Classification Methods: Implementations in R

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13 May 2022

(Statistical) Classification: What is it anyway?

-The problem of identifying which of a set of categories an observation belongs to.

-E.g. assigning an incoming email to “spam” or “inbox” mailbox.

-Classification can be thought of as two separate problems – binary classification and multiclass classification.

Methods of Classification

-We implement the following methods of classification on a well known dataset and present our results:

- Naive Bayes
- k-Nearest Neighbours
- Neural Networks
- Random Forest
- Decision Trees
- Logistic Regression
- Support Vector Machine

-We explain and present results from three methods: Naive Bayes, k-Nearest Neighbours and Neural Networks.

Dataset

-The Iris Dataset contains four features (length and width of sepals and petals) of 50 samples of three species of Iris (Iris setosa, Iris virginica and Iris versicolor).

-The dataset is often used in data mining, classification and clustering examples and to test algorithms.

Figure 1: Three species of Iris

Dataset

-We split the data into training and testing set in the ratio 67:33 repectively.

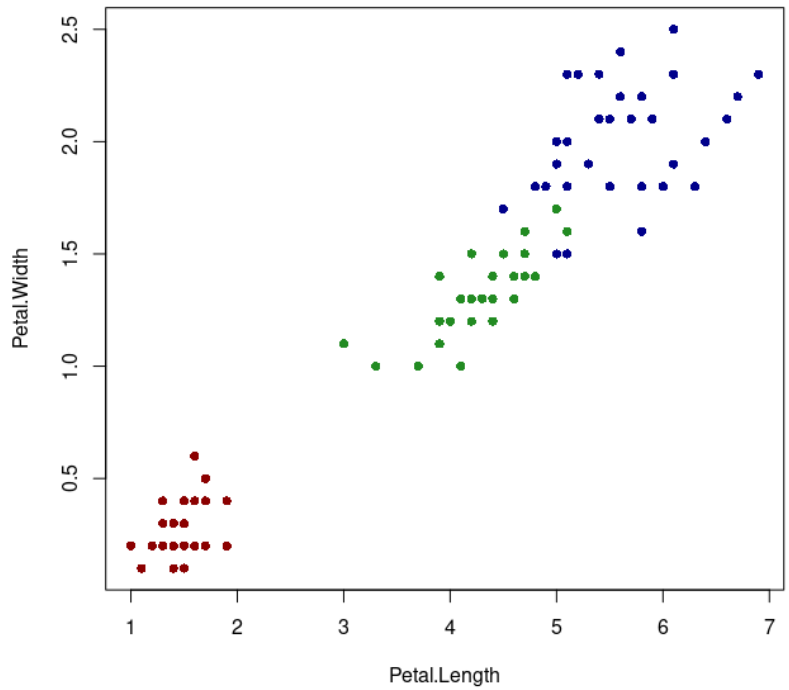


Figure 2: Training data (Iris dataset)

Dataset

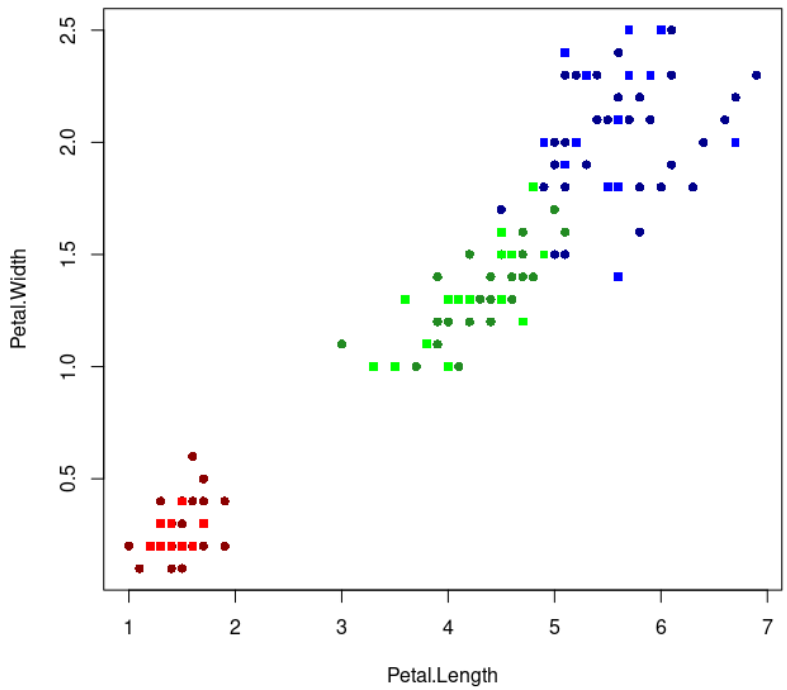


Figure 3: Testing data (Iris dataset)

Naive Bayes

-Naive Bayes classifiers are a family of simple "probabilistic classifiers" based on applying Bayes' theorem with strong (naive) independence assumptions between the features.

-The assumption is that the features are independent, i.e presence of one particular feature does not affect the other. Hence the adjective "naive".

-Requires a small number of training data to estimate the parameters necessary for classification.

-Bayes theorem expressed as:

$$P(y|X) = \frac{P(X|y)P(y)}{P(X)}$$

-y is the category variable, and X represent the parameters/features.

Naive Bayes

-We obtain the following result from a Naive Bayes implementation for classifying the Iris dataset.

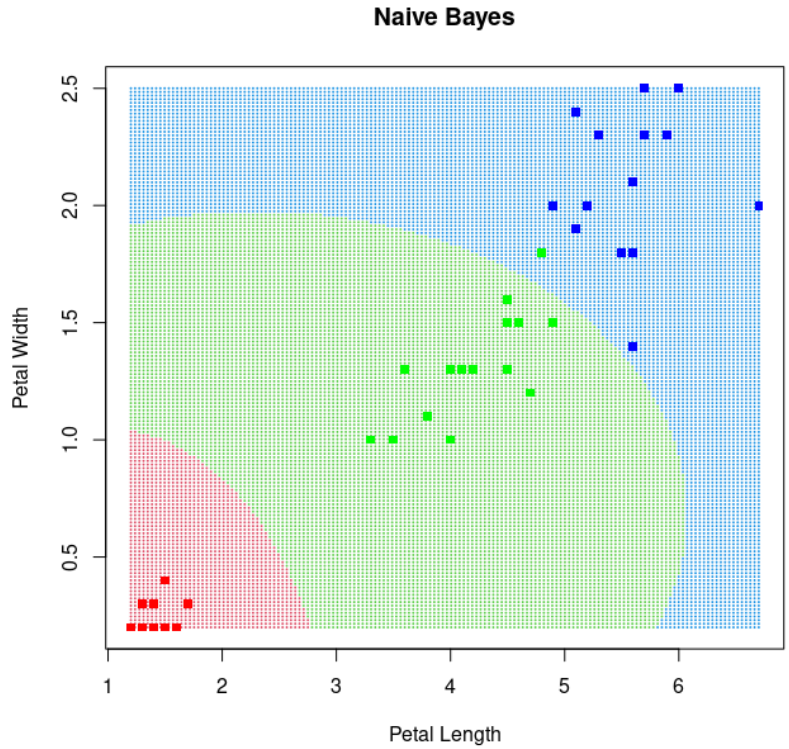


Figure 4: Classification using Naive Bayes

k-Nearest Neighbours

-A non-parametric supervised learning method.

-Uses proximity to make classifications or predictions about the grouping of an individual data point.

-Proximity is determined by using a distance metric, e.g. Euclidean distance.

-Object is assigned to the class it is most common with among its k nearest neighbors.

k-Nearest Neighbours

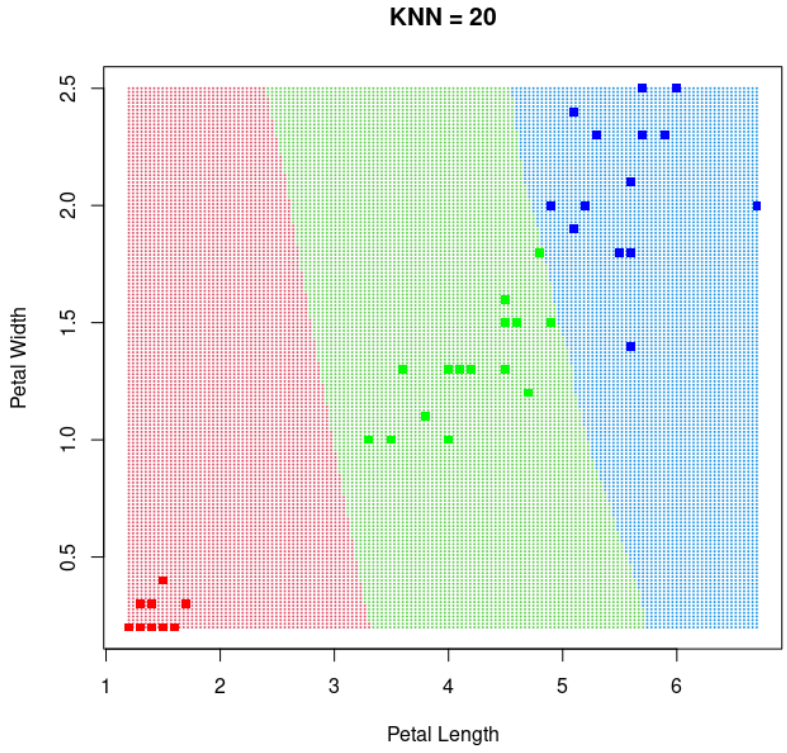


Figure 5: Classification using k-Nearest Neighbours

Neural Networks

-Neural networks (NNs) are computing systems inspired by the biological neural networks that constitute animal brain.

-They learn forming probability-weighted associations between "input" and "result".

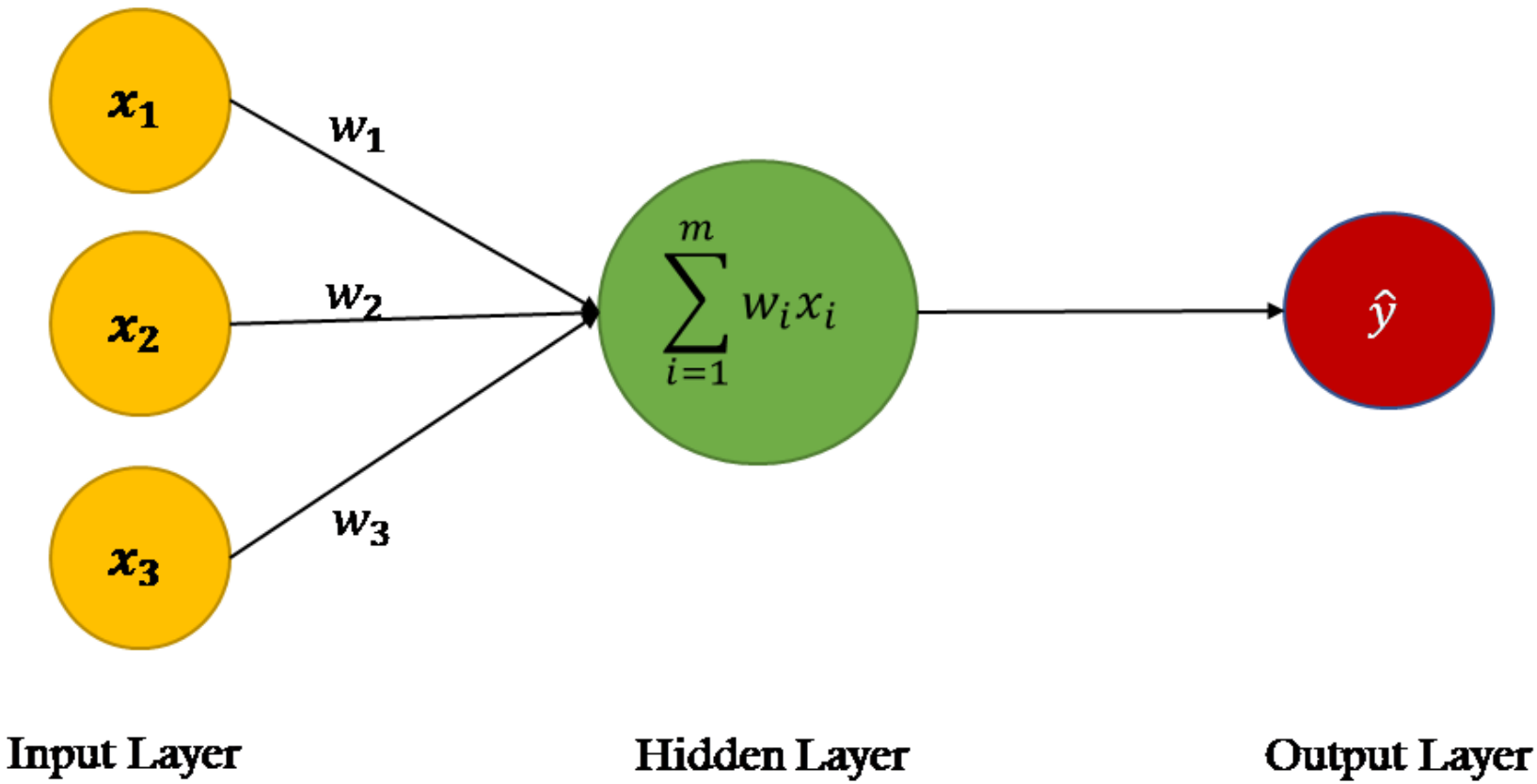
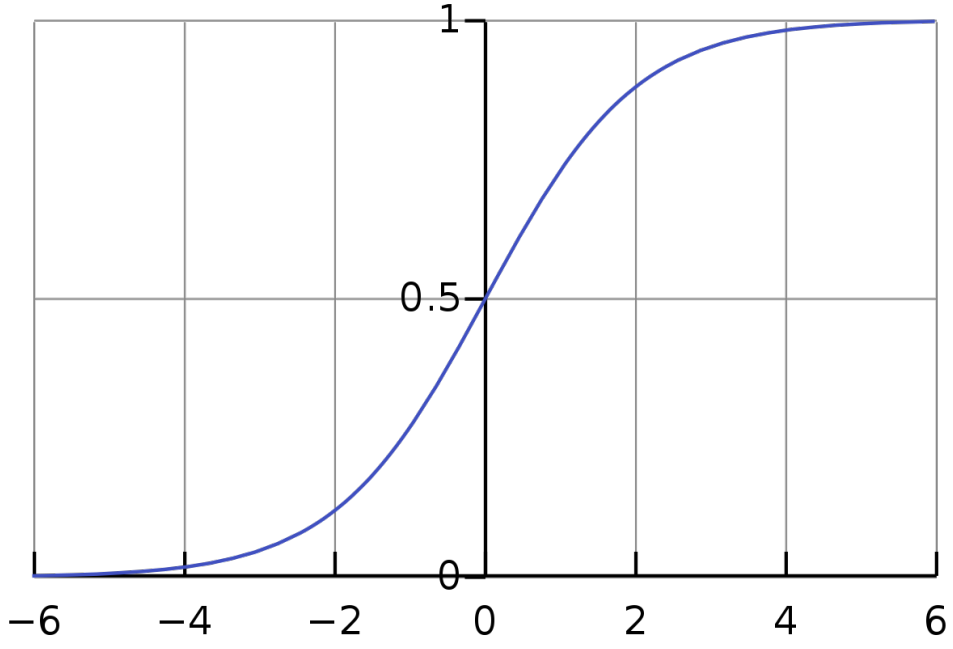


Figure 6: A single neuron

Neural Networks

-For classification tasks, NNs utilize an activation function, for example a logistic function:

$$f(x) = \frac{L}{1 + e^{-k(x-x_0)}}$$



Neural Networks

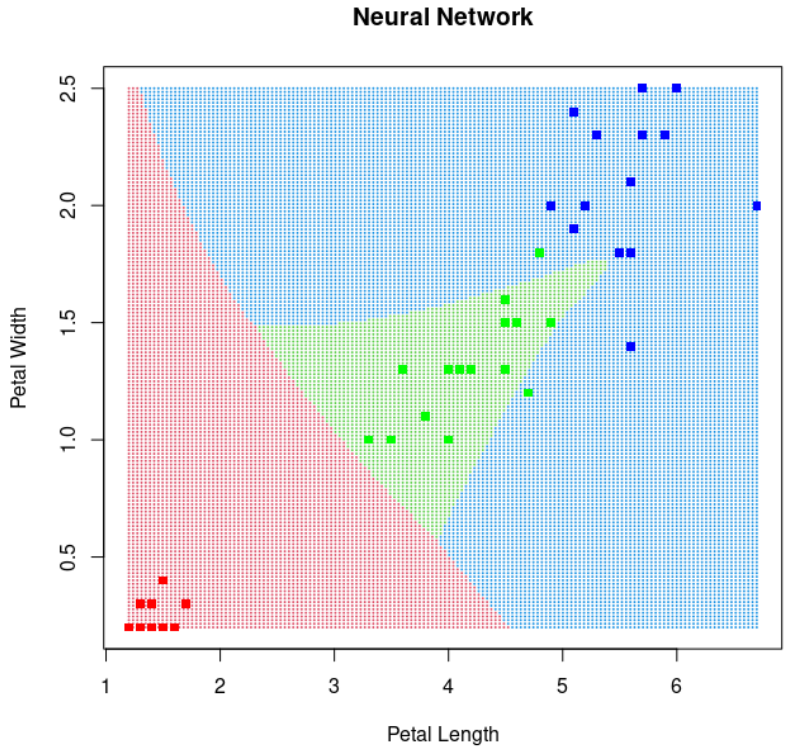


Figure 7: Classification using Neural Network

Neural Networks

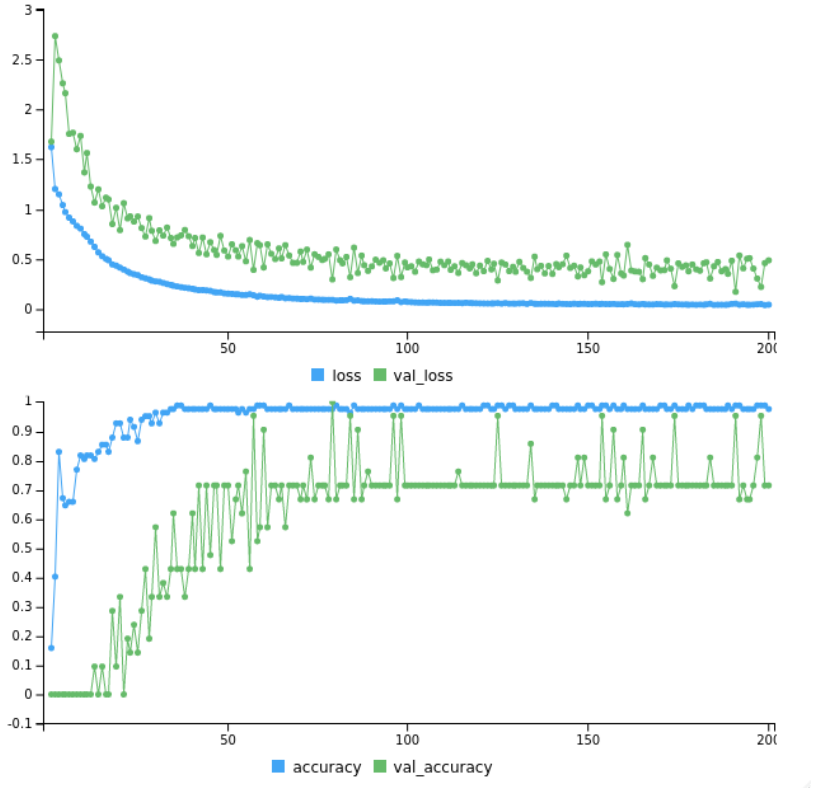


Figure 8: Loss and Accuracy

Cross Validation

Summary

-Classification accuracy scores:

NB |kNN | Logistic | SVM | NN | DT | RF + + + + + + 0.96 | 1 | 0.9787234 | 0.9787234 | NA | 0.9574468| 0.9574468

Conclusions

- We observe that kNN classifies the data with 100% accuracy.
- Neural Networks, although computationally efficient, is not an efficient method in this scenario.
- For best results, the method to be used should be carefully chosen by taking the data features into account.

References

- Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani. An Introduction to Statistical Learning : with Applications in R. Springer, 2013.
- McCulloch, Warren; Walter Pitts (1943). “A Logical Calculus of Ideas Immanent in Nervous Activity”. Bulletin of Mathematical Biophysics. 5 (4): 115–133