EXAM COMPUTER VISION

January 29, 2008, 14:00-17:00 hrs

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) Let X be a binary image X and A a structuring element as in Fig. 1.

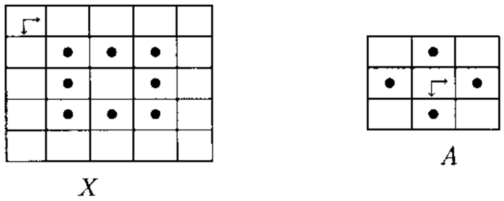

Figure 1: *Binary image X and structuring element A.*

a. (1 pt) In a similar way to Fig. 1 draw: the dilation $\delta_A(X) = X \oplus A$, the erosion $\varepsilon_A(X) = X \ominus A$, the opening $\gamma_A(X) = X \circ A$ and the closing $\phi_A(X) = X \bullet A$.

b. (0.5 pt) Furthermore, draw $\delta_A\, \varepsilon_A\, \delta_A(X)$ and $\varepsilon_A\, \delta_A\, \varepsilon_A(X)$.

c. (1 pt) Prove that for any X, A: $\delta_A\, \varepsilon_A\, \delta_A(X) = \delta_A(X)$.
Hint: Prove that $\delta_A\, \varepsilon_A\, \delta_A(X) \subseteq \delta_A(X)$ *and* that $\delta_A\, \varepsilon_A\, \delta_A(X) \supseteq \delta_A(X)$.

Problem 2. (2 pt) Consider a grey-value image f.

a. Sobel gradients in the image in horizontal (easterly) direction can be detected by linear filtering using the filter kernel (or mask) in Fig. 2 (left). Give Sobel kernels to detect gradients in northerly, north-westerly, and north-easterly direction.

b. A discrete second derivative filter in the x-direction $\frac{\partial^2}{\partial x^2}$ is defined by convolution with the kernel in Fig. 2(right). If image f is constant, the result of this filter will be zero in every pixel. Show by calculation that the result for an image $f(x,y) = ax^2 + bx + c$, is $-2a$ for each pixel with a, b, c constants.

-1	0	1
-2	0	2
-1	0	1

0	0	0
-1	2	-1
0	0	0

Figure 2: *Convolution masks for the Sobel x-gradient filter (left) and the second-order x-derivative filter (right).*

Problem 3. (2 pt) Methods to segment grey-value images into foreground and background can be divided into two categories (1) region-based and (2) edge-based.

a. (1 pt) Assign each of the following methods to the above-mentioned classes: (i) thresholding; (ii) watershed algorithm (iii) snakes.

b. (1 pt) For each method, give one or more advantages and one or more disadvantages.

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. 3. 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.

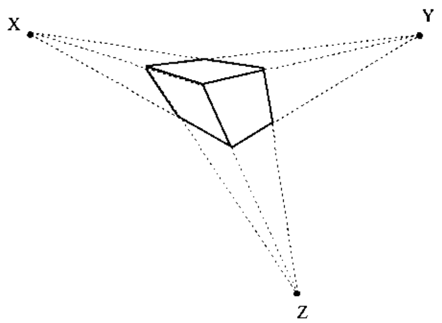

Figure 3: *Perspective projection of a cube with three vanishing points.*

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