Technical University of Denmark

Final written exam - 02458 Cognitive Modeling – 2017

14 December 2017

Instructions
All aids are allowed

The duration of the exam is four hours

All problems weigh equally in the score

Make sure you answer the questions fully. Explain how you arrived at your answer.

Problem ROC

One observer performs a signal detection task five times. Every time the reward for a hit (true positive) and the penalty for a false alarm is varied. The table below lists the number of hits and false alarms out of 50 trials.

Experiment	1	2	3	4	5
Number of hits	49	44	34	21	11
Number of false alarms	37	33	13	7	1

Fit the Receiver Operating Characteristics to the data.

- Plot the fitted curve and the data points in the same axis.
- What are the parameters of the model?
- Is it likely that the equal variance signal detection model can describe the observer's performance?

Problem PCA

When we apply PCA to image patches the principal components resemble the receptive fields of the early visual system. The number of principal components necessary reflects the complexity of the visual internal representation.

- Split the image in the file astro.mat/csv that come with this assignment into image patches of 10-by-10 pixels and perform PCA on the patches.
- How many principal components are needed to explain 99% of the variance? Is this what you would expect? Explain how you arrived at the answer.
- Transform the first six principal components back to image space and show them as image patches on a single gray-scale. Do they look like what you would expect? Explain your answer.

Problem Psychometric Function

An observer responds according to a psychometric function shaped like a cumulative Gaussian probability function in a signal detection task. The table lists the number of yes-responses out of 50 trials for five stimulus levels given in arbitrary units.

Stimulus level	0.4	0.9	1.2	1.7	2.3
Number of yes Responses	1	6	13	32	49

Fit the psychometric function to the data using a squared error function.

- What are the estimates of the parameters of the psychometric function?
- In a follow-up experiment we use only intensity levels 1 and 2. The task of the observer is to say whether the intensity level is 'high' or 'low'. What value do we expect for the sensitivity (d')?

Problem Bayes

An observer performs according to the equal variance signal detection model with a sensitivity of $d' = 1$. The observer operates with an assumption (prior probability) that there is a chance of 0.5 that a signal will appear on any given trial. The observer also operates according to the maximum a posteriori (MAP) decision rule.

- What is the probability that the observer will make a false alarm? Explain your reasoning.
- The observer now operates with an assumption (prior probability) that there is a chance of 0.3 that a signal will appear on any given trial. What is the probability that the observer will make a false alarm? Explain your reasoning. (Hints: Use the previous result. You do not have to calculate the criterion)