# Machine Learning Coursework Notes

Propose doing Decision Tree compared to Random Forest

## Datasets

### Letter Image Recognition Data

* <http://archive.ics.uci.edu/ml/datasets/Letter+Recognition>
* 16 features describing letters in various fonts and distortions
* 1 target (Letter), 26 classes
* 20 000 examples
* Poor papers
* Clean dataset, balanced
* Default tree gives approx. 60% predictability, papers gives 80%

# Dataset Notes on Plots

The scattermatrix and correlation matrix used together that:

* Width and Height are highly correlated and have a linear distribution with xbox and ybox respectively. This is likely to be more than correlation: association.
* P-values correlation are high for yBox and yEgvy.

Removing the yBox is worth a try. Removing xBox less so.

The images and results csv files show that removing yBox and yEgvy slightly reduces the accuracy, without noticeably reducing the overall run time.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **HoldOut** | **Train Prop.** | **Max**  **Split** | **Split Crit.** | **Train**  **Acc.** | **Test**  **Acc.** | **Avg**  **Misclas.** | **Entry**  **Count** | **CPU**  **Time** |
| 20 | 0.7 | 25 | gdi | 0.3686 | 0.3654 | 3056.85 | 4800 | 22.875 |
| 15 | 0.7 | 25 | gdi | 0.3691 | 0.3647 | 3049 | 4800 | 17.7656 |
| 5 | 0.7 | 25 | gdi | 0.3654 | 0.3602 | 3077.6 | 4800 | 5.5938 |
| 15 | 0.8 | 100 | deviance | 0.675 | 0.6656 | 1072.0667 | 3199 | 12.7813 |
| 10 | 0.8 | 100 | deviance | 0.6764 | 0.6645 | 1078 | 3199 | 9.0625 |
| 20 | 0.8 | 100 | deviance | 0.6739 | 0.6631 | 1083.5 | 3199 | 18.5625 |
| 1 | 0.8 | 100 | deviance | 0.6829 | 0.6608 | 1072 | 3199 | 0.8594 |
| 5 | 0.8 | 100 | deviance | 0.6738 | 0.6583 | 1099.6 | 3199 | 4.5 |
| 15 | 0.8 | 75 | deviance | 0.6499 | 0.6391 | 1157.5333 | 3199 | 14.8125 |
| 20 | 0.8 | 75 | deviance | 0.6485 | 0.6389 | 1155.4 | 3199 | 18.0625 |
| 5 | 0.8 | 75 | deviance | 0.6491 | 0.6368 | 1158 | 3199 | 4.4531 |
| 10 | 0.8 | 75 | deviance | 0.6472 | 0.6333 | 1178 | 3199 | 8.9063 |
| 1 | 0.8 | 75 | deviance | 0.6422 | 0.6292 | 1188 | 3199 | 0.9219 |
| 1 | 0.8 | 50 | deviance | 0.5915 | 0.5848 | 1339 | 3199 | 0.875 |
| 5 | 0.8 | 50 | deviance | 0.5882 | 0.5812 | 1349.8 | 3199 | 4.4063 |
| 20 | 0.8 | 50 | deviance | 0.5876 | 0.581 | 1345.85 | 3199 | 19.8125 |
| 15 | 0.8 | 50 | deviance | 0.586 | 0.5809 | 1342.4 | 3199 | 12.6563 |
| 10 | 0.8 | 50 | deviance | 0.5852 | 0.577 | 1354.5 | 3199 | 8.7344 |
| 5 | 0.8 | 25 | deviance | 0.4755 | 0.4724 | 1678.4 | 3199 | 3.9063 |

The results for all features is used to select the hyperparameters to try for the deviance split criterion:

* **Split:** deviance
* **Hold out:** 1 5 10
* **Max split:** 75 100 125 150
* **Train / Test Proportion:** 0.8

## Normalization

Decided to review normalization. It currently uses the entire dataset: change to only use the training set. Then the test set will be normalised using the training set figures:

Z = x – mean / std.dev

## Naïve Bayes

Completed Naïve Bayes hyperparameter search. Standardisation helps reduce the time taken to do the analysis. Added accuracy, precision, recall and F1. Changed previous accuracy to loss.

The following hyperparameters were tried:

* Hold out: 1 2 5
* Distributions names: normal, kernel

Widths for the kernel: 2.0 1.5 0.10 0.098351 0.0932 0.090 0.80 0.70 0.50

# Misc Notes

|  |  |
| --- | --- |
|  | Hello,  Thank you for your response which has led me to revert to my "original" plan to use random forest.  With regard to the resampling method, I understand from your perspective that bootstrapping should be used for fair comparison if one of the chosen methods is random forest. I appreciate that theoretically, though the technical implementation of bootstrapping for logistic regression took me 3 days.   From initial analysis, the accuracy of logistic regression with bootstrapping is ~62% with ~0.5% fluctuation amongst 500 runs. This is ~13% lower than 5-fold cross-validation and about 100 times more computationally expensive. The poor performance of bootstrapped prediction is not in line with the literature; e.g. Mnich et al, 2020  This discrepancy might primarily be due to the nature of my dataset as its heavily biased towards one class: for every death, there is 6 survival. Now I have these choices:  1. To use a subset of data with equal representation of both classes. This can be backed up by literature, for example, Couronne et al, (2018) report that for logistic regression and random forest "results were noticeably dependent on the inclusion criteria used to select the example datasets".  2. To use k-fold CV which might complicate comparison to random forest. I have, however, read papers with k-fold CV for comparing logistic regression (e.g. Alghamdi et al 2017) and random forest but unsure of the extent in which bootstrapping (a measure of reliability) can be fairly compared to k-fold CV (a measure of accuracy).   3. To use an alternative second method which does not rely on bootstrapping; e.g. quadratic discriminant  I would appreciate your input so that I can more forward. Many thanks.  ########### Mnich, K., Golińska, A.K., Polewko-Klim, A. and Rudnicki, W.R., 2020. Bootstrap Bias Corrected Cross Validation applied to Super Learning. arXiv preprint arXiv:2003.08342.  Couronne et al, (2018): Couronné, R., Probst, P. and Boulesteix, A.L., 2018. Random forest versus logistic regression: a large-scale benchmark experiment. BMC bioinformatics, 19(1), p.270.  Alghamdi, M., Al-Mallah, M., Keteyian, S., Brawner, C., Ehrman, J. and Sakr, S., 2017. Predicting diabetes mellitus using SMOTE and ensemble machine learning approach: The Henry Ford ExercIse Testing (FIT) project. PloS one, 12(7), p.e0179805. To Aaron: This is an optional step. However, if there is a significant class imbalance in your dataset, it's reasonable to apply oversampling/undersampling during cross validation (only on training set, not validation samples). When you compare algorithms, the two models have to be retrained on the entire training set with e.g. SMOTE using the optimal hyper-parameters discovered during model selection. Yes, you can present the best performing one. To enrich your analysis, optionally you could investigate the impact of varying degrees of SMOTE on our final models. |