Two hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Computer Vision

Date: Friday 22nd May 2015
Time: 09:45 - 11:45

Please answer any THREE Questions from the FOUR Questions provided

Use a SEPARATE answer book for each QUESTION

This is a CLOSED book examination

The use of electronic calculators is permitted provided they are not programmable and do not store text
A student is researching various methods of face detection and identification, and reads about the Viola-Jones face detector.

a) Explain why integral images are used in the Viola-Jones detector.

\[ I(x, y) = \sum_{X \leq x} \sum_{Y \leq y} I(X, Y) \]

In particular, you should give examples of the types of features the integral image can be used to construct, and explain why these features might be useful in the detection of faces. You may find it helpful to refer to the face images below in your answer.

[5 marks]

Figure 1. Examples of low-resolution face image patches.

A second student is interested in model-based approaches, and researches the Active Shape Model (ASM) and Active Appearance Model (AAM) methods. She collects a training set of neutral-expression face images, some examples of which are shown below.

Figure 2. Three face images from a larger training set.

b) Explain in detail the steps she should perform in order to construct an ASM for faces using this training set. Your answer should include details of any annotation that may be required. You may assume the training set has been suitably aligned. [12 marks]

c) She then expands her training set to include a range of facial expressions. Would the ASM or the AAM be a better choice in this case? Explain the reasoning behind your answer. [3 marks]

End of Question 1
2.

A student is trying to construct a computer vision system to analyse the pattern of veins in insect wings. During her investigation, she produces various processed versions of the original image (see Figure 3 below).

a) Explain briefly the processes of erosion and dilation as applied to binary and greyscale images. Hence (or otherwise) explain how she might apply morphological edge detection to the task of finding the veins in both the binary and greyscale processed images shown below.

[5 marks]

The student then decides that morphology is not suited to this task, and decides instead to adopt the following plan:

b) Locate pixels on the edges of the veins and the edge direction by using gradient operator(s).

c) Use the Hough transform to simplify the vein pattern by identifying straight sections of the vein network.

d) Locate true edge positions to sub-pixel accuracy for further analysis.

Explain in outline how each of the steps b), c), and d) could be achieved.

[5 marks for each step]

Figure 3. Figure showing (left) the original fly-wing image, with (centre & right) a binary and a greyscale processed version of this image.

End of Question 2
3. 

a) Briefly describe the main steps of performing image segmentation using *normalised cuts*. 

b) What are the advantages and disadvantages of 
   
i. *EM* clustering algorithm 
   
ii. *Mean-shift* clustering algorithm 
   
iii. *Normalised cuts* 

[4 marks] [4 marks] [3 marks] 

c) Consider two ideal pinhole cameras with the following top view configuration:

![Diagram of two pinhole cameras](image.png)

Draw the epipole and a few epipolar lines on the front view of the two 2D images.

[5 marks]

*End of Question 3*
4.

**Figure 4** shows a frame from a video sequence obtained by a single video camera moving through a static indoor scene. The sequence of images is to be used to generate a 3D representation of the scene. The small white squares superimposed on the image are regions that have been automatically selected as suitably “interesting” locations to be matched between frames.

a) How are the “interesting” locations selected? Outline a method that might be used to identify candidate “interesting” positions. **[8 marks]**

b) Describe a method for finding the positions in a given frame of the sequence that match the interesting points identified in another frame. **[6 marks]**

c) Explain in outline how, having obtained matching positions in different frames, the 3D structure of the scene can be determined. You should pay particular attention to the facts that the images are obtained from the same camera and that, in general, the change in position of the camera between the frames is not accurately known. **[6 marks]**