Assignment 2 - KLVTHO001

November 16, 2017

1 Introduction

Many differnet learning algorithms are used in Statistical Sciences in order to classify hand-written digits. This project is focusing on a number of these learning approaches, namely Support Vector Machine, Neural Nework and Tree Based Methods. The dataset provided for this classification problem contains a response variable which indicated whether a digit is even or odd and 784 potential predictor variables which represents various digit properties. All the aforementioned approches are fit to the dataset and the best predictive algorithm is decided.

2 Theory

2.1 Tree Based Methods

Bagging, Boosting and Random Forests are all ensemble methods and meta learners. The key difference between Bagging and Boosting lies in how the two approches use the training set. Bagging is simply just bootstrap aggregation, which is all about choosing a random sample with replacement, train the algorithm on each sample seperately and average the predictions in the end. Furthermore, the key difference between Bagging and Random Forest is that Random Forest has the ability to improve variance by reducing the correlation between each tree in the forest. This is accomplished by randomly selecting a feature-subset for each split at each node. This is the main reason why Random Forests generally will generalize better as the number of trees grows. Furthermore, The key difference between these methods is that a Random Forest and Bagging is trained in parallel, i.e. each model is build independantly. In contrast, Boosting builts the models in a sequential way, making each model dependant on the previous ones.

2.2 Support Vector Machine

Support Vector Machine is a supervised binary classification algorithm. It attempts to find a hyperplane in a high dimensional space that can seperate the two classes of data by the largest margin. In order to achieve this, the Support Vector Machine will use a kernel to find the hyperplane that separates the data best.

2.3 Artificial Neural Network

A neural network is also a supervised classifier. The network consists of several components interconnected and organized in layers. Each layer consists of neurons, which itself is a simple classifier. The input data is fed to the network and will pass through in a forward-feed manner. Furthermore, the training part is often done with the *Back Propagation* algorithm which helps find the optimal weights of each neuron in the layers of the network.

3 Method

3.1 Tree Based Methods

The `randomForest` and `gbm`-packages is used for training the Tree Based Methods. Furthermore, the models trained can be viewed in Table **??**

Method	Number of trees	Mtry	Interaction Depth	Learning Rate	Bag Fraction	CV Folds
Random Forest	500					
Bagging	500	32				
Boosting	50.000		2	0.001	1	10
Regression Tree	1					10

Table 1: Trained Models. If a field is empty, the default package settings are used.

3.2 Support Vector Machine

A radial based kernel is used for the Support Vector Machine. In addition, Principal Component Analysis is performed in order to reduce the dimensionality of the problem. Furthermore, the `caret`-package in `R` is used to fit a model to the dataset. For the Support Vector Machine a number of different soft constraints where tested, thereof $C \in \{0, 0.5, 1, 1.5, 2, 3\}$

3.3 Artificial Neural Network

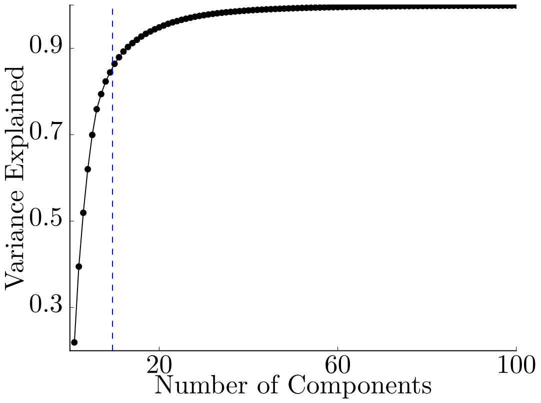
For the Neural Network, the `h2o`-package is used in order to classify the digits. A number of different hyperparameters are tested using a grid and the best trained model is then used for further analysis. The trained models for the Neural Network the models can be seen Table 2.

Parameters	Value
Epochs	5, 10
Hidden	[512, 128], [218,42]
Rate	0.005, 0.01
Input Dropout Ratio	0.1
Nfolds	10
Stopping Rounds	3
Stopping Metric	Misclassification
Stopping Tolerance	0.02

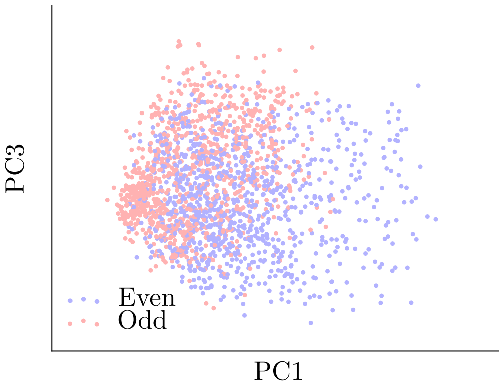
Table 2: Trained Models

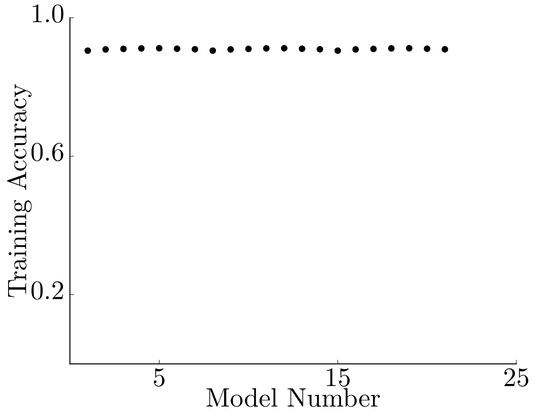
Where *Ephocs* is the number of times to iterate (stream) the dataset, *Hidden* is the hidden layer sizes, *Rate* is the the learning rate, *Input Droput Ratio* is specifying the input layer dropout ratio to improve generalization, $Nfolds$ is the the number of folds for cross-validation. Furthermore, the network stops training when misclassification rate, *Stopping Metric*, does not improve for the specified number of training rounds, based on a simple moving average. Lastly, the *Stopping Tolerance* specifies the relative tolerance for the metric-based stopping to stop training if the improvement is less than this value.

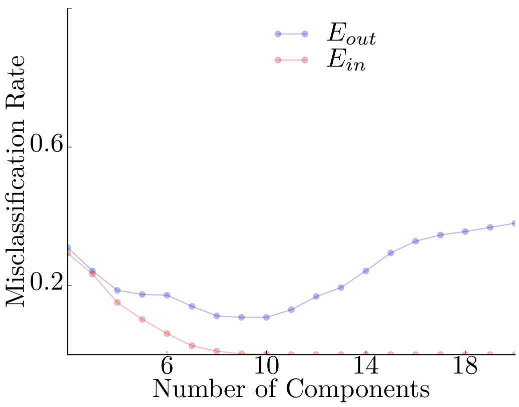
4 Results



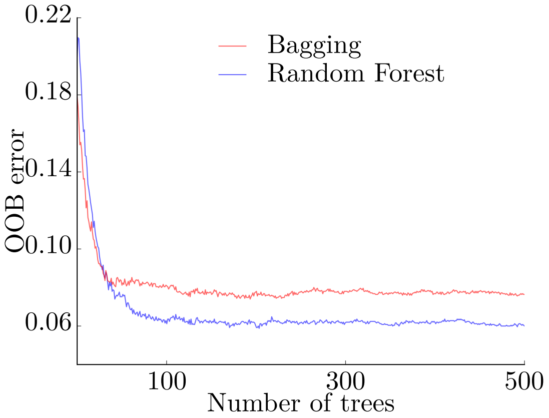
(a)







5 Results



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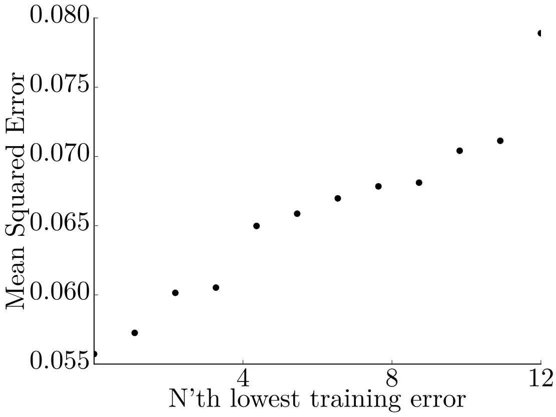

(f)

Class	Even	Odd	Total	Error Rate
Even	222	17	239	0.034
Odd	20	241	261	0.04
Total	242	258	500	0.074

Table 3: Random Forest confusion matrix

Class	Even	Odd	Total	Error Rate
Even	214	32	246	0.064
Odd	28	226	254	0.056
Total	242	258	500	0.12

Table 4: Bagging confusion matrix

6 Discussion

7 Appendix