ML LAB

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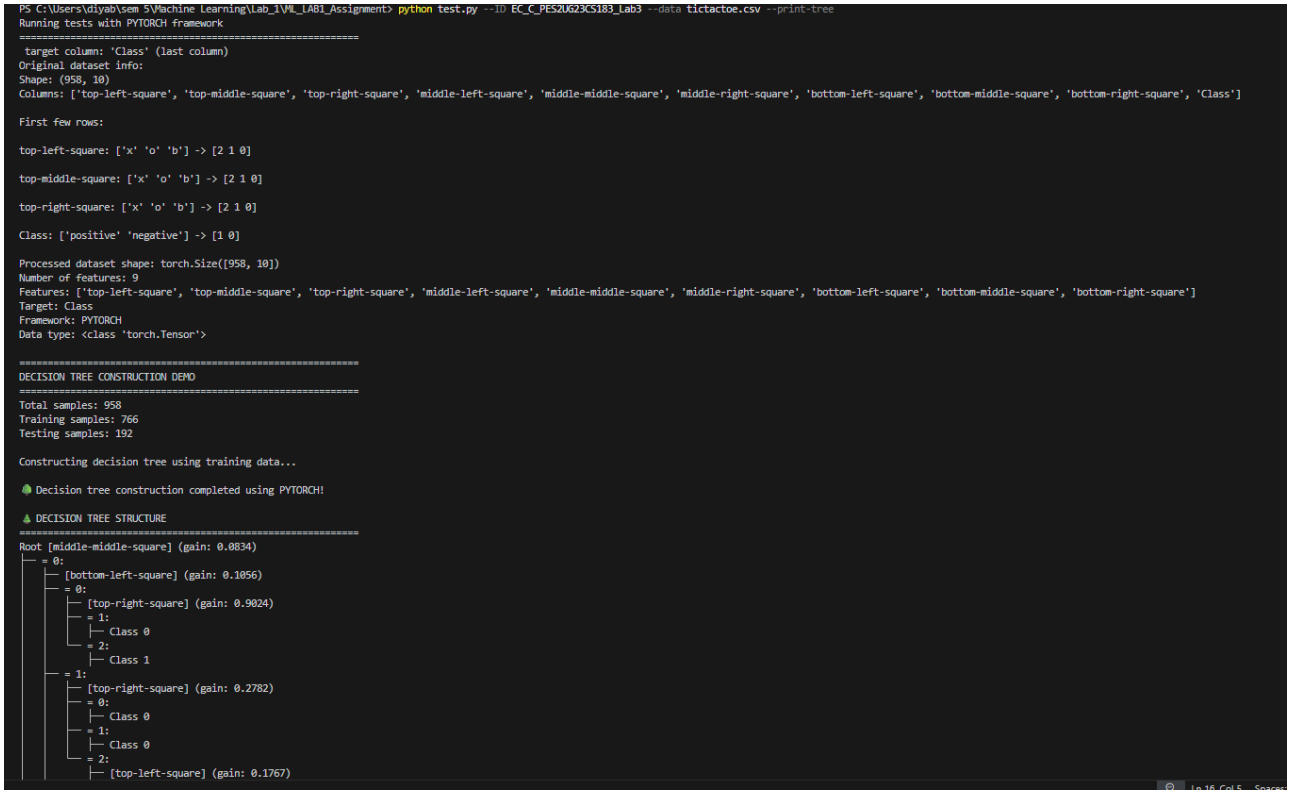
Section	C
Date	19/8/25

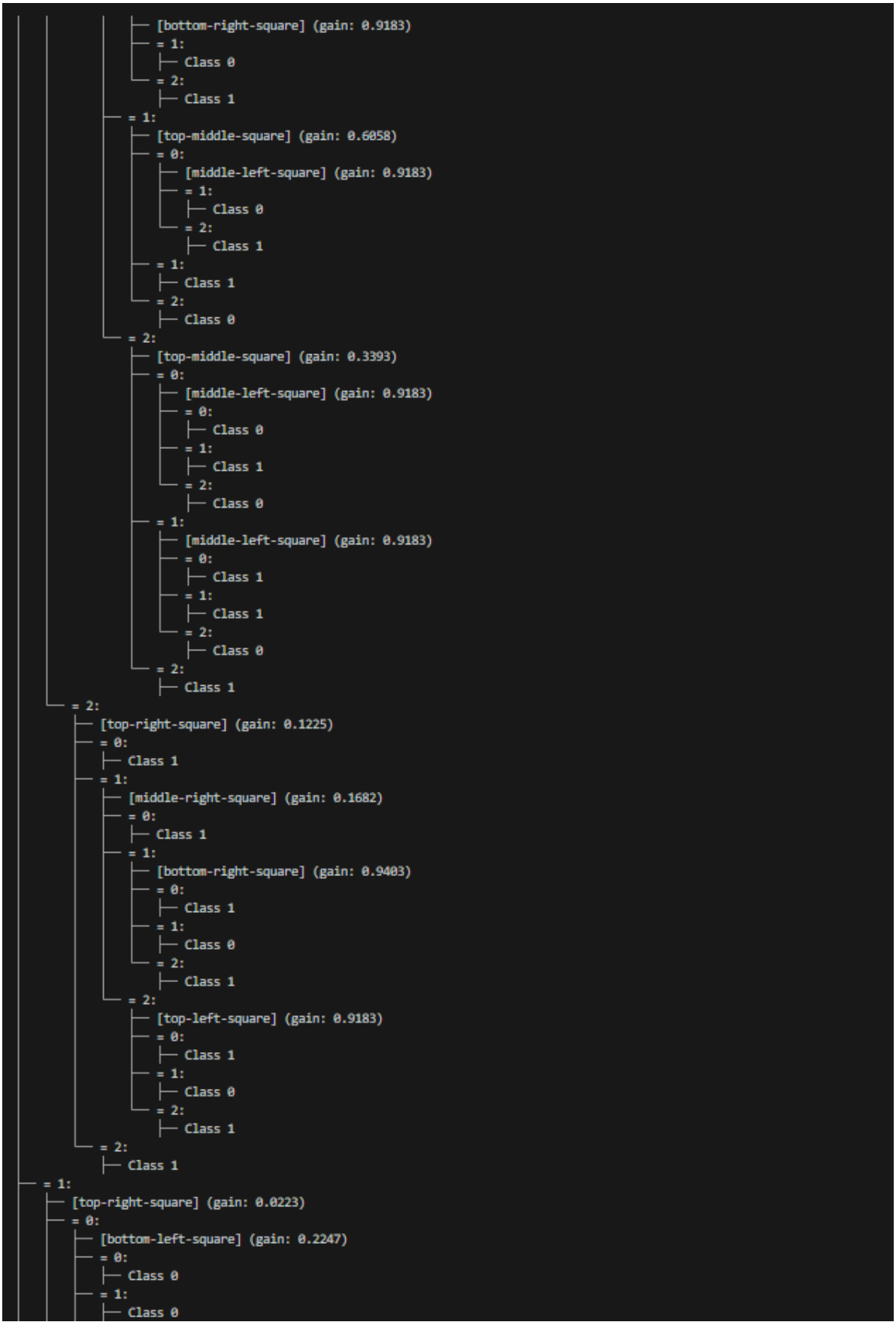
Dataset 1: Mushroom Classification

```
PS C:\Users\diyab\sem 5\Machine Learning\Lab_1\ML_LAB1_Assignment> python test.py --ID EC_C_PES2UG23CS183_Lab3 --data mushrooms.csv --print-tree
Running tests with PYTORCH framework
============================================================
 target column: 'class' (last column)
Original dataset info:
Shape: (8124, 23)
Columns: ['cap-shape', 'cap-surface', 'cap-color', 'bruises', 'odor', 'gill-attachment', 'gill-spacing', 'gill-size', 'gill-color', 'stalk-shape', 'stalk-root',
 'stalk-surface-above-ring', 'stalk-surface-below-ring', 'stalk-color-above-ring', 'stalk-color-below-ring', 'veil-type', 'veil-color', 'ring-number', 'ring-typ
e', 'spore-print-color', 'population', 'habitat', 'class']

First few rows:

cap-shape: ['x' 'b' 's' 'f' 'k'] -> [5 0 4 2 3]

cap-surface: ['s' 'y' 'f' 'g'] -> [2 3 0 1]

cap-color: ['n' 'y' 'w' 'g' 'e'] -> [4 9 8 3 2]

class: ['p' 'e'] -> [1 0]

Processed dataset shape: torch.Size([8124, 23])
Number of features: 22
Features: ['cap-shape', 'cap-surface', 'cap-color', 'bruises', 'odor', 'gill-attachment', 'gill-spacing', 'gill-size', 'gill-color', 'stalk-shape', 'stalk-root'
, 'stalk-surface-above-ring', 'stalk-surface-below-ring', 'stalk-color-above-ring', 'stalk-color-below-ring', 'veil-type', 'veil-color', 'ring-number', 'ring-ty
pe', 'spore-print-color', 'population', 'habitat']
Target: class
Framework: PYTORCH
Data type: <class 'torch.Tensor'>

============================================================
DECISION TREE CONSTRUCTION DEMO
============================================================
Total samples: 8124
Training samples: 6499
Testing samples: 1625

Constructing decision tree using training data...
```

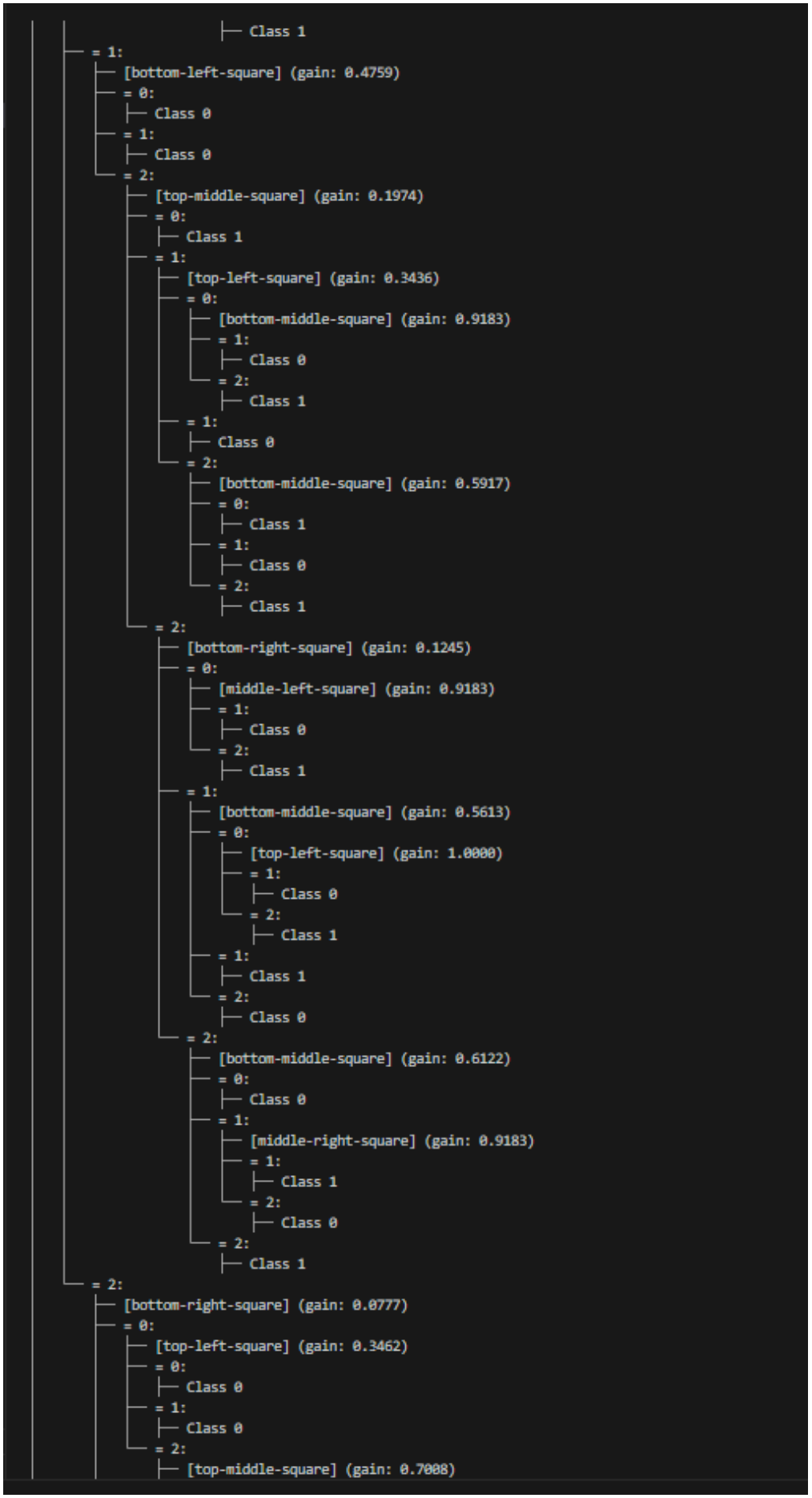
```
🌳 Decision tree construction completed using PYTORCH!

🎄 DECISION TREE STRUCTURE
============================================================
Root [odor] (gain: 0.9083)
├── = 0:
│   ├── Class 0
├── = 1:
│   ├── Class 1
├── = 2:
│   ├── Class 1
├── = 3:
│   ├── Class 0
├── = 4:
│   ├── Class 1
├── = 5:
│   ├── [spore-print-color] (gain: 0.1469)
│   ├── = 0:
│   │   ├── Class 0
│   ├── = 1:
│   │   ├── Class 0
│   ├── = 2:
│   │   ├── Class 0
│   ├── = 3:
│   │   ├── Class 0
│   ├── = 4:
│   │   ├── Class 0
│   ├── = 5:
│   │   ├── Class 1
│   ├── = 7:
│   │   ├── [habitat] (gain: 0.2217)
│   │   ├── = 0:
│   │   │   ├── [gill-size] (gain: 0.7642)
│   │   │   ├── = 0:
│   │   │   │   ├── Class 0
│   │   │   └── = 1:
│   │   │       ├── Class 1
│   │   ├── = 1:
│   │   │   ├── Class 0
│   │   ├── = 2:
│   │   │   ├── [cap-color] (gain: 0.7300)
│   │   │   ├── = 1:
│   │   │   │   ├── Class 0
│   │   │   ├── = 4:
│   │   │   │   ├── Class 0
│   │   │   ├── = 8:
│   │   │   │   ├── Class 1
│   │   │   └── = 9:
│   │   │       ├── Class 1
│   │   ├── = 4:
│   │   │   ├── Class 0
│   │   └── = 6:
│   │       ├── Class 0
│   └── = 8:
│       ├── Class 0
├── = 6:
│   ├── Class 1
├── = 7:
│   ├── Class 1
├── = 8:
│   ├── Class 1


📊 OVERALL PERFORMANCE METRICS
========================================
Accuracy:             1.0000 (100.00%)
Precision (weighted): 1.0000
Recall (weighted):    1.0000
F1-Score (weighted):  1.0000
Precision (macro):    1.0000
Recall (macro):       1.0000
F1-Score (macro):     1.0000

🌳 TREE COMPLEXITY METRICS
========================================
Maximum Depth:        4
Total Nodes:          29
Leaf Nodes:           24
Internal Nodes:       5
```

Dataset 2: Tic-Tac-Toe Endgame




[bottom-right-square] (gain: 0.9183)
= 1:
Class 0
= 2:
Class 1
= 1:
[top-middle-square] (gain: 0.6058)
= 0:
[middle-left-square] (gain: 0.9183)
= 1:
Class 0
= 2:
Class 1
= 1:
Class 1
= 2:
Class 0
= 2:
[top-middle-square] (gain: 0.3393)
= 0:
[middle-left-square] (gain: 0.9183)
= 0:
Class 0
= 1:
Class 1
= 2:
Class 0
= 1:
[middle-left-square] (gain: 0.9183)
= 0:
Class 1
= 1:
Class 1
= 2:
Class 0
= 2:
Class 1
= 2:
[top-right-square] (gain: 0.1225)
= 0:
Class 1
= 1:
[middle-right-square] (gain: 0.1682)
= 0:
Class 1
= 1:
[bottom-right-square] (gain: 0.9403)
= 0:
Class 1
= 1:
Class 0
= 2:
Class 1
= 2:
[top-left-square] (gain: 0.9183)
= 0:
Class 1
= 1:
Class 0
= 2:
Class 1
= 2:
Class 1
= 1:
[top-right-square] (gain: 0.0223)
= 0:
[bottom-left-square] (gain: 0.2247)
= 0:
Class 0
= 1:
Class 0

= 1:
[bottom-right-square] (gain: 0.9403)
= 0:
Class 1
= 1:
Class 0
= 2:
Class 1
= 2:
[top-left-square] (gain: 0.9183)
= 0:
Class 1
= 1:
Class 0
= 2:
Class 1
= 2:
Class 1
= 1:
[top-right-square] (gain: 0.0223)
= 0:
[bottom-left-square] (gain: 0.2247)
= 0:
Class 0
= 1:
Class 0
= 2:
[middle-right-square] (gain: 0.1159)
= 0:
[top-left-square] (gain: 0.1771)
= 0:
[middle-left-square] (gain: 0.9183)
= 0:
Class 1
= 1:
Class 1
= 2:
Class 0
= 1:
[bottom-right-square] (gain: 0.9710)
= 1:
Class 0
= 2:
Class 1
= 2:
Class 1
= 1:
[middle-left-square] (gain: 0.9887)
= 0:
Class 1
= 1:
Class 0
= 2:
Class 1
= 2:
[bottom-middle-square] (gain: 0.2400)
= 0:
[top-left-square] (gain: 1.0000)
= 1:
Class 0
= 2:
Class 1
= 1:
Class 0
= 2:
[bottom-right-square] (gain: 0.9710)
= 1:
Class 0
= 2:
Class 1

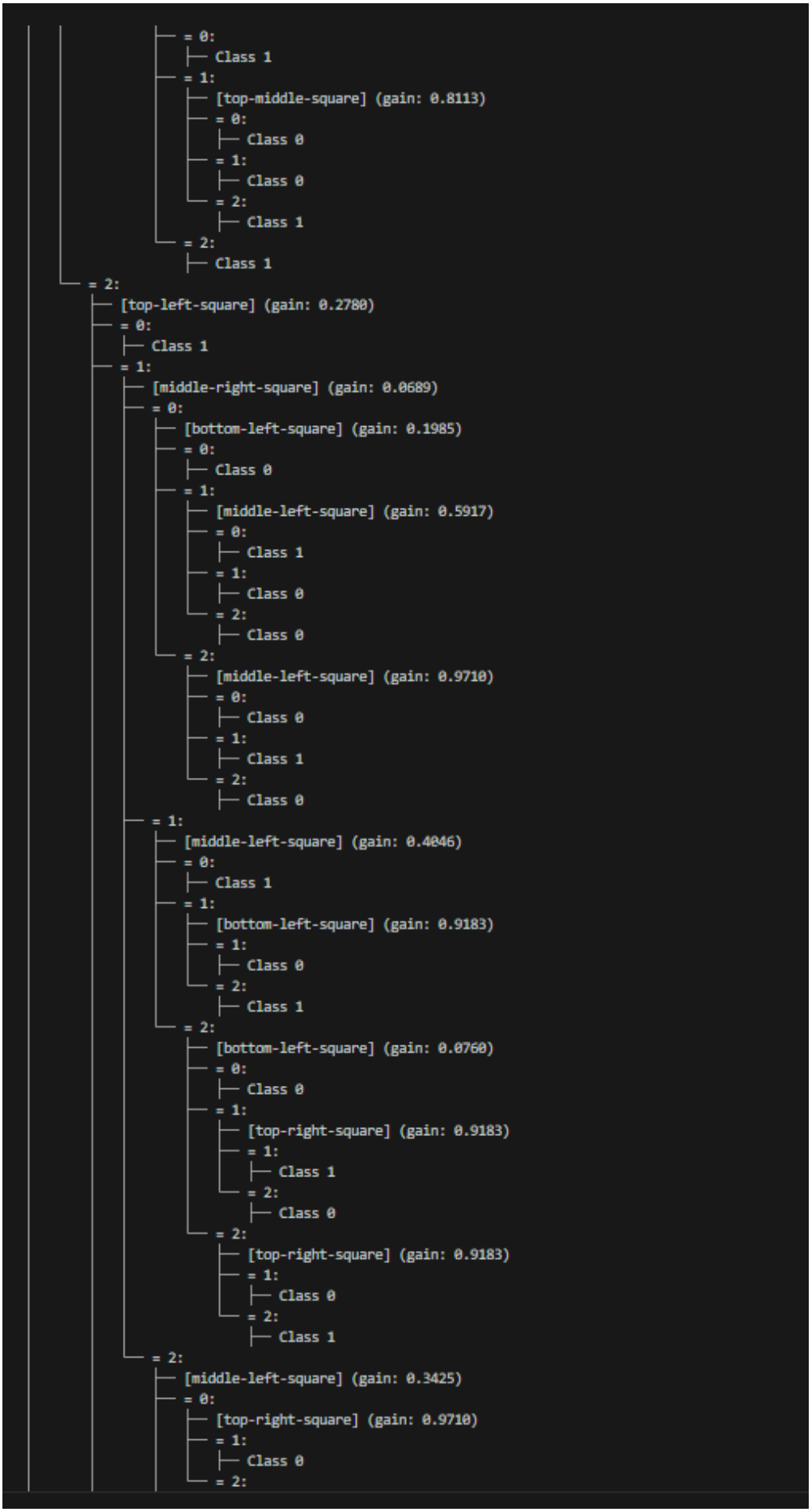

Class 1
= 1:
[bottom-left-square] (gain: 0.4759)
= 0:
Class 0
= 1:
Class 0
= 2:
[top-middle-square] (gain: 0.1974)
= 0:
Class 1
= 1:
[top-left-square] (gain: 0.3436)
= 0:
[bottom-middle-square] (gain: 0.9183)
= 1:
Class 0
= 2:
Class 1
= 1:
Class 0
= 2:
[bottom-middle-square] (gain: 0.5917)
= 0:
Class 1
= 1:
Class 0
= 2:
Class 1
= 2:
[bottom-right-square] (gain: 0.1245)
= 0:
[middle-left-square] (gain: 0.9183)
= 1:
Class 0
= 2:
Class 1
= 1:
[bottom-middle-square] (gain: 0.5613)
= 0:
[top-left-square] (gain: 1.0000)
= 1:
Class 0
= 2:
Class 1
= 1:
Class 1
= 2:
Class 0
= 2:
[bottom-middle-square] (gain: 0.6122)
= 0:
Class 0
= 1:
[middle-right-square] (gain: 0.9183)
= 1:
Class 1
= 2:
Class 0
= 2:
Class 1
= 2:
[bottom-right-square] (gain: 0.0777)
= 0:
[top-left-square] (gain: 0.3462)
= 0:
Class 0
= 1:
Class 0
= 2:
[top-middle-square] (gain: 0.7008)

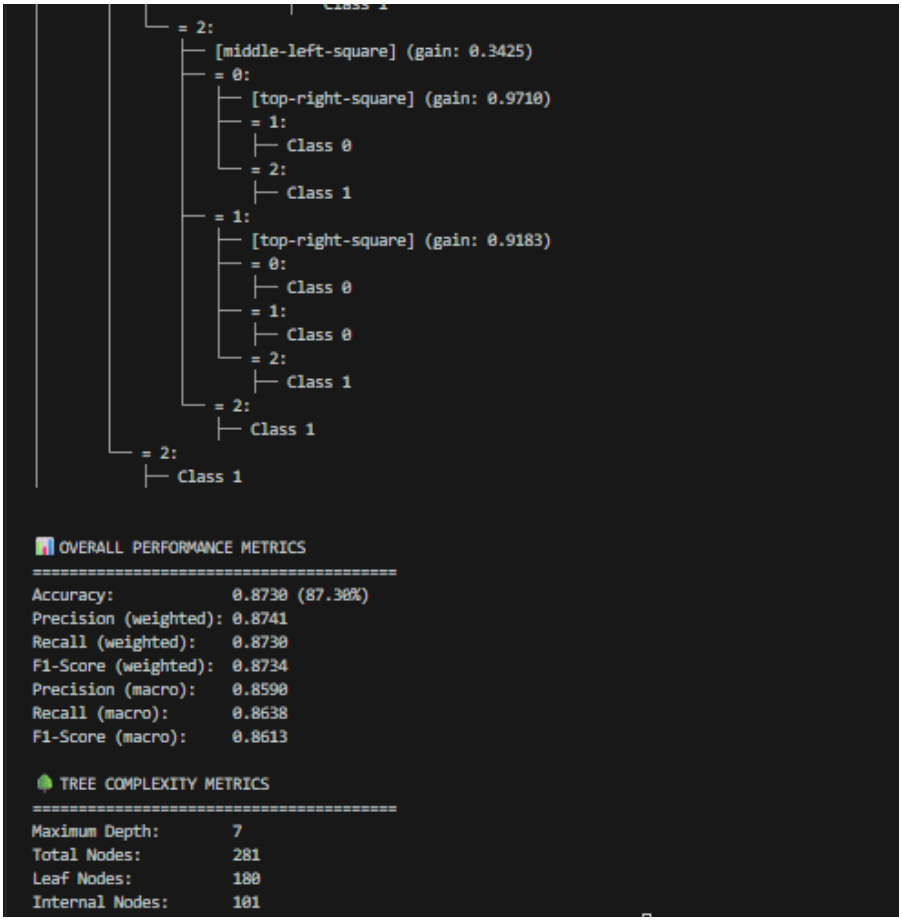
= 0:
Class 0
= 1:
[middle-right-square] (gain: 0.7219)
= 0:
Class 0
= 1:
Class 1
= 2:
Class 0
= 2:
Class 1
= 1:
[top-left-square] (gain: 0.5439)
= 0:
Class 0
= 1:
Class 0
= 2:
[top-middle-square] (gain: 0.4687)
= 0:
[bottom-middle-square] (gain: 0.9183)
= 0:
Class 1
= 1:
Class 0
= 2:
Class 0
= 1:
[middle-right-square] (gain: 0.9183)
= 0:
Class 1
= 1:
Class 1
= 2:
Class 0
= 2:
Class 1
= 2:
[middle-right-square] (gain: 0.4731)
= 0:
[top-middle-square] (gain: 0.6464)
= 0:
Class 1
= 1:
Class 0
= 2:
[top-left-square] (gain: 0.8113)
= 1:
Class 0
= 2:
Class 1
= 1:
[middle-left-square] (gain: 0.3995)
= 0:
[bottom-middle-square] (gain: 0.8113)
= 0:
Class 1
= 1:
Class 0
= 2:
Class 1
= 1:
Class 0
= 2:
[top-middle-square] (gain: 0.8113)
= 1:
Class 0
= 2:
Class 1

= 2:
Class 1
= 2:
[bottom-right-square] (gain: 0.0269)
= 0:
[top-left-square] (gain: 0.1239)
= 0:
Class 1
= 1:
[bottom-middle-square] (gain: 0.1033)
= 0:
[middle-left-square] (gain: 0.1605)
= 0:
Class 1
= 1:
[bottom-left-square] (gain: 1.0000)
= 1:
Class 0
= 2:
Class 1
= 2:
[middle-right-square] (gain: 0.5917)
= 0:
Class 0
= 1:
Class 1
= 2:
Class 1
= 1:
Class 1
= 2:
[top-middle-square] (gain: 0.4591)
= 0:
[middle-right-square] (gain: 0.9183)
= 0:
Class 0
= 1:
Class 1
= 2:
Class 0
= 1:
[top-right-square] (gain: 0.6122)
= 0:
Class 1
= 1:
Class 0
= 2:
[middle-right-square] (gain: 0.9183)
= 0:
Class 1
= 1:
Class 1
= 2:
Class 0
= 2:
Class 1
= 2:
Class 1
= 1:
[top-left-square] (gain: 0.0713)
= 0:
[middle-right-square] (gain: 0.0760)
= 0:
[bottom-left-square] (gain: 0.2455)
= 0:
Class 1
= 1:
[bottom-middle-square] (gain: 0.9710)
= 1:
Class 0
= 2:

Class 1
= 2:
Class 1
= 1:
[top-right-square] (gain: 0.7207)
= 0:
Class 1
= 1:
Class 0
= 2:
[middle-left-square] (gain: 0.3060)
= 0:
Class 1
= 1:
Class 1
= 2:
[top-middle-square] (gain: 1.0000)
= 0:
Class 1
= 2:
Class 0
= 2:
[middle-left-square] (gain: 0.2294)
= 0:
[top-middle-square] (gain: 0.5000)
= 0:
Class 0
= 1:
Class 1
= 2:
[top-right-square] (gain: 1.0000)
= 0:
Class 0
= 1:
Class 1
= 1:
[bottom-left-square] (gain: 0.3219)
= 0:
Class 1
= 1:
[top-right-square] (gain: 1.0000)
= 0:
Class 1
= 2:
Class 0
= 2:
Class 1
= 2:
Class 1
= 1:
[bottom-left-square] (gain: 0.1145)
= 0:
Class 1
= 1:
[middle-left-square] (gain: 0.3407)
= 0:
[bottom-middle-square] (gain: 0.9183)
= 1:
Class 0
= 2:
Class 1
= 1:
Class 0
= 2:
[bottom-middle-square] (gain: 0.6500)
= 0:
Class 1
= 1:
Class 0
= 2:
Class 1

= 1:
Class 0
= 2:
Class 1
= 2:
[top-right-square] (gain: 0.1913)
= 0:
Class 1
= 1:
[top-middle-square] (gain: 0.3774)
= 0:
Class 1
= 1:
Class 0
= 2:
[middle-right-square] (gain: 0.8113)
= 0:
Class 1
= 1:
Class 0
= 2:
Class 1
= 2:
Class 1
= 2:
[top-right-square] (gain: 0.0822)
= 0:
[bottom-left-square] (gain: 0.3436)
= 0:
Class 1
= 1:
[bottom-middle-square] (gain: 0.9852)
= 0:
Class 1
= 1:
Class 0
= 2:
Class 1
= 2:
Class 1
= 1:
[middle-right-square] (gain: 0.4301)
= 0:
[bottom-middle-square] (gain: 0.9183)
= 0:
Class 1
= 1:
Class 0
= 2:
Class 1
= 1:
Class 0
= 2:
[middle-left-square] (gain: 0.6101)
= 0:
Class 0
= 1:
[bottom-left-square] (gain: 0.9183)
= 1:
Class 1
= 2:
Class 0
= 2:
Class 1
= 2:
[bottom-left-square] (gain: 0.5549)
= 0:
Class 1
= 1:
[top-middle-square] (gain: 0.8113)
= 0:

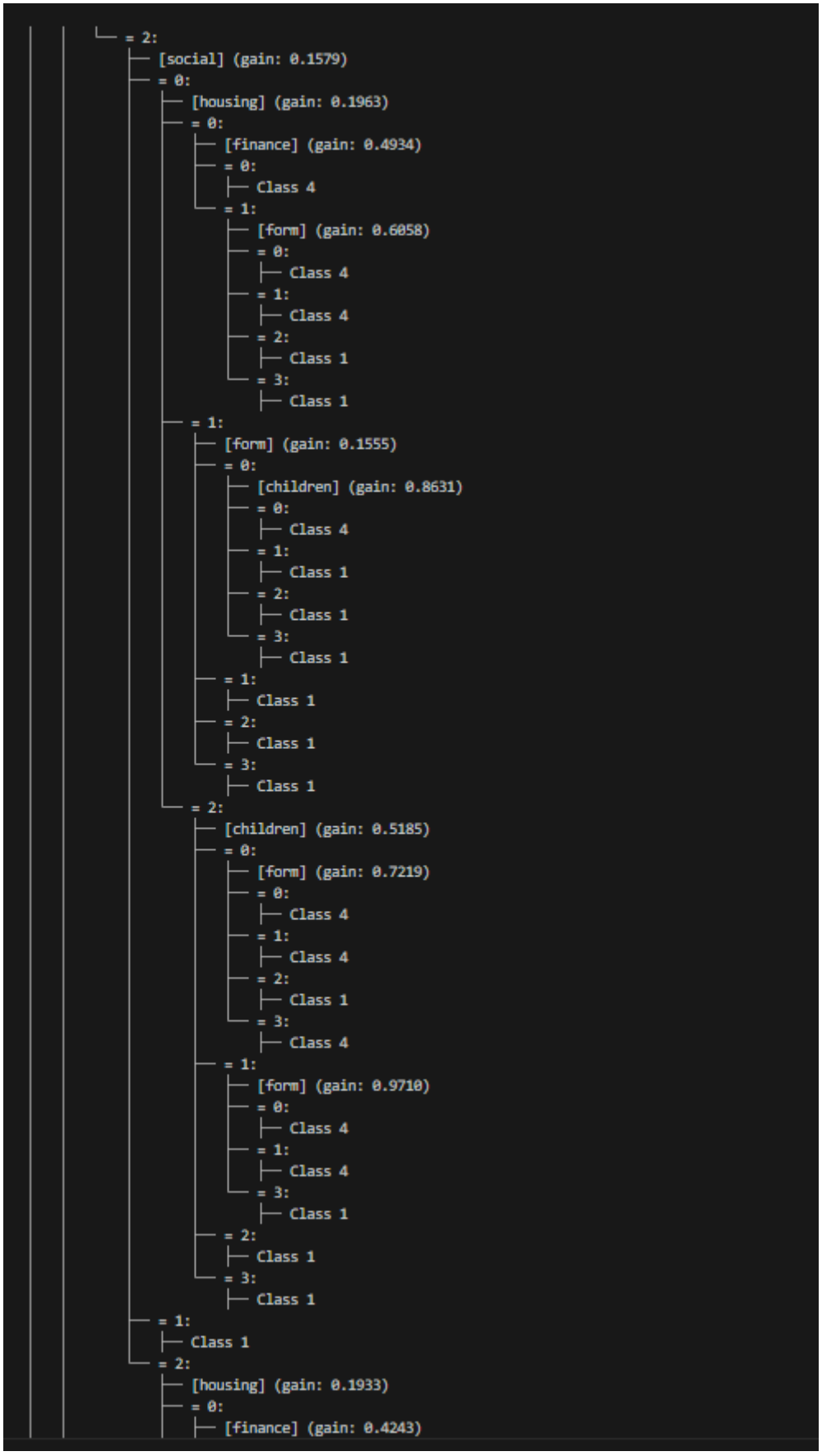

= 0:
Class 1
= 1:
[top-middle-square] (gain: 0.8113)
= 0:
Class 0
= 1:
Class 0
= 2:
Class 1
= 2:
Class 1
= 2:
[top-left-square] (gain: 0.2780)
= 0:
Class 1
= 1:
[middle-right-square] (gain: 0.0689)
= 0:
[bottom-left-square] (gain: 0.1985)
= 0:
Class 0
= 1:
[middle-left-square] (gain: 0.5917)
= 0:
Class 1
= 1:
Class 0
= 2:
Class 0
= 2:
[middle-left-square] (gain: 0.9710)
= 0:
Class 0
= 1:
Class 1
= 2:
Class 0
= 1:
[middle-left-square] (gain: 0.4046)
= 0:
Class 1
= 1:
[bottom-left-square] (gain: 0.9183)
= 1:
Class 0
= 2:
Class 1
= 2:
[bottom-left-square] (gain: 0.0760)
= 0:
Class 0
= 1:
[top-right-square] (gain: 0.9183)
= 1:
Class 1
= 2:
Class 0
= 2:
[top-right-square] (gain: 0.9183)
= 1:
Class 0
= 2:
Class 1
= 2:
[middle-left-square] (gain: 0.3425)
= 0:
[top-right-square] (gain: 0.9710)
= 1:
Class 0
= 2:

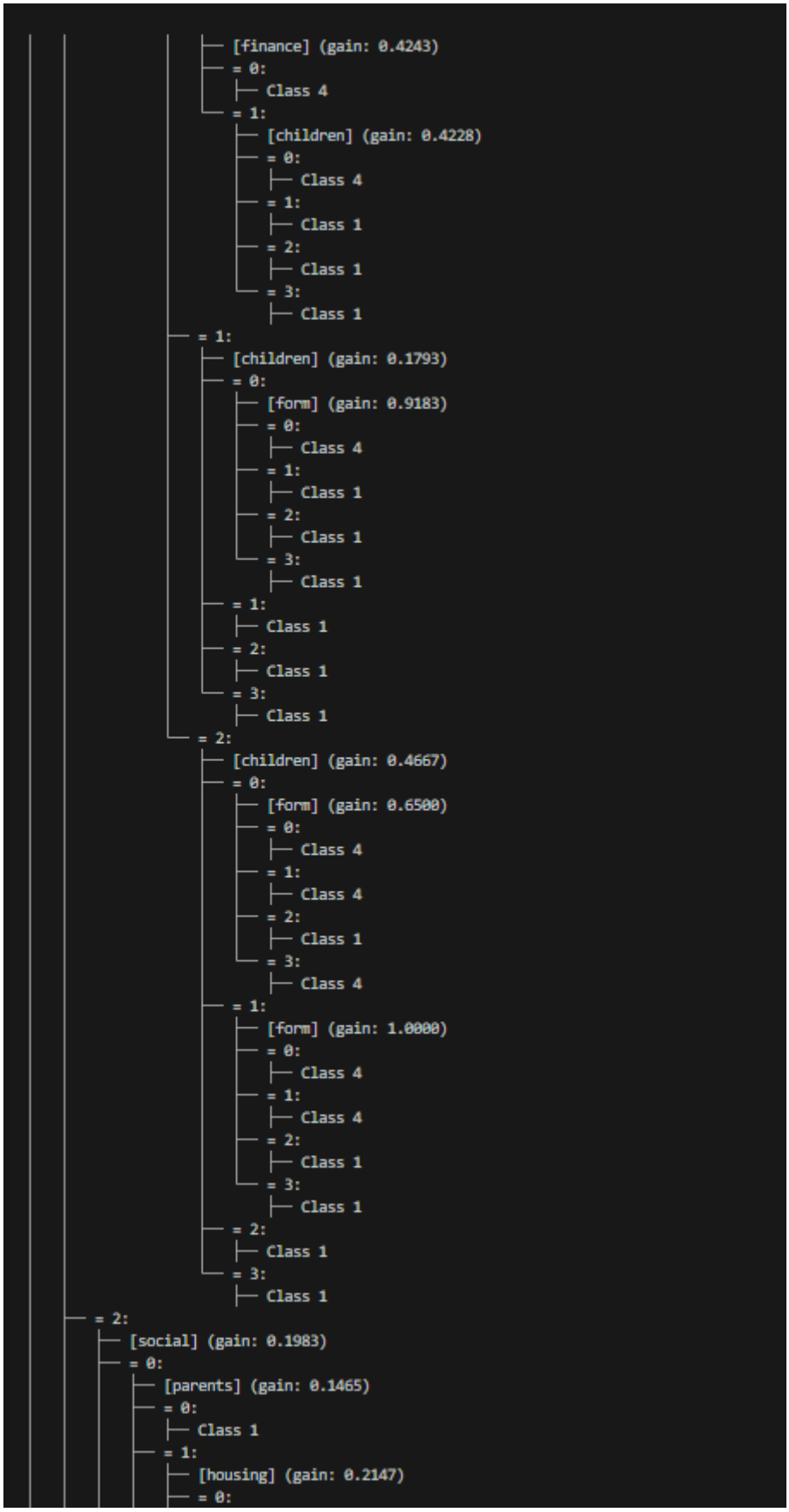


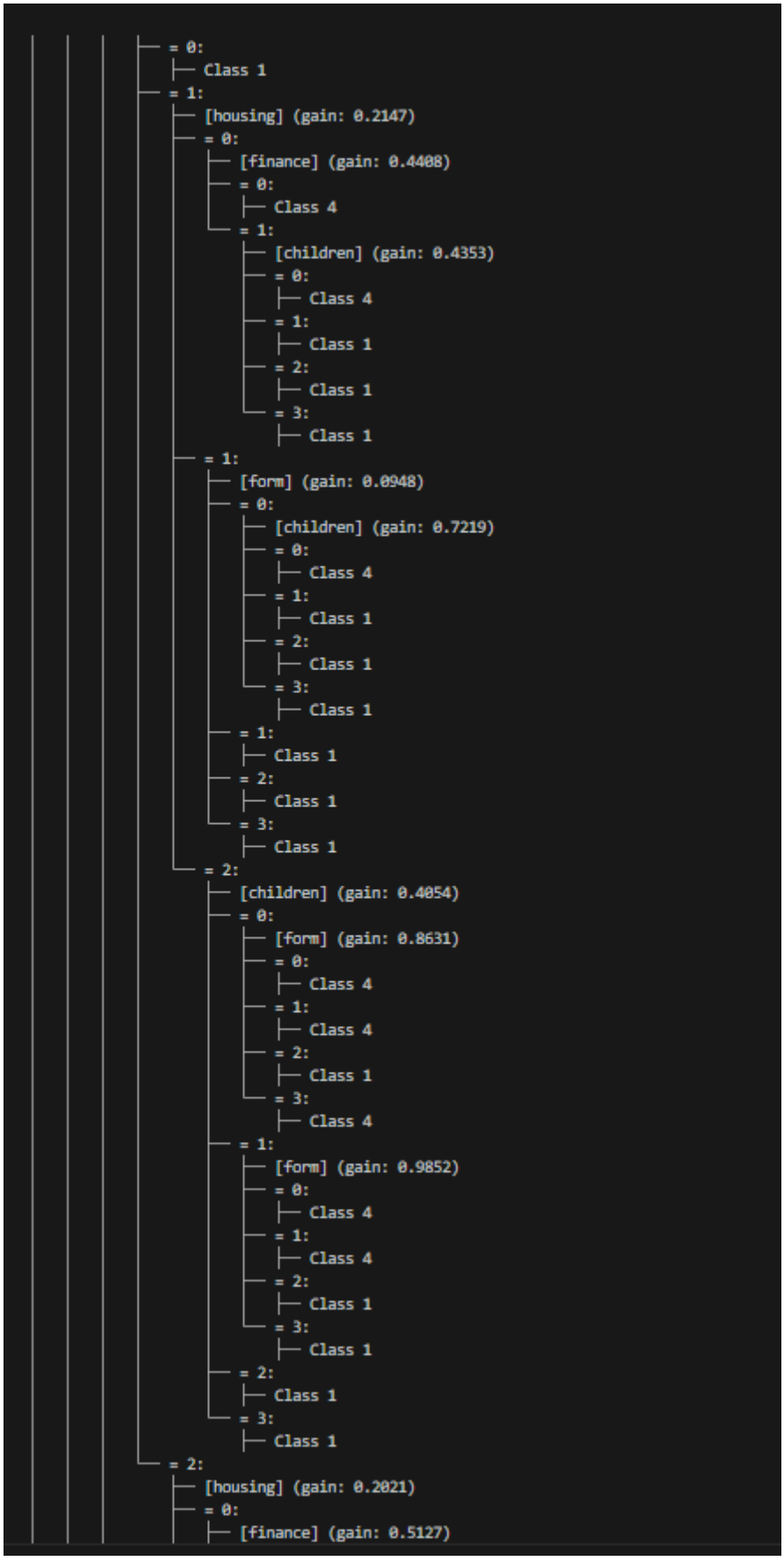
Dataset 3: Nursery School

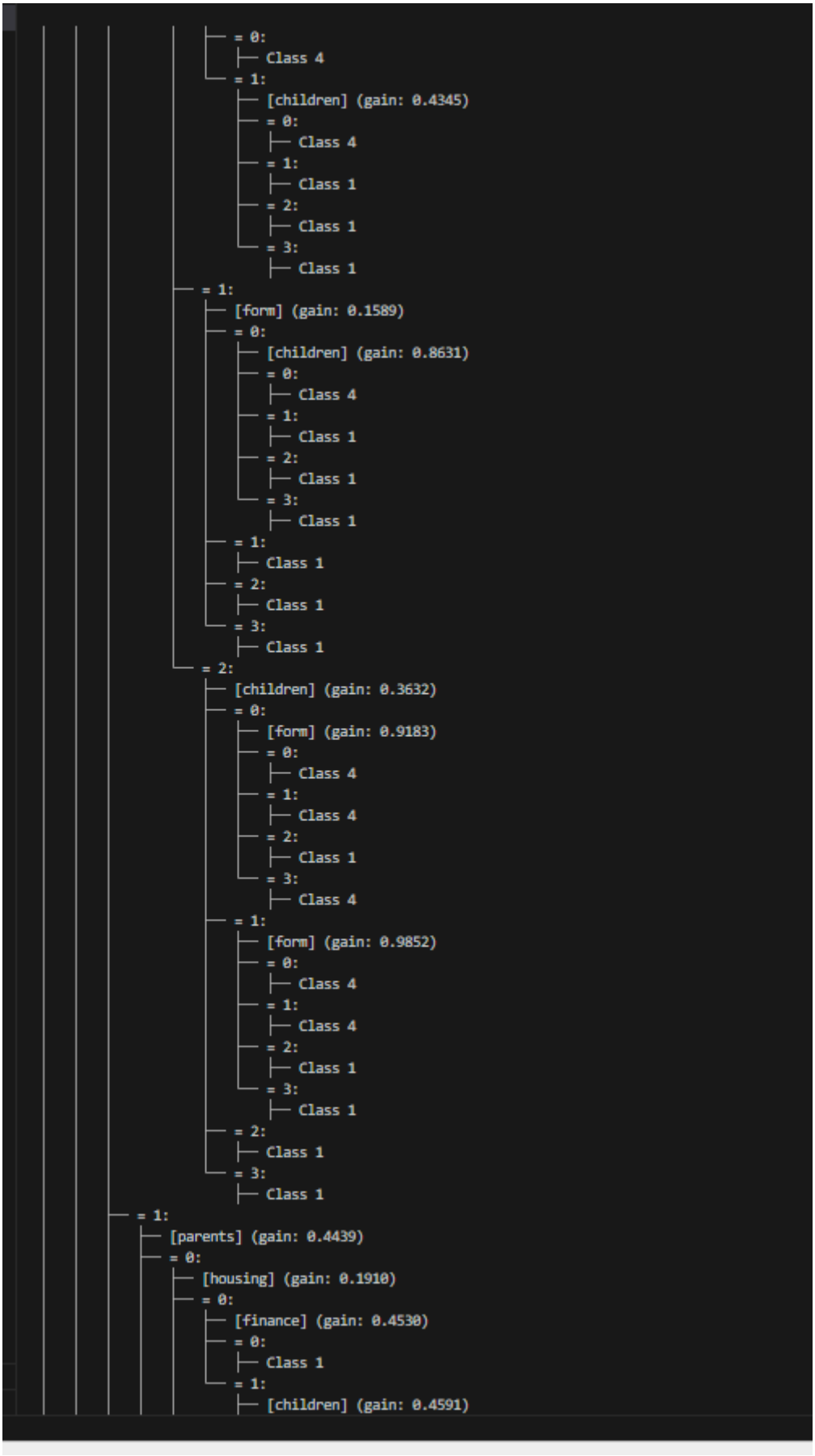
```
parents: ['usual' 'pretentious' 'great_pret'] -> [2 1 0]

has_nurs: ['proper' 'less_proper' 'improper' 'critical' 'very_crit'] -> [3 2 1 0 4]

form: ['complete' 'completed' 'incomplete' 'foster'] -> [0 1 3 2]

class: ['recommend' 'priority' 'not_recom' 'very_recom' 'spec_prior'] -> [2 1 0 4 3]

Processed dataset shape: torch.Size([12960, 9])
Number of features: 8
Features: ['parents', 'has_nurs', 'form', 'children', 'housing', 'finance', 'social', 'health']
Target: class
Framework: PYTORCH
Data type: <class 'torch.Tensor'>

============================================================
DECISION TREE CONSTRUCTION DEMO
============================================================
Total samples: 12960
Training samples: 10368
Testing samples: 2592

Constructing decision tree using training data...
```

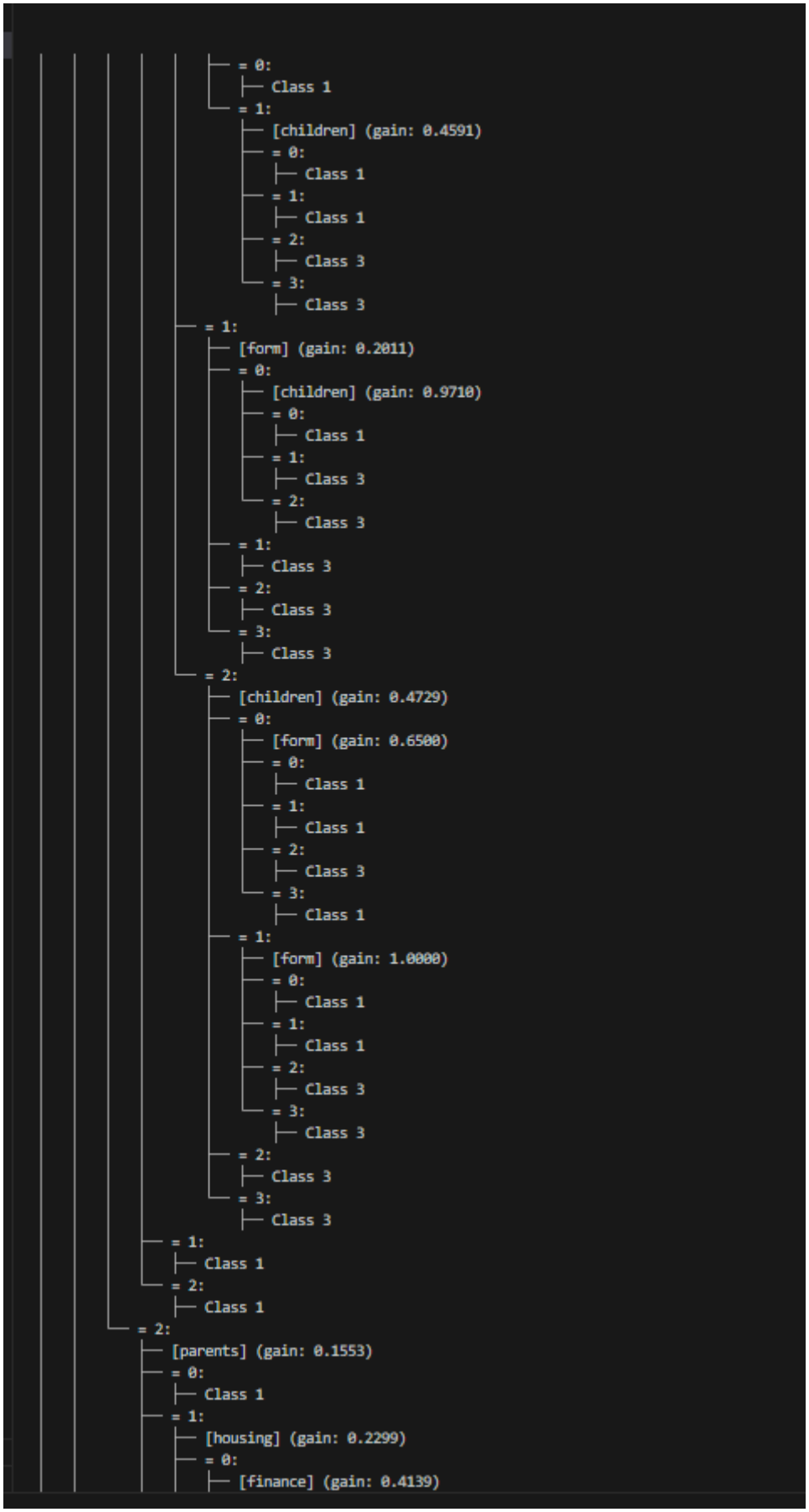
= 3:
Class 3
= 1:
[social] (gain: 0.4640)
= 0:
Class 1
= 1:
[housing] (gain: 0.1886)
= 0:
[finance] (gain: 0.5577)
= 0:
Class 1
= 1:
[form] (gain: 0.3555)
= 0:
Class 3
= 1:
Class 1
= 2:
Class 3
= 3:
Class 3
= 1:
[form] (gain: 0.1011)
= 0:
[children] (gain: 0.7219)
= 0:
Class 1
= 1:
Class 3
= 2:
Class 3
= 3:
Class 3
= 1:
Class 3
= 2:
Class 3
= 3:
Class 3
= 2:
[children] (gain: 0.5044)
= 0:
[form] (gain: 0.8113)
= 0:
Class 1
= 1:
Class 1
= 2:
Class 3
= 1:
[form] (gain: 0.9183)
= 0:
Class 1
= 1:
Class 1
= 2:
Class 3
= 3:
Class 3
= 2:

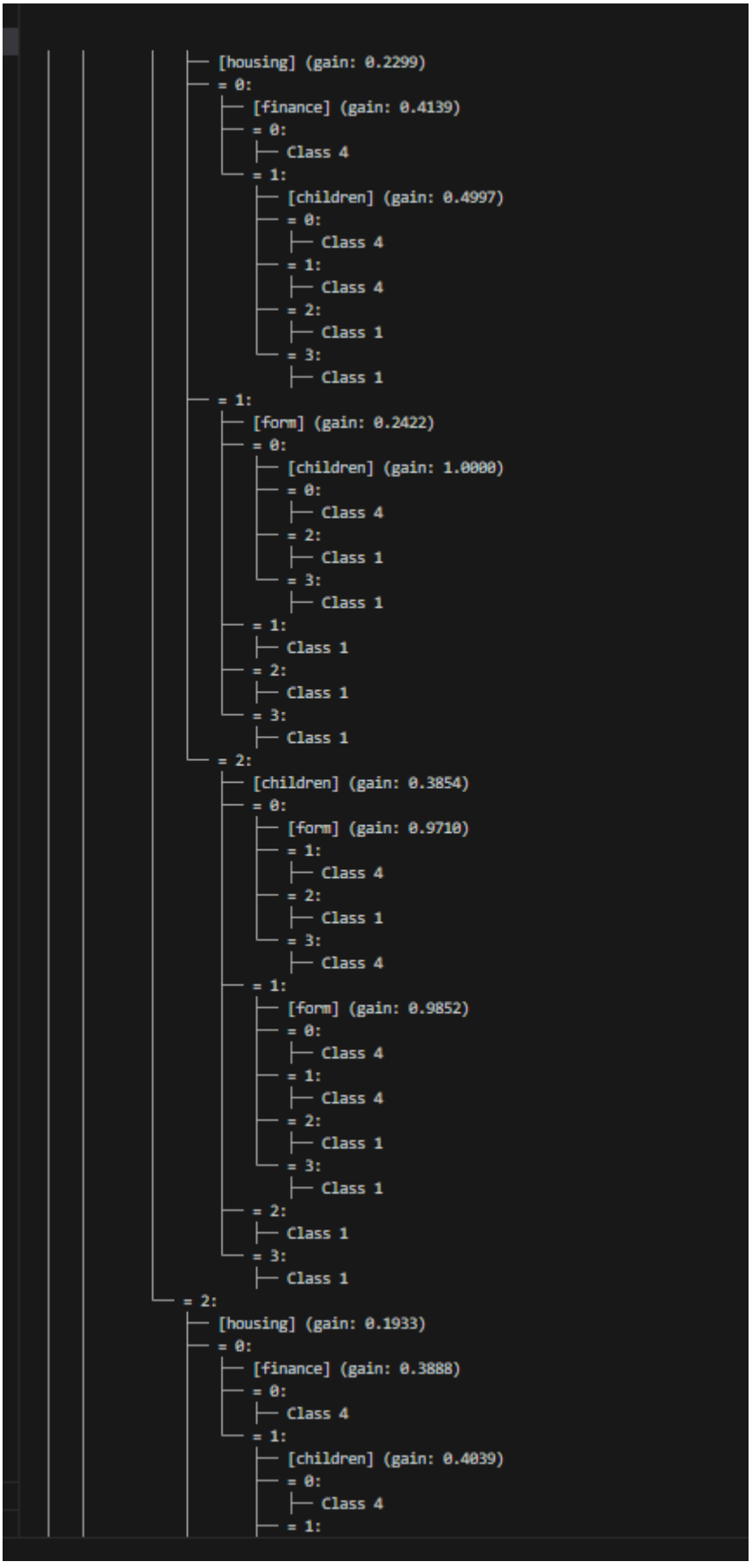

= 2:
[social] (gain: 0.1579)
= 0:
[housing] (gain: 0.1963)
= 0:
[finance] (gain: 0.4934)
= 0:
Class 4
= 1:
[form] (gain: 0.6058)
= 0:
Class 4
= 1:
Class 4
= 2:
Class 1
= 3:
Class 1
= 1:
[form] (gain: 0.1555)
= 0:
[children] (gain: 0.8631)
= 0:
Class 4
= 1:
Class 1
= 2:
Class 1
= 3:
Class 1
= 1:
Class 1
= 2:
Class 1
= 3:
Class 1
= 2:
[children] (gain: 0.5185)
= 0:
[form] (gain: 0.7219)
= 0:
Class 4
= 1:
Class 4
= 2:
Class 1
= 3:
Class 4
= 1:
[form] (gain: 0.9710)
= 0:
Class 4
= 1:
Class 4
= 3:
Class 1
= 2:
Class 1
= 3:
Class 1
= 1:
Class 1
= 2:
[housing] (gain: 0.1933)
= 0:
[finance] (gain: 0.4243)


[finance] (gain: 0.4243)
= 0:
Class 4
= 1:
[children] (gain: 0.4228)
= 0:
Class 4
= 1:
Class 1
= 2:
Class 1
= 3:
Class 1
= 1:
[children] (gain: 0.1793)
= 0:
[form] (gain: 0.9183)
= 0:
Class 4
= 1:
Class 1
= 2:
Class 1
= 3:
Class 1
= 1:
Class 1
= 2:
Class 1
= 3:
Class 1
= 2:
[children] (gain: 0.4667)
= 0:
[form] (gain: 0.6500)
= 0:
Class 4
= 1:
Class 4
= 2:
Class 1
= 3:
Class 4
= 1:
[form] (gain: 1.0000)
= 0:
Class 4
= 1:
Class 4
= 2:
Class 1
= 3:
Class 1
= 2:
Class 1
= 3:
Class 1
= 2:
[social] (gain: 0.1983)
= 0:
[parents] (gain: 0.1465)
= 0:
Class 1
= 1:
[housing] (gain: 0.2147)
= 0:


= 0:
Class 1
= 1:
[housing] (gain: 0.2147)
= 0:
[finance] (gain: 0.4408)
= 0:
Class 4
= 1:
[children] (gain: 0.4353)
= 0:
Class 4
= 1:
Class 1
= 2:
Class 1
= 3:
Class 1
= 1:
[form] (gain: 0.0948)
= 0:
[children] (gain: 0.7219)
= 0:
Class 4
= 1:
Class 1
= 2:
Class 1
= 3:
Class 1
= 1:
Class 1
= 2:
Class 1
= 3:
Class 1
= 2:
[children] (gain: 0.4054)
= 0:
[form] (gain: 0.8631)
= 0:
Class 4
= 1:
Class 4
= 2:
Class 1
= 3:
Class 4
= 1:
[form] (gain: 0.9852)
= 0:
Class 4
= 1:
Class 4
= 2:
Class 1
= 3:
Class 1
= 2:
Class 1
= 3:
Class 1
= 2:
[housing] (gain: 0.2021)
= 0:
[finance] (gain: 0.5127)


= 0:
Class 4
= 1:
[children] (gain: 0.4345)
= 0:
Class 4
= 1:
Class 1
= 2:
Class 1
= 3:
Class 1
= 1:
[form] (gain: 0.1589)
= 0:
[children] (gain: 0.8631)
= 0:
Class 4
= 1:
Class 1
= 2:
Class 1
= 3:
Class 1
= 1:
Class 1
= 2:
Class 1
= 3:
Class 1
= 2:
[children] (gain: 0.3632)
= 0:
[form] (gain: 0.9183)
= 0:
Class 4
= 1:
Class 4
= 2:
Class 1
= 3:
Class 4
= 1:
[form] (gain: 0.9852)
= 0:
Class 4
= 1:
Class 4
= 2:
Class 1
= 3:
Class 1
= 2:
Class 1
= 3:
Class 1
= 1:
[parents] (gain: 0.4439)
= 0:
[housing] (gain: 0.1910)
= 0:
[finance] (gain: 0.4530)
= 0:
Class 1
= 1:
[children] (gain: 0.4591)


= 0:
Class 1
= 1:
[children] (gain: 0.4591)
= 0:
Class 1
= 1:
Class 1
= 2:
Class 3
= 3:
Class 3
= 1:
[form] (gain: 0.2011)
= 0:
[children] (gain: 0.9710)
= 0:
Class 1
= 1:
Class 3
= 2:
Class 3
= 1:
Class 3
= 2:
Class 3
= 3:
Class 3
= 2:
[children] (gain: 0.4729)
= 0:
[form] (gain: 0.6500)
= 0:
Class 1
= 1:
Class 1
= 2:
Class 3
= 3:
Class 1
= 1:
[form] (gain: 1.0000)
= 0:
Class 1
= 1:
Class 1
= 2:
Class 3
= 3:
Class 3
= 2:
Class 3
= 3:
Class 3
= 1:
Class 1
= 2:
Class 1
= 2:
[parents] (gain: 0.1553)
= 0:
Class 1
= 1:
[housing] (gain: 0.2299)
= 0:
[finance] (gain: 0.4139)


[housing] (gain: 0.2299)
= 0:
[finance] (gain: 0.4139)
= 0:
Class 4
= 1:
[children] (gain: 0.4997)
= 0:
Class 4
= 1:
Class 4
= 2:
Class 1
= 3:
Class 1
= 1:
[form] (gain: 0.2422)
= 0:
[children] (gain: 1.0000)
= 0:
Class 4
= 2:
Class 1
= 3:
Class 1
= 1:
Class 1
= 2:
Class 1
= 3:
Class 1
= 2:
[children] (gain: 0.3854)
= 0:
[form] (gain: 0.9710)
= 1:
Class 4
= 2:
Class 1
= 3:
Class 4
= 1:
[form] (gain: 0.9852)
= 0:
Class 4
= 1:
Class 4
= 2:
Class 1
= 3:
Class 1
= 2:
Class 1
= 3:
Class 1
= 2:
[housing] (gain: 0.1933)
= 0:
[finance] (gain: 0.3888)
= 0:
Class 4
= 1:
[children] (gain: 0.4039)
= 0:
Class 4
= 1:

Class 3
= 1:
[form] (gain: 0.0182)
= 0:
[children] (gain: 0.0748)
= 0:
[housing] (gain: 0.3060)
= 0:
[finance] (gain: 1.0000)
= 0:
Class 1
= 1:
Class 3
= 1:
Class 3
= 2:
Class 3
= 1:
Class 3
= 2:
Class 3
= 3:
Class 3
= 1:
Class 3
= 2:
Class 3
= 3:
Class 3
= 2:
[housing] (gain: 0.2060)
= 0:
[finance] (gain: 0.4994)
= 0:
Class 1
= 1:
[children] (gain: 0.4516)
= 0:
[form] (gain: 0.8113)
= 0:
Class 1
= 1:
Class 1
= 2:
Class 3
= 3:
Class 1
= 1:
[form] (gain: 0.8631)
= 0:
Class 1
= 1:
Class 1
= 2:
Class 3
= 3:
Class 3
= 2:
Class 3
= 3:
Class 3
= 1:
[children] (gain: 0.1481)
= 0:
[form] (gain: 0.8524)
= 0:
Class 1
= 1:
Class 3
= 2:
Class 3

```
│               ├── [children] (gain: 0.1481)
│               ├── = 0:
│               │   ├── [form] (gain: 0.8524)
│               │   ├── = 0:
│               │   │   ├── Class 1
│               │   ├── = 1:
│               │   │   ├── Class 3
│               │   ├── = 2:
│               │   │   ├── Class 3
│               │   └── = 3:
│               │       ├── Class 3
│               ├── = 1:
│               │   ├── Class 3
│               ├── = 2:
│               │   ├── Class 3
│               └── = 3:
│                   ├── Class 3
└── = 2:
    ├── [children] (gain: 0.4086)
    ├── = 0:
    │   ├── [form] (gain: 0.8524)
    │   ├── = 0:
    │   │   ├── Class 1
    │   ├── = 1:
    │   │   ├── Class 1
    │   ├── = 2:
    │   │   ├── Class 3
    │   └── = 3:
    │       ├── Class 1
    ├── = 1:
    │   ├── [form] (gain: 0.9928)
    │   ├── = 0:
    │   │   ├── Class 1
    │   ├── = 1:
    │   │   ├── Class 1
    │   ├── = 2:
    │   │   ├── Class 3
    │   └── = 3:
    │       ├── Class 3
    ├── = 2:
    │   ├── Class 3
    └── = 3:
        ├── Class 3


📊 OVERALL PERFORMANCE METRICS
========================================
Accuracy:            0.9867 (98.67%)
Precision (weighted): 0.9876
Recall (weighted):    0.9867
F1-Score (weighted):  0.9872
Precision (macro):    0.7604
Recall (macro):       0.7654
F1-Score (macro):     0.7628

🌳 TREE COMPLEXITY METRICS
========================================
Maximum Depth:        7
Total Nodes:          952
Leaf Nodes:           680
Internal Nodes:       272
PS C:\Users\diyab\sem 5\Machine Learning\Lab_1\ML_LAB1_Assignment>
```