

# Homework: Canonical Correlation Analysis

High Dimensional Data Analysis 2021

28 Oct 2021

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Canonical Correlation Analysis (CCA) is a multivariate data analysis method that aims at finding correlations between two multivariate data sets,  $X$  and  $Y$ . The method looks for the linear combination of the  $X$ -variables and the linear combination of the  $Y$ -variables that show maximal correlation. When the number of variables in  $X$  and/or  $Y$  is very large (high-dimensional), the classical CCA method needs to be adapted to deal with the high dimensionality.

The aim of this homework assignment is:

- to understand the classical CCA method (based on the literature) and a CCA method for high-dimensional data
- to implement the CCA method and its high-dimensional version (not using existing R packages or R functions for CCA)
- apply the method to a dataset

You may consult the literature to find a description of the CCA method. Here I give one possible reference (it is a paper about an R package, but remember that you may not use this R package for the implementation):

González, I., Déjean, S., Martin, P. G., & Baccini, A. (2008). CCA: An R package to extend canonical correlation analysis. *Journal of Statistical Software*, 23(12), 1-14. <http://dx.doi.org/10.18637/jss.v023.i12>

The paper also describes a *regularised CCA* method (section 2.4), which is applicable to high-dimensional data. However, there are other high-dimensional CCA methods described in the literature. You are free to choose the regularised CCA from the paper, or any other appropriate high-dimensional CCA method.

Note that in the paper a cross-validation method is proposed for selecting e.g. the tuning parameters in the regularised CCA. **You are not required to implement this.** If tuning parameters are involved, you may set them manually to an arbitrary value (or play with it when analysing the dataset and set it to a value that seems appropriate to you – no need to motivate your choice).

You must apply your implemented method to the **nutrimouse** data, which is part of the *CCA* R package. More information about the data can be found in the paper. You must only look at the first two dimensions of the CCA, which will allow you to make two-dimensional graphs.

The dataset can be accessed in R as follows:

```
# Check if CCA package is installed and install it if it's not
if (!requireNamespace("CCA", quietly = TRUE)) {
  install.packages("CCA")
}

library(CCA)
data("nutrimouse")
```

```
X <- nutrimouse$gene # the gene expression matrix
dim(X)
#> [1] 40 120
Y <- nutrimouse$lipid # the lipids matrix
dim(Y)
#> [1] 40 21
```

The assignment should be done **alone** or in **groups of 2**.

You should write a report containing the following:

- A short (mathematical) description of the CCA methods (classical and high-dimensional) that you have implemented
- The application of your method to the *nutrimouse* data
  - Classical CCA on multivariate data with  $p < n$ . (*Hint: it will not be possible to apply the classical CCA method to the full data matrix  $X$ . You should subset the data to reflect the case of  $p < n$ .*)
  - High-dimensional CCA on data with  $p > n$
- Interpretation and conclusion of the data analysis results

The length of the written report (excluding R code, R output and graphs) should be about 2 pages.

It is recommended (but not mandatory) to prepare your report in **RMarkdown**. You can render it to either HTML (output: `html_document`) or to PDF (output: `pdf_document`). In both cases the original `.Rmd` file should be included when handing in the assignment. If you don't use RMarkdown, you should include the `.R` file(s) containing your implementation and analysis scripts.

When submitting, please use the following format:

- Report: HW-Name1-Name2. [pdf|html]
- Source code: HW-Name1-Name2.Rmd (or HW1-Name1-Name2.R)

Submissions should be done **through UFora** under the “Assignments” tab (UFora-tools --> Assignments).

**The deadline for submission is November 12th at 23:59.**