EXAM COMPUTER VISION, INMCV-08

October 30, 2008, 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**) Consider a parabolic surface of the form

$$z = d + ax^2 + by^2,$$

a. (1.5 pt) Assuming a homogeneous texture with texture constant ρ_0 determing the observed texture density $\Gamma(u, v)$ under parallel projection ($u = x$,$v = y$).

b. (1.pt Assuming we observe the density $\Gamma(u, v)$ you derived. Would this allow exact reconstruction of the surface. If not: what is missing and what could we do to resolve the problem.

Problem 2. (**2 pt**) Consider the use of snakes to segment a simple grey-scale image given in Fig. 1(a). The aim is to find the contour of the dividing bacterium as shown in Fig. 1(b) (i.e., it need not be split into two parts).

a. (1 pt) Which is the best initialization for an expanding snake (i.e. with a force at right angles to the snake in the outward direction). Discuss why it works in the best case, and how and why it should fail in the others.

b. (1 pt) Describe three key problems when applying snakes to image segmentation.

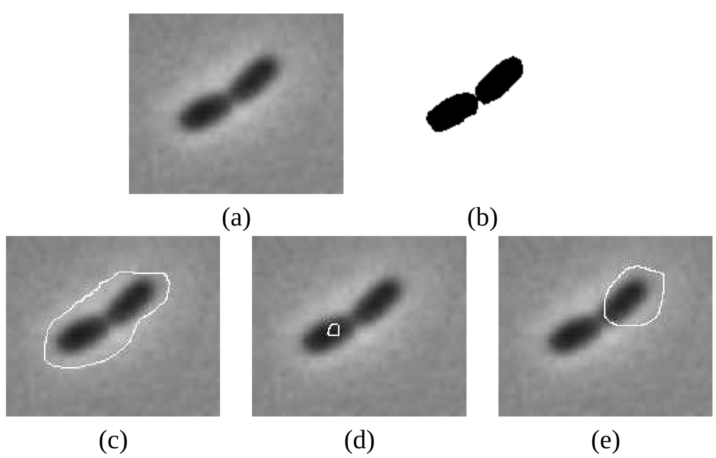

Figure 1: *Phase-contrast image of bacterium: (a) original image; (b) ideal object shape; (c), (d) and (e) initial position of snake superimposed on (a) in white.*

Problem 3. (**2 pt**) Consider a spherical surface of radius r centered at the origin with equation

$$z = d - \sqrt{r^2 - x^2 - y^2}, \qquad x^2 + y^2 \leq r$$

The surface is Lambertian with constant albedo $\rho_S = 1$, and is illuminated by a light source at a very large distance, from a direction defined by the unit vector (a, b, c), with c negative. The camera is on the negative z-axis. Show that the image intensity under orthographic projection is given by

$$E(x, y) = \frac{ax + by - c\sqrt{r^2 - x^2 - y^2}}{r}$$

Problem 4. (**2.5 pt**) Consider the following inference problem. Given a perspective projection of a cube with three sets of four parallel ribs each, with unknown orientations $\vec{w}^{(X)}$, $\vec{w}^{(Y)}$ and $\vec{w}^{(Z)}$, and three corresponding vanishing points X, Y, Z in the projection plane, see Fig. 2. Two of these points are known $(u_\infty^{(Y)}, v_\infty^{(Y)}) = (1, 2)$, $(u_\infty^{(Z)}, v_\infty^{(Z)}) = (0, -2)$. The camera constant f is unknown.

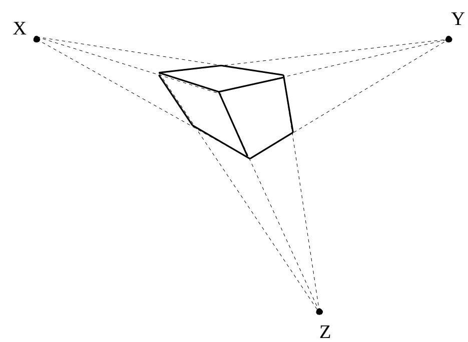

Figure 2: *Perspective projection of a cube with three vanishing points.*

Compute the three orientation vectors $\vec{w}^{(X)}$, $\vec{w}^{(Y)}$, $\vec{w}^{(Z)}$.
Hint: First compute the camera constant f.