COL341: Assignment 3

Note: random_state has been set to 0 for consistent results

Single-state

Faces at 1, Rest at 0

.	3.1A (IG)	3.1A (GINI)	3.1B (GINI)	3.1B (IG)
Training Time	139.0977933	162.330637	3.567991257	2.245169163
		On	Train	
Accuracy	0.8555	0.8635	0.9885	0.999
Precision of state 1	0.903935957	0.897602074	0.988749173	1
Precision of state 0	0.710578842	0.748358862	0.987730061	0.996015936
Recall of state 1	0.903333333	0.923333333	0.996	0.998666667
Recall of state 0	0.712	0.684	0.966	1
		On	Validation	
Accuracy	0.825	0.8175	0.9275	0.9425
Precision of state 1	0.888513514	0.874587459	0.935691318	0.969491525
Precision of state 0	0.644230769	0.639175258	0.898876404	0.866666667
Recall of state 1	0.876666667	0.883333333	0.97	0.953333333
Recall of state 0	0.67	0.62	0.8	0.91

.	3.1C (Default)	3.1C (GridSearch)	3.1D (BestPruned)	3.1E (Default)	3.1E (GridSearch)
Training Time	0.015074968	0.01129365	-	5.681501865	6.592205048
		On	Train		
Accuracy	0.9295	0.8775	0.9755	1	1
Precision of state 1	0.974842767	0.928327645	0.972638436	1	1
Precision of state 0	0.815465729	0.738317757	0.984946237	1	1
Recall of state 1	0.93	0.906666667	0.995333333	1	1
Recall of state 0	0.928	0.79	0.916	1	1
		On	Validation		
Accuracy	0.885	0.8775	0.935	0.9725	0.9825
Precision of state 1	0.934931507	0.93728223	0.936305732	0.964630225	0.977198697
Precision of state 0	0.75	0.725663717	0.930232558	1	1
Recall of state 1	0.91	0.896666667	0.98	1	1
Recall of state 0	0.81	0.82	0.8	0.89	0.93

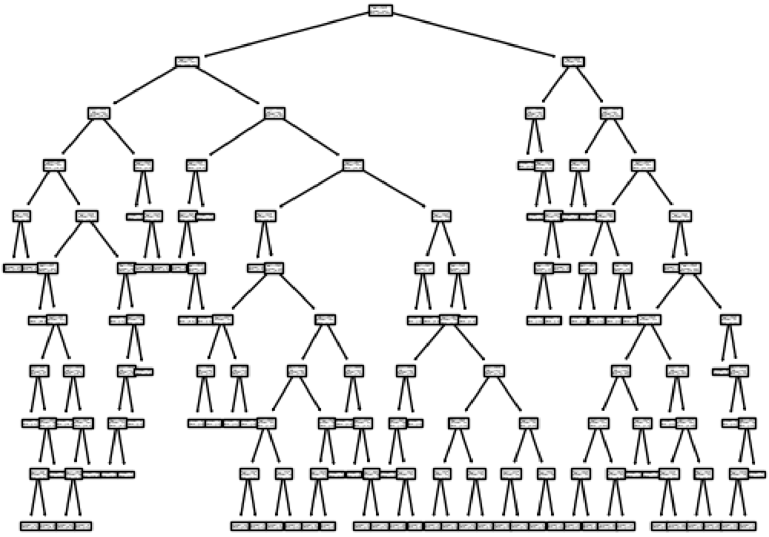
.	3.1F (Gradient)	3.1F (GradientGS)	3.1F (XGBoost)	3.1F (XGBoostGS)
Training Time	116.5799448	Too long*	5.303102255	4.706798553
		On	Train	
Accuracy	1	-	1	1
Precision of state 1	1	-	1	1
Precision of state 0	1	-	1	1
Recall of state 1	1	-	1	1
Recall of state 0	1	-	1	1
		On	Validation	
Accuracy	0.98	-	0.9875	0.9775
Precision of state 1	0.980263158	-	0.983606557	0.97704918
Precision of state 0	0.979166667	-	1	0.978947368
Recall of state 1	0.993333333	-	1	0.993333333
Recall of state 0	0.94	-	0.95	0.93

*- Insufficient processing power to compute under 8 hours

Analysis of Sections

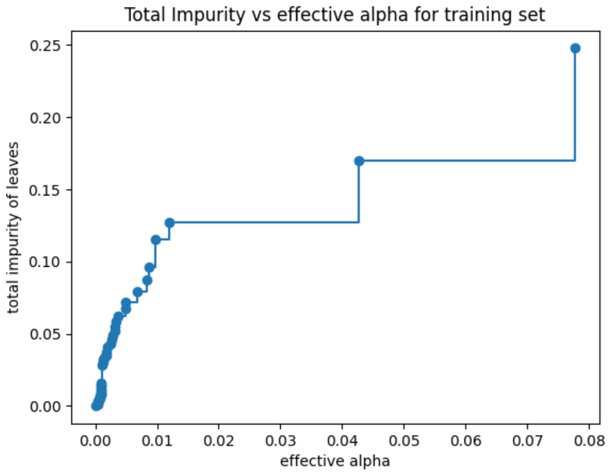
3.1c

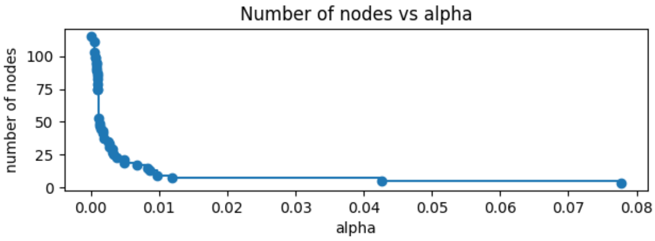
Visualised tree for SelectKBest

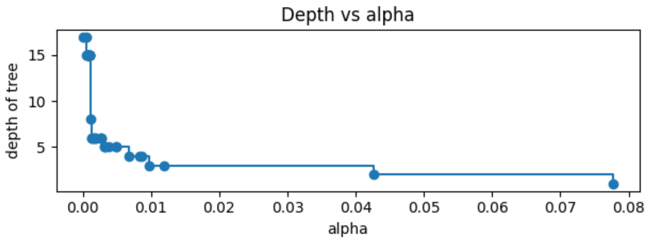


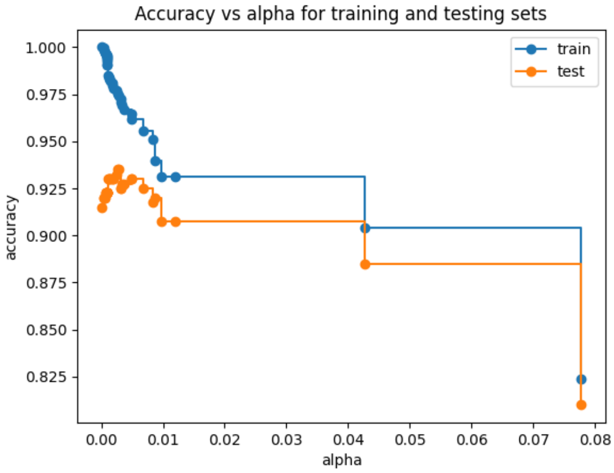
3.1d

Required graphs


Total Impurity vs effective alpha for training set


Number of nodes vs alpha


Depth vs alpha

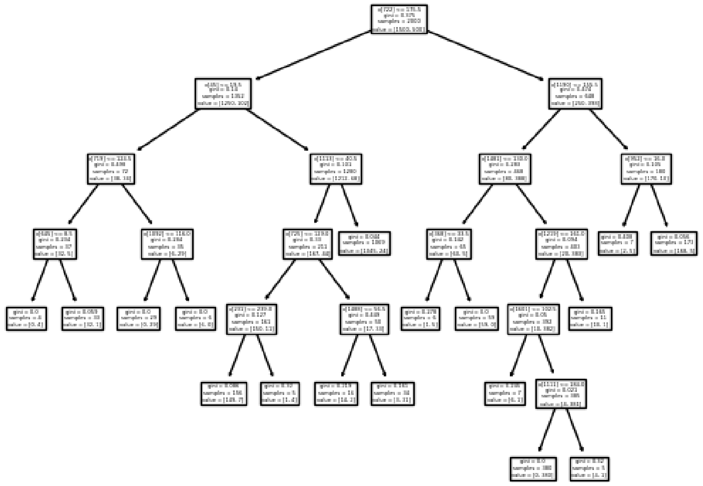

Accuracy vs alpha for training and testing sets

On training data, accuracy decreases with increase in alpha. We cannot conclude anything substantial from this. However, on testing data, accuracy first increases then decreases.

This clearly shows that post-pruning using ccp_alpha can correct overfitting to some extent (for ideal selection of ccp_alpha), however on increasing beyond this point accuracy is compromised.

ccp_alpha controls a trade-off between complexity of a subtree and how well it fits to training data. With increase in alpha, effect of complexity becomes more prominent and in turn tree is pruned, thus reducing accuracy on training data.

Cost function is penalised by adding a term + ccp_alpha*|Complexity measure of tree|, similar to addition of penalty in linear regression to make ridge regression.

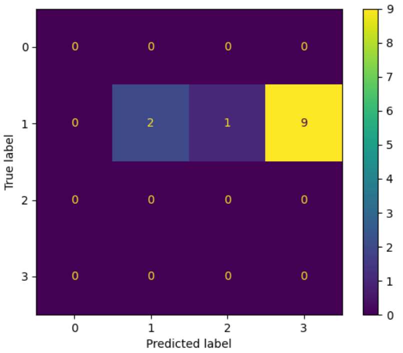


Visualisation of best-pruned tree tree on validation split

3.2g

Model used: XGBClassifier() with best parameters as learned by Grid-Search

Images are variations of completely in frame, zoomed or misaligned (9 of my own, 3 of another).

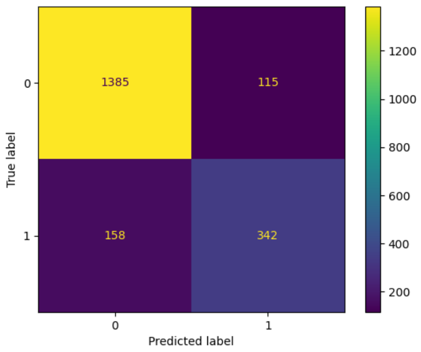


Despite good performance of classifier on validation set, it classifies these images poorly (2 correctly, 1 incorrectly as airplane, 9 incorrectly as dogs). This could be due to bias in the selection of images for training and validation purposes.

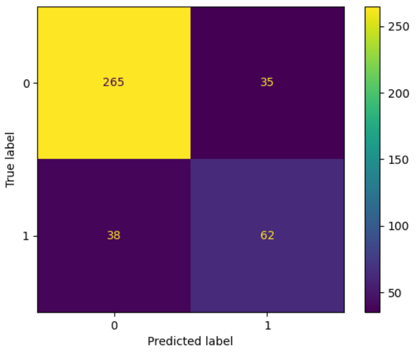
Confusion Matrix and Parameters (3.1g)

- Decision tree from scratch (3.1a)

GINI Index

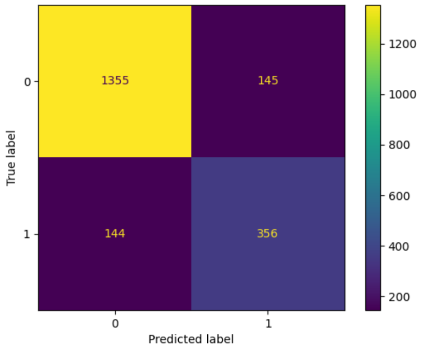


Confusion Matrix on Train data

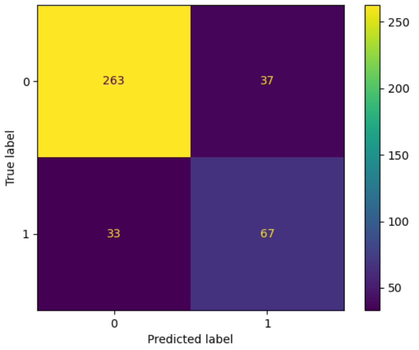


Confusion Matrix on Validation data

IG



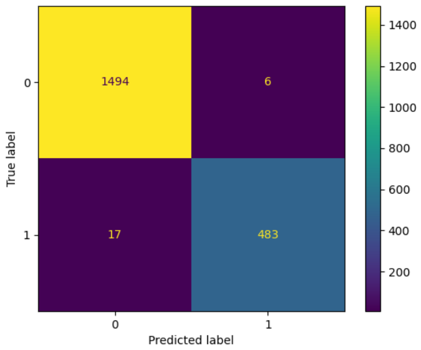
Confusion Matrix on Train data



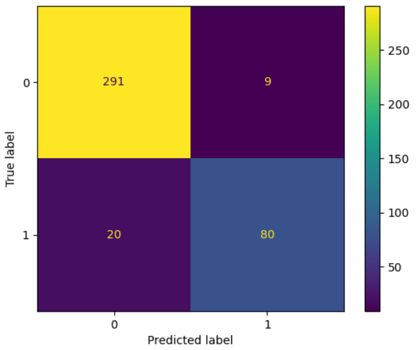
Confusion Matrix on Validation data

- Decision Tree sklearn (3.1b)

GINI Index

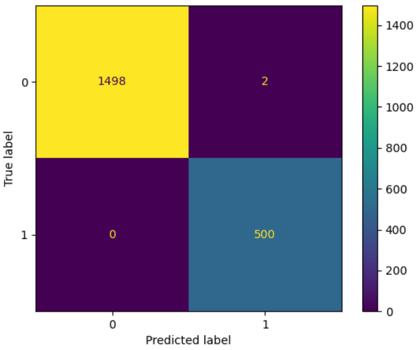


Confusion Matrix on Train data

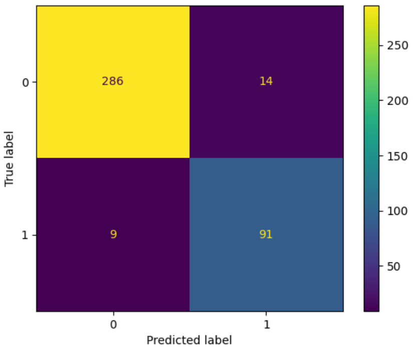


Confusion Matrix on Validation data

IG



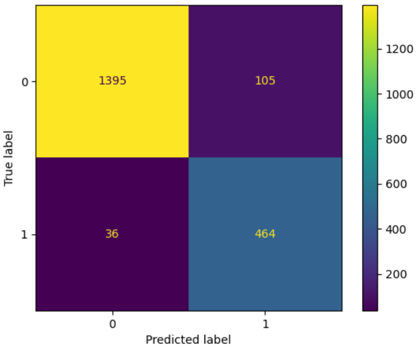
Confusion Matrix on Train data



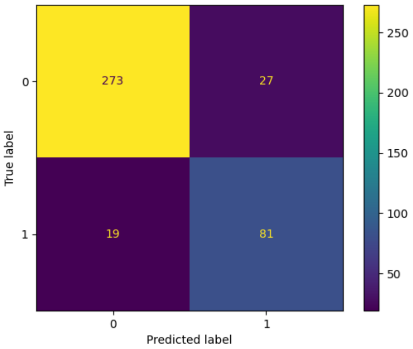
Confusion Matrix on Validation data

- Decision Tree Grid-Search (3.1c)

Default

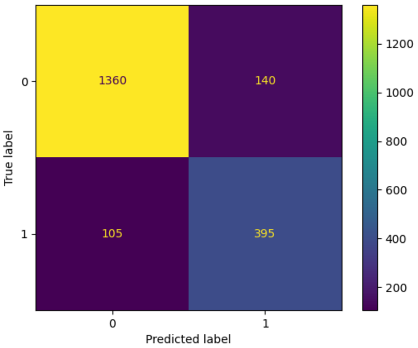


Confusion Matrix on Train data

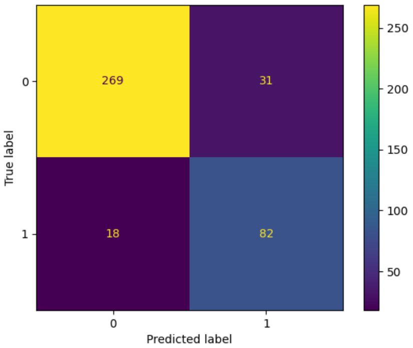


Confusion Matrix on Validation data

Best parameters: {'criterion': 'entropy', 'max_depth': 5, 'min_samples_split': 4}



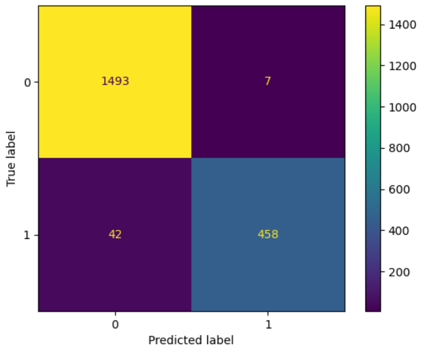
Confusion Matrix on Train data



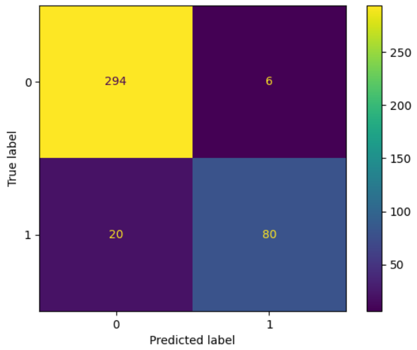
Confusion Matrix on Validation data

- Decision Tree Post Pruning with Cost Complexity Pruning (3.1d)

Best-performing tree on validation split



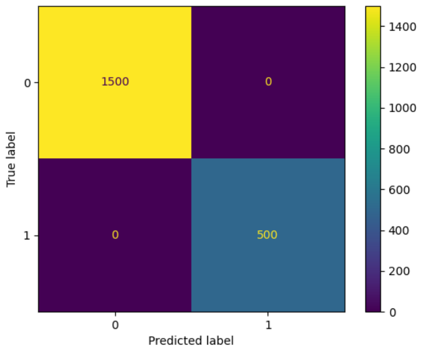
Confusion Matrix on Train data



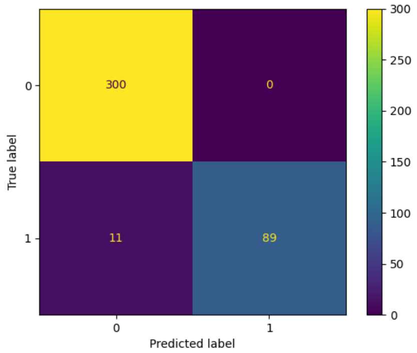
Confusion Matrix on Validation data

- Random forests (3.1e)

Default



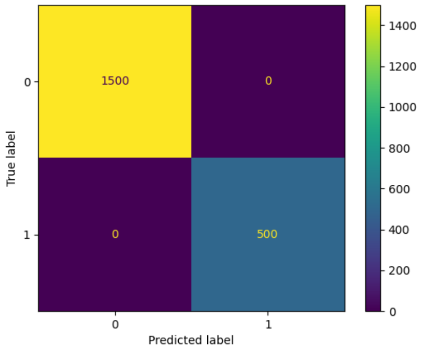
Confusion Matrix on Train data



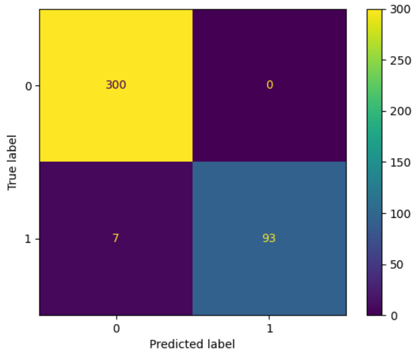
Confusion Matrix on Validation data

Grid-Search Best Parameters

Best parameters: {'criterion': 'entropy', 'max_depth': None, 'min_samples_split': 7, 'n_estimators': 150}



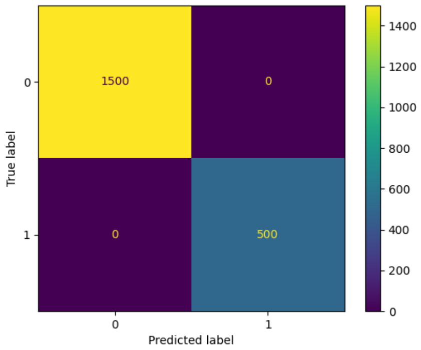
Confusion Matrix on Train data



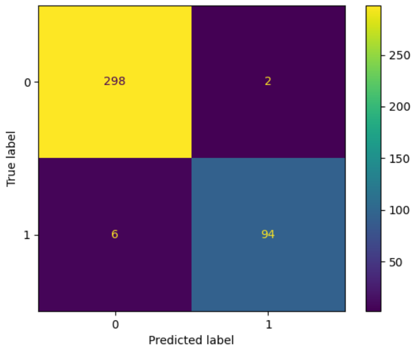
Confusion Matrix on Validation data

- Gradient Boosted Trees and XGBoost (3.1f)

Gradient Boosted with Default



Confusion Matrix on Train data

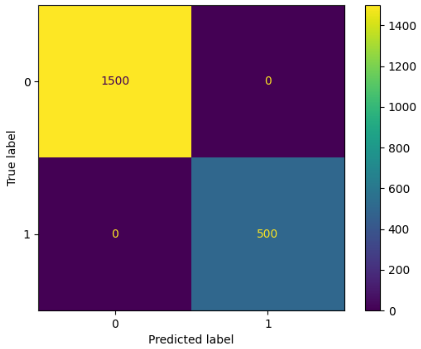


Confusion Matrix on Validation data

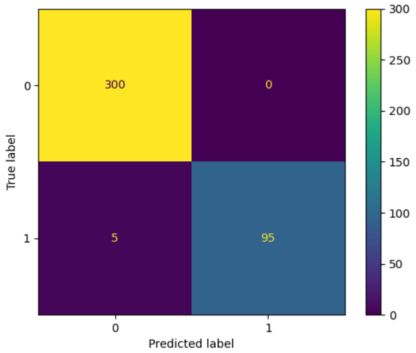
Gradient Boosted with Grid-Search Best Parameters

Note: Unable to complete regular, took ~8 hours.

XGBoost with Default



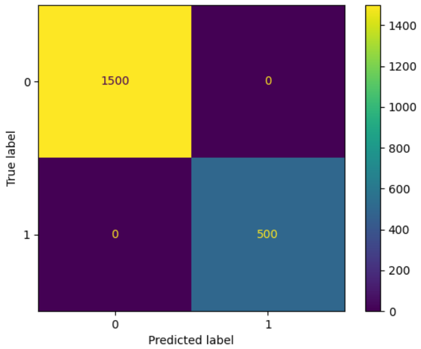
Confusion Matrix on Train data



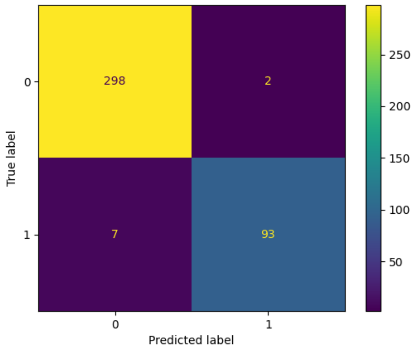
Confusion Matrix on Validation data

XGBoost with Grid-Search Best Parameters

Best parameters: {'max_depth': 6, 'n_estimators': 40, 'subsample': 0.6}



Confusion Matrix on Train data



Confusion Matrix on Validation data

Multi-state

Cars at 0, Faces at 1, Airplanes at 2, Dogs at 3

.	3.2A (GINI)	3.2A (IG)	3.2B (Default)	3.2B (GridSearch)
Training Time	3.27023983	4.622252703	0.013673067	0.014748335
		On	Train	
Accuracy	0.969	0.971	0.8105	0.669
		On	Validation	
Accuracy	0.7425	0.7225	0.6325	0.6025

.	3.2C (BestPruned)	3.2D (Default)	3.2D (GridSearch)	3.2E (Gradient)
Training Time	-	9.960266113	9.01617837	704.1730013
	On	Train		
Accuracy	0.957	1	0.9985	1
	On	Validation		
Accuracy	0.7425	0.8725	0.8775	0.8925

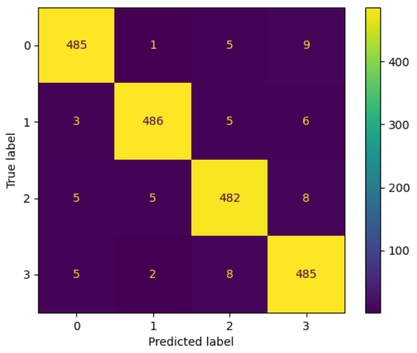
.	3.2E (GradientGS)	3.2E (XGBoost)	3.2E (XGBoostGS)
Training Time	Too long*	28.95156932	27.03962278
	On	Train	
Accuracy	-	1	1
	On	Validation	
Accuracy	-	0.9025	0.91

*- Insufficient processing power to compute under 8 hours

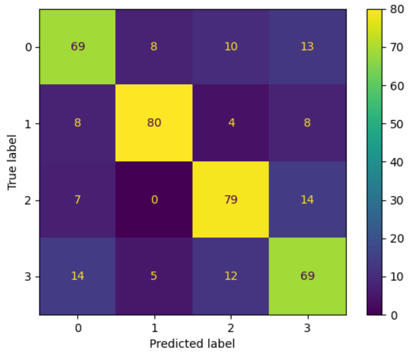
Confusion Matrix and Parameters (3.2f)

- Decision Tree sklearn (3.2a)

GINI Index

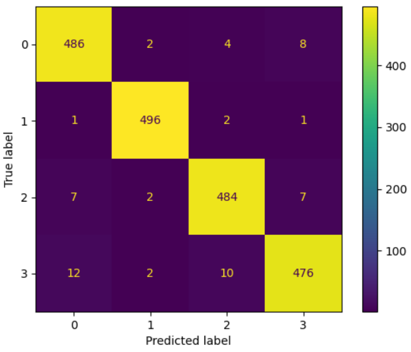


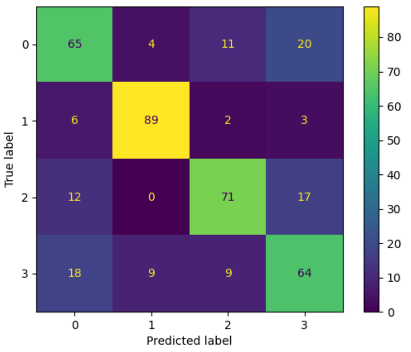
Confusion Matrix on Train data



Confusion Matrix on Validation data

IG



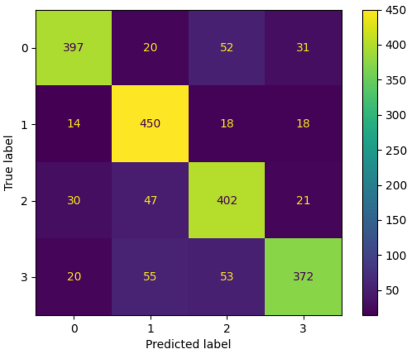


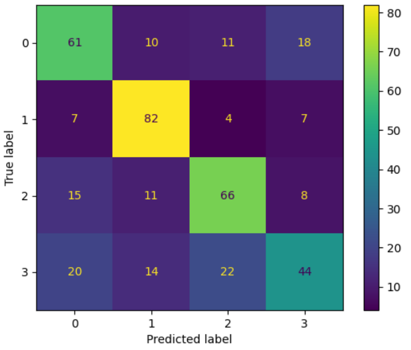
Confusion Matrix on Train data

Confusion Matrix on Validation data

- Decision Tree Grid-Search (3.2b)

Default:

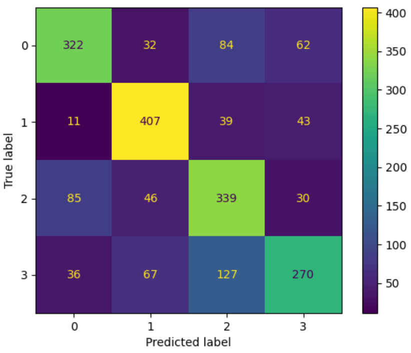


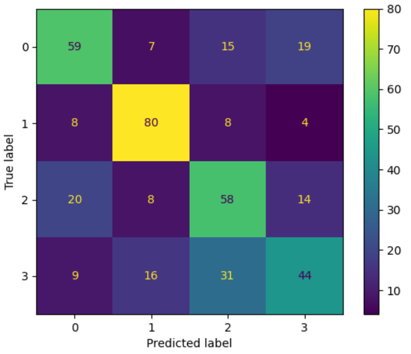


Confusion Matrix on Train data

Confusion Matrix on Validation data

Best parameters: {'criterion': 'entropy', 'max_depth': 5, 'min_samples_split': 4}



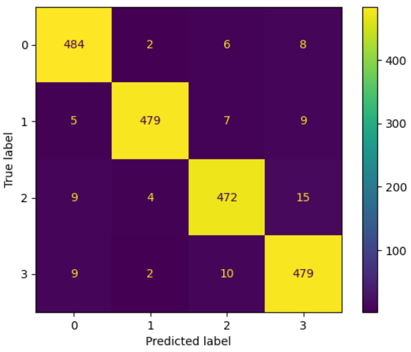


Confusion Matrix on Train data

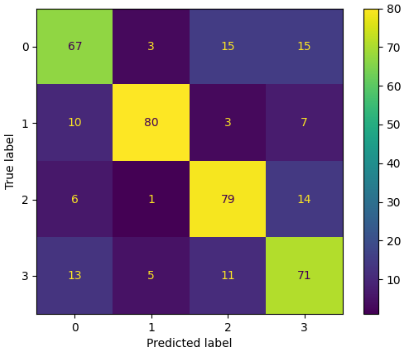
Confusion Matrix on Validation data

- Decision Tree Post Pruning with Cost Complexity Pruning (3.2c)

Best-performing tree



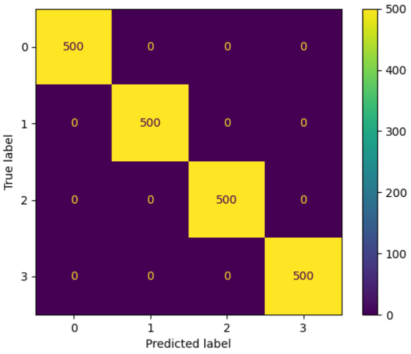
Confusion Matrix on Train data



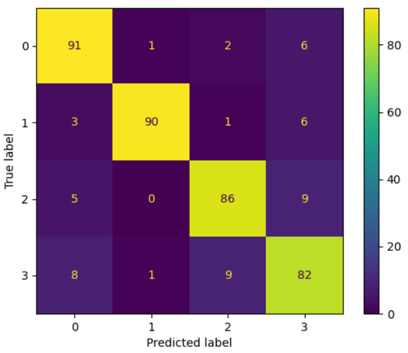
Confusion Matrix on Validation data

- Random forests (3.2d)

Default



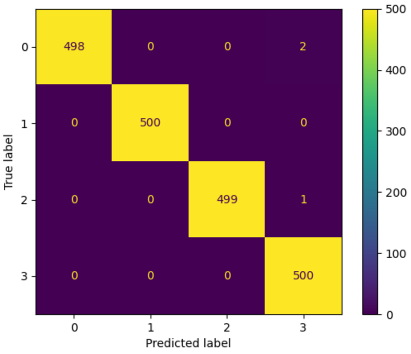
Confusion Matrix on Train data



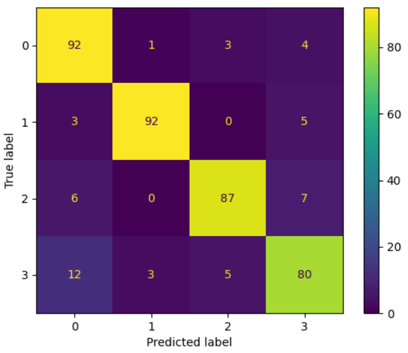
Confusion Matrix on Validation data

Grid-Search Best Parameters

Best parameters: {'criterion': 'entropy', 'max_depth': 10, 'min_samples_split': 10, 'n_estimators': 100}



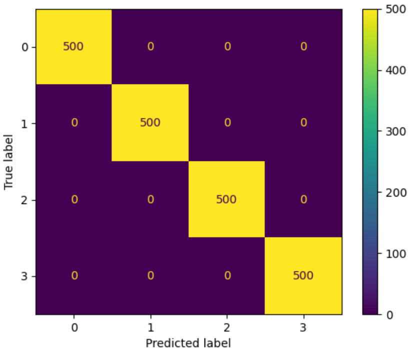
Confusion Matrix on Train data



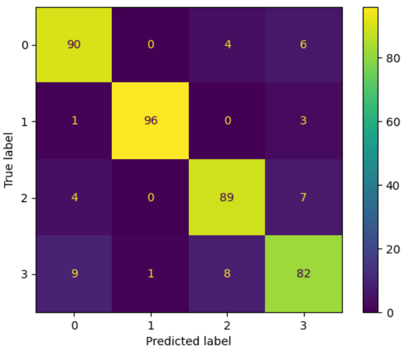
Confusion Matrix on Validation data

- Gradient Boosted Trees and XGBoost (3.2e)

Default



Confusion Matrix on Train data

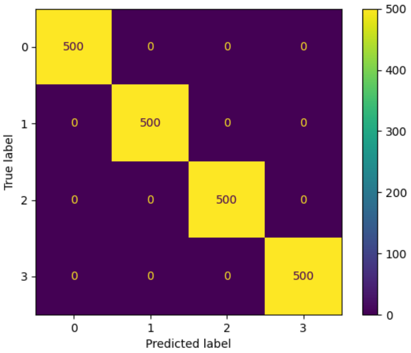


Confusion Matrix on Validation data

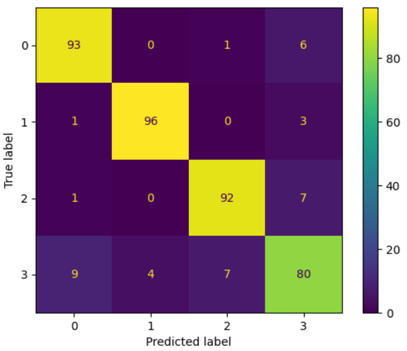
Gradient Boosted with Grid-Search Best Parameters

Note: Unable to complete, took ~8 hours

Default



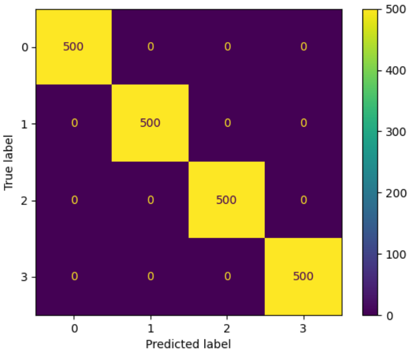
Confusion Matrix on Train data



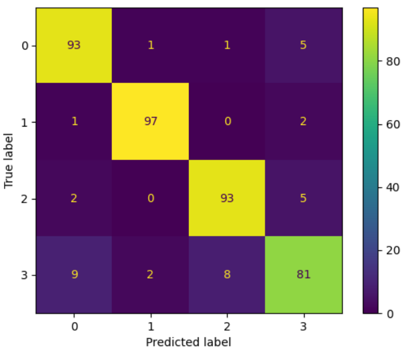
Confusion Matrix on Validation data

XGBoost with Grid-Search Best Parameters

Best parameters: {'max_depth': 10, 'n_estimators': 50, 'subsample': 0.6}



Confusion Matrix on Train data



Confusion Matrix on Validation data

Glossary

$$Accuracy = \frac{True\ Positive + True\ Negative}{Total}$$

$$Precision = \frac{True\ Positive}{True\ Positive\ +\ False\ Positive}$$

$$Recall = \frac{True\ Positive}{True\ Positive\ +\ False\ Negative}$$