Yale University
Department of Computer Science

CS475/CS575/EE475: Computational Vision and Biological Perception

Problem Set #1

Due on Wednesday, Feb. 13, 2008.

General Instructions

In this assignment you will use MATLAB to explore ideas from class. Please read "Pavel's Notes on Matlab" before beginning. Please submit figures in support of your answers and keep your explanations brief.

Scripts can be downloaded from `http://zoo.cs.yale.edu/classes/cs475/resource/`.

1 Image manipulation: image as a matrix

(a) Create a new directory and download the image Paolina.tiff.[1] Open the image with `imread` and convert it to a matrix with double precision numbers. Display the image with `imshow` in Figure 1 and with `imagesc` in Figure 2.

(b) Plot the image level sets in Figure 2. You may need to adjust the axes by typing `axis ij`. This is the image coordinate axis in which the y axis decreases from top to bottom, opposite to the default direction `axis xy`.

(c) Compute the image gradient magnitudes at each image location as the matrix `gmag`. The magnitude of a vector v is given by the formula

$$|v| = \sqrt{v_x^2 + v_y^2}.$$

Display `gmag` in color code.

(d) Display the gradient vector field for the image in Figure 2. Display the unit length vector field of gradient directions in Figure 3.

(e) Compute the image g as defined below where f denotes the original image modified by adding a factor of its gradient magnitude.

$$g(x, y) = f(x, y) + \beta \left|\nabla f(x, y)\right|, \text{for} \quad \beta = 1, 10, 100$$

Display the results in Figure 4.

(f) Comment briefly on each of the figures that you obtained.

[1] Go to http://zoo.cs.yale.edu/classes/cs475/image.html

2 A. coli

(a) Download `acoli_path.m` and `acoli_hist.m` to your working directory. Use `help acoli_path` to find out how to invoke it. Use `acoli_hist` to display histograms (use `axis xy`) with 10, 20 or 100 bins along each axis.

(b) Food detector. Assume that the food function does not change with time. Is it possible to choose parameters for A. coli so that the food function can be obtained from the observed behavior? Obtain the two different food functions using your method and compare them to the ones returned by `acoli_hist`. EXTRA: What is the best combination of parameters? Why is it the best?

3 Artificial Neurons

Download the files `nsimulator.m` and `hw1p03sample1.m` to your MATLAB directory. The simulator documentation is available in the usual way – `help nsimulator` – and the script `hw1p03sample1` contains an example of what you can do with the simulator. I suggest that you run the sample script first and then modify it as needed.

(a) Create a simulator with a single neuron. Run the simulation for 0.1 s while injecting a current of 0 nA. Repeat the simulation for 1 nA and 10 nA. What do you see? Repeat for each of the three settings for several initial membrane potential values; e.g., -60mV, -80mV, 0mV. How do the injection current and the initial membrane potential influence the behavior of the neuron?

(b) Create a simulator for two neurons. Inject 2.5 nA of current into Neuron 1 and 0 nA into Neuron 2. Make Neuron 1 inhibit Neuron 2. Simulate for 0.1 s. Repeat the simulation for different values of injected current into Neuron 2: 1.0 nA, 10 nA. Compare the behavior of Neuron 2 to the behavior of the neuron in the previous part (single neuron simulator). Repeat the experiment for an excitatory connection. What can you say about the effect of Neuron 1 on Neuron 2?

Hint: You may find it useful to initialize the membrane potential to the same value – e.g., -60mV – in all simulations.

(c) Create a simulator for two neurons. Inject 2.5 nA into each one and initialize the membrane potential to -60mV for each one. Connect the two neurons so each excites the other. Can you obtain the behavior shown in Fig. 5.20 A (p. 188) from Chapter 5 of "Theoretical Neuroscience" ? Repeat the experiment by initializing each neuron to different membrane potentials. Do you observe a phase shift? Repeat for inhibitory connections. Do the neurons synchronize?