COMP 61342

Two hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Computer Vision

Date: Wednesday 5th June 2019

Time: 09:45 - 11:45

Please answer all FOUR Questions.
Each Question is worth 20 marks

Use a SEPARATE answer book for each QUESTION

This is a CLOSED book examination

The use of electronic calculators is NOT permitted

[PTO]

1.

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) Define **disparity** in stereo vision. Given a pair of stereo images, what do we mean by the term **image rectification**?

[5 marks]

End of Question 1

2.
A COMP61342 student is studying learnt, statistical, model-based approaches to computer vision. She has a dataset of n vectors thus:

$$\{\underline{x}^{\alpha} | \alpha = 1, \ldots n\},$$
$$\underline{x}^{\alpha} \in \mathbb{R}^{d}, \ \underline{x}^{\alpha} = \{x_1^{\alpha}, x_2^{\alpha}, \ldots x_d^{\alpha}\}.$$

a) Explain in detail how **Principal Component Analysis (PCA)** could be applied to this dataset. How are the properties and output of PCA used when building a statistical model of shape (SSM), and explain why PCA is useful in this case.

[5 marks]

b) Explain **in detail** how statistical modelling methods using PCA can be used to build a computer vision system to find a previously unseen example of an object in a new image. You should explain in detail how the datasets used are constructed from the raw data.

[10 marks]

c) Give at least three **disadvantages** of such a model-based approach to computer vision. Discuss whether or not these disadvantages can be overcome, and if so, how they might be overcome.

[5 marks]

End of Question 2

3.

a) Explain what an **interest point** is.

[2 marks]

b) You are asked to develop a computer vision system that can detect motorbikes from side views, such in the images below (**Figure 1**).

Figure 1

Suppose that we have computed clusters of local features from a training set, and determined how likely features in each cluster are to be part of a motorbike. Describe how this information could be used in a "Bag of Words" motorbike detector. **[8 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

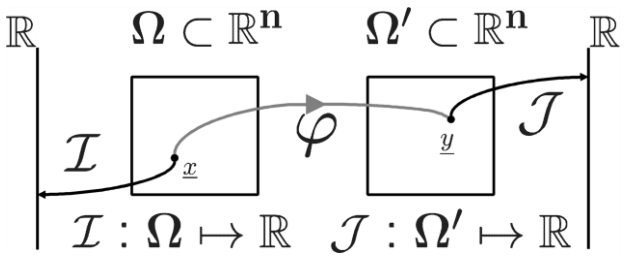
In your answer you need to consider all steps in the process, from images to depth values. You also need to give a diagram to illustrate your answer.

[10 marks]

End of Question 3

4.

a) The following diagram is a mathematical representation of two greyscale images, in the context of non-rigid image registration.



By referring to this diagram, or otherwise, explain the concepts of the **pullback** and **pushforward** mappings, and how they are used to create warped images. Why might one mapping be preferred over the other when building an implementation of pairwise image registration?

[4 marks]

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

[6 marks]

c) Consider the data in **figure 3**.

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

ii) What will happen if instead we run the EM algorithm with *three* clusters on this data set? Explain why you expect this to happen. **[4 marks]**

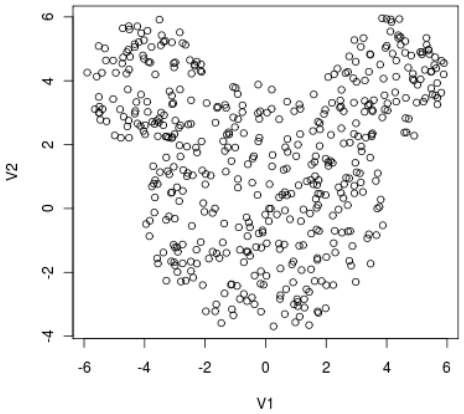


Figure 3

End of Question 4

END OF EXAMINATION