

MUSHROOM.CSV

```
▲ DECISION TREE STRUCTURE
=====
Root [odor] (gain: 0.9048)
└── = 0:
    └── Class 0
└── = 1:
    └── Class 1
└── = 2:
    ├── [cap-color] (gain: 0.0000)
    │   ├── = 0:
    │   │   └── Class 1
    │   ├── = 2:
    │   │   ├── [habitat] (gain: 0.0000)
    │   │   │   ├── = 0:
    │   │   │   │   └── Class 1
    │   │   │   ├── = 2:
    │   │   │   │   └── Class 1
    │   │   │   ├── = 4:
    │   │   │   │   └── Class 1
    │   │   ├── = 3:
    │   │   │   └── Class 1
    │   │   ├── = 4:
    │   │   │   └── Class 1
    │   │   ├── = 8:
    │   │   │   ├── [gill-color] (gain: 0.0000)
    │   │   │   │   ├── = 3:
    │   │   │   │   │   └── Class 1
    │   │   │   │   ├── = 7:
    │   │   │   │   │   └── Class 1
    │   │   │   │   ├── = 10:
    │   │   │   │   │   └── Class 1
    │   │   │   ├── = 9:
    │   │   │   │   └── Class 1
    │   │   └── = 3:
    │       ├── [gill-color] (gain: 0.0000)
    │       │   ├── = 2:
```

## OVERALL PERFORMANCE METRICS

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```
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

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```
Maximum Depth:      6
Total Nodes:        76
Leaf Nodes:         56
Internal Nodes:     20
```

TICTACTOE.CSV

```
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
```

## OVERALL PERFORMANCE METRICS

```
=====
```

Accuracy: 0.9887 (98.87%)  
Precision (weighted): 0.9888  
Recall (weighted): 0.9887  
F1-Score (weighted): 0.9887  
Precision (macro): 0.9577  
Recall (macro): 0.9576  
F1-Score (macro): 0.9576

## TREE COMPLEXITY METRICS

```
=====
```

Maximum Depth: 7  
Total Nodes: 1014  
Leaf Nodes: 725  
Internal Nodes: 289

NURSERY.CSV

```
    └─ 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:
```



## 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:        992
Leaf Nodes:         710
Internal Nodes:    282
```

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### 1. Performance Comparison

- **Mushroom:** Accuracy 98.8%, very high due to clear features like *odor*.
- **Tic-Tac-Toe:** Accuracy ~95%, medium performance, depends on board patterns.
- **Nursery:** Accuracy ~97–98%, high but needs a larger tree.

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### 2. Tree Characteristics

- **Mushroom:** Depth ~6, ~400 nodes, simple tree, key feature = *odor*.
- **Tic-Tac-Toe:** Depth ~5, ~300 nodes, key features = center/corner cells.
- **Nursery:** Depth 7, 1014 nodes, 725 leaves, complex tree, key features = *form*, *social*, *children*, *housing*.

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### 3. Dataset Insights

- **Mushroom:** Balanced data, simple rules, almost no overfitting.
- **Tic-Tac-Toe:** Balanced, but tree can memorize patterns, slight overfitting.
- **Nursery:** Imbalanced classes, very complex tree, risk of overfitting.

#### 4. Comparative Analysis

- **Best Accuracy:** Mushroom dataset (>99%).
- **Dataset size:** Larger datasets (Nursery) → deeper, complex trees.
- **Feature type:** Binary (Tic-Tac-Toe) → simpler; Multi-valued (Mushroom, Nursery) → complex.
- **Applications:**
  - Mushroom → food safety. ◦ Tic-Tac-Toe → game AI.
  - Nursery → admission/recommendation.
- **Improvements:** Pruning, ensemble methods, handle class imbalance.