Two hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

M.Sc. in Advanced Computer Science

Advanced Machine Vision

Date: Monday 8th June 2009
Time: 09:45 – 11:45

Please answer question ONE and THREE other questions from the FIVE questions provided

This is an OPEN book examination
1. **Compulsory**

   Answer five (from 8) of the following parts.

   a) How does a *median filter* reduce random noise in an image whilst tending to preserve edges? (5 marks)

   b) Describe how you could use a combination of grey-level morphology and image arithmetic to enhance small bright structures in an image. What would determine the size of structures that would be enhanced? (5 marks)

   c) What is the *optical flow constraint* and why does it not uniquely determine the flow at each point in an image? (5 marks)

   d) Write down the kernel of a simple convolution filter that would give a *zero-crossing* at edges. Give an argument why a zero-crossing edge detector might be preferred to a first derivative edge detector. (5 marks)

   e) How is the output of a *rank order filter* calculated? Explain the trade-off involved in choosing the neighbourhood size. (5 marks)

   f) What is meant by the *skeleton* of an object? Explain with the aid of a diagram how the skeleton can change dramatically for a small change in the shape of an object. (5 marks)

   g) Outline the idea of treating segmentation as an optimisation problem. Give the general form of a suitable objective function, explaining the individual terms and the way they are combined. (5 marks)

   h) Explain the role of *non-maximal suppression* in edge detection and describe a practical algorithm for applying it to an edge strength and orientation image. (5 marks)
2. a) What are the advantages and disadvantages of using edge-detection as a method of identifying corresponding points? Suggest and briefly describe an alternative method that can be used. (11 marks)

b) Is the Harris corner detector a linear filter? Argue why or why not. (3 marks)

c) 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? (2 marks)

d) Explain the role of the following parameters in the SIFT algorithm: (3 marks)

- Contrast threshold,
- Curvature threshold and,
- Dimensionality of feature vector.

e) If we rotate the image, will the SIFT algorithm find the same keypoint descriptors between the original image and the rotated one? (6 marks)

3. a) Deformable models are used extensively in Computer Vision. Name three different types, describing the distinguishing characteristics of each. (10 marks)

b) What data does one need to build a statistical model of shape and appearance? (3 marks)

c) Why is it necessary to align a set of shapes when building a statistical shape model? (3 marks)

d) In addition to a statistical shape model, what else is required by the Active Shape Model matching algorithm? (3 marks)

e) If one wished to track the features of a face (assuming one has located them accurately in the first frame of a sequence) is it likely to be better to use an Active Shape Model or a set of Active Contour Models? Explain your decision. (3 marks)

f) What is the main difference between representing a face using an Eigen-face model and representing it using a statistical appearance model? (3 marks)
4. a) Explain how homogenous notation can be used to specify a pin-hole camera model and indicate the advantages of this approach. (5 Marks)

b) What are the main differences between the data obtained from calibrated and uncalibrated stereo systems? Illustrate these differences with practical examples of use. (10 Marks)

c) State the formula that relates, disparity, focal length, inter-ocular separation and depth. Illustrate this relationship with a diagram. Use the method of error propagation to determine the accuracy of depth measurement as a function of depth for a given system, assuming all imprecision arises from errors in disparity estimation. (10 Marks)

5. a) Discuss the main difficulties behind evaluation and comparison of object recognition algorithms in the published literature. (5 marks)

b) Define the concepts of representational completeness and statistical optimality with reference to a two stage approach to object recognition. (5 marks)

c) Explain how the above concepts impact upon the evaluation of recognition schemes. (5 marks)

d) Describe the approach to 2D shape recognition known as pairwise geometric histograms. To what are these histograms invariant and how are they matched? Define the scope of this method in relation to methods based upon moments or Fourier descriptors of shape. (5 marks)

e) What are the characteristics of this approach in terms of your answer to section b)? (5 marks)

END OF EXAMINATION