This is the final written exam in 02458 Cognitive Modelling

There are four assignments in the exam. Each problem counts towards your total score by a number of points, which is indicated in the headline for the problem.

You may use your notes, all course material, the code you have used to solve the excercises during the course. You may use any textbooks or articles.

You may access the internet but you may not communicate with anyone in any way during the exam.

The exam starts at 9 am and ends at 1 pm.

The exam problems consists of two pages in addition to this cover pages.

You can submit your answers as a pdf file and your code as appendix.

1. Psychophysics - Weber's law (20 points)

Researchers have conducted a sound intensity change detection experiment in which they measure the difference threhold (Just Noticeable Difference) as a function of the baseline sound intensity. Their results are listed in the table below.

Sound intensity (dB)	2	5	10	14	19	23	34	45	55	70	85	98
Difference threshold (dB)	2.20	3.10	3.90	2.94	3.45	3.45	4.76	5.85	7.70	9.80	11.90	13.72

Fit Weber's original law to the data. Plot the data and the model estimates in the same graph. Evaluate the fit by visual inspection (look at the graph and describe whether you think it is a good fit)

Can you find a range of sound intensities where you get a better fit than the fit to the entire range of sound intensities? Describe your reasoning.

Fit Weber's law corrected for the effect of the absolute threshold to the data. Plot the data and the model estimates in the same graph. Evaluate the fit by visual inspection (look at the graph and describe whether you think it is a better fit).

2. Bayesian observer (20 points)

In the following experiment on speech perception observers classify speech sounds as "ba", "da" or "ga".

In Experiment 1 we can assume that the observer uses a uniformative (flat) prior. The distribution of responses for the /ba/ sound is listed in the table below

Response	Ba	Da	Ga
Response percentage	82	8	10

In Experiment 2 the same speech sounds are presented but in this experiment the observer's prior assumption is that the speech sound /ba/ is presented in 50% of all trials while the remaining contain the speech sounds /da/ and /ga/ in equal proportion.

What do you expect the response distribution to be for the /ba/ sound in Experiment 2? Explain you reasoning using probability theory starting with Bayes' rule.

3. Linear regression and PCA for face perception (35 points)

Fagertun, Andersen and Paulsen (2012) conducted a study of a gender classification task presenting the observers with 298 frontal face photos. From the responses and reaction times, they calculated a perceived gender strength index (GSI) for each image. The range of the GSI is [-1;1] where -1 corresponds to the maximally male GSI, 1 corresponds to the maximally female GSI and 0 corresponds to a gender-neutral face.

The attached archive contains a file with the 298 images as a 298-by-2500 matrix. The first 149 images are of male faces. The remaining images are of female faces. The 2500 columns

of the matrix contains the greyscale pixel values of the 50-by-50 pixel images. The first 50 elements of each column correspond to the first column of pixels in the image and so forth. The attached archive also contains a file with the GSI for each image.

Load the images and perform PCA after subtracting the mean on the image matrix. How much of the variance in the images is contained in the first 15 components?

Reconstruct the images in columns 3, 76 and 262 using the first 15 principal components. Display the three reconstructed images and the three original images. By looking at the images estimate whether it is possible to identify the gender of the faces from the original and reconstructed images.

Build a linear regression model that predicts the GSI as a function of the PCA scores for the first 15 components. List the coefficients for each of the 15 predictors and the intercept.

Use the model to generate new faces that have GSI equal to the values:
-1, -0.5, 0, 0.5, 1 and plot them as images. Look at the images and describe the most prominent changes that occur with varying GSI.

4. Signal Detection Theory and Psychophysics (25 points)

The GSI is likely to correlate with how confident observers are in the perceptual discrimination of gender. For images with values close to -1, the observer is likely be very confident that the image is of a male face. Images with values close to 1 indicate that the observer is very confident that the image is of a female face.

Re-bin the GSI data into four intervals divided by boundaries at -0.5, 0, 0.5. Fit an unequal variance signal detection model to the re-binned data. Describe how you do this in detail. List the parameter values. Plot the ROC curve. Does the parameter values support an equal or an unequal variance model?

Calculate the variance of the GSI values for male faces and for and female faces. Does this result support an equal or an unequal variance model?

Compare the two approaches you have used to distinguish between the equal and unqual variance models. The two approaches do not point to the same conclusion. Why could that be?

Reference

Fagertun, J., Andersen, T., & Paulsen, R. R. (2012). Gender Recognition Using Cognitive Modeling. In *Lecture Notes in Computer Science*. *Computer Vision – ECCV 2012* (pp. 300–308). Springer.