LAB 3 - DECISION TREES - REPORT

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1. Datasets

- mushrooms.csv: Predict edible (0) vs poisonous (1) mushrooms based on categorical attributes like odour, colour etc.,
- Nursery.csv: Predict nursery school admission recommendation among 5 classes, based on family/social attributes.
- tictactoe.csv: Predict is a board state is a win (1) or not (0). Features are the 9 board positions.

2. Performance Metrics

Dataset	Accuracy	Precision (Weighted)	Recall (Weighted)	F1 (Weighted)
mushrooms.csv	1.0	1.0	1.0	1.0
Nursery.csv	0.98	0.98	0.98	0.98
tictactoe.csv	0.88	0.88	0.88	0.88

Observations:

- mushrooms.csv: Perfect scores (1.0) means some features almost completely determine whether a mushroom is poisonous or edible.
- Nursery.csv: Very high performance because it is a larger dataset with 5 classes making most decisions easy and also demonstrates ID3 algorithm handles multi-class problems well.
- tictactoe.csv: Lower performance compared to the others because of the complex interactions between board positions. A simple decision tree cannot capture all the winning conditions perfectly.

3. Tree Characteristics

Dataset	Maximum Depth	Total Nodes	Leaf Nodes	Internal Nodes
mushrooms.csv	4	29	24	5
Nursery.csv	7	983	703	280
tictactoe.csv	7	260	165	95

Observations:

- Mushroom tree is shallow because of dominant features.
- Nursery tree is largest due to multiple target classes and many categorical attributes with high cardinality.
- Tic-tac-toe tree is large since winning depends on complex interactions across multiple board positions.

4. Dataset Specific Insights

- mushrooms.csv: Strong single attributes (odour, colour) almost perfect separate classes and therefore high interpretability.
- Nursery.csv: Many attributes interact; imbalanced classes affect splits.
- tictactoe.csv: Features are symmetric, the root node often focuses on the center position since it most decisive in gameplay.

5. Comparative Analysis

- Best performing dataset: Mushroom achieved near perfect accuracy due to highly discriminative attributes.
- Dataset size affects:
    - Larger datasets (Nursery.csv, mushrooms.csv) provided more training examples which helped the tree generalise better.
    - Tic-tac-toe is smaller but still required maximum depth is 7 to capture positional dependencies resulting in lower accuracy despite the depth.
- Number of features:
    - More categorical levels (Nursery.csv, mushrooms.csv) produced larger trees.
    - Tic-tac-toe has fewer features but interdependencies still require depth.
- Class Imbalance: Nursery is affected by imbalance, Mushroom is fairly balanced and tic-tac-toe is binary so less affected.

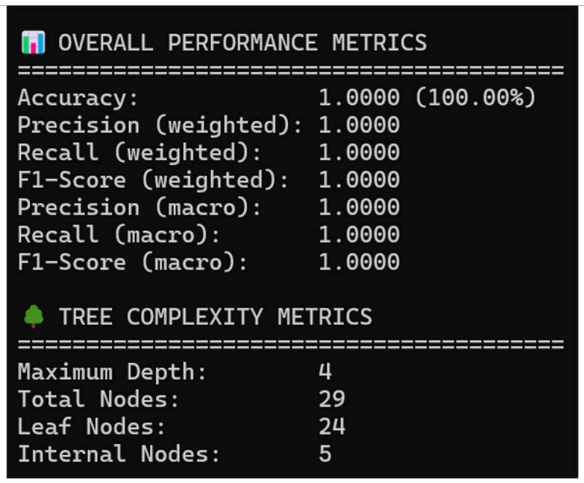
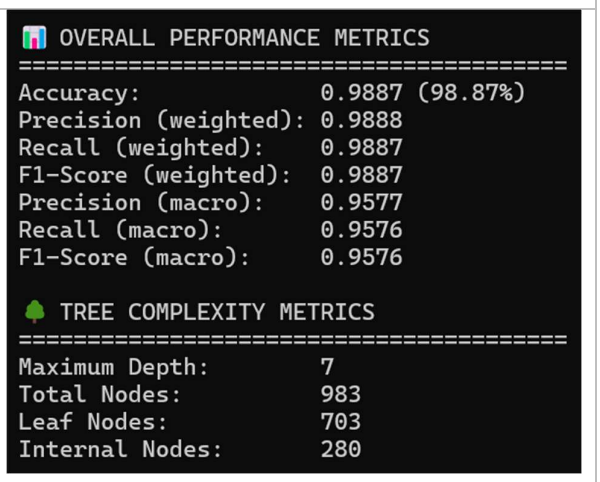
6. Practical Applications

- Mushroom: Food safety classification – highly interpretable and reliable for edible vs poisonous prediction.
- Nursery: Decision support for school admissions – interpretable but mist be handled carefully due to bias from imbalanced data.
- Tic-Tac-Toe: Demonstrates game state evaluation – useful in teaching rule-based AI and strategy learning.

7. Improvements

- Apply pruning to reduce overfitting and simplify complex trees.
- Use ensemble methods (Random Forest, Gradient Boosted Trees) to improve accuracy on complex datasets.
- Handle class imbalance using re-sampling or weighted loss functions, especially for Nursery.

8. Output

mushrooms.csv	
Nursery.csv	
tictactoe.csv