COMP 61342

Two hours

Question ONE is COMPULSORY

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Computer Vision

Date: Tuesday 30th May 2017

Time: 09:45 - 11:45

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

Use a SEPARATE answerbook for each QUESTION

This is a CLOSED book examination

The use of electronic calculators is NOT permitted

[PTO]

1. <u>This question is COMPULSORY.</u>

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 *image rectification*? **[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 student has a set of shapes extracted from a database of images, and wishes to study the variation of shape across the database. An expert has already annotated each shape example with suitable landmarks.

a) Why is it necessary to **align** a set of shapes before building a model of shape variation? Describe **in detail** how such alignment could be done.

[5 marks]

After successful alignment, the student now has a dataset of n shapes thus:

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

She now decides to apply **Principal Component Analysis (PCA)** to this dataset.

b) Explain **in detail** how PCA could be applied to this dataset.
How are the properties and output of PCA of use in the resultant statistical model of shape?

[5 marks]

c) Explain **in detail** how the mathematical methods and statistical modelling methods described above can be used to build a computer vision system suitable for finding a new example of an object in a new image.
What are the main **disadvantages** of such a model-based vision system?

[10 marks]

End of Question 2

[PTO]

3.

Consider the data in figure 1.

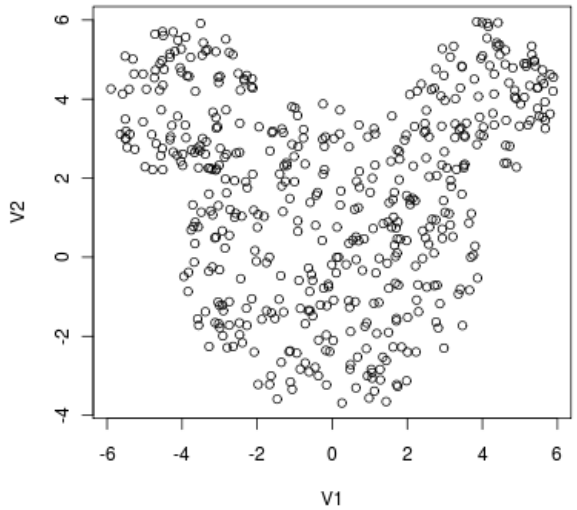

Figure 1

a) 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]**

b) Propose and *describe* an alternative algorithm to cluster the data in figure 1. Justify your choice.

[7 marks]

c) What are the *advantages* and *disadvantages* of K-means clustering algorithm and your proposed alternative algorithm? **[7 marks]**

End of Question 3

4.

Figure 2 shows a pair of stereo images that have been captured using a pair of calibrated cameras.

a) Explain the difference between sparse and dense matching algorithms for stereo-based scene reconstruction. **[4 marks]**

b) Describe a method for detecting **interest points** in an image. **[6 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.

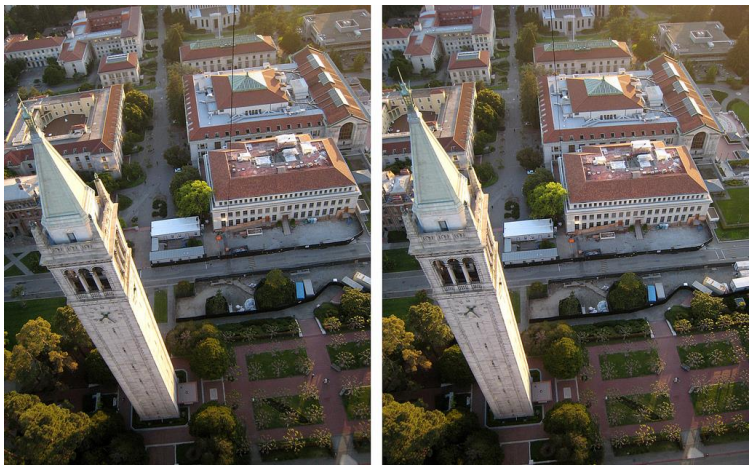

Figure 2

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

[PTO]

5.

a) Give a brief outline of the **three** main constituents of a non-rigid pairwise image-registration algorithm. Compare and contrast an algorithm that uses a **non-parametric** representation of image warps, with one that uses a **parametric** representation.

[6 marks]

b) Describe, using diagrams or otherwise, a simple linear warping algorithm for defining a one-to-one mapping between two triangulated meshes. You need only consider **one** triangle of the entire mesh, and how to map to the corresponding point(s) in a second triangle of another mesh.

[4 marks]

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

[6 marks]

d) Why might we wish to perform registration across an entire population? In such a case, would fully groupwise registration be a better choice than repeated pairwise registration? Give the reasons for your answer.

[4 marks]

End of Question 5

END OF EXAMINATION