Cognitive Modelling

Homework 2 – Modelling of face perception

For this homework, you will run a simple experiment in groups, collect and analyze data, and build a model.
This homework is inspired by the papers:

1. Fagertun, Jens, Tobias Andersen, and Rasmus Reinhold Paulsen. "Gender recognition using cognitive modeling." European Conference on Computer Vision. Springer, Berlin, Heidelberg, 2012
2. Jens Fagertun, Tobias Andersen, Thomas F. Hansen, Rasmus R. Paulsen:3D gender recognition using cognitive modeling. IWBF 2013: 1-4

You can find the papers on DTU Findit.

Some of the methods are described in the Introduction to Machine Learning book by Herlau, Schmidt and Mørup, which you can find here: https://gitlab.compute.dtu.dk/tuhe/books

The experiments in brief

During the first experiment, the participant looks at a sequence of photos of faces, and for each they must rate them on a scale that will be chosen (e.g., is the face smiling?). Several participants look at the same faces, and their ratings is the dependent variable in a linear model where the images themselves (or rather, their Principal Components' scores) are the predictors.

The purpose of the second experiment is to validate the linear model that you developed from the data in the first experiment. You will use the linear model to create a synthetic continuum of faces and present these synthetic images to (preferably naive) observers, who will rate the synthetic images (e.g., how much is this face smiling) on a scale from 1-7.

The homework step-by-step

Below you have a guide of what needs to be done to complete this project. **Note that there are questions in bold in the guide. Your report should consist of the answers to these questions and nothing else.** In addition to the report, you should submit your code and data (the images you used and the behavioral data).

Setup of the experiment

1. Choose a face database to use as stimuli.
    a. If your group consists of two people you can use the AR data set that you can find on DTU Learn with the exercise. You may also choose one of the options for groups with three members (see below).
    b. If your group consists of three people you must download images of one of the databases below. You must choose the facial feature to model. It can be angry, smiling or gender.
        i. https://susanqq.github.f io/UTKFace/ ("Aligned&Cropped" version)
        ii. https://kdef.se/index.html (requires registration)

iii. https://fei.edu.br/~cet/facedatabase.html (“Frontal Images” version)

2. Select the images that you want to use. Choose a subset of the stimuli in the dataset, at least 200 of them. For this part, you will have to manually review the files and/or use the tags set by the creators of the database (normally contained in the filenames). Ideally you want images that look similar (exclude those that have very different face position, lighting conditions, age, …) and have a roughly comparable number of stimuli in each of the categories for the feature of interest that you chose, with a variety of “intensity” levels. Place the chosen images in a folder on the computer where you will run the experiment.
    a. **Questions: What is the feature of interest? Describe in detail how you selected the images based on the feature of interest and on features of no interest.**
3. Run the experiment
    a. Write a program that presents images, accept ratings from an observer. Importantly, the program must save the ratings and information relating the rating to the rated image.
    b. Collect some data. Your group members are your test persons. Start the stimulus presentation script and let the test person rate all the stimuli. You should collect data from each member of your group. You may collect data from more people.
4. Data pre-processing
    a. Load the data in your analysis environment of choice (Matlab, Python, …)
    b. Normalise the ratings for each person and then pool them into one data set.
    c. **Question: Explain every step of the conversion of the raw data to the normalised pooled data. Verify that normalisation worked by plotting histograms of ratings for each test person.**
5. PCA and feature selection
    a. Subtract the mean image from all the images. Do *not* standardise (divide by the standard deviation).
    b. Run PCA on the images. The scores (i.e., the representation of the images in PCA space) will be the predictors in the model.
    c. Visually inspect the first few PCA components as images. Do this by adding/subtracting the scaled PC that you want to inspect to the mean.
    d. **Question: Provide a figure of the scaled PCs added to the mean. What do the PCs represent? How much variance do they encode?**
6. Select a subset of relevant PCs. Their scores will be the predictors in your model.
    a. Use forward selection to select the relevant PCs. You can use a routine like Matlab’s sequentialfs or you can setup a homemade stepwise selection with cross validation. **Question: Explain how your feature selection method works (your own or a routine from a toolbox).**
7. Linear model
    a. Build a linear regression model that predicts the ratings based on the PCA scores.
8. Generate samples from the model.
    a. Use your model to generate synthetic face pictures with a given index. You should generate 5 synthetic images that spans the index range in your data set. You should also generate synthetic images that extends the index range in your data set (one image in each end of the range).
    b. **Question: Explain in detail how you fit the model and how you use it to generate synthetic faces. Show the continuum as images.**
    c. **Question: Explain in detail how you created these continua and show them.**
9. Set up a second experiment. This experiment is a rating task in which the participants rate the synthetic images according the dependent variable that you have modeled (gender, smile,...).

Use the seven-step synthetic continua that you have generated as stimuli. Present each image at least 10 times. Present the images in random order. Use at least two naive participants (friends, students in another group) for this experiment. **Question: Analyse your results using ROC curves: Choose a baseline stimulus and fit/plot ROC curves for all the other stimuli with respect to the baseline stimulus. Do the ROC curves appear like you would expect? Explain your reasoning. Analyse your results using psychometric functions: fit/plot psychometric functions for each response criterion. Do the psychometric functions appear like you would expect? Explain your reasoning.**