Technical University of Denmark

Final written exam - 02458 Cognitive Modeling – 2019

12 December 2019

Instructions

Note that the exam questions are NOT weighed equally. The percentage written in the title for each exam question indicates its influence on the final grade.

Upload your answers as one single PDF file. You may submit code in appendix.

All aids are allowed

The duration of the exam is four hours

Problem 1: The strong fusion model (25 %)

An observer performs a task of pointing towards the location (azimuthal angle) of a brief sound burst. The sound burst is presented simultaneously with a flash of light in order to induce the ventriloquist effect. The sound is presented at three different locations. At each location the sound is presented 100 times and the azimuthal angle that the observer points to is recorded. The location of the flash of light is held constant. The recorded azimuthal angles are found in the file xAV.txt where there is one column for each of the three locations and 100 rows corresponding to the observer's responses. The observer also performs the task of pointing towards the location of the flash of light when there is no sound. The recorded azimuthal angles for this task are found in file xV.txt.

Based on the observations we are interested in how the observers ability to localize the sound when there is no visual stimulus. Estimate the distribution of the observer's responses for the three sound locations when there is no visual stimulus. You can assume that the observer behaves according to the strong fusion model, that the observer's responses are normally distributed and that the observer does not lapse (zone out). Explain your approach.

Problem 2: Signal Detection Theory (15 %)

An observer is performing a signal detection task with three response options: "yes", "no" and "maybe". The response counts are listed in the table below.

	Answer: Yes	Answer: No	Answer: Maybe
Stimulus: No signal	29	15	6
Stimulus: Signal	19	27	4

Fit an unequal variance signal detection model to the data. What are the values of the free parameters of the model? Describe your approach.

Problem 3: Signal Detection Theory and Psychophysics (10 %)

An observer performs a visual signal detection task in which the signal intensity is 5 cd/m^2. The observer's sensitivity, d', is 1.1. What does that tell us about the psychometric function? Explain your reasoning.

Problem 4: Faces and PCA (40 % + 10 % for bonus question)

The attached archive (faces.zip) contains 400 pictures of faces, aligned so that they all have the eyes at the same positions. All the pictures have resolution 260x360.

The attached text file (smile_intensity.txt) contains simulated scores for how smiling the faces are ("smile intensity"), where the values around 0 are the "not smiling" class, and the values around 1 are the "smiling" class.

Note: the text file can be loaded in Matlab with the command:

```
a = readtable("smile_intensity.txt");
```

Please answer the following questions. Your answer should also contain the code that you wrote to obtain the result.

1. Load the images, convert each of them to greyscale and represent the set of all images as a matrix of 400 rows (one per image) and 93600 columns (one per pixel). Run PCA on this matrix and draw the first 6 components as images, indicating the percentage of the total variance that each of them represents.
2. Identify the minimum value n such that the first n Principal Components model at least 90% of the total variance in the dataset.
3. Build a linear regression model that predicts the smile intensity as a function of the PCA scores for the first 20 components. List the coefficients for each of the 20 predictors.
4. **Bonus question**: feature selection. Run stepwise feature selection (e.g., using the `sequentialfs` Matlab function) to identify which of the components identified in point 2. are best at modelling the smile intensity variable. Include a 10-fold cross validation step in the process. Which features are selected? Explain your approach.
5. Consider the linear regression model from point 3. (or from 4, If you answered the bonus question). Use the model to generate new faces that have smile intensity values equal to the values: -0.5, 0, 0.5, 1, 1.5 and draw them as images.