1. Decision Trees (and Random Forests)

1(a) Decision Tree Construction

Decision tree was constructed with the following depths : 5, 10, 15, 20, 25
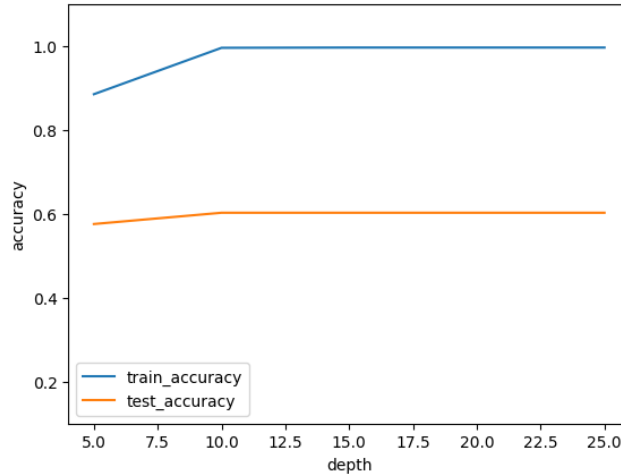

Figure 1: Test and train accuracy

only win test accuracy : 50.05
only lose test accuracy : 49.94

1(b) Decision Tree One Hot Encoding

Categorical attributes having more than 2 categories have been encoded using one hot encoding. The above categorical attributes having more than 2 categories were replaced with respective one hot encoding attributes.Transformed dataset with maximum depths for {15, 25, 35, 45}
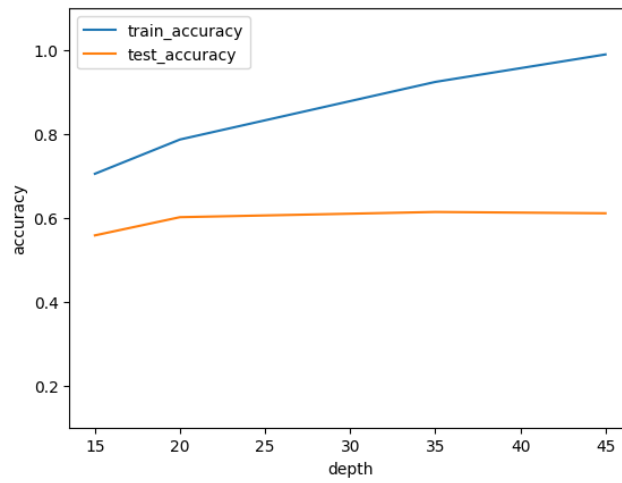
Figure 2: Test and train accuracy

1(c) Decision Tree Post Pruning

1(d) Decision Tree sci-kit learn

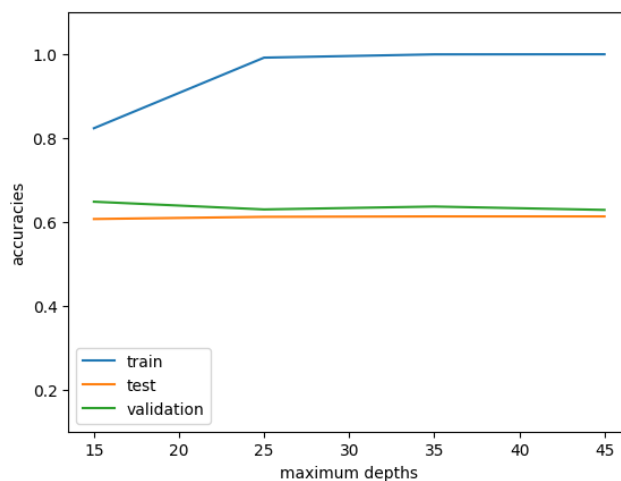max depths = {15, 25, 35, 45} ccp alphas = {0.001, 0.01, 0.1, 0.2}

Figure 3: Test and train accuracy varied with depth

DecisionTreeClassifier(ccp_alpha=0.001, criterion='entropy', max_depth=15)

Test accuracy from DT model of part b = 0.6111

Test accuracy from Sk-learn model = 0.6132

1 Random Forest

Fitting 5 folds for each of 100 candidates, totalling 500 fits

Training Accuracy of the Best Estimator: 99.05

Testing Accuracy of the Best Estimator: 72.39

Validation Accuracy of the Best Estimator: 69.89

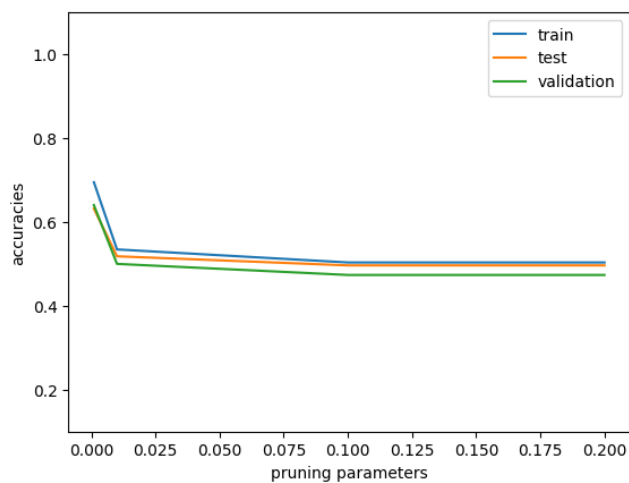OOB Score of the Best Estimator: 0.72

Figure 4: Test and train accuracy varied with ccp$_alphas$

Neural Network Experiment Report

November 3, 2023

Introduction

Briefly introduce the problem, the motivation behind the experiment, and the goals of your study.

Part(a)

- Mini-Batch Size (M): 32

- Number of Features (n): 1024

- Number of Target Classes (r): 5

- Learning rate : 0.001

Part (b): Single Hidden Layer Experiment

Describe the experiment details, including the varying number of hidden layer units.

- Learning Rate: 0.01

- Mini-Batch Size: 32

- Hidden Layer Units: [1, 5, 10, 50, 100]

- Stopping Criterion: 1e-5

Results

Metrics for Training Data	
Metrics	Values
Precision	0.25
Recall	0.29
F1 Score	0.18
Accuracy	29.42%

Metrics for Training Data (Run 1)

Metrics for Testing Data	
Metrics	Values
Precision	0.14
Recall	0.29
F1 Score	0.18
Accuracy	29.00%

Metrics for Testing Data (Run 1)

Metrics for Training Data	
Metrics	Values
Precision	0.32
Recall	0.36
F1 Score	0.26
Accuracy	36.43%

Metrics for Training Data (Run 2)

Metrics for Testing Data	
Metrics	Values
Precision	0.23
Recall	0.36
F1 Score	0.26
Accuracy	35.80%

Metrics for Testing Data (Run 2)

Metrics for Training Data	
Metrics	Values
Precision	0.43
Recall	0.46
F1 Score	0.43
Accuracy	46.36%

Metrics for Training Data (Run 3)

Metrics for Testing Data	
Metrics	Values
Precision	0.40
Recall	0.46
F1 Score	0.41
Accuracy	45.70%

Metrics for Testing Data (Run 3)

Metrics for Training Data	
Metrics	Values
Precision	0.55
Recall	0.56
F1 Score	0.55
Accuracy	56.35%

Metrics for Training Data (Run 4)

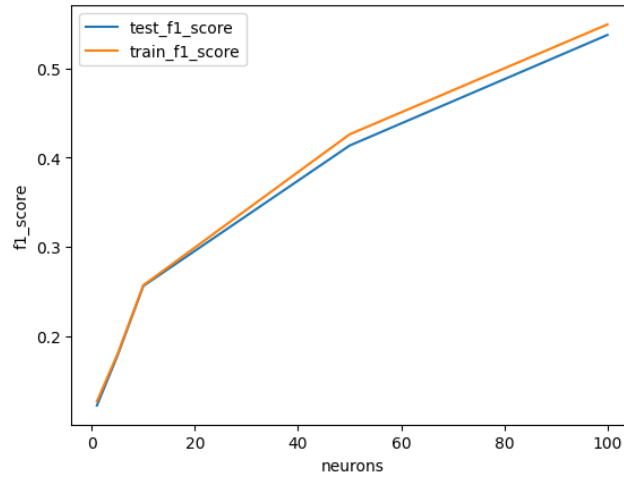| Metrics for Testing Data	
Metrics	Values
Precision	0.54
Recall	0.55
F1 Score	0.54
Accuracy	55.00%

Metrics for Testing Data (Run 4)

Figure 5: $f_1 scores$

f1 score and accuracy increases with increase in number of neurons in a layer.

Part (c): Varying Network Depth Experiment

Describe the experiment details, including the varying network depths.

- Learning Rate: 0.01

- Mini-Batch Size: 32

- Hidden Layer Sizes: [512], [512, 256], [512, 256, 128], [512, 256, 128, 64]

- Stopping Criterion: 1e-5

Results

Metrics for Training Data	
Metrics	Values
Precision	0.62
Recall	0.61
F1 Score	0.61
Accuracy	60.91%

Table 1: [512]

Metrics for Test Data	
Metrics	Values
Precision	0.59
Recall	0.58
F1 Score	0.58
Accuracy	58.00%

Table 2: [512]

Metrics for Training Data	
Metrics	Values
Precision	0.66
Recall	0.67
F1 Score	0.66
Accuracy	66.70%

Table 3: [512, 256]

Metrics for Test Data	
Metrics	Values
Precision	0.62
Recall	0.63
F1 Score	0.62
Accuracy	63.00%

Table 4: [512, 256]

Metrics for Training Data	
Metrics	Values
Precision	0.71
Recall	0.70
F1 Score	0.70
Accuracy	70.05%

Table 5: [512, 256, 128]

Metrics for Test Data	
Metrics	Values
Precision	0.64
Recall	0.63
F1 Score	0.63
Accuracy	63.00%

Table 6: [512, 256, 128]

Metrics for Training Data	
Metrics	Values
Precision	0.66
Recall	0.67
F1 Score	0.67
Accuracy	67.37%

Table 7: [512, 256, 128, 64]

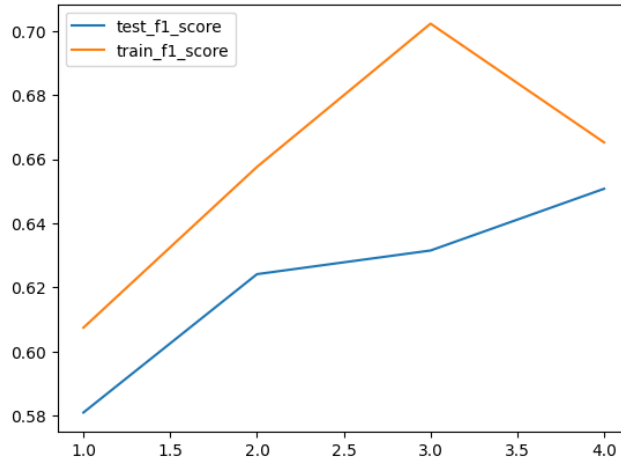| Metrics for Test Data	
Metrics	Values
Precision	0.65
Recall	0.65
F1 Score	0.65
Accuracy	65.40%

Table 8: [512, 256, 128, 64]

Figure 6: f$_1$ $scores$

Part (d): Adaptive Learning Rate Experiment

- Initial Learning Rate: 0.01

- Mini-Batch Size: 32

- Hidden Layer Sizes: [512], [512, 256], [512, 256, 128], [512, 256, 128, 64]

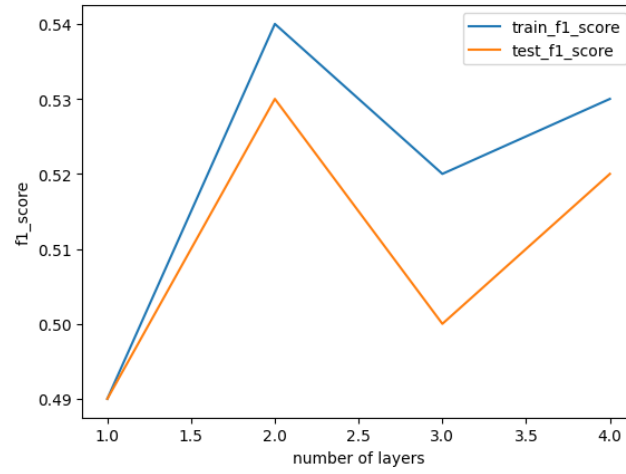- Stopping Criterion: 1e-6

Results

Figure 7: $f_1 scores$

From below results we can see that for adaptive learning training in fatser but accuracy is compromised.

Metrics for Training Data	
Metrics	Values
Precision	0.49
Recall	0.49
F1 Score	0.49
Accuracy	49.37%

Table 9: Metrics for Training Data [512]

Metrics for Test Data [512]	
Metrics	Values
Precision	0.49
Recall	0.49
F1 Score	0.49
Accuracy	49.20%

Table 10: Metrics for Test Data [512]

Metrics for Training Data	
Metrics	Values
Precision	0.54
Recall	0.54
F1 Score	0.54
Accuracy	54.06%

Table 11: Metrics for Training Data [512, 256]

Metrics for Test Data [512, 256]	
Metrics	Values
Precision	0.53
Recall	0.53
F1 Score	0.53
Accuracy	52.50%

Table 12: Metrics for Test Data [512, 256]

Metrics for Training Data	
Metrics	Values
Precision	0.52
Recall	0.52
F1 Score	0.52
Accuracy	52.28%

Table 13: Metrics for Training Data [512, 256, 128]

Metrics for Test Data [512, 256, 128]	
Metrics	Values
Precision	0.51
Recall	0.50
F1 Score	0.50
Accuracy	50.20%

Table 14: Metrics for Test Data [512, 256, 128]

Metrics for Training Data [512, 256]	
Metrics	Values
Precision	0.53
Recall	0.55
F1 Score	0.53
Accuracy	54.74%

Table 15: Metrics for Training Data [512, 256]

Metrics for Test Data [512, 256]	
Metrics	Values
Precision	0.52
Recall	0.53
F1 Score	0.52
Accuracy	53.00%

Table 16: Metrics for Test Data [512, 256]

Metrics for Training Data	
Metrics	Values
Precision	0.53
Recall	0.55
F1 Score	0.53
Accuracy	54.74%

Table 17: Metrics for Training Data [512, 256, 128, 64]

Metrics for Test Data	
Metrics	Values
Precision	0.52
Recall	0.53
F1 Score	0.52
Accuracy	53.00%

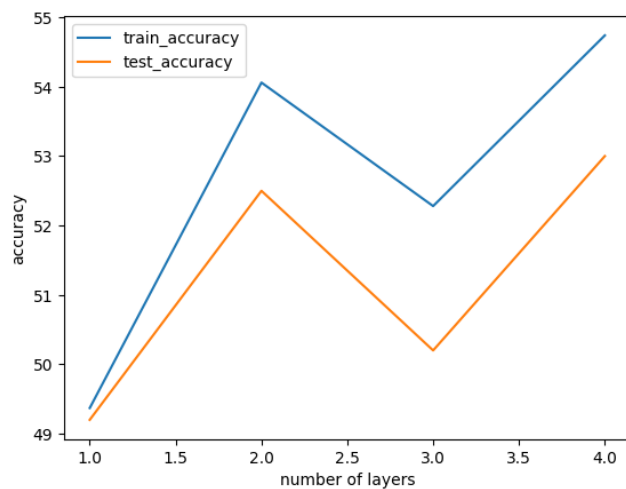Table 18: Metrics for Test Data [512, 256, 128, 64]

Figure 8: accuracy

Part (e): ReLU Activation Experiment

Describe the experiment details, including the use of ReLU activation and subgradients for non-differentiability.

- Initial Learning Rate: 0.01

- Mini-Batch Size: 32

- Hidden Layer Sizes: [512], [512, 256], [512, 256, 128], [512, 256, 128, 64]
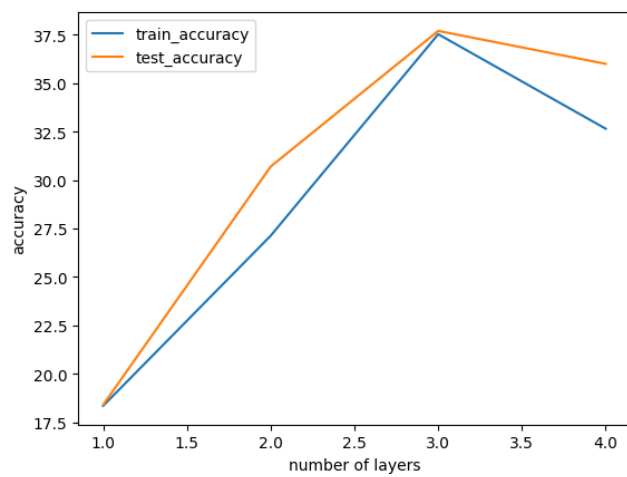
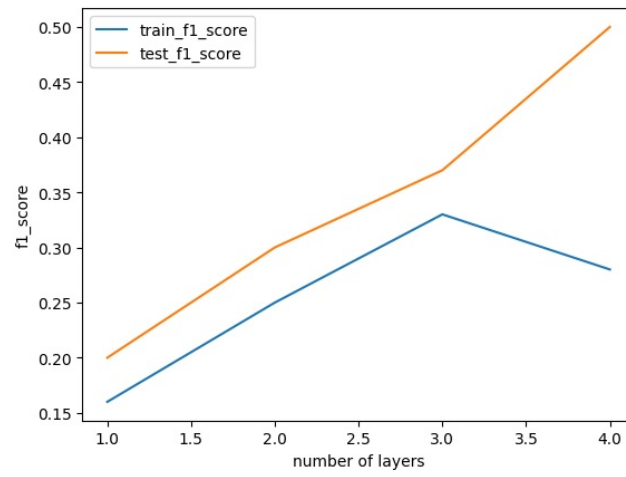- Stopping Criterion: 1e-6

Results

Figure 9: accuracy

Figure 10: $f_1 scores$

Metrics for Training Data	
Metrics	Values
Precision	0.24
Recall	0.18
F1 Score	0.16
Accuracy	18.35%

Table 19: Metrics for Training Data [512]

Metrics for Test Data	
Metrics	Values
Precision	0.20
Recall	0.18
F1 Score	0.17
Accuracy	18.40%

Table 20: Metrics for Test Data [512]

Metrics for Training Data	
Metrics	Values
Precision	0.36
Recall	0.27
F1 Score	0.25
Accuracy	27.13%

Table 21: Metrics for Training Data [512, 256]

Metrics for Test Data	
Metrics	Values
Precision	0.38
Recall	0.31
F1 Score	0.30
Accuracy	30.70%

Table 22: Metrics for Test Data [512, 256]

Metrics for Training Data	
Metrics	Values
Precision	0.46
Recall	0.38
F1 Score	0.33
Accuracy	37.53%

Table 23: Metrics for Training Data [512, 256, 128]

Metrics for Test Data	
Metrics	Values
Precision	0.48
Recall	0.38
F1 Score	0.37
Accuracy	37.70%

Table 24: Metrics for Test Data [512, 256, 128]

Metrics for Training Data	
Metrics	Values
Precision	0.30
Recall	0.33
F1 Score	0.28
Accuracy	32.65%

Table 25: Metrics for Training Data [512, 256, 128, 64]

Metrics for Test Data	
Metrics	Values
Precision	0.29
Recall	0.36
F1 Score	0.50
Accuracy	36.00%

Table 26: Metrics for Test Data [512, 256, 128, 64]

Part (f): MLPClassifier Experiment

Describe the experiment details using MLPClassifier from scikit-learn.

- Hidden Layer Sizes: [512], [512, 256], [512, 256, 128], [512, 256, 128, 64]

- Activation Function: ReLU

- Solver: SGD

- Learning Rate Schedule: Inversely proportional to epochs
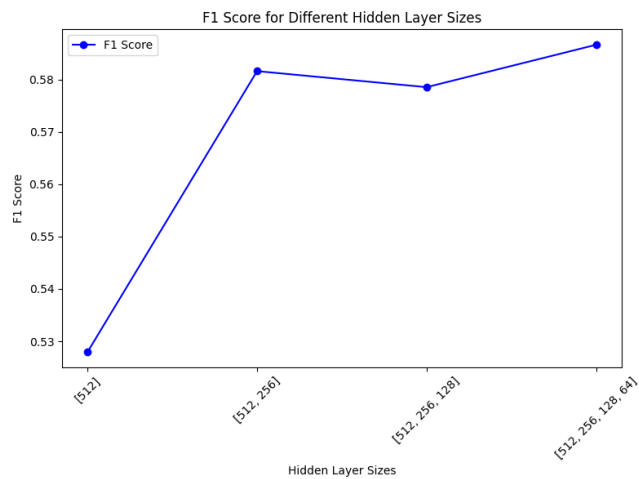
- Batch Size: 32

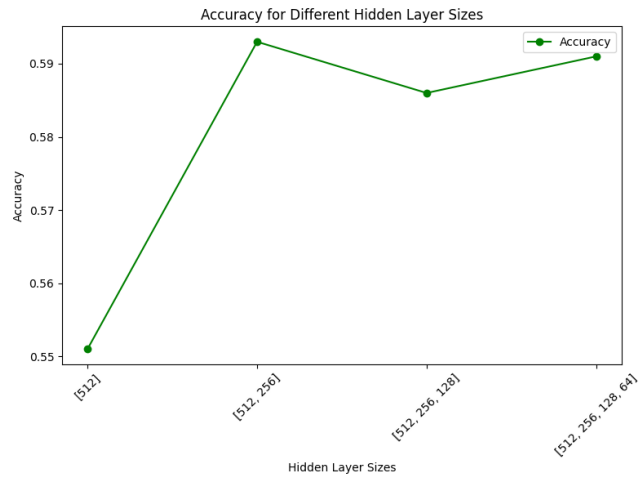- Stopping Criterion: [1e-5]

Results

Figure 11: $f_1 scores$

Figure 12: accuracy