



HOMEWORK III: MODELS FOR CLASSIFICATION

This exercise set relates to classification methods (logistic regression, linear and quadratic discriminant analysis, neural networks, k-nearest neighbors and support vector machines) applied to a set of data containing a number of observations for predictors and outcome.

Choose either Alternative 1 or Alternative 2, below. Regardless of your choice, your submission must comply with the guidelines at the end of this document.

ALTERNATIVE 1

You are given a set of data¹ consisting of $N = 8708$ observations related to grant applications made between the years 2005 and 2008. For each observation of grant application, there are $D = 1882$ predictor variables. Given the extremely correlated predictors, the D variables have been filtered and only the **reducedSet** of predictors ($D_{\text{reducedSet}} = 252$) must be used for classification². The class outcome, **successful** and **unsuccessful**, is contained in the column **Class**.

The observations for the predictors and the class are split between training and test sets and given in the **training** ($N_{\text{tr}}=8190$) and **testing** ($N_{\text{ts}}=518$) sets of data.

You must

1. Use the predictors in the training set to learn a linear classification model and test the model using the test set. For the task, you must select either a logistic classification or a linear discriminant analysis method. How many predictors would you use to fit the model? After training the model, compute the confusion matrix and overall fraction of correct predictions. Explain what the confusion matrix is telling you about the types of misclassifications made by the method.
2. Use the predictors in the training set to learn a nonlinear classification model and test the model using the test set. For the task, you must select at least two methods among the following: quadratic discriminant analysis, neural networks, k-nearest neighbours and support vector machines. Depending on your selection of method, tune the model in a convenient way (if needed use cross-validation). After training the model, compute

¹The data can be i) found attached to the homework assignment, or ii) downloaded from the Kaggle web site (<http://www.kaggle.com/c/unimelb>) and reproduced in R using the script ('CreateGrantData.R') given in the package: **AppliedPredictiveModeling**.

²For a complete explanation of the predictor groups refer to the book M. Kuhn and K. Johnson, **Applied predictive modeling**, Springer (2014).

the confusion matrix and overall fraction of correct predictions. Explain the confusion matrix and the types of misclassifications made by the method.

3. Compare the results obtained using the linear and nonlinear classification methods. Does the nonlinear structure improve the classification performance?

ALTERNATIVE 2

Assuming that you have at your disposal a set of data of your own interest (for examples, those used in HW1 and/or HW2), the dataset consists of a certain number of observations, each observation consists of a certain number of predictors and an outcome that you wish to classify, you might prefer to investigate the characteristics of your own data.

In this case, you must first describe your dataset and, if needed, you must pre-process it, or properly refer to the previous HWs. You must describe the data and provide their features in terms of number of observations, number of predictor variables and outcome). Then, you must split the set of data into training and test set and perform the steps defined in Alternative 1.

GUIDELINES

Regardless of your choice (Alternative 1 or 2), you must generate the following:

- Article: You must generate a report in the format of a conference paper following the template adapted from the IEEE conference proceedings³ that is attached to the homework assignment. The paper should not be longer than 6 pages and must include the following:
 - Title: Here, you summarise your paper in one sentence. [Spend time on it and try some alternatives⁴. As part of the preparation, this will help both you to write a clear abstract and the reader to grasp the content of the work.]
 - Abstract: Here, you introduce the main objective and overview of the work [Provide a short and informative view of the work, its scope and results].
 - Introduction: Here, you provide some context and background [Briefly, explore the literature in order to define classification and the models that can be used for it. Discuss some examples of application and provide the references.]
 - Methods: Here, you briefly describe your data set and the methods you use for classification. Provide a brief description of the methods, their pros and cons. [Also report and comment the main characteristics of the data. Each figure or table must be discussed in the text. Describe the features and the theoretical background of the methods you use for the classification.]

³Also available at: <https://www.ieee.org/conferences/publishing/templates.html>.

⁴Avoid the obvious title “Homework 3: classification models”.

- Results: Here, you compare the models. Are there any difference between the models? Is there statistical difference between them? [Report and comment the main results of the analysis.]
- References: Here, you provide bibliographic references [Report the books and/or articles that you used for studying the methods and perform the analysis. Each reference reported in this section must be cited in the main text].
- o Code listing: The code you used to perform the analysis. Regardless of your choice programming, your code must be executable/functioning. The code (and the relevant functions, if needed) can be either pasted at the end of the 6-page article (for instance as an appendix) or packaged together with the paper as a zip file.

The work can be done individually or in group of maximum 4 co-authors. You can chose to write your paper either in English or Portuguese⁵.

You are allowed to consult external resources; however, all sources must be properly cited. If you choose to use AI tools while working on your HW, do so responsibly, for example, to clarify concepts or check your reasoning, not to generate complete solutions. Using AI to produce full answers undermines your learning and violates academic integrity policies. You must acknowledge the use of such tools by citing them appropriately. Include both the prompt and the AI-generated output in an appendix of your homework report or in a separate file in your Git repository.

The work must be submitted by JANUARY 11, 2026. No submission delays nor extensions will be accepted/given.

⁵In L^AT_EX, specify `\usepackage[portuguese]{babel}` in the preamble to change the language.