TTE-5210 Konenäkö tuotantoautomaatiossa — Spring 2009
TTE-5216 Machine Vision in Production Automation — Tentti / Exam 4.5.2009

Vastaa suomeksi jos haluat opintopisteet kurssilta TTE-5210 ja englanniksi jos haluat pisteet kurssilta TTE-5216. Kysymykset löytyvät englanniksi toiselta puolelta ja ne ovat samat molemmille kursseille.

Answer in Finnish if you want your credit points from course TTE-5210 and in English for course TTE-5216. Questions in English are on the other side of this paper and they are the same on both courses.

1. Explain (write and/or draw) the following machine vision related terms, max. about 5 lines per item (1 point per item, max 6 points)
    a. Camera field-of-view (FOV)
    b. Image segmentation
    c. Camera integration or exposure time
    d. Coaxial illumination
    e. Dark-field illumination
    f. Line scan camera

2. Are the following statements true or false? Give reasons for your choice. Plain true/false statement will not give full point but the reasoning is more important! (1 p/item, max 4 points)
    a. Consider green (λ = 550 nm) and red (λ = 650 nm) laser pointers having the same power and the same spot size. Of these two, the red pointer appears brighter to human eye.
    b. Grey-scale and color cameras having the same detector pixel resolution always produce images having the same true image resolution.
    c. Increasing the camera lens aperture size increases the image depth-of-focus.
    d. The brightness of an individual pixel is linearly dependent on amount of incoming light.

3. Consider the following 3 bit gray-scale image (on the attached paper)
    a. Calculate the histogram of the image (2 points)
    b. Determine and use a global threshold value to segment the targets from the image. The targets cover approximately one quarter of the image (2 points)
    c. How many 8-connected targets there are? Draw and identify them on the image. (3 points)
    d. Stretch the histogram to cover 4 bit range (3 pts)

4. We have targets of varying colors, shapes, and sizes located on approximately 300x200 mm area. The targets are thin, flat, and not transparent. They never are on top of each other or they never touch each other. The idea is that a robot will pick targets having a certain surface area independent of their color. The background and the illumination can be chosen freely. Answer and **give reasons** for the following items:
    a. Choose a camera from the attached list so that you achieve a spatial resolution of about 0.25 mm/pix. (1 point)
    b. What kind of measurement resolution you can expect to achieve with the selected camera? (1 point)
    c. Select the imaging geometry and distance for the selected camera when we want to use a 25 mm focal length lens. (2 p)
    d. What kind of illumination you would use when you can freely choose? (2 p)
    e. What kind of machine vision tool you would use to select and to locate the targets? Shortly explain the operating principle and the main parameters of the selected tool. (2 p)
    f. What things you should consider during system (camera + robot) calibration? (2 p)

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Tehtävän 3 kuva / Image for problem 3

1	0	6	6	6	6	6	7	7	7	7	7
0	0	6	6	6	6	6	7	7	7	7	7
6	6	0	1	6	6	6	7	7	1	7	7
7	7	1	7	7	7	7	7	0	1	7	7
7	7	7	7	7	7	7	0	0	1	7	7
6	0	1	6	6	6	0	0	0	1	7	7
6	1	1	6	6	6	0	0	0	6	7	7
5	5	5	5	5	1	1	1	1	6	7	7
6	6	6	6	6	6	6	6	6	6	7	7

Muutama (mahdollisesti) hyödyllinen kaava / Some (maybe) useful equations

$$m = \frac{h''}{h} = \frac{s''}{s} \qquad \frac{1}{f} = \frac{1}{s} + \frac{1}{s''} \qquad \frac{f}{z} = \frac{r'}{r} \qquad \frac{x'}{x} = \frac{y'}{y} = \frac{r'}{r} \qquad f = h_d \frac{D}{h_{FOV}} \qquad f = w_d \frac{D}{w_{FOV}}$$

$$M_{ij} = \sum_{x=1}^{N} \sum_{y=1}^{M} x^i y^j f(x,y) \qquad X = \frac{M_{10}}{M_{00}} \qquad Y = \frac{M_{01}}{M_{00}}$$

$$z' = S(z) = \begin{cases} z_1, when\_z < a \\ z_1 + \dfrac{z_k - z_1}{b-a} * (z-a), when\_a \le z \le b \\ z_k, when\_z > b \end{cases}$$

Ihmissilmän spektrivaste /
Spectral response of human eye