NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 1 EXAMINATION 2017-2018

EE6222 – MACHINE VISION

November/December 2017 Time Allowed: 3 hours

INSTRUCTIONS

1. This paper contains 5 questions and comprises 3 pages.
2. Answer all 5 questions.
3. All questions carry equal marks.
4. This is a closed-book examination.

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1. (a) Explain briefly three different spatial domain noise removal methods.

(6 Marks)

(b) Gaussian smoothing is commonly used to reduce noise in digital images prior to differentiation. Show the most effective approach to realize first order differentiation and Gaussian smoothing together.

The two-dimensional Gaussian function is $G(x,y) = \frac{1}{2\pi\sigma^2} exp\left[-\frac{x^2+y^2}{2\sigma^2}\right]$

(8 Marks)

(c) Given that the standard deviation is 1, derive the four one-dimensional windows to perform the first order differentiation and noise smoothing operations together using the approach in part 1(b).

(6 Marks)

2. (a) Describe the following in detail:

(i) Histogram

(ii) Improving the robustness of chain codes against rotation, scaling, and starting point variations

(10 Marks)

(b) Cluster the two-dimensional data given in Table 1 by using the *K*-means algorithm using $K = 2$ with initial cluster centers as sample 1 and sample 2, respectively.

Table 1

Sample #	1	2	3	4	5	6	7	8
Dimension 1	0	1	1	7	9	8	8	2
Dimension 2	1	0	1	8	6	8	9	1

(10 Marks)

3. (a) Describe the random forest pattern classification method in detail. Your description should include training data generation, major training steps and testing process.

(10 Marks)

(b) Two sets of corresponding 3-D point sets are given:

$$X = \{ x_1, x_2, \ldots, x_N \},$$
$$P = \{ p_1, p_2, \ldots, p_N \}.$$

(i) Show that the 3-D translation t is

$$t = \mu_x - R\,\mu_p$$

where R is the rotation matrix, μ_x is the centre of X, and μ_p is the centre of P.

(ii) What is the minimum number of points required for this solution?

(10 Marks)

4. (a) Draw a graph to show the relationship of epipolar geometry.

(5 Marks)

(b) Show the steps of image rectification for binocular stereo settings.

(10 Marks)

(c) Derive the error estimation from the disparity equation

$$Z = f\frac{B}{dx},$$

where Z is the depth, B is the baseline, f is the focal length, and dx is the disparity.

(5 Marks)

5. (a) The cross ratio of four collinear points is defined as

$$[ABCD] = \left(\frac{AC}{BC}\right) / \left(\frac{AD}{BD}\right).$$

(i) Show that [ABCD] = [CDAB].

(ii) Compute the cross ratio [ABDC] using 4 image points of N-vectors. Derive the equations for [ABDC].

(10 Marks)

(b) Explain how a vision based system can be used for airplane auto-landing on a commercial runway. State all necessary assumptions, with respect to cross ratio, vanishing points, and space lines.

(10 Marks)

END OF PAPER

EE6222 MACHINE VISION

Please read the following instructions carefully:

1. **Please do not turn over the question paper until you are told to do so. Disciplinary action may be taken against you if you do so.**

2. You are not allowed to leave the examination hall unless accompanied by an invigilator. You may raise your hand if you need to communicate with the invigilator.

3. Please write your Matriculation Number on the front of the answer book.

4. Please indicate clearly in the answer book (at the appropriate place) if you are continuing the answer to a question elsewhere in the book.