UNIVERSITY OF SOUTHAMPTON COMP6223W1

SEMESTER 1 EXAMINATION 2014 - 2015

COMPUTER VISION (MSC)

DURATION 120 MINS (2 Hours)

This paper contains 6 questions

Answer **THREE** questions.

An outline marking scheme is shown in brackets to the right of each question.

University approved calculators MAY be used.

A foreign language translation dictionary (paper version) is permitted provided it contains no notes, additions or annotations.



 

**Question 1.**

(a) **Describe** the need for averaging in image analysis in smoothing and in edge detection operators. **Describe** also what is understood to be an optimal averaging operator.

[10 marks]

(b) The Sobel edge detection process includes differencing (along one axis) and averaging (along the other axis) which is an approximation to the Gaussian averaging operator. **Determine** the nature of this approximation and **describe** its potential consequences in image analysis.

[14 marks]

(c) **Determine** whether the smoothing given by a $5 \times 5$ operator with approximate averaging is faster than a $3 \times 3$ Gaussian operator. **Describe** what is most likely to be the factor that is critical to the difference in speed.

[9 marks]

**Question 2.**

Given an image that contains only a human face, from the top of the head to the neck (in a vertical sense) **describe**:

(a) those features that are suited to model-based analysis and a technique that might be used to extract parameters that describe them.

(b) those features that are not suited to model-based analysis and a technique that might be used to extract parameters that describe them.

Your answers might include techniques that are hybrid: a combination of model-based and statistical.

**Describe** also how both of the techniques could be altered to handle changes in facial expression and change in inclination of the face relative to that of the camera.

[33 marks]

**TURN OVER**

33

**Question 3.**

(a) **Describe** the *differences* and *similarities* between template matching and the Hough transform.

[10 marks]

(b) **Describe** how the Hough transform for circles operates and **provide** a pseudo code implementation of the technique.

[14 marks]

(c) **Describe** how edge direction could be incorporated to improve the speed of operation of the Hough transform for circles.

[9 marks]

**Question 4.**

(a) **Describe** what a covariance matrix is. **Illustrate** your answer with example $2 \times 2$ covariance matrices and sketches of the corresponding 2D data distributions.

[8 marks]

(b) **Describe** what the eigenvalues and eigenvectors of a covariance matrix represent.

[4 marks]

(c) **Provide** a description of the idea behind the PCA algorithm together with pseudo-code detailing the steps.

[10 marks]

(d) Eigenfaces is a classic approach to face recognition that uses PCA to reduce the dimensionality of global features based on raw pixel values. **Describe** two classification approaches that could be used with the reduced dimension features to build a face-recognition system. What are the *advantages* and *disadvantages* of the two techniques?

[11 marks]

**TURN OVER**

**Question 5.**

(a) Local interest points have many uses in computer vision. **Describe** in detail a technique that allows you to find a set of robust and repeatable local interest points on an image.

[13 marks]

(b) The SIFT feature is a very popular form of local descriptor. **Provide** a detailed description of how a SIFT descriptor is computed using diagrams as necessary.

[10 marks]

(c) **Describe** a method for finding correspondences between two images using interest points described by SIFT features. **Provide** details on how this technique could be improved under the assumption of a Homographic mapping between the two images.

[10 marks]

**Question 6.**

(a) **Define** what is meant when a computer vision system has any of the following properties:

- Constraint
- Robustness
- Invariance

[9 marks]

(b) For the following computer vision applications, **describe** ways in which the vision system can be engineered to achieve robustness by considering invariance and constraints:

- An application for detecting QR codes on a mobile phone.
- A system for the automatic recognition of number plates on cars.
- An industrial machine for sorting beans by their colour.

[12 marks]

(c) Bruises can be detected in an image of an apple by thresholding and then applying connected component analysis. Apples will be rejected by supermarkets if they have bruises bigger than 1cm$^2$ in size that are approximately circular (the ratio of the longest axis to smallest must be less than 2). **Develop** a feature that can be computed from a connected component to determine whether or not an apple should be rejected. Give details of the bounds on the numeric values of the feature that would cause an apple to be rejected. Assume the imaging system has a resolution of 1pixel/mm in both x and y directions.

[12 marks]

**END OF PAPER**