Probabilistic Models of the Visual Cortex

Fall 2019 Homework 1

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September 16, 2019

Due on Oct 1 before the class. Late homework will not be accepted unless permission is obtained well in advance in documented extenuating circumstances. Please start early on the coding part and make sure the software (i.e. the jupyter notebook) works for you. If you have any questions about the homework, email TA Hongru Zhu: hzhu38@jhu.edu.

Question 1. NI and AI vision (14 points)

Please give brief and clear answers to the questions below.

1. Vision is extremely hard due to complexity and ambiguity. Name three complexities (3 points) and two ambiguities of vision (2 points).

2. Understanding of NI vision can help with AI vision problems. Give three perceptual phenomena known to NI that could help AI (3 points) and another two which are unlikely to help AI (2 points).

3. The visual ventral stream is known for most of object recognition as well as

other aspects of visual processing. Name three types of theory for the object recognition in the ventral stream (3 points) and 1 metaphor for it (1 points).

Question 2. Visual Illusions (12 points)

Visual illusions teach us about the assumptions that the brain makes when interpreting images. These assumptions are often correct but occasionally wrong, as shown by the illusions. Write a few (two or three) sentences explaining each of the illusions below. Which ones of them involve low-, mid-, or high-level vision? Note that all these illusions are discussed in the Early Vision chapter by Yuille and Kersten. (each worth 2 points)

1. Neon color spreading `http://www.michaelbach.de/ot/col-neon/index.html`

2. Motion binding `http://www.michaelbach.de/ot/mot-motionBinding/index.html`

3. Hollow face illusion `http://www.michaelbach.de/ot/fcs_hollow-face/index.html`

4. Dalmatian dog `http://www.michaelbach.de/ot/cog_dalmatian/index.html`

5. Ball in box `http://youtu.be/hdFCJepvJXU`

6. Checker-shadow illusion `http://www.michaelbach.de/ot/lum-adelsonCheckShadow/index.html`

Question 3. Linear Filters (12 points)

1. In the class, we discussed about the model of simple and complex cells, briefly describe the difference between them. (i.e. input, type of information that are sensitive to, etc) (4 points) Are complex cells considered to be a linear filter of its input, and why or why not? (2 points)

2. What kind of information does a first derivative of Gaussian filter capture from an image? (1 point) How about the second order derivative of the Gaussian filter? (1 point) What is a quadrature pair, and how it is linked to the second order derivative of the Gaussian filter? (2 points) Suppose you would like to smooth the image after applying a first derivative of Gaussian filter by a Gaussian filter, does the order of applying filters matter (i.e. chage the order of applying the Gaussian and the derivative of Gaussian filter), and why or why not? (2 points)

Question 4. Experimental Section: Filtering sinusoid input (16 points)

This question is to probe receptive field models of neurons, such as Gabor functions and Laplacian of a Guassian, using sinusoid input. Full description is given at the webpage below.

`http://nbviewer.jupyter.org/github/ccvl/VisualCortexCourse/blob/master/`
`HW1/HW1Intro.ipynb`