

# Machine Learning Lab Assignment - 1

Name: Dhruv Maheshwari

Sem 5 – C

Date: 19<sup>th</sup> Aug 2025

Link to Kaggle Notebook:

<https://www.kaggle.com/code/dhruvmaheshwari2004/pes2ug23cs173>

The image shows two side-by-side Jupyter Notebook interfaces. Both notebooks have a dark theme and are titled 'PES2UG23CS173'.

**Top Notebook (Left):**

```
# For Mushroom dataset
!python /kaggle/input/machinelearninglab/test.py --ID EC_C_PES2UG23CS173_Lab3 --data /kaggle/input/machinelearninglab/mushrooms.csv

# For Tic-Tac-Toe dataset
!python /kaggle/input/machinelearninglab/test.py --ID EC_C_PES2UG23CS173_Lab3 --data /kaggle/input/machinelearninglab/tictactoe.csv

# For Nursery dataset
!python /kaggle/input/machinelearninglab/test.py --ID EC_C_PES2UG23CS173_Lab3 --data /kaggle/input/machinelearninglab/Nursery.csv
```

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-type', '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-type', 'spore-print-color', 'population', 'habitat']
Target: class
Framework: PYTORCH
Data type: <class 'torch.Tensor'>
```

**Bottom Notebook (Right):**

```
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!

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
```

Running tests with PYTORCH framework

```
=====
target column: 'class' (last column)
Original dataset info:
Shape: (958, 10)
Columns: ['top-left-square', 'top-middle-square', 'top-right-square', 'middle-left-square', 'middle-middle-square', 'middle-right-square', 'bottom-left-square', 'bottom-middle-square', 'bottom-right-square', 'Class']
```

**Entropy Calculation:** To determine a dataset's entropy, a function is developed. The degree of class mixing in a given set of examples can be ascertained by measuring the impurity or randomness of the data using entropy.

**Average Information:** The average information of a particular attribute is determined by another function. In essence, this is a weighted average of the entropy of each subset that was produced by dividing the dataset according to that characteristic.

**Information Gain:** A third function determines the information gain for each attribute using the two functions mentioned above. The decrease in entropy that arises from dividing the data according to a specific feature is measured by information gain. For a split, the best attribute to use is the one with the highest information gain.

**Attribute Selection:** The last function iterates through all of the features that are available and chooses the one with the greatest information gain in order to determine which attribute should be used for the subsequent split in the tree.

PES2UG23CS173 Draft saved

```

File Edit View Run Settings Add-ons Help
+ ✎ Run All Code
First few rows:
top-left-square: ['x' 'o' 'b'] -> [2 1 0]
top-middle-square: ['x' 'o' 'b'] -> [2 1 0]
top-right-square: ['x' 'o' 'b'] -> [2 1 0]
Class: ['positive' 'negative'] -> [1 0]

Processed dataset shape: torch.Size([958, 10])
Number of features: 9
Features: ['top-left-square', 'top-middle-square', 'top-right-square', 'middle-left-square', 'middle-middle-square', 'middle-right-square', 'bottom-left-square', 'bottom-middle-square', 'bottom-right-square']
Target: Class
Framework: PYTORCH
Data type: <class 'torch.Tensor'>

=====
DECISION TREE CONSTRUCTION DEMO
=====
Total samples: 958
Training samples: 766
Testing samples: 192

Constructing decision tree using training data...
Decision tree construction completed using PYTORCH!

OVERALL PERFORMANCE METRICS
=====
Accuracy: 0.8730 (87.30%)
Precision (Weighted): 0.8741
Recall (Weighted): 0.8730
F1-Score (Weighted): 0.8734
Precision (Macro): 0.8598
Recall (Macro): 0.8638
F1-Score (Macro): 0.8613

```

PES2UG23CS173 Draft saved

```

File Edit View Run Settings Add-ons Help
+ ✎ Run All Code
TREE COMPLEXITY METRICS
=====
Maximum Depth: 7
Total Nodes: 281
Leaf Nodes: 188
Internal Nodes: 101
Running tests with PYTORCH framework
=====
target column: 'class' (last column)
Original dataset info:
Shape: (12960, 9)
Columns: ['parents', 'has_nurs', 'form', 'children', 'housing', 'finance', 'social', 'health', 'class']

First few rows:
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...
Decision tree construction completed using PYTORCH!

```

PES2UG23CS173 Draft saved

```

File Edit View Run Settings Add-ons Help
+ ✎ Run All Code
OVERALL PERFORMANCE METRICS
=====
Accuracy: 0.9867 (98.67%)
Precision (Weighted): 0.9876
Recall (Weighted): 0.9867
F1-Score (Weighted): 0.9872
Precision (Macro): 0.9868
Recall (Macro): 0.9854
F1-Score (Macro): 0.9828

```

TREE COMPLEXITY METRICS

```

=====
Maximum Depth: 7
Total Nodes: 952
Leaf Nodes: 688
Internal Nodes: 272
+ Code + Markdown

```

```

[7]: # To visualize the tree for the Mushroom dataset
!python /kaggle/input/machinelearninglab/test.py --ID EC_C_PES2UG23CS173_Lab3 --data /kaggle/input/machinelearninglab/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-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-type', 'spore-print-color', 'population', 'habitat', 'class']

```

**Execution:** The implemented code is run on each dataset using commands to record performance metrics like F1-score, recall, accuracy, and precision.

**Analysis:** A thorough analysis is based on the results of these tests. A thorough comparison of the findings from all three datasets is included in the notebook. This analysis includes:

**Performance Metrics:** A comparison of each dataset's classification metrics.

PES2UG23CS173 Draft saved

File Edit View Run Settings Add-ons Help

+ X Run All Code

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-type', '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!
```

PES2UG23CS173 Draft saved

File Edit View Run Settings Add-ons Help

+ X Run All Code

▲ DECISION TREE STRUCTURE

```
Root [cpr] (gain: 0.9683)
├── 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
```

**Tree Characteristics:** An analysis of the depth and total number of nodes in the resultant tree.

**Feature Importance:** An examination of the features (the tree's root and early splits) that were deemed most crucial for decision-making.

```

PES2UG23CS173 Draft saved
File Edit View Run Settings Add-ons Help
+ ✎ 📁 ▶ Run All Code ▾
└─ 1:
   └─ Class 0
   └─ 2:
      └─ [cap-color] (gain: 0.7300)
         └─ 1:
            └─ Class 0
            └─ 4:
               └─ Class 0
               └─ 8:
                  └─ Class 0
                  └─ 9:
                     └─ Class 1
                     └─ 1:
                        └─ Class 1
                        └─ 4:
                           └─ Class 0
                           └─ 6:
                              └─ Class 0
                           └─ 8:
                              └─ Class 0
                           └─ 6:
                              └─ Class 1
                           └─ 7:
                              └─ Class 1
                           └─ 8:
                              └─ 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

PES2UG23CS173 Draft saved
File Edit View Run Settings Add-ons Help
+ ✎ 📁 ▶ Run All Code ▾
└─ 9:
   └─ 4:
      └─ Class 1
      └─ 6:
         └─ 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

+ Code + Markdown

```

Insights: An end-of-term report explaining how the performance and shape of the decision tree varied in response to dimensions such as dataset size, feature dimension, and class distribution for each particular problem. The report also indicates the benefits of applying an interpretable model such as a decision tree.

### Whole Output:

```
|   └── 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
```

```
Running tests with PYTORCH framework
```

```
=====
target column: 'Class' (last column)
Original dataset info:
Shape: (958, 10)
Columns: ['top-left-square', 'top-middle-square', 'top-right-square', 'middle-left-square', 'middle-middle-square', 'middle-right-square', 'bottom-left-square', 'bottom-middle-square', 'bottom-right-square', 'Class']
```

First few rows:

```
top-left-square: ['x' 'o' 'b'] -> [2 1 0]
```

```
top-middle-square: ['x' 'o' 'b'] -> [2 1 0]
```

```
top-right-square: ['x' 'o' 'b'] -> [2 1 0]
```

```
Class: ['positive' 'negative'] -> [1 0]
```

```
Processed dataset shape: torch.Size([958, 10])
```

```
Number of features: 9
```

```
Features: ['top-left-square', 'top-middle-square', 'top-right-square', 'middle-left-square', 'middle-middle-square', 'middle-right-square', 'bottom-left-square', 'bottom-middle-square', 'bottom-right-square']
```

```
Target: Class
```

```
Framework: PYTORCH
```

```
Data type: <class 'torch.Tensor'>
```

```
=====
DECISION TREE CONSTRUCTION DEMO
```

```
=====
Total samples: 958
Training samples: 766
Testing samples: 192
```

Constructing decision tree using training data...

🌲 Decision tree construction completed using PYTORCH!

#### 🌲 DECISION TREE STRUCTURE

```
=====
Root [middle-middle-square] (gain: 0.0834)
```

```
└── = 0:
    ├── [bottom-left-square] (gain: 0.1056)
    └── = 0:
        ├── [top-right-square] (gain: 0.9024)
        │   ├── = 1:
        │   │   ├── Class 0
        │   │   └── = 2:
        │   │       └── Class 1
        │   └── = 1:
        │       ├── [top-right-square] (gain: 0.2782)
        │       │   ├── = 0:
        │       │   │   ├── Class 0
        │       │   │   └── = 1:
        │       │       └── Class 0
        │       └── = 2:
        │           ├── [top-left-square] (gain: 0.1767)
        │           │   ├── = 0:
        │           │   │   ├── [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 0
    └── = 1:
        └── [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 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:
        └── Class 0
    └── [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:
        └── Class 1
    └── [bottom-middle-square] (gain: 0.2400)

```

```
└── = 0:
    └── [top-left-square] (gain: 1.0000)
        └── = 1:
            └── Class 0
                └── = 2:
                    └── Class 1
    └── = 1:
        └── [bottom-right-square] (gain: 0.9710)
            └── = 1:
                └── Class 0
                    └── = 2:
                        └── Class 1
    └── = 2:
        └── [bottom-left-square] (gain: 0.4759)
            └── = 0:
                └── Class 0
            └── = 1:
                └── Class 0
            └── = 2:
                └── [top-middle-square] (gain: 0.1974)
                    └── = 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 0
                    └── = 2:
                        └── Class 1
            └── [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
            └── 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
            └── = 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 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
            = 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
            = 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:
                    └─ Class 1
            = 2:
                └─ [bottom-left-square] (gain: 0.5549)
            = 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:
                                        └── Class 1
                            └── = 1:
                                └── [top-right-square] (gain: 0.9183)
                                    └── = 0:
                                        └── Class 0
                                    └── = 1:
                                        └── Class 0
                                    └── = 2:
                                        └── Class 1
                            └── = 2:
                                └── Class 1
            └── = 2:
                └── Class 1

```

#### 📊 OVERALL PERFORMANCE METRICS

```
=====
Accuracy: 0.8730 (87.30%)
Precision (weighted): 0.8741
Recall (weighted): 0.8730
F1-Score (weighted): 0.8734
Precision (macro): 0.8590
Recall (macro): 0.8638
F1-Score (macro): 0.8613
```

#### 🌲 TREE COMPLEXITY METRICS

```
=====
Maximum Depth: 7
Total Nodes: 281
Leaf Nodes: 180
```

```
Internal Nodes: 101
Running tests with PYTORCH framework
=====
target column: 'class' (last column)
Original dataset info:
Shape: (12960, 9)
Columns: ['parents', 'has_nurs', 'form', 'children', 'housing', 'finance', 'social', 'health', 'class']
```

First few rows:

```
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...

♣ Decision tree construction completed using PYTORCH!

#### ♣ DECISION TREE STRUCTURE

```
=====
Root [health] (gain: 0.9595)
└── = 0:
    └── Class 0
└── = 1:
    └── [has_nurs] (gain: 0.3555)
        ├── = 0:
            ├── [parents] (gain: 0.1673)
            ├── = 0:
                ├── [form] (gain: 0.0171)
                ├── = 0:
                    ├── [children] (gain: 0.0662)
                    ├── = 0:
                        ├── [housing] (gain: 0.2401)
                        ├── = 0:
                            ├── [finance] (gain: 0.9710)
                            ├── = 0:
                                └── Class 1
                            ├── = 1:
                                └── Class 3
                            ├── = 2:
                                └── Class 3
                            ├── = 3:
                                └── Class 3
                        ├── = 1:
                            └── Class 3
                        ├── = 2:
                            └── Class 3
                        ├── = 3:
                            └── Class 3
                    ├── = 1:
                        └── Class 3
                    ├── = 2:
                        └── Class 3
                    ├── = 3:
                        └── Class 3
                ├── = 1:
                    └── [form] (gain: 0.0269)
                    ├── = 0:
                        ├── [children] (gain: 0.1080)
                        ├── = 0:
                            ├── [housing] (gain: 0.3219)
                            ├── = 0:
                                ├── [finance] (gain: 1.0000)
                                ├── = 0:
                                    └── Class 1
                                ├── = 1:
                                    └── Class 3
                            ├── = 1:
                                └── Class 3
                            ├── = 2:
                                └── Class 3
                        ├── = 1:
                            └── Class 3
                    ├── = 1:
                        └── Class 3
```

```
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 1:
        └── Class 3
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 2:
        └── Class 3
└── [housing] (gain: 0.2558)
└── = 0:
    └── [finance] (gain: 0.4787)
    └── = 0:
        └── Class 1
    └── = 1:
        └── [children] (gain: 0.5240)
        └── = 0:
            └── [form] (gain: 0.5917)
            └── = 0:
                └── Class 1
            └── = 1:
                └── Class 1
            └── = 2:
                └── Class 1
            └── = 3:
                └── Class 3
            └── = 1:
                └── Class 1
            └── = 2:
                └── [form] (gain: 0.9911)
                └── = 0:
                    └── Class 1
                └── = 1:
                    └── Class 1
                └── = 2:
                    └── Class 3
                └── = 3:
                    └── Class 3
            └── = 2:
                └── Class 3
            └── = 3:
                └── Class 3
        └── = 1:
            └── [children] (gain: 0.1214)
        └── = 0:
            └── [form] (gain: 0.7871)
            └── = 0:
                └── Class 1
            └── = 1:
                └── Class 3
            └── = 2:
                └── Class 3
            └── = 3:
                └── Class 3
            └── = 1:
                └── Class 3
            └── = 2:
                └── Class 3
            └── = 3:
                └── Class 3
        └── = 2:
            └── [children] (gain: 0.4000)
        └── = 0:
            └── [form] (gain: 0.8740)
            └── = 0:
                └── Class 1
            └── = 1:
                └── Class 1
            └── = 2:
                └── Class 3
            └── = 3:
                └── Class 1
        └── = 1:
            └── [form] (gain: 0.9911)
            └── = 0:
                └── Class 1
            └── = 1:
                └── Class 1
            └── = 2:
                └── Class 3
            └── = 3:
                └── Class 3
            └── = 2:
                └── Class 3
            └── = 3:
                └── Class 3
        └── = 1:
            └── [parents] (gain: 0.6347)
            └── = 0:
                └── [form] (gain: 0.0262)
                └── = 0:
                    └── [children] (gain: 0.1127)
```

```

    └── = 0:
        └── [housing] (gain: 0.3210)
    └── = 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
            └── = 1:
                └── Class 3
        └── [housing] (gain: 0.1945)
    └── = 0:
        └── [finance] (gain: 0.4975)
            └── = 0:
                └── Class 1
                    └── = 1:
                        └── [children] (gain: 0.4013)
                    └── = 0:
                        └── [form] (gain: 0.9183)
                            └── = 0:
                                └── Class 1
                            └── = 1:
                                └── Class 1
                            └── = 2:
                                └── Class 3
                            └── = 3:
                                └── Class 1
                            └── = 1:
                                └── [form] (gain: 0.9940)
                            └── = 0:
                                └── Class 1
                            └── = 1:
                                └── Class 1
                            └── = 2:
                                └── Class 3
                            └── = 3:
                                └── Class 3
                            └── = 2:
                                └── Class 3
                            └── = 3:
                                └── Class 3
            └── = 1:
                └── [children] (gain: 0.1810)
        └── = 0:
            └── [form] (gain: 0.9183)
                └── = 0:
                    └── Class 1
                └── = 1:
                    └── Class 3
                └── = 2:
                    └── Class 3
                └── = 3:
                    └── Class 3
                └── = 1:
                    └── Class 3
                └── = 2:
                    └── Class 3
                └── = 3:
                    └── Class 3
                └── = 2:
                    └── Class 3
            └── [children] (gain: 0.4161)
        └── = 0:
            └── [form] (gain: 0.8813)
                └── = 0:
                    └── Class 1
                └── = 1:
                    └── Class 1
                └── = 2:
                    └── Class 3
                └── = 3:
                    └── Class 1
            └── = 1:
                └── [form] (gain: 0.9940)
                └── = 0:
                    └── Class 1
                └── = 1:
                    └── Class 1

```

```

    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 2:
        └── Class 1
    └── = 2:
        └── [parents] (gain: 0.4605)
    └── = 0:
        └── [housing] (gain: 0.2382)
    └── = 0:
        └── [finance] (gain: 0.4152)
        └── = 0:
            └── Class 1
        └── = 1:
            └── [children] (gain: 0.5697)
            └── = 0:
                └── [form] (gain: 0.7219)
                └── = 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:
            └── [form] (gain: 0.1487)
        └── = 0:
            └── [children] (gain: 0.8740)
            └── = 0:
                └── Class 1
            └── = 1:
                └── Class 3
            └── = 2:
                └── Class 3
            └── = 3:
                └── Class 3
            └── = 1:
                └── Class 3
            └── = 2:
                └── Class 3
            └── = 3:
                └── Class 3
            └── = 2:
                └── Class 3
        └── = 0:
            └── [children] (gain: 0.4240)
        └── = 0:
            └── [form] (gain: 0.7871)
            └── = 0:
                └── Class 1
            └── = 1:
                └── Class 1
            └── = 2:
                └── Class 3
            └── = 3:
                └── Class 1
        └── = 1:
            └── [form] (gain: 0.9940)
            └── = 0:
                └── Class 1
            └── = 1:
                └── Class 1
            └── = 2:
                └── Class 3
            └── = 3:
                └── Class 3
            └── = 2:
                └── Class 3
            └── = 3:
                └── Class 3
        └── = 1:
            └── Class 1
        └── = 2:
            └── Class 1
        └── = 3:
            └── [parents] (gain: 0.4674)

```

```

    └── = 0:
        └── [housing] (gain: 0.1941)
    └── = 0:
        └── [finance] (gain: 0.5239)
    └── = 0:
        └── Class 1
    └── = 1:
        └── [children] (gain: 0.4173)
    └── = 0:
        └── [form] (gain: 0.8813)
    └── = 0:
        └── Class 1
    └── = 1:
        └── Class 1
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 1
    └── = 1:
        └── [form] (gain: 0.9852)
    └── = 0:
        └── Class 1
    └── = 1:
        └── Class 1
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 1:
        └── [form] (gain: 0.1462)
    └── = 0:
        └── [children] (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: 0.3591)
    └── = 0:
        └── [form] (gain: 0.9183)
    └── = 0:
        └── Class 1
    └── = 1:
        └── Class 1
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 1
    └── = 1:
        └── [form] (gain: 0.9940)
    └── = 0:
        └── Class 1
    └── = 1:
        └── Class 1
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 1:
        └── Class 1
    └── = 2:
        └── Class 1
    └── = 4:
        └── [form] (gain: 0.0257)
    └── = 0:
        └── [children] (gain: 0.1010)
    └── = 0:
        └── [housing] (gain: 0.3429)
    └── = 0:
        └── [finance] (gain: 0.9975)
    └── = 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:
        └── [has_nurs] (gain: 0.2950)
    └── = 0:
        └── [parents] (gain: 0.2187)
    └── = 0:
        └── [social] (gain: 0.1160)
    └── = 0:
        └── [housing] (gain: 0.1454)
    └── = 0:
        └── [finance] (gain: 0.6675)
    └── = 0:
        └── Class 1
    └── = 1:
        └── [children] (gain: 0.2536)
    └── = 0:
        └── Class 1
    └── = 1:
        └── Class 3
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 1:
        └── [children] (gain: 0.1818)
    └── = 0:
        └── [form] (gain: 0.9183)
    └── = 0:
        └── Class 1
    └── = 1:
        └── Class 3
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 1:
        └── Class 3
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 2:
        └── [children] (gain: 0.3871)
    └── = 0:
        └── [form] (gain: 0.8113)
    └── = 0:
        └── Class 1
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 1
    └── = 1:
        └── [form] (gain: 0.9852)
    └── = 0:
        └── Class 1
    └── = 1:
        └── Class 1
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 1:
        └── [form] (gain: 0.0280)
    └── = 0:
        └── [children] (gain: 0.1090)
    └── = 0:
        └── [housing] (gain: 0.3219)
    └── = 0:
        └── Class 1
    └── = 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:
        └── Class 3
    └── [housing] (gain: 0.2661)
    └── = 0:
        └── [finance] (gain: 0.5230)
        └── = 0:
            └── Class 1
        └── = 1:
            └── [children] (gain: 0.4131)
            └── = 0:
                └── Class 1
            └── = 1:
                └── Class 1
            └── = 2:
                └── Class 3
            └── = 3:
                └── Class 3
            └── Class 3
        └── = 1:
            └── Class 3
        └── = 2:
            └── [children] (gain: 0.4667)
        └── = 0:
            └── [form] (gain: 0.9183)
            └── = 1:
                └── Class 1
            └── = 2:
                └── Class 3
            └── = 3:
                └── Class 1
            └── = 1:
                └── [form] (gain: 0.9183)
            └── = 0:
                └── Class 1
            └── = 1:
                └── Class 1
            └── = 2:
                └── Class 3
            └── = 3:
                └── Class 3
            └── Class 3
        └── = 2:
            └── Class 3
        └── = 3:
            └── Class 3
    └── = 1:
        └── [social] (gain: 0.1315)
        └── = 0:
            └── [housing] (gain: 0.1639)
            └── = 0:
                └── [finance] (gain: 0.5716)
                └── = 0:
                    └── Class 1
                └── = 1:
                    └── [children] (gain: 0.3178)
                    └── = 0:
                        └── Class 1
                    └── = 1:
                        └── Class 1
                    └── = 2:
                        └── Class 3
                    └── = 3:
                        └── Class 3
                    └── Class 3
                └── = 1:
                    └── [form] (gain: 0.1842)
                └── = 0:
                    └── [children] (gain: 0.9183)
                    └── = 0:
                        └── Class 1
                    └── = 1:
                        └── Class 3
                    └── = 2:
                        └── Class 3
                    └── = 3:
                        └── Class 3
                    └── Class 3
                └── = 1:
                    └── Class 3
                └── = 2:
                    └── Class 3
                └── = 3:
                    └── Class 3
                └── Class 3
            └── = 2:
                └── [children] (gain: 0.3640)
            └── = 0:
                └── [form] (gain: 0.9183)

```

```

    |--- = 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:
    |   |--- [form] (gain: 0.0279)
    |   |--- = 0:
    |       |--- [children] (gain: 0.1293)
    |       |--- = 0:
    |           |--- [housing] (gain: 0.3113)
    |           |--- = 0:
    |               |--- Class 1
    |               |--- = 2:
    |                   |--- Class 3
    |               |--- = 1:
    |                   |--- Class 3
    |               |--- = 2:
    |                   |--- Class 3
    |               |--- = 3:
    |                   |--- Class 3
    |               |--- = 1:
    |                   |--- Class 3
    |               |--- = 2:
    |                   |--- Class 3
    |               |--- = 3:
    |                   |--- Class 3
    |
    |--- = 2:
    |   |--- [housing] (gain: 0.1811)
    |   |--- = 0:
    |       |--- [finance] (gain: 0.5034)
    |       |--- = 0:
    |           |--- Class 1
    |           |--- = 1:
    |               |--- [children] (gain: 0.4345)
    |               |--- = 0:
    |                   |--- Class 1
    |                   |--- = 1:
    |                       |--- Class 3
    |                       |--- = 2:
    |                           |--- Class 3
    |                           |--- = 3:
    |                               |--- Class 3
    |
    |--- = 1:
    |   |--- [form] (gain: 0.1793)
    |   |--- = 0:
    |       |--- [children] (gain: 0.9183)
    |       |--- = 0:
    |           |--- Class 1
    |           |--- = 1:
    |               |--- Class 3
    |               |--- = 2:
    |                   |--- Class 3
    |                   |--- = 3:
    |                       |--- Class 3
    |
    |--- = 1:
    |   |--- Class 3
    |   |--- = 2:
    |       |--- Class 3
    |       |--- = 3:
    |           |--- Class 3
    |
    |--- = 2:
    |   |--- [children] (gain: 0.5445)
    |   |--- = 0:
    |       |--- [form] (gain: 0.5917)
    |       |--- = 0:
    |           |--- Class 1
    |           |--- = 1:
    |               |--- Class 1
    |               |--- = 2:
    |                   |--- Class 3
    |                   |--- = 3:
    |                       |--- Class 1
    |
    |--- = 1:
    |   |--- [form] (gain: 0.9710)

```

```

    └── = 0:
        └── Class 1
    └── = 1:
        └── Class 1
    └── = 2:
        └── Class 3
            └── = 3:
                └── Class 3
    └── = 2:
        └── Class 3
            └── = 3:
                └── Class 3
    └── = 2:
        └── [social] (gain: 0.4394)
    └── = 0:
        └── Class 1
    └── = 1:
        └── [housing] (gain: 0.2023)
    └── = 0:
        └── [finance] (gain: 0.4895)
    └── = 0:
        └── Class 1
            └── = 1:
                └── [children] (gain: 0.4290)
    └── = 0:
        └── Class 1
            └── = 1:
                └── Class 3
            └── = 2:
                └── Class 3
            └── = 3:
                └── Class 3
        └── Class 3
    └── = 1:
        └── [form] (gain: 0.1793)
    └── = 0:
        └── [children] (gain: 0.9183)
    └── = 0:
        └── Class 1
            └── = 1:
                └── Class 3
            └── = 2:
                └── Class 3
            └── = 3:
                └── Class 3
        └── Class 3
    └── = 2:
        └── [children] (gain: 0.4440)
    └── = 0:
        └── [form] (gain: 0.7219)
    └── = 0:
        └── Class 1
            └── = 1:
                └── Class 1
            └── = 2:
                └── Class 3
            └── = 3:
                └── Class 1
        └── Class 1
    └── = 1:
        └── [form] (gain: 1.0000)
    └── = 0:
        └── Class 1
            └── = 1:
                └── Class 1
            └── = 2:
                └── Class 3
            └── = 3:
                └── Class 3
        └── Class 3
    └── = 2:
        └── Class 3
            └── = 3:
                └── Class 3
        └── Class 3
    └── = 2:
        └── Class 1
    └── = 1:
        └── [parents] (gain: 0.4874)
    └── = 0:
        └── [social] (gain: 0.1600)
    └── = 0:
        └── [housing] (gain: 0.2766)
    └── = 0:
        └── [finance] (gain: 0.3753)
    └── = 0:
        └── Class 1
            └── = 1:
                └── [children] (gain: 0.4799)
    └── = 0:
        └── Class 1
            └── = 1:
                └── Class 1
        └── Class 1

```

```

    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 1:
        └── [form] (gain: 0.0841)
    └── = 0:
        └── [children] (gain: 0.6500)
    └── = 0:
        └── [form] (gain: 0.0841)
    └── = 1:
        └── Class 1
    └── = 1:
        └── Class 3
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 1:
        └── Class 3
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 2:
        └── Class 3
    └── = 0:
        └── [form] (gain: 0.3844)
    └── = 0:
        └── [form] (gain: 0.8113)
    └── = 0:
        └── Class 1
    └── = 1:
        └── Class 1
    └── = 2:
        └── Class 1
    └── = 3:
        └── Class 1
    └── = 1:
        └── [form] (gain: 0.9852)
    └── = 0:
        └── Class 1
    └── = 1:
        └── Class 1
    └── = 2:
        └── Class 1
    └── = 3:
        └── Class 3
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 1:
        └── Class 3
    └── = 2:
        └── [housing] (gain: 0.2257)
    └── = 0:
        └── [finance] (gain: 0.4696)
    └── = 0:
        └── Class 1
    └── = 1:
        └── [form] (gain: 0.4591)
    └── = 0:
        └── Class 1
    └── = 1:
        └── Class 1
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 1:
        └── [children] (gain: 0.1842)
    └── = 0:
        └── [form] (gain: 0.9183)
    └── = 0:
        └── Class 1
    └── = 1:
        └── Class 3
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 1:
        └── Class 3
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 2:
        └── [children] (gain: 0.3839)
    └── = 0:
        └── [form] (gain: 0.9183)
    └── = 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:
        └── [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:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 2:
        └── Class 1
    └── = 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)
|   |   └= 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:
        └── [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
    └── = 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

```



```

    └── = 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)
                    └── = 0:
                        └── Class 4
                    └── = 1:
                        └── [children] (gain: 0.4997)
                            └── = 0:
                                └── Class 4
                            └── = 1:
                                └── Class 4
                            └── = 2:
                                └── Class 1
                            └── = 3:
                                └── Class 1
                            └── Class 1
            └── = 1:
                └── [form] (gain: 0.2422)
            └── = 0:
                └── [children] (gain: 1.0000)
                    └── = 0:
                        └── Class 4
                    └── = 2:
                        └── Class 1
                    └── = 3:
                        └── Class 1
                        └── Class 1
            └── = 1:
                └── Class 1
            └── = 2:
                └── Class 1
            └── = 3:
                └── Class 1
                └── Class 1
    └── = 2:
        └── [children] (gain: 0.3854)
    └── = 0:
        └── [form] (gain: 0.9710)
            └── = 1:
                └── Class 4
            └── = 2:
                └── Class 1
            └── = 3:
                └── Class 4
            └── Class 4
    └── = 1:
        └── [form] (gain: 0.9852)
            └── = 0:
                └── Class 4
            └── = 1:
                └── Class 4
            └── = 2:
                └── Class 1
            └── = 3:
                └── Class 1
                └── Class 1
            └── = 2:
                └── Class 1
            └── = 3:
                └── Class 1
                └── 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 1
    └── = 2:
        └── Class 1
    └── = 3:
        └── Class 1
    └── Class 1
    └── = 1:
        └── [form] (gain: 0.1555)
    └── = 0:
        └── [children] (gain: 0.8631)
    └── = 0:
        └── Class 4
    └── = 1:
        └── Class 1
    └── = 2:
        └── Class 1
    └── = 3:
        └── Class 1
    └── Class 1
    └── = 1:
        └── Class 1
    └── = 2:
        └── Class 1
    └── = 3:
        └── Class 1
    └── Class 1
    └── = 2:
        └── [children] (gain: 0.4323)
    └── = 0:
        └── [form] (gain: 0.8113)
    └── = 0:
        └── Class 4
    └── = 1:
        └── Class 4
    └── = 2:
        └── Class 1
    └── = 3:
        └── Class 4
    └── Class 4
    └── = 1:
        └── [form] (gain: 0.9183)
    └── = 0:
        └── Class 4
    └── = 2:
        └── Class 1
    └── = 3:
        └── Class 1
    └── Class 1
    └── = 2:
        └── Class 1
    └── = 3:
        └── Class 1
    └── Class 1
    └── = 3:
        └── [parents] (gain: 0.2121)
    └── = 0:
        └── [social] (gain: 0.4863)
    └── = 0:
        └── Class 1
    └── = 1:
        └── [housing] (gain: 0.2658)
    └── = 0:
        └── [finance] (gain: 0.3976)
    └── = 0:
        └── Class 1
    └── = 1:
        └── [children] (gain: 0.4997)
    └── = 0:
        └── Class 1
    └── = 1:
        └── Class 1
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── Class 3
    └── = 1:
        └── [form] (gain: 0.0874)
    └── = 0:
        └── [children] (gain: 0.6500)
    └── = 0:
        └── Class 1
    └── = 1:
        └── Class 3
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── Class 3
    └── = 1:
        └── Class 3
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── Class 3

```



```
    └── = 0:
        └── Class 4
    └── = 1:
        └── [children] (gain: 0.5183)
            └── = 0:
                └── Class 4
            └── = 1:
                └── Class 4
            └── = 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: 0.5370)
    └── = 0:
        └── [form] (gain: 0.5917)
            └── = 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: 0.1711)
    └── = 0:
        └── [children] (gain: 0.1577)
    └── = 0:
        └── [form] (gain: 0.4513)
            └── = 0:
                └── Class 4
            └── = 1:
                └── [housing] (gain: 0.7219)
                    └── = 0:
                        └── Class 4
                    └── = 1:
                        └── Class 1
                    └── = 2:
                        └── Class 1
                    └── = 3:
                        └── Class 4
            └── = 2:
                └── [housing] (gain: 0.3219)
                └── = 0:
                    └── Class 1
                └── = 1:
                    └── Class 1
                └── = 2:
                    └── Class 1
                └── = 3:
                    └── Class 4
        └── = 1:
            └── [form] (gain: 0.3601)
            └── = 0:
                └── [housing] (gain: 1.0000)
                └── = 1:
                    └── Class 1
                └── = 2:
                    └── Class 1
                └── = 3:
                    └── [housing] (gain: 0.9183)
```

```

  └── = 0:
    └── Class 4
  └── = 1:
    └── Class 1
  └── = 2:
    └── Class 4
  └── = 2:
    └── Class 1
  └── = 3:
    └── Class 1
  └── = 2:
    └── [housing] (gain: 0.3215)
  └── = 0:
    └── [finance] (gain: 1.0000)
  └── = 0:
    └── Class 4
  └── = 1:
    └── Class 1
  └── = 1:
    └── Class 1
  └── = 2:
    └── Class 1
  └── = 2:
    └── Class 1
  └── = 3:
    └── [housing] (gain: 0.2669)
  └── = 0:
    └── [finance] (gain: 0.9852)
  └── = 0:
    └── Class 4
  └── = 1:
    └── Class 1
  └── = 1:
    └── Class 1
  └── = 2:
    └── Class 1
  └── = 2:
    └── Class 1
  └── = 1:
    └── Class 1
  └── = 2:
    └── [housing] (gain: 0.2669)
  └── = 0:
    └── [finance] (gain: 0.4233)
  └── = 0:
    └── [form] (gain: 0.3912)
  └── = 0:
    └── Class 2
  └── = 1:
    └── Class 4
  └── = 2:
    └── Class 4
  └── = 3:
    └── Class 4
  └── = 1:
    └── [form] (gain: 0.5710)
  └── = 0:
    └── Class 4
  └── = 1:
    └── Class 1
  └── = 2:
    └── Class 1
  └── = 3:
    └── Class 1
  └── = 1:
    └── Class 1
  └── = 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: 0.1769)
  └── = 0:
    └── [form] (gain: 0.9183)
  └── = 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
    └── = 4:
        └── [social] (gain: 0.1355)
    └── = 0:
        └── [housing] (gain: 0.2568)
    └── = 0:
        └── [finance] (gain: 0.4099)
    └── = 0:
        └── Class 1
    └── = 1:
        └── [children] (gain: 0.4312)
    └── = 0:
        └── [form] (gain: 0.8113)
    └── = 0:
        └── Class 1
    └── = 1:
        └── Class 1
    └── = 2:
        └── Class 1
    └── = 3:
        └── Class 3
    └── = 1:
        └── Class 1
    └── = 1:
        └── [form] (gain: 0.9940)
    └── = 0:
        └── Class 1
    └── = 1:
        └── Class 1
    └── = 2:
        └── Class 1
    └── = 3:
        └── Class 3
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 1:
        └── Class 3
    └── = 0:
        └── [form] (gain: 0.0887)
    └── = 0:
        └── [children] (gain: 0.6723)
    └── = 0:
        └── Class 1
    └── = 1:
        └── Class 3
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 1:
        └── Class 3
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 2:
        └── [children] (gain: 0.4779)
    └── = 0:
        └── [form] (gain: 0.8524)
    └── = 0:
        └── Class 1
    └── = 1:
        └── Class 1
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 1
    └── = 1:
        └── [form] (gain: 0.9495)
    └── = 0:
        └── Class 1
    └── = 1:
        └── Class 1
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 2:
        └── Class 3
    └── = 3:
        └── Class 3
    └── = 1:
        └── [form] (gain: 0.0182)

```

```

= 0:
└── [children] (gain: 0.0748)
└── = 0:
    └── [housing] (gain: 0.3060)
    └── = 0:
        └── [finance] (gain: 1.0000)
        └── = 0:
            └── = 1:
                └── Class 1
            └── = 1:
                └── Class 3
            └── = 2:
                └── Class 3
            └── = 2:
                └── Class 3
            └── = 1:
                └── Class 3
            └── = 2:
                └── Class 3
            └── = 3:
                └── Class 3
            └── = 1:
                └── Class 3
            └── = 2:
                └── Class 3
            └── = 3:
                └── Class 3
            └── = 2:
                └── 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
                └── = 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
```