NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 1 EXAMINATION 2015-2016

EE6222 – MACHINE VISION

November/December 2015 Time Allowed: 3 hours

INSTRUCTIONS

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

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1. Describe the following operations in detail:

   (a) Two different region based image segmentation methods. (6 Marks)

   (b) Erosion and dilation. (6 Marks)

   (c) Minimum distance classification. (4 Marks)

   (d) k nearest neighbour classification. (4 Marks)

2. (a) Explain the need for applying a smoothing operation prior to performing differentiation operation and explain the attractive properties of the Gaussian smoother. (7 Marks)

Note: Question No. 2 continues on page 2

(b) Derive the most computationally efficient smoothing approach to be used when performing first order gradient computations.

(6 Marks)

(c) Compute discrete smoothing windows for the implementation in part 2(b) when the standard deviation, σ = 1.2.

(7 Marks)

3. (a) (i) What is the objective in stereo vision to rectify images?

(ii) State one method to find image disparity in parallel stereo images.

(iii) Describe the steps to obtain the camera's focal length.

(iv) How do you relate the information data on the lens, for example 8mm, to the camera's focal length?

(10 Marks)

(b) Given the space line $\boldsymbol{l} = \{\boldsymbol{n},\boldsymbol{p}\}$ (see Figure 1), prove that the space line equation is

$$\boldsymbol{r} \times \boldsymbol{p} = \boldsymbol{n}$$

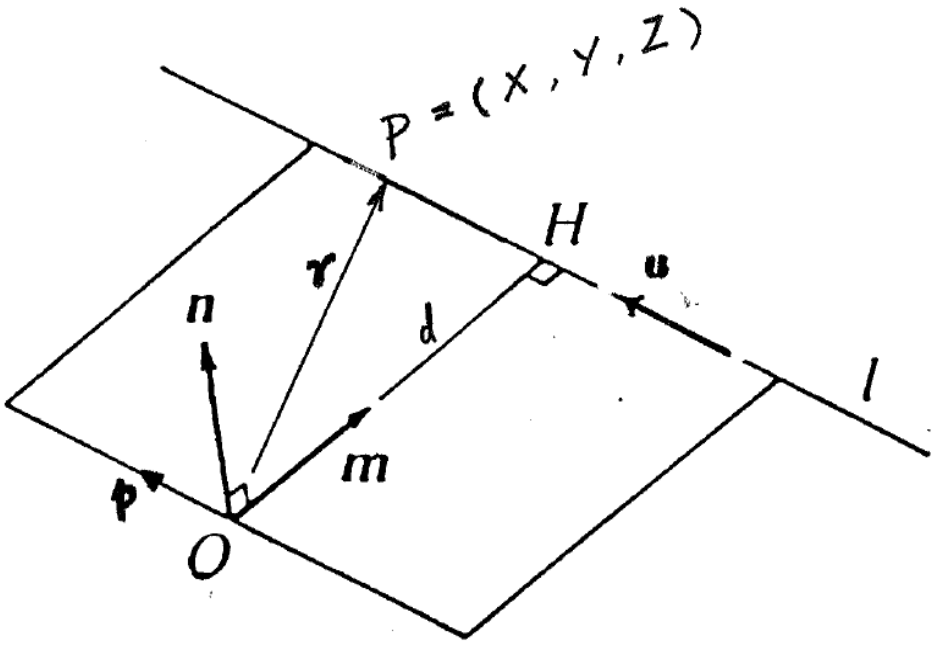

Figure 1. The space line $\boldsymbol{l}$

(10 Marks)

4. (a) (i) What is a quaternion?

(ii) Given a 3D rotation matrix, find the rotation axis and the rotation angle. Let $\boldsymbol{l} = (l_1, l_2, l_3)^T$ denote the unit vector of the rotation axis, θ denote the rotation angle. The rotation matrix can be expressed as

$$R = \begin{pmatrix} C + l_1^2 V & l_1 l_2 V - l_3 S & l_1 l_3 V + l_2 S \\ l_1 l_2 V + l_3 S & C + l_2^2 V & l_2 l_3 V - l_1 S \\ l_1 l_3 V - l_2 S & l_2 l_3 V + l_1 S & C + l_3^2 V \end{pmatrix}$$

where $C = \cos\theta$, $S = \sin\theta$, and $V = 1 - \cos\theta$

(iii) The cross ratio of 4 collinear points is defined as

$$[ABCD] = \frac{AC}{BC} / \frac{AD}{BD}$$

What is the invariance property of the cross ratio?

(10 Marks)

(b) A target tracking algorithm detects a moving object, and reports the centre of this object as $\boldsymbol{p}=(m_1, m_2, m_3)^T$ (N-vector). Derive its image velocity

$$\boldsymbol{v} = \begin{pmatrix} \frac{\partial x}{\partial t} \\ \frac{\partial y}{\partial t} \end{pmatrix}.$$

(10 Marks)

5. (a) (i) The fundamental matrix is given as

$$(x_{im}^{(l)} \quad y_{im}^{(l)} \quad 1) \begin{bmatrix} f11 & f12 & f13 \\ f21 & f22 & f23 \\ f31 & f32 & f33 \end{bmatrix} \begin{pmatrix} x_{im}^{(r)} \\ y_{im}^{(r)} \\ 1 \end{pmatrix} = 0$$

How many points are required to solve this equation? Propose a method to solve it.

(ii) Assume that the fundamental matrix is known. Given an image point in pixels in the left image, how would you find the epipolar line?

Note: Question No. 5 continues on page 4

(iii) If the essential matrix is known and an image point is given in the left image, how do you find the epipolar line in the right image?

(10 Marks)

(b) Describe the random vector functional link network (RVFL) in detail. Your description should include graphical illustration of its structure, major training steps, important equations and selection among potential alternatives.

(10 Marks)

END OF PAPER