UE Machine Learning: Supervised Techniques

Exercise 7 Report

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Sequence Data (One-hot encoded Data):

Using 10 Cross Validation to train the RBF SVM:

C Parameter	Sigma Parameter	Cross Validation Error	Cross Validation Run Time
5	0.001	11.95 %	10.57044 secs
5	0.01	15.15 %	15.93966 secs
5	0.1	34.05 %	16.1011 secs
5	1	34.2 %	15.9258 secs
5	10	34.05 %	15.4783 secs
5	100	34.15 %	15.2985 secs
10	0.001	11.7 %	10.109 secs
10	0.01	14.7 %	15.6695 secs
10	0.1	34.4 %	15.8919 secs
10	1	34.15 %	16.1955 secs
10	10	34.65 %	15.4999 secs
10	100	34.55 %	15.7556 secs
50	0.001	11.85 %	10.3031 secs
50	0.01	15.85 %	15.3035 secs
50	0.1	34 %	17.9066 secs
50	1	34.25 %	16.8074 secs
50	10	34.65 %	15.7029 secs
50	100	34.1 %	15.7569 secs
100	0.001	11.15 %	9.8851 secs
100	0.01	15.35 %	15.6489 secs
100	0.1	34.05 %	15.6377 secs
100	1	34.65 %	15.8796 secs
100	10	34.65 %	15.3996 secs
100	100	34.45 %	15.1953 secs

200	0.001	12.3 %	10.097 secs
200	0.01	15.75 %	16.0958 secs
200	0.1	34.2 %	15.9296 secs
200	1	33.85 %	16.3399 secs
200	10	34.15 %	15.9439 secs
200	100	34.25 %	15.7323 secs

Using 10 Cross Validation to train the random forest and comparing results to out-of- bag estimate:

Cross Validation	No. of trees	OOB Error Estimate	Cross Validation Error	Cross Validation Run Time
10	10	19.32 %	14.6 %	3.764281 secs
10	100	12.05 %	1.1 %	34.61006 secs
10	1000	11 %	0 %	5.739604 mins
10	10000	10.9 %	0 %	57.26711 mins

The best model trained by RBF SVM has a Cross-Validation error = 11.15% with run time equivalent to 9.8 seconds. On the other hand, the best random forest model has a cross validation error of 0% and OOB of 10.9%, however the runtime is considerably worse as it takes the model 57.26711 minutes to finish training.

Training Time overview:

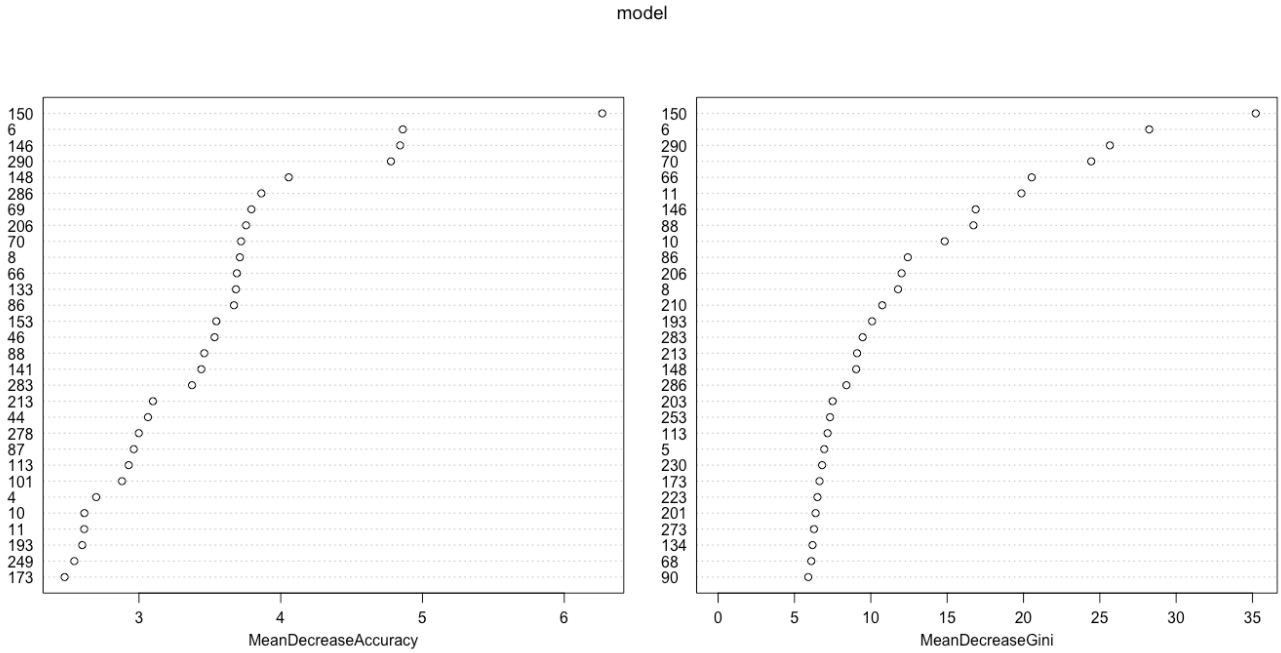
The runtime of random forest is comparable to those of the SVM as far as the number of trees is small. However, when the number of trees increases, the run time increases too.

Parameter selection overview:

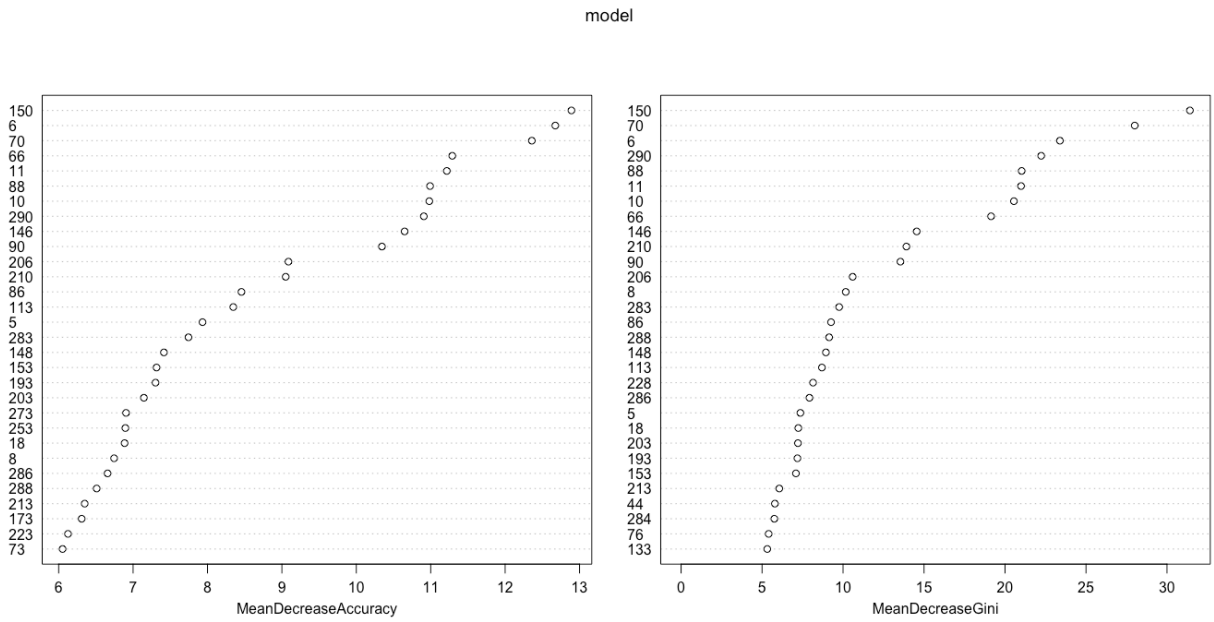
RBF SVM depends on 2 parameters (c and sigma), that is why there is more combinations for models. The search strategy followed here is grid search where each value of C is tested with every value for Sigma. Random forests depend mainly on one parameter which is the number of trees. Which mean there is less combinations for the model compared to RBF SVM. The random forest is trained with each value for the number of trees.

Sequence Dataset Variable Importance for Random Forests:

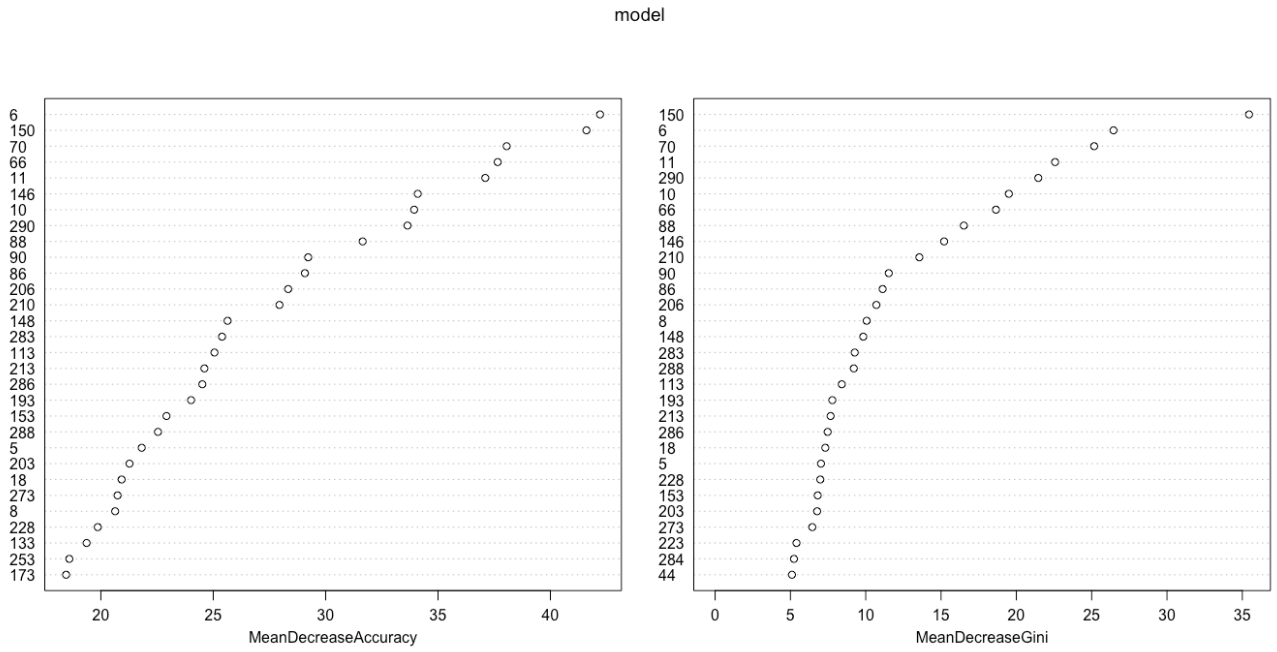
The following figure shows the variable importance for a random tree with 10 trees:



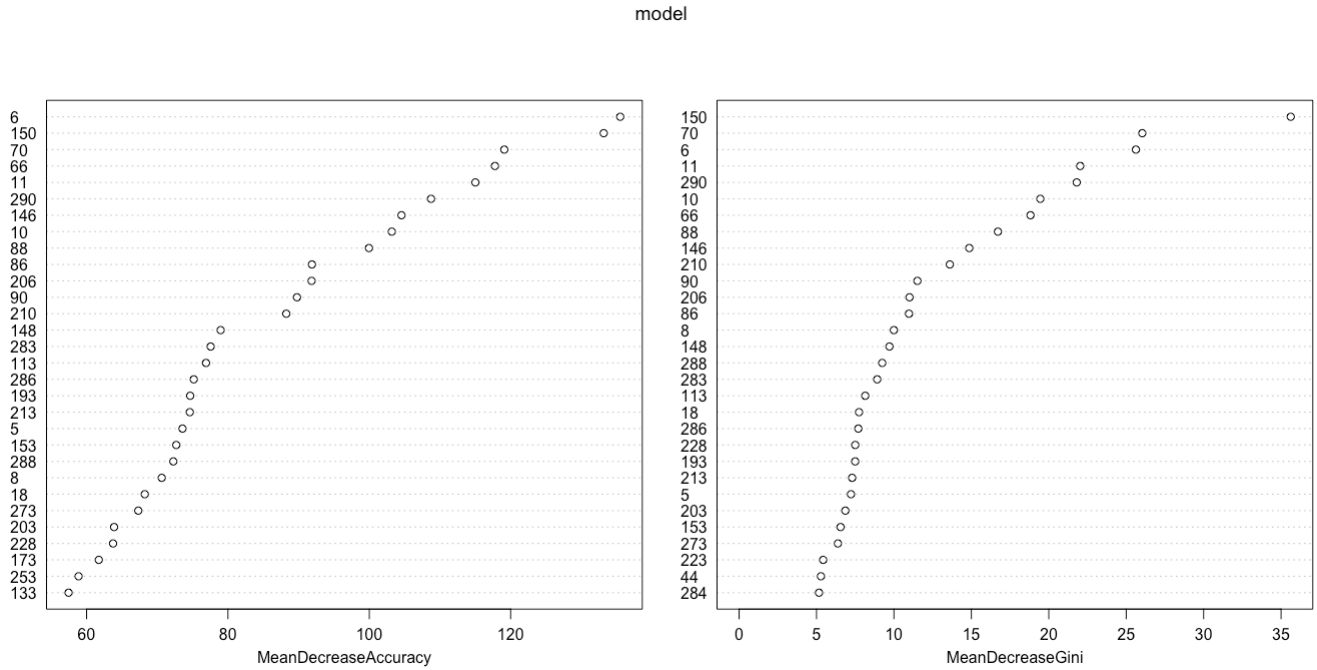
The following figure shows the variable importance for a random tree with 100 trees:



The following figure shows the variable importance for a random tree with 1000 trees:



The following figure shows the variable importance for a random tree with 10000 trees:



From the last 4 figures, one can see that some of the dataset variables has noticeable effect on the accuracy of the tree classification (e.g. variables 150, 71, 11, 290, 60, 88) seem to play a vital role in the random forest classification process. The insight that can be deduced from this observation is that the existence of a certain acid composition in a specific position is very important in the process of defining the type of the acid.

Preferred Method for Acid Sequences Dataset:

I would prefer using random forest on this dataset rather that SVMs for the following reasons:

1- The best SVM has cross-validation error of 11.15 %.
2- Random forests with 1000 trees (cross error = 0 %, OOB Error = 11 %) or 10000 trees (cross error = 0 %, OOB Error = 10.9 %) perform better than the best SVM in terms of cross-validation error and OOB Estimate Error too.
3- The runtime for random forests with 1000 or 10000 trees is considerably more that SVM, however accuracy is better.

Breast Cancer Dataset:

Using 10 Cross Validation to train the RBF SVM:

C Parameter	Sigma Parameter	Cross Validation Error	Cross Validation Run Time
5	0.001	2.92 %	0.0616 secs
5	0.01	3.22 %	0.0649 secs
5	0.1	4.1 %	0.605 secs
5	1	4.24 %	0.1217 secs
5	10	12.75 %	0.174 secs
5	100	25.02 %	0. 1712 secs
10	0.001	3.07 %	0.0523 secs
10	0.01	2.92 %	0.05 secs
10	0.1	4.39 %	0.0697 secs
10	1	3.8 %	0.1258 secs
10	10	12.6 %	0.1746 secs
10	100	25.17 %	0.1616 secs
50	0.001	3.07 %	0.0485 secs
50	0.01	3.07 %	0.0678 secs
50	0.1	4.53 %	0.0654 secs
50	1	4.39 %	0.1081 secs
50	10	12.57 %	0.1773 secs
50	100	24.87 %	0.1727 secs
100	0.001	3.51 %	0.0501 secs
100	0.01	3.22 %	0.065 secs
100	0.1	4.54 %	0.0736 secs
100	1	3.95 %	0.1219 secs
100	10	13.16 %	0.1745 secs
100	100	25.48 %	0.1709 secs

200	0.001	3.36 %	0.0579 secs
200	0.01	3.81 %	0.0794 secs
200	0.1	4.24 %	0.0661 secs
200	1	3.5 %	0.1148 secs
200	10	13.04 %	0.169 secs
200	100	25.34 %	0.1646secs

Using 10 Cross Validation to train the random forest and comparing results to out-of- bag estimate:

Cross Validation	No. of trees	OOB Error Estimate	Cross Validation Error	Cross Validation Run Time
10	10	4.88 %	4.55 %	0.0547 secs
10	100	3.22 %	0.294 %	0.3429 secs
10	1000	2.64 %	0 %	2.6231 secs
10	10000	2.64 %	0 %	25.9456 secs

The best model trained by RBF SVM has a Cross-Validation error = 2.92% with run time equivalent to 0.05 seconds. On the other hand, the best random forest model has a cross validation error of 0% and OOB of 2.64%, however the runtime is worse as it takes the model 2.6231 seconds to finish training but it is not very bad of course.

Training Time overview:

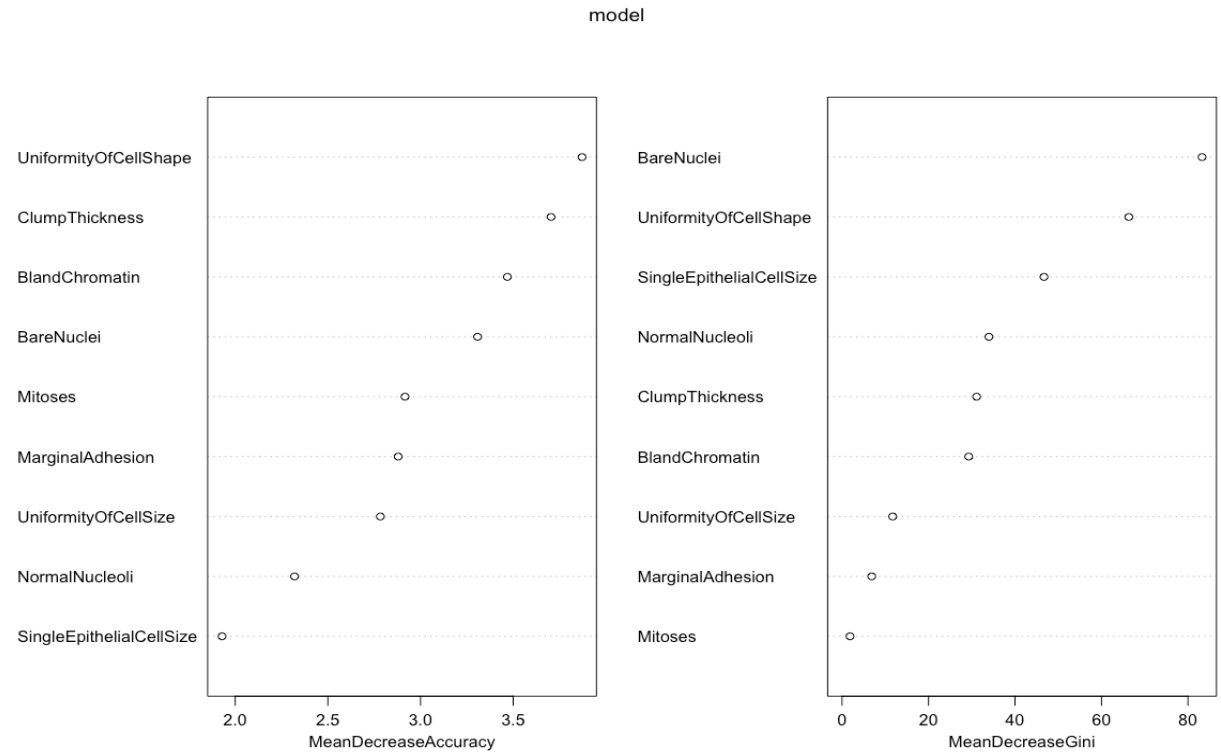
The runtime of random forest is very comparable to those of the SVM even for random forest trees with 1000 or 10,000 trees.

Parameter selection overview:

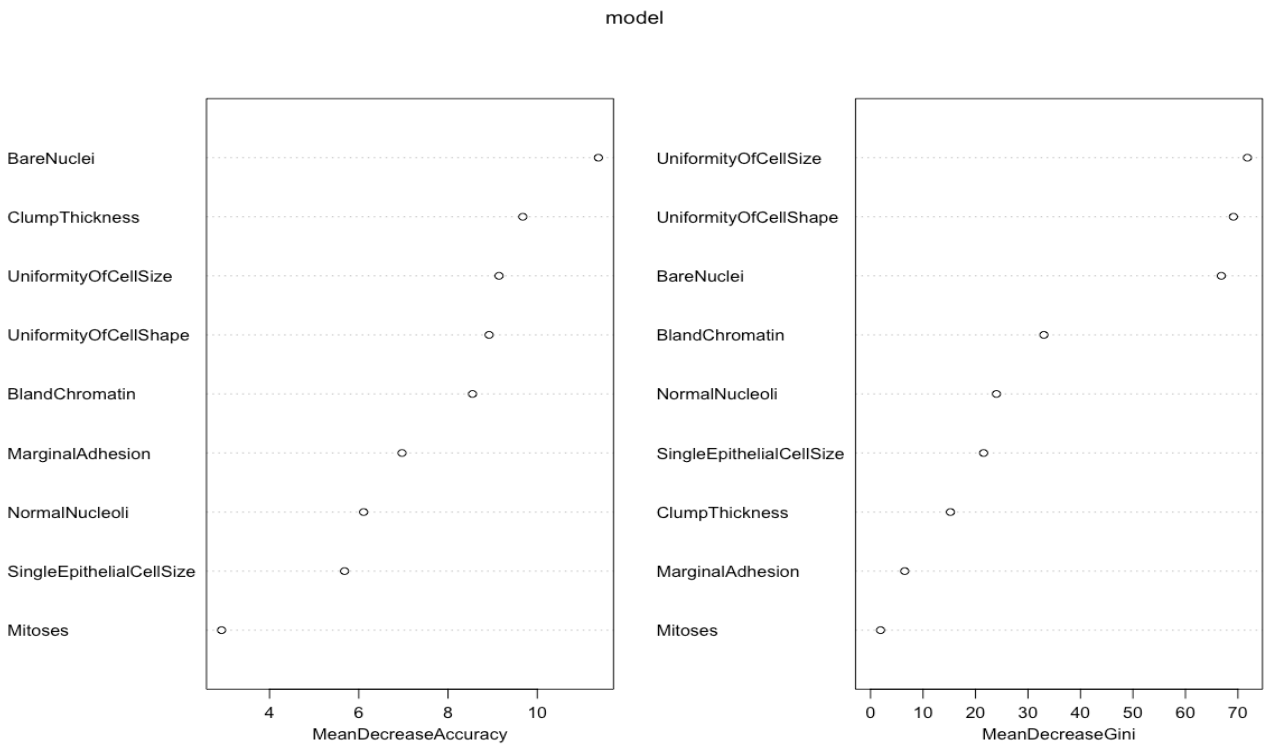
RBF SVM depends on 2 parameters (c and sigma), that is why there is more combinations for models. The search strategy followed here is grid search where each value of C is tested with every value for Sigma. Random forests depend mainly on one parameter which is the number of trees. Which mean there is less combinations for the model compared to RBF SVM. The random forest is trained with each value for the number of trees.

Breast Cancer Dataset Variable Importance for Random Forests:

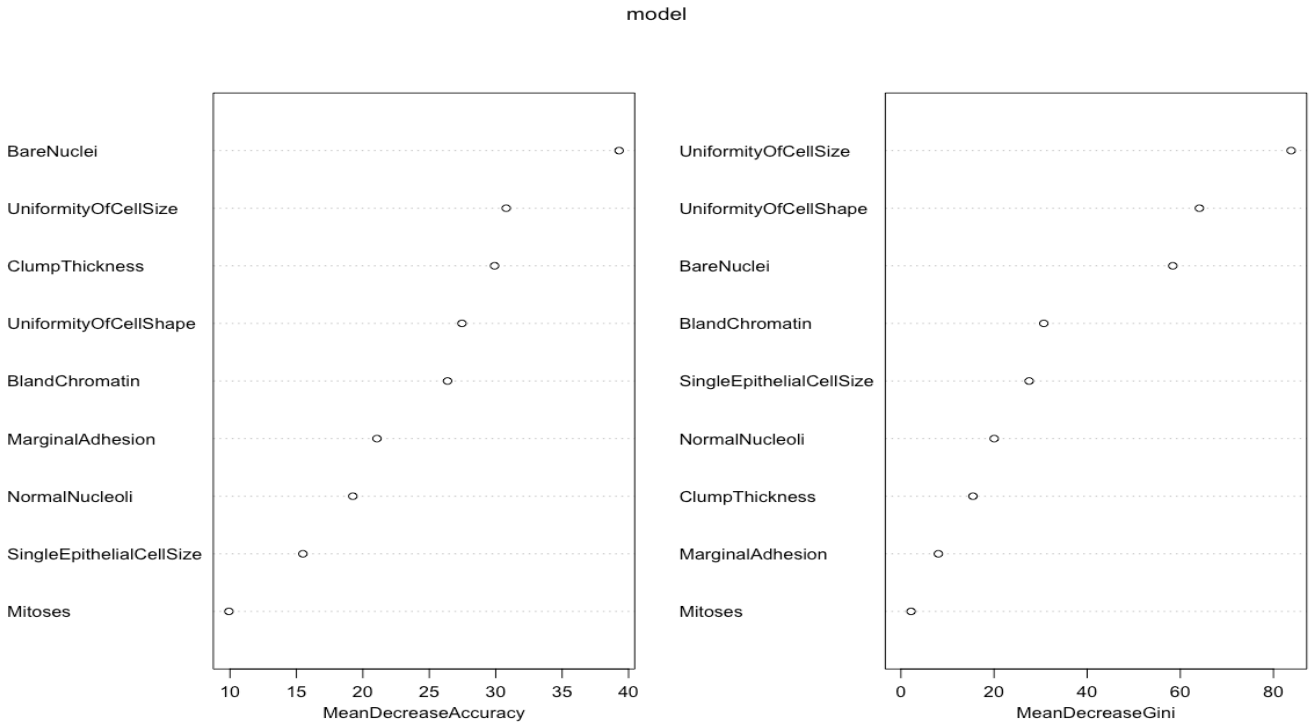
The following figure shows the variable importance for a random tree with 10 trees:



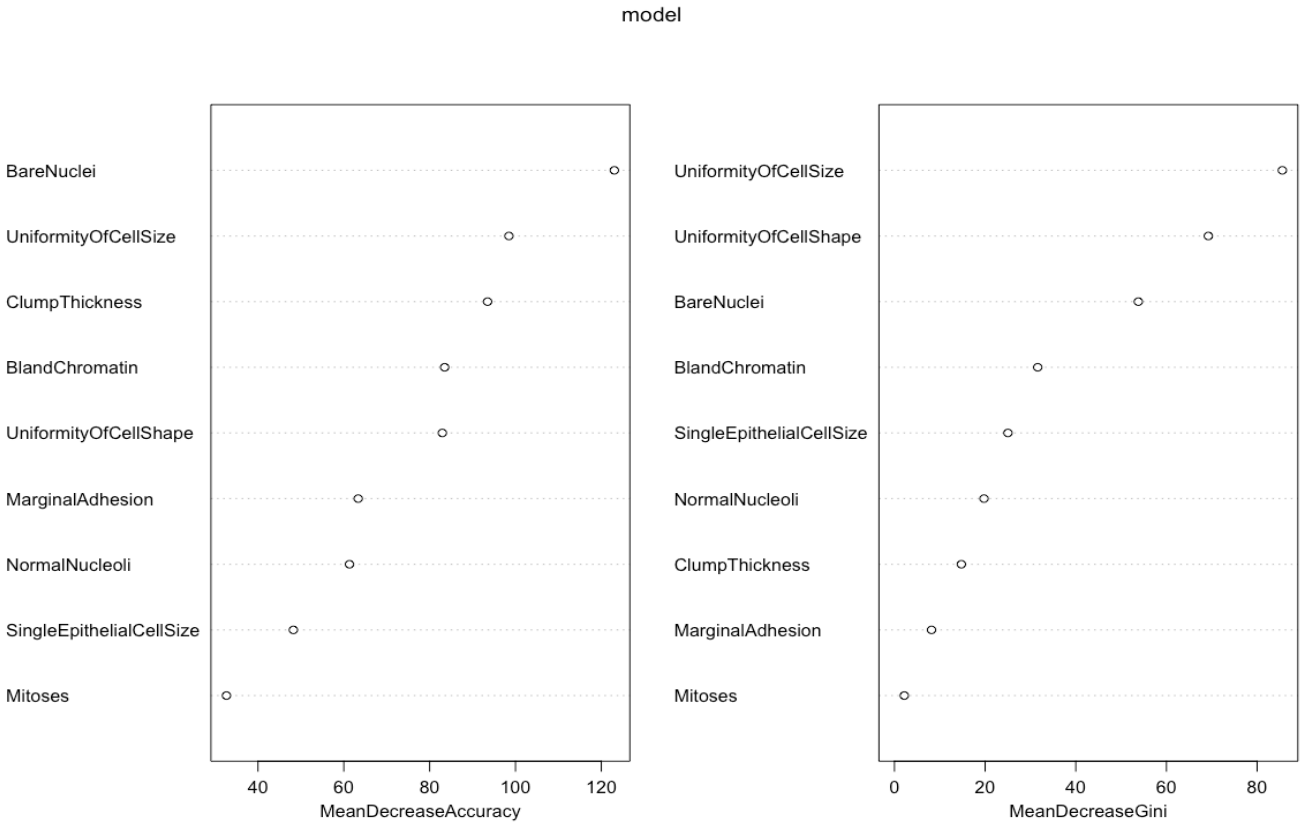
The following figure shows the variable importance for a random tree with 100 trees:



The following figure shows the variable importance for a random tree with 1000 trees:



The following figure shows the variable importance for a random tree with 10000 trees:



From the last 4 figures, one can see that some of the dataset variables has noticeable effect on the accuracy of the tree classification (e.g. Uniformity of Cell Size & Bare Nuclei & Uniformity of Cell Shape) seem to play a vital role in the random forest classification process. The insight that can be deduced from this observation is that the values of such attribute as the shape and size of a cell are a good indicator whether a patient has breast cancer or not.

Preferred Method for Breast Cancer Dataset:

I would prefer using random forest on this dataset rather that SVMs for the following reasons:

1- The best SVM has cross-validation error of 2.92 %.
2- Random forests with 1000 trees (cross error = 0 %, OOB Error = 2.64 %) or 10000 trees (cross error = 0 %, OOB Error = 2.64 %) perform better than the best SVM in terms of cross-validation error and OOB Estimate Error too.
3- The runtime for random forests with 1000 or 10000 trees in this dataset is very low that it is comparable to that of SVM, however accuracy is better.

Wine Dataset:

Using 10 Cross Validation to train the RBF SVM:

C Parameter	Sigma Parameter	Cross Validation Error	Cross Validation Run Time
5	0.001	2.22 %	0.0471 secs
5	0.01	1.11 %	0.0402 secs
5	0.1	1.66 %	0.0412 secs
5	1	34.2 %	0.0749 secs
5	10	60.09 %	0.0653 secs
5	100	60.06 %	0.0555 secs
10	0.001	2.22 %	0.0433 secs
10	0.01	2.25 %	0.0387 secs
10	0.1	1.11 %	0.0433 secs
10	1	34.86 %	0.0552 secs
10	10	60.29 %	0.0612 secs
10	100	60.29 %	0.0618 secs
50	0.001	2.28 %	0.038 secs
50	0.01	3.92 %	0.0388 secs
50	0.1	1.69 %	0.0423 secs
50	1	35.52 %	0.0528 secs
50	10	60.22 %	0.0588 secs
50	100	60.06 %	0.0702 secs
100	0.001	3.36 %	0.0409 secs
100	0.01	3.36 %	0.0366 secs
100	0.1	1.11 %	0.0468 secs
100	1	33.26 %	0.0572 secs
100	10	60.19 %	0.0635 secs
100	100	60.13 %	0.0586 secs

200	0.001	2.84 %	0.0404 secs
200	0.01	5.13 %	0.0399 secs
200	0.1	1.14 %	0.0419 secs
200	1	34.93 %	0.057 secs
200	10	60.16 %	0.0584 secs
200	100	59.9 %	0.0555 secs

Using 10 Cross Validation to train the random forest and comparing results to out-of- bag estimate:

Cross Validation	No. of trees	OOB Error Estimate	Cross Validation Error	Cross Validation Run Time
10	10	3.39 %	2.94 %	0.0256 secs
10	100	2.25 %	0 %	0.1434 secs
10	1000	1.69 %	0 %	0.8892 secs
10	10000	1.69 %	0 %	8.4717 secs

The best model trained by RBF SVM has a Cross-Validation error = 1.11% with run time equivalent to 0.0433 seconds. On the other hand, the best random forest model has a cross validation error of 0% and OOB of 1.69%, however the runtime is a little bit worse as it takes the model 0.8892 seconds to finish training but it is not very bad of course.

Training Time overview:

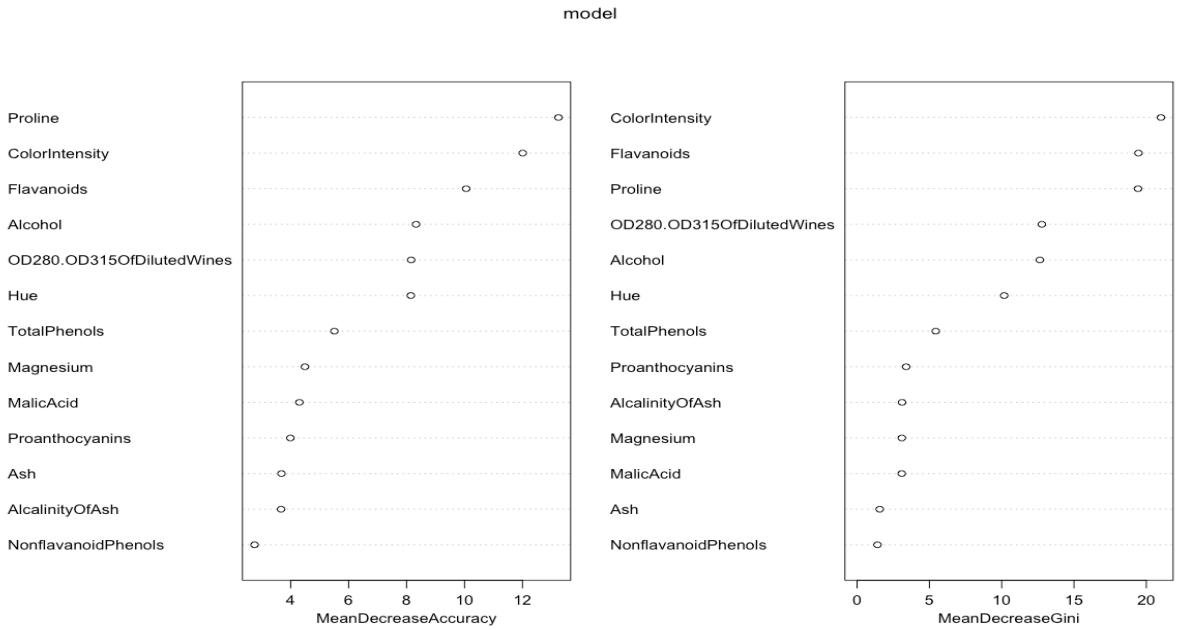
The runtime of random forest is very comparable to those of the SVM even for random forest trees with 1000 or 10,000 trees.

Parameter selection overview:

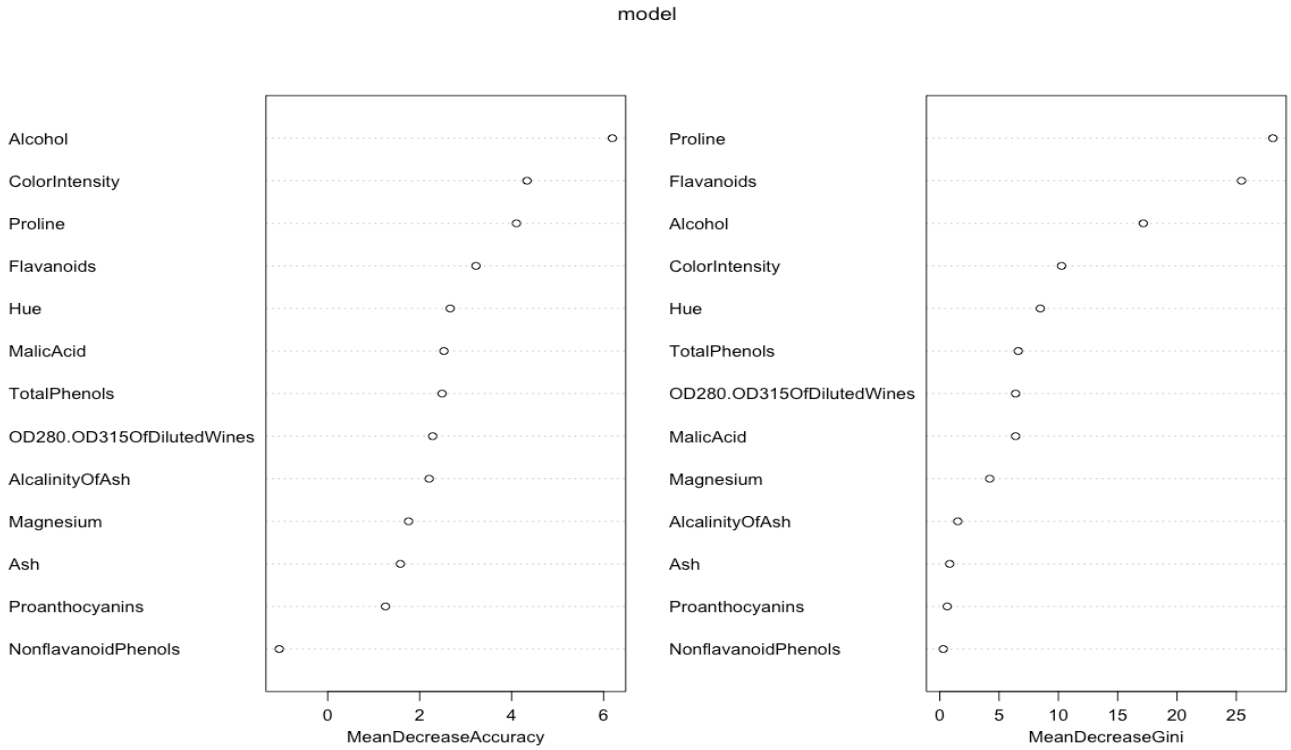
RBF SVM depends on 2 parameters (c and sigma), that is why there is more combinations for models. The search strategy followed here is grid search where each value of C is tested with every value for Sigma. Random forests depend mainly on one parameter which is the number of trees. Which mean there is less combinations for the model compared to RBF SVM. The random forest is trained with each value for the number of trees.

Wine Dataset Variable Importance for Random Forests:

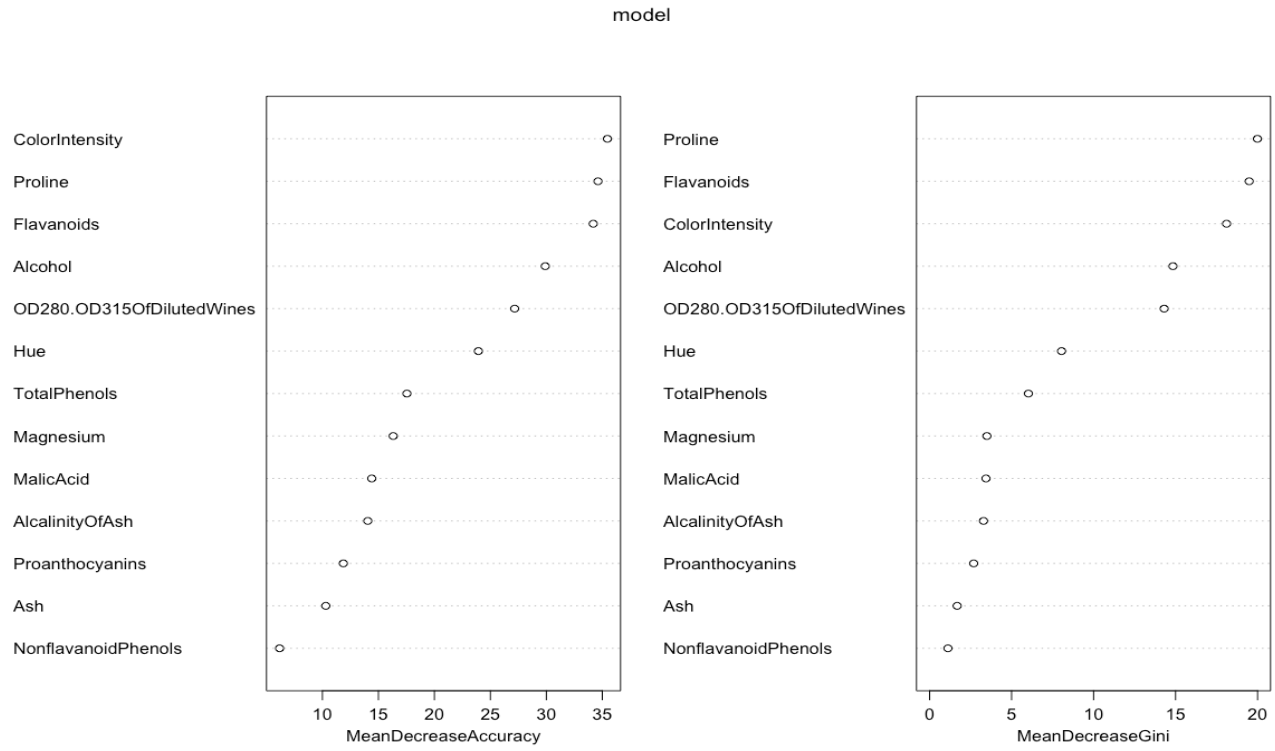
The following figure shows the variable importance for a random tree with 10 trees:



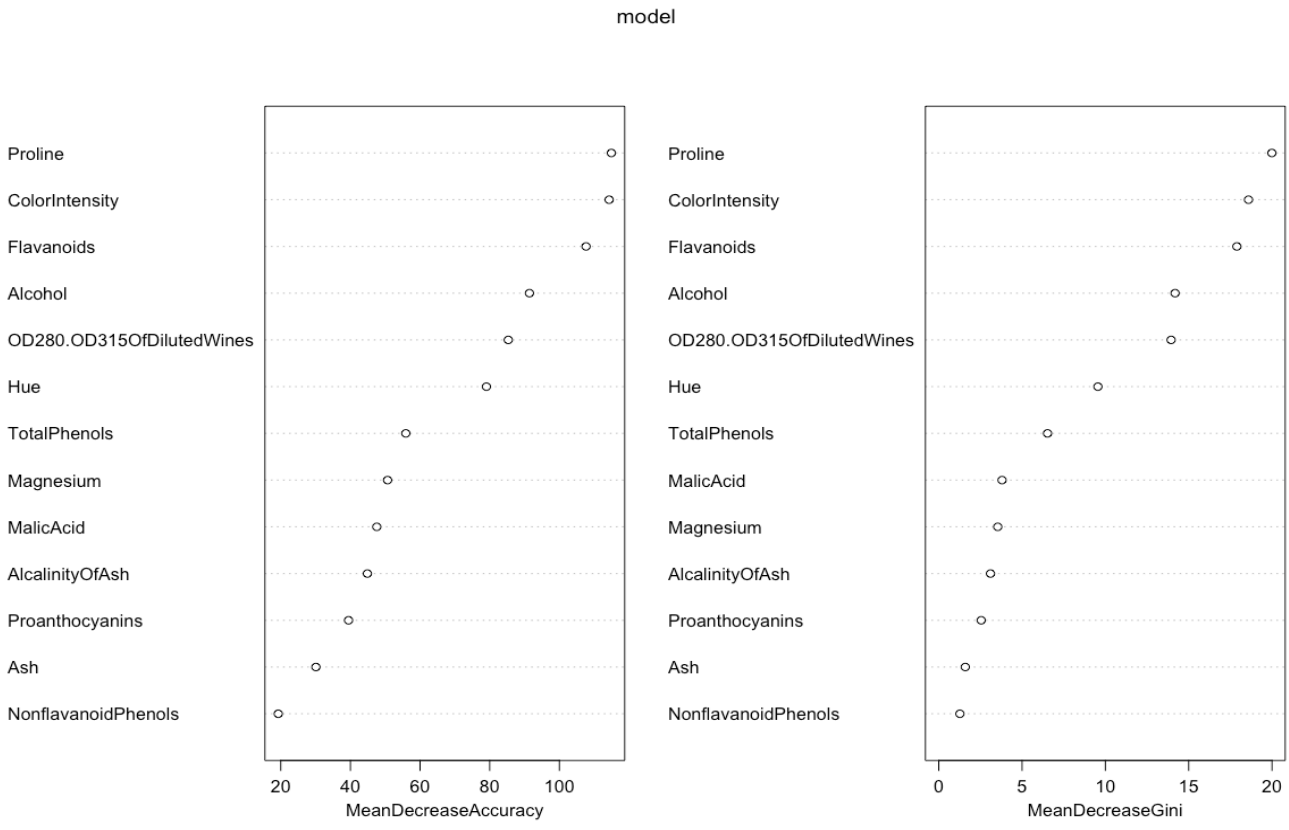
The following figure shows the variable importance for a random tree with 100 trees:



The following figure shows the variable importance for a random tree with 1000 trees:



The following figure shows the variable importance for a random tree with 10000 trees:



From the last 4 figures, one can see that some of the dataset variables has noticeable effect on the accuracy of the tree classification (e.g. Proline & Flavanoids & Alcohol & Color Intensity) seem to play a vital role in the random forest classification process. The insight that can be deduced from this observation is that the values of such attribute as Alcohol and Color Intensity are a good indicator of the class of the wine.

Preferred Method for Wine Dataset:

Deciding which is better for this dataset is tough as both SVM and Random Forest perform very well on this dataset. The best models of each type have very close error values and also the runtime for both is very low. However the best RBF SVM has a very low validation error which might be a plus for choosing SVM.