Data Provided: None

The University Of Sheffield.

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2014-15 (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.** Explain the differences between *face detection* and *face recognition*. What conditions would make face recognition a challenging problem? **(4)**

b. Subspace learning approaches are commonly used for face recognition. Briefly describe the two principal approaches employed. Which one would you expect to be better? Justify your answer. **(4)**

c. Using a suitable diagram, describe the key geometric features of the pinhole camera model. Derive a simple expression relating the projection of a point on the sensor plane to the corresponding point in the object space.

What is the principal shortcoming of the pinhole camera? How does a real camera differ from this model and what are the main effects encountered as a consequence of the non-pinhole model? **(4)**

d. What is the objective of histogram equalisation of the grey-levels in a monochrome image? Describe the steps involved in histogram equalisation. What does histogram equalisation do to the appearance of the image? **(8)**

2. **a.** Object recognition methods fall into two broad classes: global-based methods, and parts- or local-based methods. Explain the basic properties of these two approaches. Compare the advantages and disadvantages of both object recognition methods. **(2)**

b. Describe the principal processing steps in the implementation of the Canny edge detector. What are the three distinct design objectives set-out by Canny and how does each of the processing steps in the algorithm achieve these goals? **(8)**

Explain why the Canny edge detector produces unpredictable results in the neighbourhood of corners **(2)**

c. In relation to characterising a detector, describe what you understand by the following terms:

i. True positives
ii. False positives
iii. True negatives
iv. False negatives

How would you estimate these quantities? **(4)**

Also in relation to characterising a detector, what is a receiver operating characteristic (ROC)? Sketch typical ROC plots for a 'good' detector, and a detector that performs no better than random guessing. What features of the ROC plot suggest a good detector? **(4)**

3. Explain how the Hough transform can be used to detect straight lines of the form:

$$y = mx + c$$

in an image. (Assume that a suitable edge detection process has been performed on the image.) **(8)**

How can the computational burden of making entries into the Hough accumulator be reduced? **(4)**

Is it possible to estimate the length of the line *directly* from the Hough transform accumulator? **(4)**

Explain how you would determine the width of the bins in a Hough transform accumulator. **(4)**

4. a. In the field of linear filtering of images, what is meant by a *separable filter*? Assuming an $M \times M$ image and an $N \times N$ kernel, calculate the *approximate* saving in the number of arithmetic operations required to perform a filtering operation as a two-dimensional convolution compared to performing the same filtering operation in separable form. For the case of $M = 512$, determine the kernel size for which it is computationally advantageous to switch to the separable implementation. **(5)**

b. It is desired to apply an *affine* transformation to the image in Figure 1 to produce a view approximately equivalent to that which would have been acquired with the optical axis of the camera *normal* to the front of the building. Outline how you could calculate a suitable affine transform based only on the information in the image. Carefully explain how you would determine the coefficients of the transform together with the effects of any assumptions you make.

Figure 1 **(9)**

Explain any special precautions you would take in extracting relevant data from the original image in order to compute the transform. **(3)**

If you applied the transform calculated above to the image, what would the street lamp in front of the building look like in the transformed image? What does this tell you about the implicit assumptions in an affine transformation? **(3)**

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