Due Date Oct 19. Fall 2017. Homework 2

Prof. Alan Yuille

October 5, 2017

Due on Oct 19 . Submit pdf file on Blackboard by 11:59:59 PM on the due date. Format file name as *firstname*-*lastname*-hw2.pdf. Do not include the iPython notebook code in the pdf submission as it is not required. If you have any questions about the homework, email TA Donald Li: sli97@jhu.edu

Question 1. Fourier Basis and Sparse Coding (15 points)

1. Recall that Fourier theory represents an image by a linear combination of basis functions, namely sinusoids, where the coefficients of the basis functions can be obtained by the Fourier inverse transform. Write down the formulas for the Fourier transform and inverse Fourier transform. (4 points) To generalize, if we have a new set of orthonormal basis, and we would like to use this set of basis to represent the image, how do we calculate the coefficient of the image in the new basis? (2 points)

2. Use three to four sentences to explain what is sparse coding? (3 points) The sparsity penalty encourages many of the coefficients of basis functions to be

zero. How does the degree of sparsity depend on the parameter λ which penalizes the sum of the magnitude of the coefficients. (2 point) Motivate this by studying the one-dimensional case with the function $f(x; a) = (x - a)^2 + \lambda|x|$ and the rule $\hat{x} = \arg\min f(x; a)$. Show that, for some values of a, the answer is sparse (i.e. $\hat{x} = 0$). (4 points)

Question 2. Hebbian Learning and Binocular Stereo (15 points)

1. Is Hebbian learning a kind of supervised learning? Why or why not? (2 points) In the Hebbian learning equation, there is a term to decrease the value of all weight by the amount proportional to their strength, what is the purpose of this term, and if there is no such term in the equation, what will be the problem? (3 points)

2. Observe the stereokinetic effect and the Ames Windows illusion, write two to three sentences to explain each . (4 points)
   Stereokinetic effect
   `http://www.michaelbach.de/ot/mot-ske/index.html`
   Ames Windows illusion:
   `http://www.michaelbach.de/ot/sze-AmesBallerina/index.html`

3. Using the stereo disparity model, is it possible for a single cell to detect disarity by itself when $\rho_l - \rho_r = \omega D$? (2 points) Briefly describe how a neural network estiamte disparity. (4 points)

Question 3. Experimental Section: Sparse Coding (20 points) This consists the project as described in this IPython notebook:
`http://nbviewer.jupyter.org/github/shipui2005/ProbHW2/blob/master/HW2Intro.`

`ipynb`

Project: Learn a Sparse Code for Natural Images. Use an unsupervised sparse coding technique to learn receptive fields from naturally occurring image statistics.

The Sparse Coding project encourages people to team up in groups of up to three people with at least person being technically proficient, and teams should have a mix of engineering and non-engineering students as much as possible. The code for this project is unstable on Windows, so it is best that each team uses OS X or Linux.