 5 **(6 marks)**

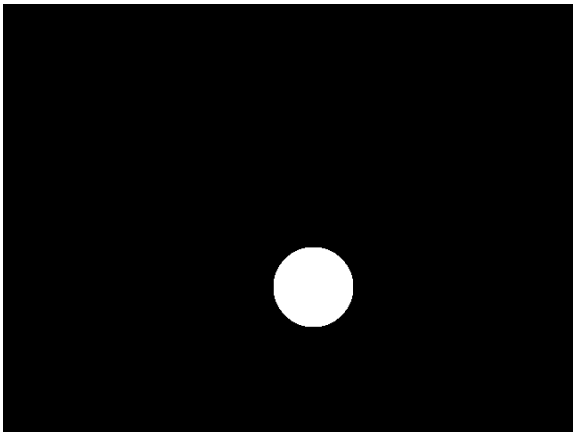
The following code was written by a week 1 OpenCV student. The code is fully functional and returns a valid image, however writing code in this manner does not follow best coding practice. Assuming the resulting image is incorrect, outline how this program should be refactored and give advice to the student on how to debug their result.

```
1. import cv2 as cv # OpenCV

2. image = cv.imread("Stars.png")

3. image = cv.cvtColor(image,cv.COLOR_BGR2GRAY)
4. image = cv.resize(image,(300,300),0,0,cv.INTER_LINEAR)

5. r, image = cv.threshold(image,125,255,cv.THRESH_BINARY)

6. cv.imshow("Our Image",image)
7. cv.waitKey(0)
```

Question 6 **(4+8+4=16 marks)**

a. Write a program **`badSleight.py`** that reads in **`coins.png`** as a greyscale image. The desired greyscale image is shown below.

b. In the same program, create a circle with a radius of **`45`** at coordinates **`[348, 317]`** on a blank image as shown below.



c. Replace the coin with the average pixel value in the rest of the image as below:

Question 7 **(4+8+6=18 marks)**

Write a program **goodSleight.py** which removes coins from the **coins.png** image. The aim is to achieve a better-looking result than the previous question and to remove all coins.

Combining the knowledge you have attained throughout this course and following the suggestions given, provide solutions to the following questions.

a. Use the following tuned function to detect Hough circles. Note: you **may not** modify its parameters.

```
# hough circles: parameters are tuned for detecting the
coins (almost perfectly)
circles = cv2.HoughCircles(img, cv2.cv.CV_HOUGH_GRADIENT,
dp=1.5, minDist=30, minRadius=15, maxRadius=60)
```

After detecting the Hough circles, display the resulting circles on the original colour image. The output should look as shown below:

b. Create a mask that will completely remove all coins from the image.
c. In Question 6, a crude attempt was made to hide one coin. A better result can be achieved by using the built-in OpenCV function `inpaint`, which calculates the normalized weighted sum of background neighbourhoods. The code below will help you achieve this.

```
# Convert the mask to a 8bit single channel image
bytemask = np.asarray(black, dtype=np.uint8)

# remove coins mask: normalized weighted sum of the
(coin) background neighbourhood
inpainted = cv2.inpaint(img, bytemask, inpaintRadius=5,
flags=cv2.INPAINT_TELEA)
```

A successful solution should yield a near-identical result to the following image:

Question 8 **[18 marks]**

Microbiologists use Petri dishes to culture cells such as bacteria and mosses. A growth medium is placed in the dish and cells from the desired specimen are placed in the growth medium. The cells are then allowed time to grow and develop. Different dishes may contain different elements, such as antibiotics, or be placed in different environments, such as extreme heat or cold.

As the cells develop they form what are known as colonies. By examining these colonies and looking at for example the number of colonies or the size of colonies, microbiologists can make conclusions about the influences of the environment on the specimens.

You have been asked to develop a system to assist the microbiologists. Your system needs to be able to provide user feedback only on the number of colonies as in the example output below.

8 colonies

In your exam folder you will find an image called **`dish.png`**. Implement a system to count the colonies using this image as sample input, producing output as above. You may choose to circle the colonies if you wish.

If you can not produce a working system up to 50% of the marks can be achieved by describing the following:

- How would you go about implementing such a system?
- Provide an overview of the entire system, from data acquisition to user feedback.
- Also highlight the strengths and weaknesses of your proposed solution as well as possible extensions.

And so peace once again descended on the land.

END OF EXAMINATION