CSE190 – Image Processing – Homework #5
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`http://www-cse.ucsd.edu/~sjb/classes/wi02/cse190`
Due (in class) 1:25pm Wed. Feb. 20, 2002.

Written exercises

1. GW, Problem 8.1.
2. GW, Problem 8.12.
3. GW, Problem 8.14.
4. Consider the symmetric 2×2 matrix

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

By finding the roots of the characteristic equation,

$$\det(\lambda I - A) = 0,$$

show that the eigenvalues of A are given by

$$\lambda = \frac{\mathrm{tr}(A) \pm \sqrt{\mathrm{tr}(A)^2 - 4\det(A)}}{2}$$

Matlab exercises

1. Binary image processing.

   Before doing this problem, study the `bwmorph`, `bwlabel`, and `imfeature` functions in Matlab.

   (a) Reproduce GW Figure 9.5(a,b).
   (b) Reproduce GW Figure 9.14(a,b).
   (c) Perform connected components labelling on the particles image for GW Problem 9.27. Based on the area of each connected component, produce a new image containing only the isolated (nonoverlapping) particles.

   Things to turn in:

   - Printouts of output and code listings for steps 1a, 1b, and 1c.

2. Shape and the scatter matrix.

   This problem makes use of the result in written exercise 4 above and the additional fact that the angle of the principal eigenvector of A is given by

$$\phi = \frac{1}{2}\tan^{-1}\left(\frac{2b}{a-c}\right)$$

   The angle of the other eigenvector is $\phi + \pi/2$. Note: in Matlab, use `atan2` to compute the inverse tangent.

   (a) Load in GW Figure 11.10 and extract its boundary. (Note: due to JPEG artifacts, the image is not exactly binary, so you'll need to threshold it at a value slightly larger than zero.) Use `find` to obtain the (x, y) coordinates of the boundary pixels. Plot these coordinates using the `axis('image')` and `axis('ij')` options.

(b) Compute the centroid **m** and add it to the preceding plot using the `'x'` pointmarker.

(c) Compute and display the scatter matrix C. Find its eigenvalues and eigenvectors, first using the above shortcuts, then using the Matlab function `eig`, and demonstrate that both methods give you the same result.

(d) Compute the aspect ratio of this shape using the formula $(\lambda_{max}/\lambda_{min})^{1/2}$.

(e) By visual inspection, estimate the rotation of the shape with respect to horizontal. Compare this to the estimate of the rotation provided by ϕ. Now derotate the boundary coordinates so that the shape is oriented along the x-axis, and make a plot of the result.

Things to turn in:

- Code listing for all steps.
- Plot for steps 2a and 2b.
- Program output for steps 2c and 2d.
- Written comments and plot for step 2e.