Machine Learning for Neuroscience

ML4NS

Slides and notebooks: `https://ml4ns.github.io`

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Lecture 2. Linear models

In lecture 2, we cover some of the basic concepts of linear models.
In statistics, linear models describe a continuous response variable (the dependent variable) as a function of one or more predictor variables (the independent variable(s)). Such models can help us to understand and predict the behaviour of complex systems and analyse patterns in data.

In this lecture, we introduce the core theme of linear regression. We discuss the differences between the two main types of regression models (lasso and ridge) and when they might be used, citing applications for each. We also provide an overview of the different metrics that can be used to evaluate the performance of such models. We further expand on the generalisation of linear regression to the binary classification setting. Finally, we consider the importance of choosing the right model based on the training data.

Figure 2.1 demonstrates how linear regression assumes a target variable $(f(X))$ to be dependent on a feature (X). Figure 2.2 illustrates a decision boundary as would be used in a binary classification setting. Figure 2.3 illustrates the difference between training and generalisation errors of a model with regard to the data.

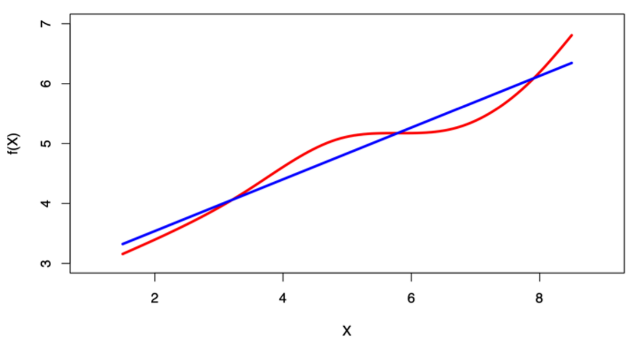

Figure 2.1. Linear Regression

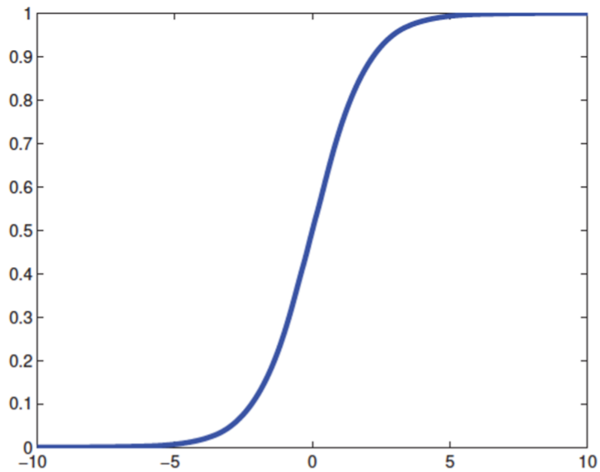

Figure 2.2. Decision Boundary for Binary Classification

In principle, supervised learning techniques are often designed in two ways: classification and regression. In linear regression, the linear regression model uses a linear model with coefficients $w = (w1, \ldots, wn)$ to minimise the residual sum of squares between the observed targets in the dataset and the targets that are predicted by the linear approximation used in the model.

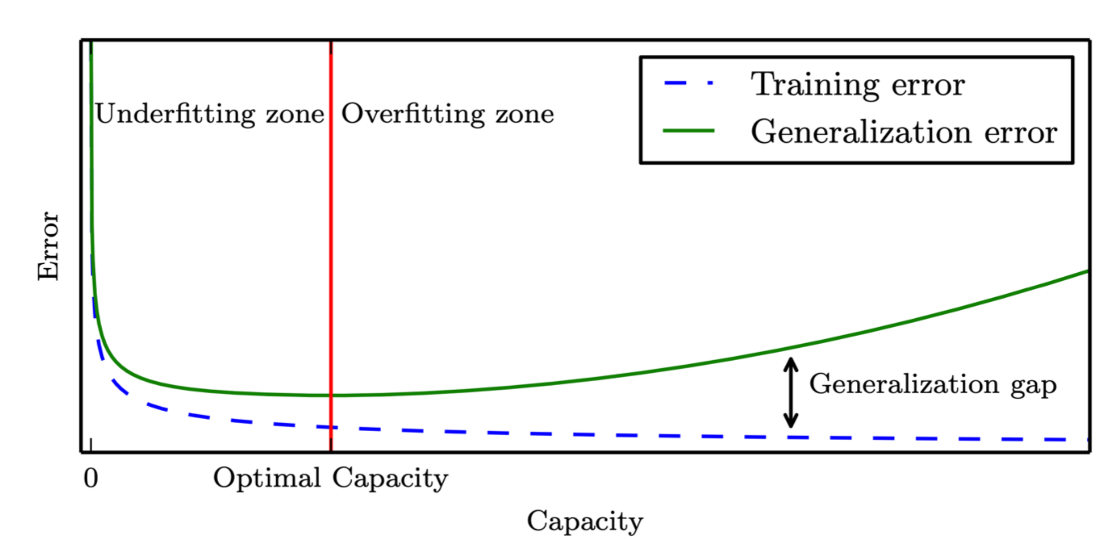

Figure 2.3. Training and Test Errors
Source: Deep Learning, Ian Goodfellow et al., MIT press.

An example of regression in neuroscience/neurology is predicting the change in a score of the mini-mental state examination (MMSE) of a person living with dementia as a function of the duration of time since diagnosis.
Using linear regression in a binary classification setting is the process of applying a linear combination of the inputs passed through a logistic function. This is otherwise known as logistic regression due to its similarity to linear regression (although it is a form of classification, not regression!). An example of how you might use a logistic regression model would be to predict whether a patient has a disease or not based on a given set of observations/measurements.

The lab code on the GitHub page provides practical examples of developing linear regression models with lasso and ridge regularisation. The lecture slides and the lab will also demonstrate how linear regression can be used in a binary classification setting (logistic regression).