2. With regards to human vision

(a) Describe the role of ON/OFF cells in the perceived enhancement of contrast in human vision. [6]:

(b) Discuss the evolution of Light Capturing Devices (photocells) to allow the progress of detection of light from 1D to 2D. [10]

(c) Use schematics and diagrams to illustrate this evolution where appropriate. [4]

1. The Laplacian Operator is the two-dimensional equivalent of the second derivative used for edge detection. The formula for the Laplacian of a function f(x,y) is

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$

which can be approximated by

$\nabla^2 \approx$

0	-1	0
-1	4	-1
0	-1	0

(a) Given the 3x3 Intensity Image below, apply the Laplacian Operator above to obtain a 3x3 output matrix [9]

I =

8	9	9
9	10	11
10	11	12

(b) To determine edges, after applying the Laplacian Operator, we simply can not take the magnitude. What additional step is needed to find pixels that are edges? [2]

(c) Why are 2nd order edge detectors, such as the Laplacian Operator shown above, better at detecting sharper edges in Intensity Images, as compared to 1st order based operators? You should provide a direct comparison between 1st order and 2nd order derivatives for full marks. [9]

2. With regards to human vision

(a) Describe the role and behaviour of the following in the visual system:

i. Rod Photoreceptors [3]

ii. Cone Photoreceptors [3]

(b) Objects selectively absorb some wavelengths (colours) and reflect others.

i. State two different forms of colour vision proposed that allows humans do differentiate colours. [4]

ii. Discuss these two forms of colour vision in detail, stating the pros and cons of each form. You should outline the mechanism for each theory that allows colour determination. [10]

1. For edge detection using intensity images, we often approximate the gradient of the intensity using Masks.

(a) What is the advantage of Sobel operator over Roberts operator when used for edge detection? [4]

(b) Why are second order edge detectors better at finding edges than first order detectors? [2]

(c) Describe how the computational speed of applying a 2D Gaussian filter to an image raster can be improved. [2]

(d) Convolve the Image Raster with the Mask shown below. You will only need to find the output corresponding to the sixteen highlighted central elements of the original image raster. [10]

Mask

1	2	1
0	0	0
-1	-2	-1

Image Raster

0	0	0	0	0	1
0	0	0	0	1	1
0	0	0	1	1	1
0	0	1	1	1	1
0	1	1	1	1	1
1	1	1	1	1	1

(e) What feature in the image raster does this mask in part (d) detect? [2]

(c) You are asked to design and implement a secure entry devise to the School of Computer Science, based on facial detection and recognition of each student and staff. The system must be able to identify each individual member and allow appropriate access through secure doors. You should describe the technique that you would apply together with the problems you believe you would encounter in such a system so that you can:

(i) Gather the required information for processing. [2 marks]

(ii) Identify each individual member. You need to outline the details of your chosen method that will allow make this possible. [10 marks]

(iii) Determine and minimise the drawbacks of the suggested technique. [8 marks]

[20 marks]

(a) Feature detection as used for objection recognition and tracking needs to be robust to different types of invariance.

(i) Explain how the following types of invariance can be achieved (state all applicable algorithms):

i. Illumination [2 marks]

ii. Scale [2 marks]

iii. Rotation [2 marks]

(ii) Corner detection is frequently used in motion detection and image registration.

i. Explain why a corner is a better feature as compared to edges. [2 marks]

ii. Explain and outline how Moravec operator can be used for corner detection. [8 marks]

(iii) Motion Correspondence can be used to match features in one image with those in another, to estimate motion. State and explain the THREE principles of motion correspondence. Specifically state how an algorithm is designed to ensure features adhere to these principles. [4 marks]

[20 marks]

- What is Deep Learning?
- Outline the different Deep Learning Algorithms for Computer Vision.
- Explain the fundamental differences between Supervised and self/unsupervised learning and give examples in Computer Vision.
- What are hidden layers, convolution layers, pooling layers and fully connected layers?
- How are weights calculated and what are non-linear funcyions?
- Identify examples where ReLU would be better suited as compared to other activation functions, for example Sigmoid.
- What is backprojection?
- What is a loss function?
- What is data augmentation and commonly used augmentation methods in Computer Vision.