UNIVERSITY OF LIMERICK

OILLSCOIL LUIMNIGH
FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ELECTRONIC & COMPUTER ENGINEERING

MODULE CODE: CE6021

MODULE TITLE: MACHINE VISION

SEMESTER: AUTUMN 2022

DURATION OF EXAM: 2 ½ HOURS

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INSTRUCTION TO CANDIDATES:

ANSWER ANY 4 OF 5 QUESTIONS.

EACH QUESTION CARRIES 20 MARKS. YOU WILL BE MARKED OUT OF 80.

THIS EXAM PAPER IS WORTH 45% OF THE FINAL MODULE RESULT.

READ EACH PROBLEM COMPLETELY AND THOROUGHLY BEFORE BEGINNING TO WORK ON IT.

INCLUDE ANY GRAPH PAPER OR ADDITIONAL SHEETS WITH YOUR SCRIPT.

CLEARLY MARK YOUR FINAL ANSWERS TO QUESTIONS.

_____

Q1

(a) Given a thin convex lens with a focal length $f = 0.005m$. If an object is placed $S_o = 0.012m$ in front of the lens as shown in Figure 1 how far behind the lens will the image be formed?

[5 marks]

(b) How much magnification of the object is produced by the lens in this case?

[3 marks]
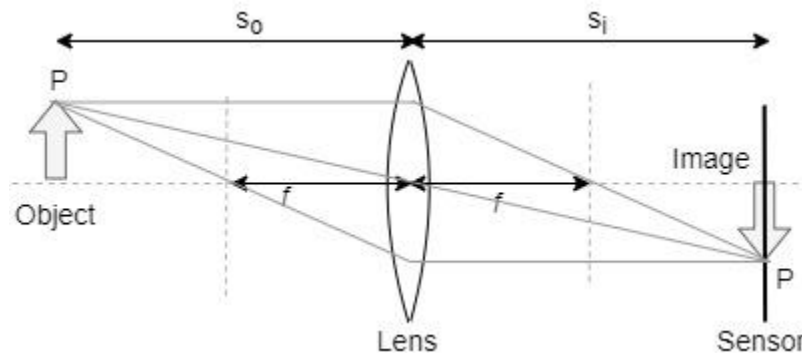

<u>Figure 1.</u>

(c) Give brief answers to the questions below:
 i.   What are the two key stages in producing a digital image?
 ii.   What is the function of the shutter in a digital camera?
 iii.   What is a typical image error seen with slow shutter operation?
 iv.   How can a colour image be produced using a single image sensor?
 v.   List the two most common types of digital image sensor?
 vi.   What physical principle is used in image sensors to convert incident light to electrons?
 vii.   What effect is observed in the image captured by a digital camera with a high amplifier gain and fast shutter speed?

[7 marks]

(d) Given the approximate Depth of Field Formula $D \approx \frac{2NCU^2}{f^2}$, calculate the circle of confusion for an approximate depth of field of 30m, given a camera with an F number of 7.2, a focal length of 50mm and a subject distance of 35m.

[5 marks]

Q2

(a)

   i.   What is the fundamental difference between the convolution and cross correlation operations?

   ii.   Under what condition will convolution and cross correlation produce the same result?

   iii. Determine the result of convolving the 2x2 kernel **A** with the 3x3 image B shown in Figure 2.

[4 Marks]

B

1	1	2
2	0	1
3	0	1

$*$

A

1	2
1	3

Figure 2.

(b)

   i.   Determine the result of applying a 3 x 3 median filter to the image shown in Figure 3.

[2 marks]

11	10	8	6
7	10	6	4
3	2	5	9
9	4	8	10

Figure 3.

   ii.   Which morphology operation could be applied to the binary image shown in Figure 4. in order to remove the small holes in the white region of the image yet keep the size of the foreground object the same?
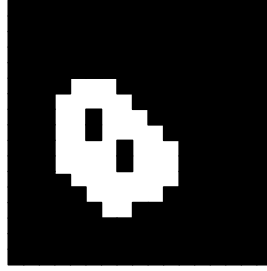
[2 Marks]

Figure 4.

(c) Describe the Harris Corner algorithm. Write your answer as pseudo code showing the key steps to detect corners in an image.

[12 Marks]

Q3

(a) Give brief answers to the following questions:
  i.   What are the 4 key steps in the SIFT Algorithm.
  ii.   What is the reason behind determining the characteristic orientation in the SIFT keypoint descriptor?

[3 marks]

(b) In the SIFT algorithm a pixel with a calculated magnitude of μ =10 is to be divided between the 4 nearest histograms (centres as shown in figure 5). Calculate the contribution to the histogram with centre (0,2) using bilinear interpolation.
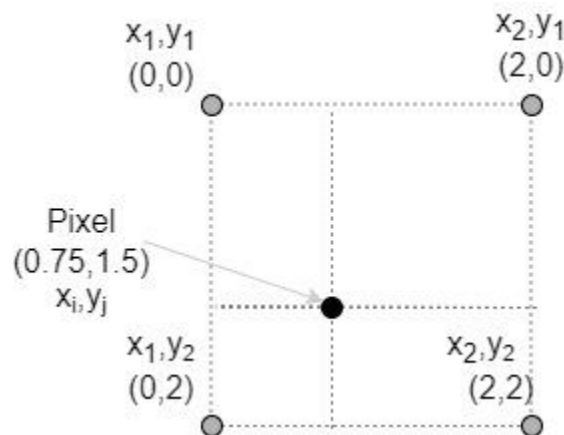
[5 marks]

Figure 5.

(c)
  i.   Describe an algorithm (using pseudo code) that can be used to detect circular regions at different scales in an image.

[9 Marks]

  ii.   Briefly explain how your algorithm is computationally efficient for convolution operations.

[3 Marks]

Q4

(a) Give Brief answers to the following questions:
      i.   Define the term supervised learning.
     ii.   What are the three key components in a supervised learning system?
   iii.   What is the difference between Classification and Regression?
   iv.   If a classifier model has a high bias and low variance, what type of fitting behaviour are we likely to see if the model is trained on the data?
    v.   If a classifier model has a low bias and high variance, what type of fitting behaviour are we likely to see if the model is trained on the data?
   vi.   List some ways (2) to minimise overfitting during training?

[8 marks]

(b) If we build a speed limit (60Km/hr) sign detection system and we find that out of 250 detections it correctly recognises 80 (60Km/hr) signs, it incorrectly identified 12 signs (i.e. 100km/hr, 80km/hr as 60km/hr) and it failed to identify 6 (60Km/hr) signs, calculate the Accuracy, Precision and Recall of the system.

[4 marks]

(c) Describe the Eigenfaces Method for Facial recognition. You can give your answer in the form of pseudo code. Separate the procedure for training and identification of a query image.

[8 marks]

Q5

(a) List 3 key enhancements or approaches within the Viola Jones Algorithm that enable fast object detection.

[3 marks]

(b) Obtain the integral image of the image patch in Figure 6. and find the sum of the pixels under the shaded region <u>using values from the integral image</u>. (For the sum calculation clearly write your answer in the form A-B-C+D = _ , where A,B,C,D are values from the integral image used to calculate the sum)

[8 marks]

1	2	1	2	1
0	1	0	2	1
1	2	1	0	1
1	0	1	1	2
2	1	0	1	1

Figure 6.

(c) Give Brief Answers to the following questions:
   i.   How does an image pyramid solve the object scale problem when used with a fixed size object detector window?
   ii. Give one advantage and one disadvantage to increasing the number of levels in the pyramid.
   iii. What is the function of "Non-Maximal Suppression" in Object Detection?

[5 marks]

(d) Briefly describe how the Bag of features representation is generated for an image.

[4 marks]