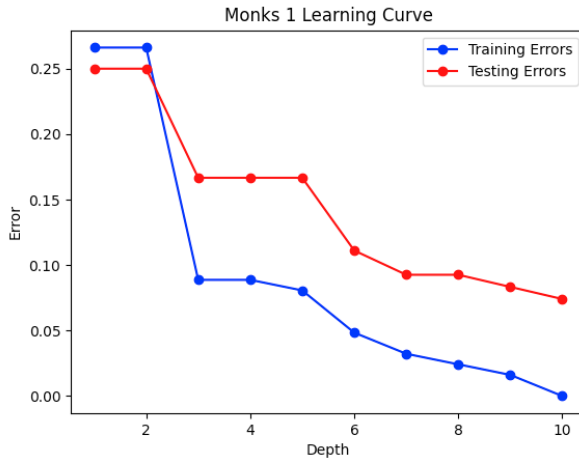


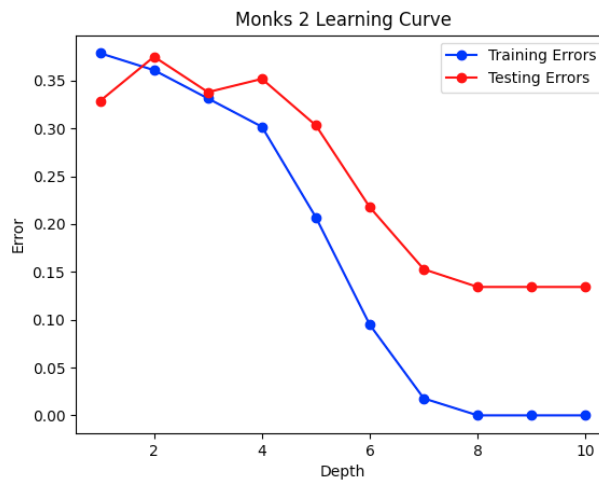
CS 6375.004 Programming Assignment #1
Tahmid Imran and Amogh Yatnatti

a.

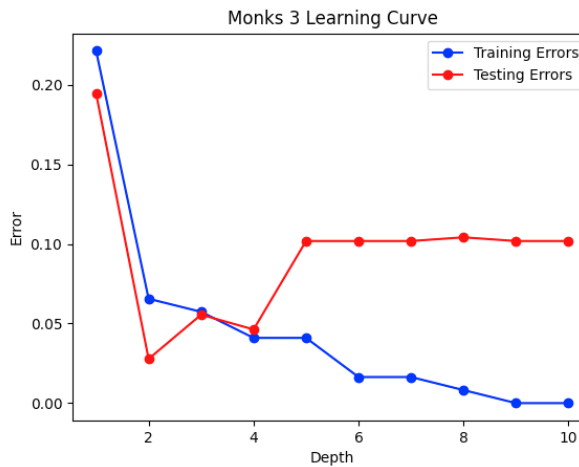
a. Learning Curves



i. Monks 1:



ii. Monks 2:



iii. Monks 3:

- b. Visualization Trees (of depth 10, doing it for every depth would result in a very long report):
- i. Monks 1:

```

TREE
+-- [SPLIT: x4 = 1]
|
+-- [SPLIT: x0 = 1]
|
+-- [SPLIT: x1 = 1]
|
+-- [SPLIT: x4 = 3]
|
+-- [SPLIT: x3 = 1]
|
+-- [SPLIT: x5 = 1]
|
+-- [SPLIT: x4 = 2]
|
+-- [SPLIT: x2 = 1]
|
+-- [LABEL = 1]
|
+-- [SPLIT: x2 = 1]
|
+-- [SPLIT: x0 = 2]
|
+-- [SPLIT: x1 = 2]
|
+-- [LABEL = 1]
|
+-- [SPLIT: x1 = 2]
|
+-- [LABEL = 0]
|
+-- [SPLIT: x0 = 2]
|
+-- [SPLIT: x1 = 2]
|
+-- [LABEL = 0]
|
+-- [SPLIT: x1 = 2]
|
+-- [LABEL = 1]
|
+-- [SPLIT: x4 = 2]
|
+-- [LABEL = 1]
|
+-- [SPLIT: x5 = 1]
|
+-- [SPLIT: x2 = 1]
|
+-- [SPLIT: x0 = 2]
|
+-- [LABEL = 0]
|
+-- [SPLIT: x0 = 2]
|
+-- [SPLIT: x1 = 2]
|
+-- [LABEL = 0]
|
+-- [SPLIT: x1 = 2]
|
+-- [LABEL = 1]
|
+-- [SPLIT: x2 = 1]
|
+-- [LABEL = 1]
|
+-- [SPLIT: x3 = 1]
|
+-- [SPLIT: x0 = 2]
|
+-- [SPLIT: x1 = 2]
|
+-- [LABEL = 1]
|
+-- [SPLIT: x1 = 2]
|
+-- [LABEL = 0]
|
+-- [SPLIT: x0 = 2]
|
+-- [LABEL = 1]
|
+-- [SPLIT: x4 = 3]
|
+-- [SPLIT: x1 = 2]
|
+-- [SPLIT: x0 = 2]
|
+-- [LABEL = 1]
|
+-- [SPLIT: x0 = 2]
|
+-- [LABEL = 0]
|
+-- [SPLIT: x1 = 2]
|
+-- [SPLIT: x0 = 2]
|
+-- [LABEL = 0]
|
+-- [SPLIT: x0 = 2]
|
+-- [LABEL = 1]
|
+-- [SPLIT: x1 = 1]
|
+-- [LABEL = 0]
|
+-- [SPLIT: x0 = 1]
|
+-- [SPLIT: x1 = 1]
|
+-- [LABEL = 0]
|
+-- [SPLIT: x1 = 1]
|
+-- [LABEL = 1]
|
+-- [SPLIT: x4 = 1]
|
+-- [LABEL = 1]

```

ii. Monks 2 (2 parts):

[illegible]

```

| | | | | +--- [SPLIT: x5 = 1]
| | | | | | +--- [LABEL = 0]
| +--- [SPLIT: x4 = 2]
| | | | | +--- [SPLIT: x2 = 1]
| | | | | | +--- [SPLIT: x1 = 2]
| | | | | | | +--- [SPLIT: x0 = 1]
| | | | | | | | +--- [SPLIT: x1 = 1]
| | | | | | | | | +--- [LABEL = 0]
| | | | | | | | | +--- [SPLIT: x1 = 1]
| | | | | | | | | | +--- [SPLIT: x5 = 1]
| | | | | | | | | | | +--- [LABEL = 0]
| | | | | | | | | | | +--- [SPLIT: x5 = 1]
| | | | | | | | | | | | +--- [LABEL = 1]
| | | | | | | | | | | | +--- [SPLIT: x0 = 1]
| | | | | | | | | | | | | +--- [LABEL = 1]
| | | | | | | | | | | | +--- [SPLIT: x1 = 2]
| | | | | | | | | | | | | +--- [LABEL = 0]
| | | | | | | | | | | | +--- [SPLIT: x2 = 1]
| | | | | | | | | | | | | +--- [SPLIT: x5 = 1]
| | | | | | | | | | | | | | +--- [LABEL = 1]
| | | | | | | | | | | | | +--- [SPLIT: x5 = 1]
| | | | | | | | | | | | | | +--- [SPLIT: x0 = 1]
| | | | | | | | | | | | | | | +--- [LABEL = 1]
| | | | | | | | | | | | | | +--- [SPLIT: x0 = 1]
| | | | | | | | | | | | | | | +--- [LABEL = 0]
+--- [SPLIT: x3 = 1]
| | | | | +--- [SPLIT: x4 = 1]
| | | | | | +--- [SPLIT: x0 = 1]
| | | | | | | +--- [SPLIT: x5 = 1]
| | | | | | | | +--- [SPLIT: x2 = 1]
| | | | | | | | | +--- [SPLIT: x1 = 1]
| | | | | | | | | | +--- [LABEL = 0]
| | | | | | | | | | +--- [SPLIT: x1 = 1]
| | | | | | | | | | | +--- [LABEL = 1]
| | | | | | | | | | | +--- [SPLIT: x2 = 1]
| | | | | | | | | | | | +--- [SPLIT: x1 = 1]
| | | | | | | | | | | | | +--- [LABEL = 1]
| | | | | | | | | | | | | +--- [SPLIT: x1 = 1]
| | | | | | | | | | | | | | +--- [LABEL = 0]
| | | | | | | | | | | | +--- [SPLIT: x5 = 1]
| | | | | | | | | | | | | +--- [SPLIT: x2 = 1]
| | | | | | | | | | | | | | +--- [SPLIT: x1 = 1]
| | | | | | | | | | | | | | | +--- [LABEL = 1]
| | | | | | | | | | | | | | +--- [SPLIT: x1 = 1]
| | | | | | | | | | | | | | | +--- [LABEL = 0]
| | | | | | | | | | | | +--- [SPLIT: x2 = 1]
| | | | | | | | | | | | | +--- [LABEL = 0]
| | | | | | | | | | | | +--- [SPLIT: x0 = 1]
| | | | | | | | | | | | | +--- [SPLIT: x4 = 3]
| | | | | | | | | | | | | | +--- [LABEL = 0]
| | | | | | | | | | | | | +--- [SPLIT: x4 = 3]
| | | | | | | | | | | | | | +--- [SPLIT: x2 = 1]
| | | | | | | | | | | | | | | +--- [SPLIT: x5 = 1]
| | | | | | | | | | | | | | | +--- [LABEL = 1]
| | | | | | | | | | | | | | +--- [SPLIT: x5 = 1]
| | | | | | | | | | | | | | | +--- [LABEL = 0]
| | | | | | | | | | | | | +--- [SPLIT: x2 = 1]
| | | | | | | | | | | | | | +--- [LABEL = 0]
+--- [SPLIT: x4 = 1]
| | | | | +--- [SPLIT: x0 = 2]
| | | | | | +--- [LABEL = 0]
| | | | | +--- [SPLIT: x0 = 2]
| | | | | | +--- [SPLIT: x5 = 1]
| | | | | | | +--- [SPLIT: x2 = 1]
| | | | | | | | +--- [LABEL = 1]
| | | | | | | | +--- [SPLIT: x2 = 1]
| | | | | | | | | +--- [LABEL = 0]
| | | | | | | +--- [SPLIT: x5 = 1]
| | | | | | | | +--- [LABEL = 0]

```

iii. Monks 3:

```
TREE
+--- [SPLIT: x1 = 3]
|   +--- [SPLIT: x4 = 4]
|       |   +--- [SPLIT: x4 = 3]
|           |       +--- [SPLIT: x0 = 2]
|               |       +--- [LABEL = 1]
|                   +--- [SPLIT: x0 = 2]
|                       |       +--- [SPLIT: x5 = 1]
|                           |       +--- [LABEL = 1]
|                               +--- [SPLIT: x5 = 1]
|                                   |       +--- [SPLIT: x4 = 1]
|                                       |       +--- [LABEL = 0]
|                                           +--- [SPLIT: x4 = 1]
|                                               |       +--- [LABEL = 1]
|
|   +--- [SPLIT: x4 = 3]
|       |   +--- [SPLIT: x2 = 1]
|           |       +--- [LABEL = 1]
|               +--- [SPLIT: x2 = 1]
|                   +--- [SPLIT: x0 = 3]
|                       +--- [SPLIT: x5 = 1]
|                           +--- [SPLIT: x0 = 1]
|                               +--- [SPLIT: x1 = 1]
|                                   +--- [SPLIT: x3 = 1]
|                                       |       +--- [LABEL = 0]
|                                           +--- [SPLIT: x3 = 1]
|                                               |       +--- [LABEL = 1]
|                                                   +--- [SPLIT: x1 = 1]
|                                                       |       +--- [LABEL = 1]
|                                                           +--- [SPLIT: x0 = 1]
|                                                               |       +--- [LABEL = 1]
|                                                                   +--- [SPLIT: x5 = 1]
|                                                                       +--- [SPLIT: x3 = 1]
|                                                                           |       +--- [LABEL = 0]
|                                                                               +--- [SPLIT: x3 = 1]
|                                                                                   +--- [SPLIT: x1 = 1]
|                                                                                       |       +--- [LABEL = 1]
|                                                                                           +--- [SPLIT: x1 = 1]
|                                                                                               |       +--- [LABEL = 0]
|
|           +--- [SPLIT: x0 = 3]
|               +--- [LABEL = 1]
|
|   +--- [SPLIT: x4 = 4]
|       +--- [LABEL = 0]
+--- [SPLIT: x1 = 3]
    +--- [SPLIT: x3 = 1]
        |       +--- [LABEL = 0]
    +--- [SPLIT: x3 = 1]
        +--- [SPLIT: x2 = 1]
            |       +--- [LABEL = 0]
        +--- [SPLIT: x2 = 1]
            +--- [SPLIT: x0 = 1]
                |       +--- [LABEL = 1]
            +--- [SPLIT: x0 = 1]
                +--- [LABEL = 0]
```

c. Error Rates (might have to zoom in to see the values)

- i. Monks 1:

Training Error: [0.2661290322580645, 0.2661290322580645, 0.08870967741935484, 0.08870967741935484, 0.08064516129032258, 0.04838709677419355, 0.03225806451612903, 0.024193548387096774, 0.016129032258064516]
Testing Error: [0.25, 0.25, 0.16666666666666666, 0.16666666666666666, 0.16666666666666666, 0.11111111111111111, 0.09259259259259259, 0.09259259259259259, 0.08333333333333333]

ii. Monks 2:

Training Error: [0.378698224852071, 0.3609467455621302, 0.33136094674556216, 0.30177514792899407, 0.20710059171597633, 0.09467455621301775, 0.01775147928994083, 0.0, 0.0]
Testing Error: [0.3287037037037037, 0.375, 0.33796296296296297, 0.35185185185185186, 0.30324074074074076, 0.2175925925925926, 0.15277777777777778, 0.13425925925925927, 0.13425925925925927]

iii. Monks 3:

```
Training Error: [0.22131147540983606, 0.06557377049180328, 0.05737704918032787, 0.040983606557377046, 0.040983606557377046, 0.01639344262295082, 0.01639344262295082, 0.00819672131147541, 0.0]
Testing Error: [0.19444444444444445, 0.027777777777777776, 0.05555555555555555, 0.046296296296296294, 0.10185185185185185, 0.10185185185185185, 0.10185185185185185, 0.10410000000000000, 0.10185185185185185]
```

- b. Confusion Matrix and Tree of Depths 1 and 2 for Monks 1:

```

TREE
+-- [SPLIT: x4 = 1]
|   +-- [LABEL = 0]
+-- [SPLIT: x4 = 1]
|   +-- [LABEL = 1]
[[108, 108], [0, 216]]
      Confusion Matrix
      Positive  Negative
Positive |-----|-----|
         | 108   | 108   |
         |-----|-----|
Negative |  0    | 216   |
         |-----|-----|

TREE
+-- [SPLIT: x4 = 1]
|   +-- [SPLIT: x0 = 1]
|       +-- [LABEL = 0]
|       +-- [SPLIT: x0 = 1]
|           +-- [LABEL = 0]
+-- [SPLIT: x4 = 1]
|   +-- [LABEL = 1]
[[108, 108], [0, 216]]
      Confusion Matrix
      Positive  Negative
Positive |-----|-----|
         | 108   | 108   |
         |-----|-----|
Negative |  0    | 216   |
         |-----|-----|

```

- c. Monks 1 Confusion Matrix and Tree using sklearn's default Decision Tree Algorithm:

```

Sklearn's Confusion Matrix:
[[181  35]
 [ 15 201]]

```

- a.

d.

a. Part C (Tree and Confusion Matrix of Depth 1 and 2 of Car's Data):

```
TREE
+-- [SPLIT: x5 = low]
|   +-- [LABEL = 0]
+-- [SPLIT: x5 = low]
|   +-- [LABEL = 0]
[[0, 161], [0, 358]]
Confusion Matrix
Positive Negative
-----|-----|
Positive| 0      | 161   |
-----|-----|
Negative| 0      | 358   |
-----|-----|

TREE
+-- [SPLIT: x5 = low]
|   +-- [SPLIT: x3 = 2]
|       +-- [LABEL = 1]
|       +-- [SPLIT: x3 = 2]
|           +-- [LABEL = 0]
+-- [SPLIT: x5 = low]
|   +-- [LABEL = 0]
[[161, 0], [65, 293]]
Confusion Matrix
Positive Negative
-----|-----|
Positive| 161    | 0      |
-----|-----|
Negative| 65     | 293    |
-----|-----|
```

b. Part D (Car's Data Confusion Matrix and Tree using sklearn's default Decision Tree Algorithm):

```
Sklearn's Confusion Matrix:
[[354  4]
 [ 2 159]]
```

i.

