NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 1 EXAMINATION 2020-2021

EE6222 – MACHINE VISION

November / December 2020   Time Allowed: 2 hours

INSTRUCTIONS

1.   This paper contains 4 questions and comprises 2 pages.

2.   Answer all 4 questions.

3.   All questions carry equal marks.

4.   This is a closed book examination.

5.   Unless specifically stated, all symbols have their usual meanings.

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1.   (a)   2   4   6   6   12
                 3   5   6   10   14
                 1   3   5   9   13
                 2   5   9   11   14
                 1   2   8   9   13

   (i)   For the 5×5 image shown above, compute the within class variance as defined by Otsu's optimal threshold selection method when the threshold level is set to 7.

   (ii)   Write down the steps for obtaining Otsu's optimal threshold level.

(11 Marks)

   (b)   (i)   Explain the principle of edge detection using second-order differentiation.

   (ii)   Show how Gaussian smoothing and second-order differentiation can be performed in a single step. Construct a 7×7 convolution kernel to accomplish these two tasks simultaneously, using $\sigma = 0.9$.

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

(14 Marks)

2. (a) From the first principles, show that the Bayes decision function with 0-1 loss is given by the following expression:

$$d_j(\mathbf{x}) = p(\mathbf{x}|\omega_j)p(\omega_j), \quad j = 1,2,\dots M$$

where $\mathbf{x}, M, p(\ )$ and ω_j denote the unknown pattern vector to be classified, the total number of classes, probability and j^{th} class, respectively.

(12 Marks)

(b) Apply Batchelor-Wilkin's clustering algorithm with the proportion parameter set to 0.4 to cluster the following data points:

(0,0), (0,1), (1,1), (4,4), (3,3), (3,4), (8,8), (7,8), (7,7).

Comment on the implications of setting the proportion parameter to 0.65.

(13 Marks)

3. (a) In parallel binocular stereo settings, rectification plays an important part in camera calibration. Give detailed steps of stereo rectification.

(15 Marks)

(b) Show that the N-vector of an image line $Ax + By + C = 0$ is given as

$$n = \pm N\left[\begin{pmatrix} A \\ B \\ C/f \end{pmatrix}\right],$$

where f is the focal length.

(10 Marks)

4. Space lines are represented in P-vectors and can be estimated using motion parallax.

(a) Explain the motion parallax for a space line, in particular, the relationship between two positions of the camera for a pure translation with sketches and drawings.

(10 Marks)

(b) If a space line of N-vector $\boldsymbol{n}$ moves to a space line of N-vector $\boldsymbol{n}'$ by a camera translation $\boldsymbol{h}$, show that the P-vectors $\boldsymbol{p}$ is given by

$$\boldsymbol{p} = \frac{\boldsymbol{n} \times \boldsymbol{n}'}{(\boldsymbol{h}, \boldsymbol{n}')}.$$

(15 Marks)

END OF PAPER

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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.