Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2015-16 (2.0 hours)

EEE6219 Computer Vision

Answer **THREE** questions. **No marks will be awarded for solutions to a forth question.** Solutions will be considered in the order that they are presented in the answer book. Trial answers will be ignored if they are clearly crossed out. **The numbers given after each section of a question indicate the relative weighting of that section.**

1. **a.** i. Assume that an edge detector produces a string (or linked list) of edgels. Describe a possible recursive algorithm to approximate such an edge string with a series of straight line segments.

ii. How would such an algorithm be terminated? **(5)**

iii. Approximating an edge string with a series of straight line segments will obviously lead to some error. In the algorithm you have described above, what bounds the error? **(3)**

iv. Explain why it may be desirable to approximate an edge string using straight line segments. Give a possible example of such a use. **(3)**

b. Suppose you are given a grey-level medical image containing views of a complex network of blood vessels. (Assume the image does not contain any other anatomical features other than blood vessels.) Suggest how you could go about automatically detecting the blood vessels in the image as a series of disconnected vessel points. Clearly explain the *principles* underlying your approach. **(6)**

Further suppose that you wanted to extract the *network* of vessels by tracking along the detected points. Are there any particular points in the image which will prove difficult for the algorithm you have described above? (It is not necessary to describe the tracking algorithm.) **(3)**

2. **a.** i. Describe the physical analogy underlying *watershed segmentation* of a grey-level image into connected regions.

ii. Explain how a watershed segmentation algorithm would be implemented in practice. How would the segmentation process terminate? **(5)**

iii. What is the main shortcoming of watershed segmentation? How can this problem be reduced?

iv. Are there any further techniques that could be employed to improve the quality of the segmentation result? **(2)**

b. The image in Figure 1 was acquired with a CMOS camera. Explain why the blades of the helicopter appears to be bent.

Figure 1: Image of a helicopter acquired with a CMOS imager. **(4)**

c. A solid-state camera sensor comprises a grid of light-sensitive regions of dimensions $W \times W$. Explain the effect of the finite size, W of the pixel sensor on the frequency content of the acquired image. **(5)**

In practice, the pixels on a camera sensor do not butt together exactly – rather, there is a small gap between adjacent pixels. What happens when you reduce the pixel size W relative to the pixel pitch, say Y - namely, when the pixel fill factor W/Y is reduced from unity to less than one? **(4)**

3. **a.** i. Briefly describe the pyramid representation of an image. For what purposes are pyramids useful in computer vision? **(6)**

ii. In terms of the frequency domain, how do the levels of a Laplacian pyramid differ from each other? What image processing operation does this implement?

iii. Describe the practical use of having such an image representation. **(3)**

b. i. In the context of object recognition, outline the *bag of visual words* approach.

ii. What is the fundamental limitation of the bag of words approach? **(4)**

c. i. What is a level set?

ii. What is the advantage of using a level set for segmenting an arbitrary shape from an image compared to, say, parameterising the shape with some curve? **(5)**

Sketch an illustration of how a level set can be used to segment an object from an image which contains holes. **(2)**

4. **a.** i. In motion estimation, what is the *aperture problem*?

ii. What fundamental limitation does it impose?

iii. How can it be overcome? **(4)**

b. i. In tracking, what is the *data association* problem?

ii. What is the fundamental approach to dealing with this? **(3)**

iii. Explain the operation of the Kalman filter – in words – without recourse to any mathematical formulae.

iv. Illustrate how the Kalman filter can be used to address the data association problem in tracking. **(5)**

c. i. Describe the main processing steps involved in the Random Sampling for Consensus (RANSAC) algorithm.

ii. In using the RANSAC algorithm, how many points would you use to calculate a candidate fit to, say, a straight line? Justify your answer. **(4)**

iii. What is the major disadvantage of the RANSAC algorithm? **(2)**

iv. How many iterations should it take for the RANSAC algorithm to converge on the globally-correct answer? **(2)**

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