EXAM COMPUTER VISION

November 6, 2007, 9:00 hrs

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During the exam you may use the book, lab manual, copies of sheets and your own notes.

Put your name on all pages which you hand in, and number them. Write the total number of pages you hand in on the first page. Write clearly and not with pencil or red pen. ***Always motivate your answers.*** *Good luck!*

Problem 1. (2.5 pt) Any binary image X consists of a number of connected foreground components. Consider an operator γ_λ which removes all connected foreground components of an input image X with an area a height ($y_{\mathsf{Max}} - y_{\mathsf{Min}} + 1$, with y_{Min} and y_{Max} the minimum and maximum y coordinates of pixels in the component) smaller than λ.

a. (0.5 pt) is γ_λ increasing?

b. (0.5 pt) is γ_λ anti-extensive?

c. (1 pt) is γ_λ an opening (in the wider sense of the word)?

Now consider operator ψ_λ which removes connected components if the ratio height/width (with width defined as $x_{\mathsf{Max}} - x_{\mathsf{Min}} + 1$, similar to height) is smaller than λ instead of the height.

d. (0.5 pt) Is ψ_λ increasing? If not give counter-example.

Problem 2. (3.5 pt) Consider photometric stereo with **three** sources of light. The directions of the light-sources are given by three vector $\vec{s}_1, \vec{s}_2, \vec{s}_3$ normalized and orthogonal with respect to eachother Fig. 1.

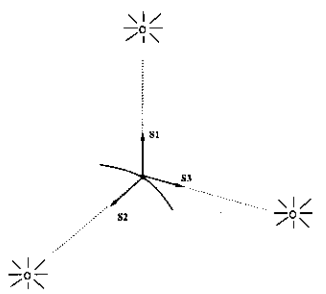

Figure 1: *Photometric stereo with three sources.*

We assume the surface is a Lambertian reflector with constant albedo $\rho_S = 1$, so that the irradiance equation is just:

$$E(x, y) = \vec{n} \cdot \vec{s},$$

with $\vec{n}$ the normal to the surface ($\|\vec{n}\| = 1$) at the illuminated point.

a. (2 pt) By taking three separate exposures E_1, E_2, E_3 in which either $\vec{s}_1$, $\vec{s}_2$ and $\vec{s}_3$ switched o, respectively we obtain three irradiance equations.
Show how to compute the normal $\vec{n}$ from this information.
Hint: the three vectors $\vec{s}_1, \vec{s}_2, \vec{s}_3$ form an orthonormal basis in the space of 3D vectors.

b. (1.5 pt) Assume only two of the light sources are used. Show that we now have two solutions for the normal $\vec{n}$, and give these solutions.

Problem 3. (3 pt) Consider a stereo pair of images from two camera as shown below with $O_L = (-10, 0, 0)$ and $O_R = (10, 0, 0)$, $f = 20$

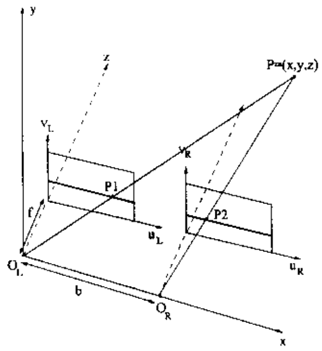

Figure 2: *Standard stereo set-up.*

a. (1 pt) Suppose two features are found at $(u_R, v_R) = (-5, 1)$ and $(u_L, v_L) = (2, -1)$, could they concern the same object? If so, what is its (x, y, z)-position, if not: why not?

b. (1 pt) Suppose a feature is detected in the left camera image at $(u_L, v_L) = (2, 1)$ and the right camera image at $(u_R, v_R) = (-2, 1)$. What is the (x, y, z)-position of the object?

c. (1pt) Describe two (general) ways to solve the correspondence problem, with advantages and disadvantages.