RHODES UNIVERSITY
DEPARTMENT OF COMPUTER SCIENCE

EXAMINATION: JUNE 2019

COMPUTER SCIENCE HONOURS
PAPER 1 – IMAGE PROCESSING

Internal Examiner: Mr. J. Connan
Dr. D. Brown

MARKS: 120
DURATION: 4 hours

External Examiners: Prof. I. Sanders

GENERAL INSTRUCTIONS TO CANDIDATES

1. This paper consists of 11 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 11 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 [58 Marks]

Question 1 **(5 marks)**
Briefly explain how Bilinear interpolation is used to infer new pixel values when scaling an image.

Question 2 **(8 marks)**
With the aid of a diagram, provide a brief overview of the RGB and HSV colour spaces.

Question 3 **(5 marks)**
What is a filter and how do we typically use filters in image processing?

Question 4 **(8 marks)**
When the images in Figure 1 are overlapped a secret message is revealed. Explain how these images are created and why overlapping them reveals the hidden message.

Question 5 **(10 marks)**
Provide a brief overview of the Lempel-Ziv-Welch (LZW) compression algorithm.

Question 6 **(10 marks)**
Apply histogram equalization to this image given

$$h(v) = round\left(\frac{cdf(v) - cdf_{min}}{(MxN) - cdf_{min}} x(L-1)\right)$$

82	93	77	100	72
155	135	100	93	82
82	135	77	93	100
88	135	77	93	85

Question 7 **(12 marks)**
What will the result be when you use a 3x3 median filter on this image? The image is already zero-padded.

0	0	0	0	0	0	0
0	2	3	5	0	3	0
0	3	1	8	4	7	0
0	8	2	0	6	9	0
0	9	1	3	8	9	0
0	4	6	3	5	7	0
0	0	0	0	0	0	0

Section B Practical [62 Marks]

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

Question 8 (6 marks)

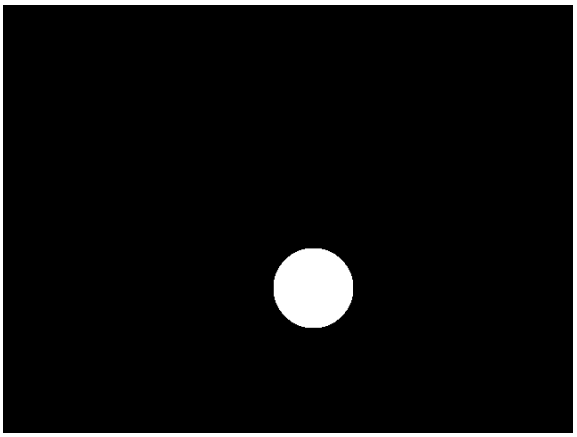
The following code was written by a week 1 OpenCV student. The student presented the program to a friend for feedback. The code is fully functional and returns a valid image, however, writing code in this manner does not follow best coding practice. Furthermore, the student's friend complained that it was difficult to view the image. 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("Potato.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("A Image",image)
7. cv.waitKey(1)
```

Question 9 (2+4+6=12 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 of the **rest** of the image as below:

Question 10 **(4+8+4+4+6=26 marks)**

a. Write a program **`replaceFruit.py`** that reads in **`manyFruit.png`** and **`appleFace.png`**, unchanged with the alpha channel, and converts them to greyscale. The desired greyscale images are shown below.

b. In the same program, create a mask of the orange and the closest peach.

c. Display the orange and the peach on a new blank image of the same resolution as **`manyFruit.png`** in colour:

d. Now that you have shown that you can superimpose two fruits onto a blank image, remove the orange from **`manyFruit.png`**, displaying the result in colour.

e. Replace the orange with the apple image found in **`appleFace.png`**, displaying the result in colour.

Question 11 **[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