CSE166 – Image Processing – Homework #6
Instructor: Prof. Serge Belongie
`http://www-cse.ucsd.edu/classes/fa07/cse166`
Due (in class) 11:00am Tuesday Dec. 4, 2006.

General Homework Guidelines

- Use the Cover Sheet provided.
- Please attach all code that you use. Attach code at end of submission.
- In general try to keep your answers concise. Use as many words as you need and no more. Also work on your presentation skills. This means organize your plots and displays. Always use titles and add captions when appropriate. *Points will be awarded for clarity and presentation.*

Reading

- GW Second Edition 10.2.2 and 11.4.
  or
  GW Third Edition 10.2.6 (from p733 to p738) and 11.4.
- GW Second and Third Edition Review Material Ch. 1, "A Brief Review of Matrices and Vectors."

Written exercises

1. GW Second Edition, Problem 10.13.
   or
   GW Third Edition, Problem 10.23
2. GW Second Edition, Problem 10.14.
   or
   GW Third Edition, Problem 10.22
3. GW Second Edition, Problem 11.17.
   or
   GW Third Edition, Problem 11.20
4. GW Second Edition, Problem 11.18.
   or
   GW Third Edition, Problem 11.21
5. Consider the 2×2 matrix

$$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}.$$

   Show that the inverse is given by

$$A^{-1} = \frac{1}{\det(A)} \begin{bmatrix} d & -b \\ -c & a \end{bmatrix}.$$

Matlab exercises

1. Hough Transform.

   (a) Implement the Hough Transform (HT) using the (ρ, θ) parameterization as described in GW Second Edition Section 10.2.2. or GW Third Edition p. 733-738. Use accumulator cells with a resolution of $1°$ in θ and 1 pixel in ρ.

(b) Produce a simple 11×11 test image made up of zeros with 5 ones in it, arranged like the 5 points in GW Second Edition Figure 10.20(a) or GW Third Edition Figure 10.33(a). Compute and display its HT; the result should look like GW Second Edition Figure 10.20(b) or GW Third Edition Figure 10.33(b). Now threshold the HT to find the (ρ, θ)-coordinates of cells with more than 2 votes and plot the corresponding lines in (x, y)-space on top of the original image.

(c) Load in the matchstick image in GW Second Edition Figure 8.02(a) and shrink it to half its size using `I=imresize(I,0.5,'bil');`. Compute and display its edges using the Sobel operator with default threshold settings, i.e., `BW=edge(I,'sobel');`. Now compute and display the HT of `BW`. As before, threshold the HT and plot the corresponding lines atop the original image; this time, use a threshold of 50% of the maximum accumulator count over the entire HT.

(d) Repeat the previous step for another image of your choice. The image can be from the textbook or elsewhere, but its size must be at least 128×128 and it should contain several extended straight lines.

Things to turn in:

- Code listing for part 1a.
- Code listing for generating results in parts 1b, 1c, and 1d.
- Printouts of program output for parts 1b, 1c, and 1d.

2. Interest Point Detection.

(a) Compute the eigenvalues $(\lambda_{max}, \lambda_{min})$ of the Förstner interest operator for the checkerboard image in the figure for GW Second Edition Problem 10.18(right). Use a window size of 3×3. On top of the original checkerboard image, plot the coordinates (use the `'.'` pointmarker) of all pixels for which $\lambda_{min} > \tau$, with τ set to 80% of the maximum value of λ_{min} over the whole image. The resulting coordinates should fall on or near the corners of the squares in the image.

(b) Repeat the above steps for the fingerprint image in GW Second Edition Figure 10.29(a) or GW Third Edition Figure 10.38(a); this time set τ to 20% of the maximum value of λ_{min} over the whole image. The resulting coordinates should fall on or near the minutia points of the fingerprint, but due to noise, there will also be many spurious responses. As a final step, compute ϕ, the angle of the principal eigenvector for each pixel, and display it as an image.

Things to turn in:

- Code listing and plots for each step.