COMP 61342

Two hours

Question ONE is COMPULSORY

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Computer Vision

Date: Wednesday 6th June 2018

Time: 14:00 - 16:00

Please answer Question ONE
and also THREE other Questions from the FIVE Questions provided

Use a SEPARATE answerbook for each QUESTION

Each Question is worth 20 marks.

This is a CLOSED book examination

The use of electronic calculators is NOT permitted

[PTO]

1. This question is COMPULSORY.

Answer ANY FOUR (from 6) of the following parts.

a) What is the *optical flow constraint* and why does it not uniquely determine the flow at each point in an image? **[5 marks]**

b) How does a *median filter* reduce random noise in an image whilst tending to preserve edges? **[5 marks]**

c) Is the Harris corner detector a linear filter? Argue why or why not. Assume that the Harris corner detector is applied to an unsmoothed image. What type of image would trigger the detector at places that clearly don't contain a corner? **[5 marks]**

d) Given a pair of stereo images, what do we mean by the term *camera calibration*? Explain using a simple diagram.

[5 marks]

e) What is the main assumption that lies behind the idea of using image smoothing for noise suppression? **[5 marks]**

f) Explain and contrast the region-based and edge-based approaches to extracting structure from images. **[5 marks]**

End of Question 1

2.

A COMP61342 student wishes to study shape and shape variation. She has access to a database of images containing the 2D segmented shapes, and the shapes have been suitably annotated by an expert.

a) Describe ***briefly*** the steps necessary to obtain a mathematical representation of this shape dataset that contains **only** variation of shape, but ***not*** variation of pose.

[3 marks]

Having successfully removed the unwanted variation from her dataset, she now proceeds to perform a statistical analysis.

b) Explain **in detail** how she could construct a suitable statistical model of shape from this dataset. What properties would the annotation need to have in order to make this analysis of shape successful?

[7 marks]

Another COMP61342 student now wants to use the results of this statistical analysis of shape to construct a deformable model able to locate examples of similar objects in images. There are various ways to do this.

c) Choose **one** such method, and explain **in detail** how such a computer vision system could be built, and how it incorporates the suitable learnt information. In particular, you should make reference to image search and the type(s) of structures that such a method might be able to locate, or that it might fail to locate.

[10 marks]

End of Question 2

3.

a) Describe one method for detecting interesting feature points, which occur at a range of scales in an image **[6 marks]**

b) The *SIFT descriptor* is a popular method for describing selected interest points based on local neighborhood properties so that they can be matched reliably across images. Assuming *interest points* (*keypoints*) have been previously detected, briefly describe the main steps of creating the SIFT keypoint *descriptor* at a given interest point. **[8 marks]**

c) Explain the role of the following parameters in the SIFT algorithm: **[6 marks]**

i. Contrast threshold,

ii. Curvature threshold and,

iii. Dimensionality of feature vector.

End of Question 3

4.

a) Consider the data in **figure 1**.

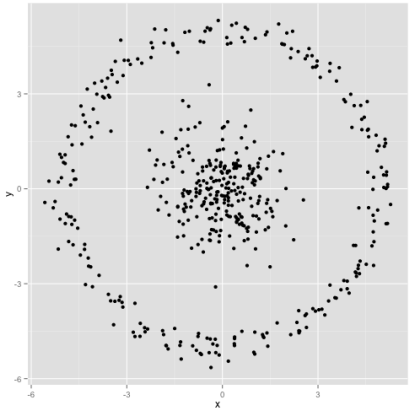

Figure 1

What do you expect to happen if we run the K-means algorithm with two clusters on this data set? Explain why you expect this to happen. **[6 marks]**

b) Explain what corner detector is and give an example of such detector. What is the main difference in the information provided by edge and corner features? **[4 marks]**

c) Explain how you could use the pair of images in **figure 2** to calculate the distances from the camera of the surface features that appear in the scene.

Figure 2

In your answer you need to consider all steps in the process, from images to depth values. You also need to give a diagram to illustrate your answer. **[10 marks]**

End of Question 4

5.

When reading a journal paper, a COMP61342 student comes across the following example of an objective function suitable for an intensity-based non-rigid pairwise registration algorithm:

$$\mathcal{L} = a \sum_{\alpha=1}^{d} \int_{\Omega} (\triangle u_\alpha(\underline{r}))^2 \, d\underline{r} + \int_{\Omega} |I_s(\underline{r}) - I_t(\underline{r}_{\underline{u}})| \, d\underline{r},$$

where:

$$\underline{r} = \{r_\alpha : \alpha = 1, \ldots d\},$$

$$\underline{u}(\underline{r}) = \{u_\alpha(\underline{r}) : \alpha = 1, \ldots d\}, \;\; \underline{r}_{\underline{u}} \doteq \underline{r} + \underline{u}(\underline{r}),$$

$$\triangle \doteq \frac{\partial^2}{\partial r_1^2} + \frac{\partial^2}{\partial r_2^2} + \ldots + \frac{\partial^2}{\partial r_d^2}.$$

a) Give a ***detailed*** and ***complete*** explanation of the role of each term in the objective function. You should include how its form allows it to fulfil that role. Make sure you identify the meaning of ***every*** function or operator that appears.

[6 marks]

b) Along with an image-matching term, what ***other*** components are required when constructing a general pairwise non-rigid image registration algorithm? You should include both the ***non-parametric*** and ***parametric*** cases. For each basic constituent that you mention, you should give at least one example.

[10 marks]

c) Outline at least **two** distinct applications of non-rigid image registration to biomedical imaging, making clear in each case why registration is either required or useful.

[4 marks]

End of Question 5

END OF EXAMINATION