

# CSE 318: Artificial Intelligence Sessional

## Assignment 4: Decision Tree Analysis

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## 1 Introduction

This report presents a comparative analysis of decision tree performance using three different splitting criteria: **Information Gain (IG)**, **Information Gain Ratio (IGR)**, and **Normalized Weighted Information Gain (NWIG)**. The analysis evaluates classification accuracy, tree complexity, and the effects of maximum tree depth on two datasets: [Iris](#) and [Adult](#).

## 2 Methodology

### 2.1 Datasets

- **Iris Dataset:** 150 instances, 4 attributes
- **Adult Dataset:** 32,561 instances, 14 attributes

### 2.2 Experimental Setup

- 80% training, 20% testing split
- 20 iterations per configuration
- Maximum tree depths tested: 0 (no pruning) to 5 (10 for Iris)
- Splitting criteria: IG, IGR, NWIG

### 2.3 Splitting Criteria

- **Information Gain (IG):**

$$IG(S, A) = Entropy(S) - \sum_{v \in Values(A)} \frac{|S_v|}{|S|} Entropy(S_v)$$

- **Information Gain Ratio (IGR):**

$$IGR(S, A) = \frac{IG(S, A)}{IV(A)}$$

where  $IV(A)$  is the intrinsic value of attribute A.

- **Normalized Weighted Information Gain (NWIG):**

$$NWIG(S, A) = \frac{IG(S, A)}{\log_2(k+1)} \left( 1 - \frac{k-1}{|S|} \right)$$

where  $k$  is the number of unique values of attribute A.

## 3 Results

### 3.1 Iris Dataset

Table 1: Iris Dataset Performance

Criterion	Max Depth	Avg Accuracy	Avg Nodes	Avg Depth
IG	0	0.9450	15.3	5.4
IG	2	0.9317	5.0	2.0
IG	5	0.9450	14.1	4.8
IGR	0	0.9450	15.3	5.3
IGR	2	0.9350	5.0	2.0
IGR	5	0.9450	14.4	4.9
NWIG	0	0.9467	29.5	7.1
NWIG	2	0.9567	5.0	2.0
NWIG	5	0.9450	20.1	5.0

### 3.2 Adult Dataset

Table 2: Adult Dataset Performance

Criterion	Max Depth	Avg Accuracy	Avg Nodes	Avg Depth
IG	0	0.8321	7098.7	53.2
IG	2	0.8017	7.1	2.0
IG	5	0.8302	258.9	5.0
IGR	0	0.8194	8885.0	63.2
IGR	2	0.8069	7.0	2.0
IGR	5	0.8329	245.2	5.0
NWIG	0	0.8160	6113.0	58.4
NWIG	2	0.8124	7.0	2.0
NWIG	5	0.8380	379.6	5.0

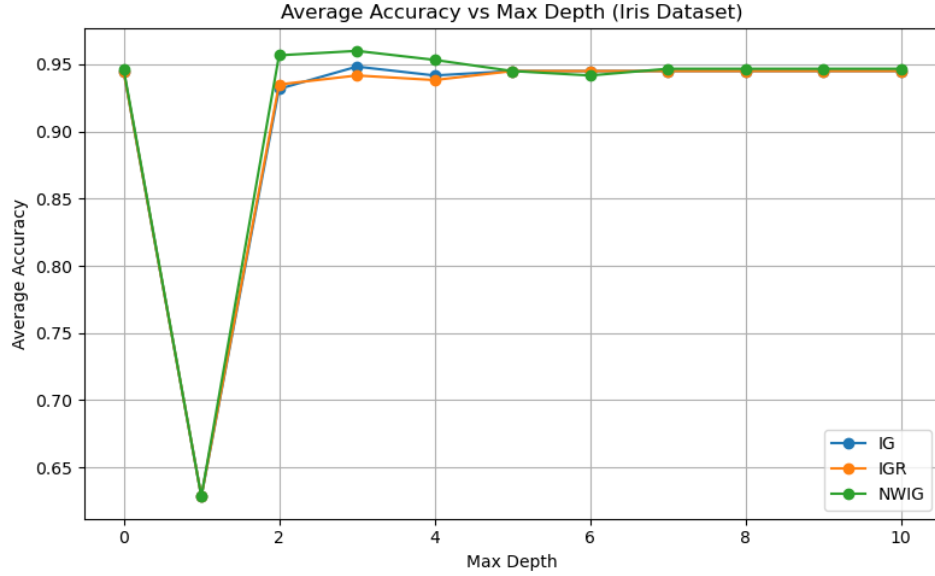


Figure 1: Iris Dataset: Accuracy vs Max Depth

## 4 Analysis

### 4.1 Performance Comparison

- **Iris Dataset:** All criteria perform similarly, with NWIG showing slightly better accuracy at depth 2 (95.67% vs 93.17% for IG and 93.50% for IGR).
- **Adult Dataset:** NWIG achieves the highest accuracy (83.80%) at depth 5, outperforming both IG (83.02%) and IGR (83.29%).

### 4.2 Tree Complexity

- For both datasets, tree size grows exponentially with depth when unpruned (depth 0).
- NWIG produces larger trees than IG and IGR at higher depths, particularly noticeable in the Iris dataset.

### 4.3 Optimal Depth

- **Iris:** Depth 2–3 provides optimal balance between accuracy and complexity.
- **Adult:** Depth 3–5 shows best performance, with accuracy plateauing beyond depth 3.

## 5 Discussion

The results demonstrate that:

- NWIG generally provides the best accuracy, especially for the more complex Adult dataset.

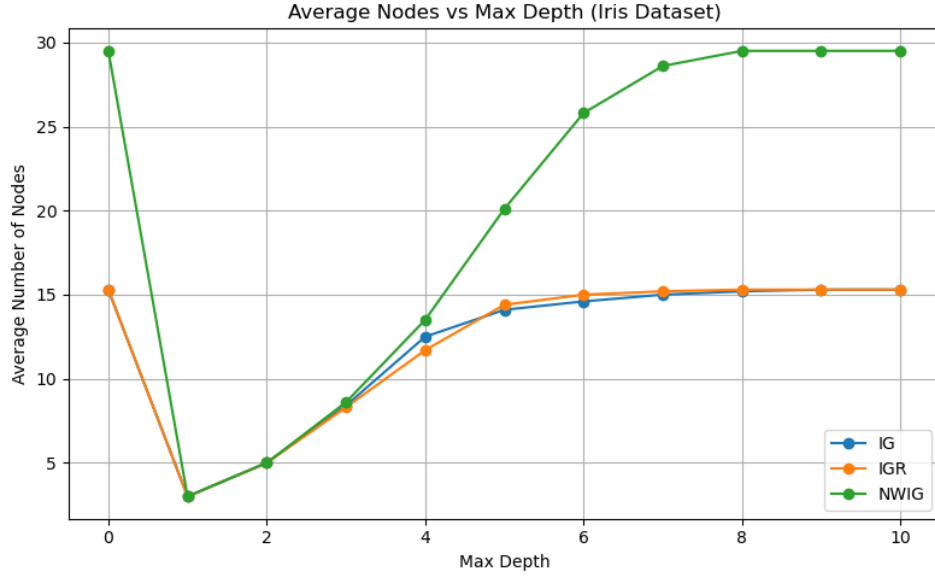


Figure 2: Iris Dataset: Tree Size vs Max Depth

- IGR produces more compact trees but may sacrifice some accuracy.
- Moderate pruning (depth 2–5) achieves better performance than both unpruned and heavily pruned trees.
- Dataset characteristics significantly impact the relative performance of different criteria.

## 6 Conclusion

Based on the analysis:

- **Recommended Criterion:** NWIG for best accuracy, IGR for simpler trees.
- **Optimal Depth:** 3–5 for most scenarios.
- **Dataset Consideration:** Choice of criterion should consider dataset complexity.

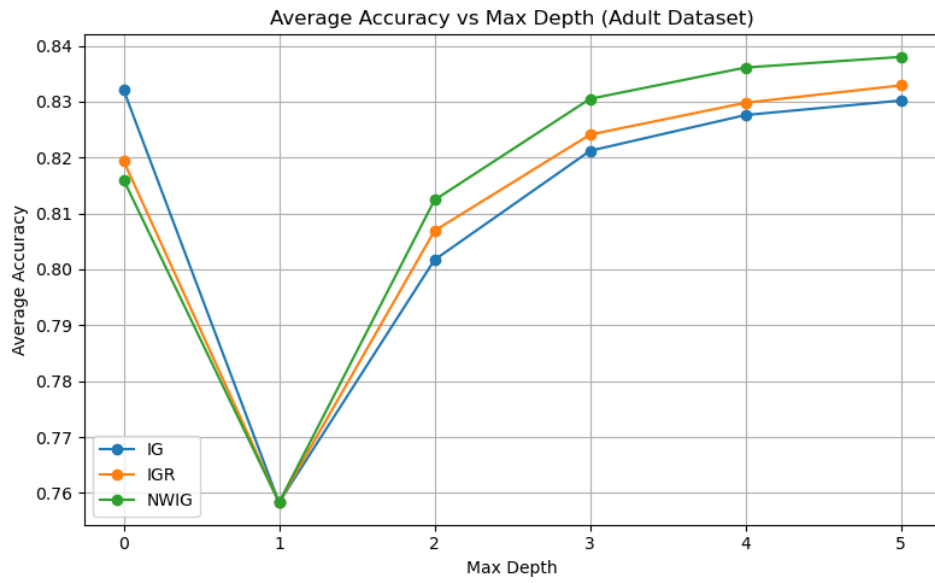


Figure 3: Adult Dataset: Accuracy vs Max Depth

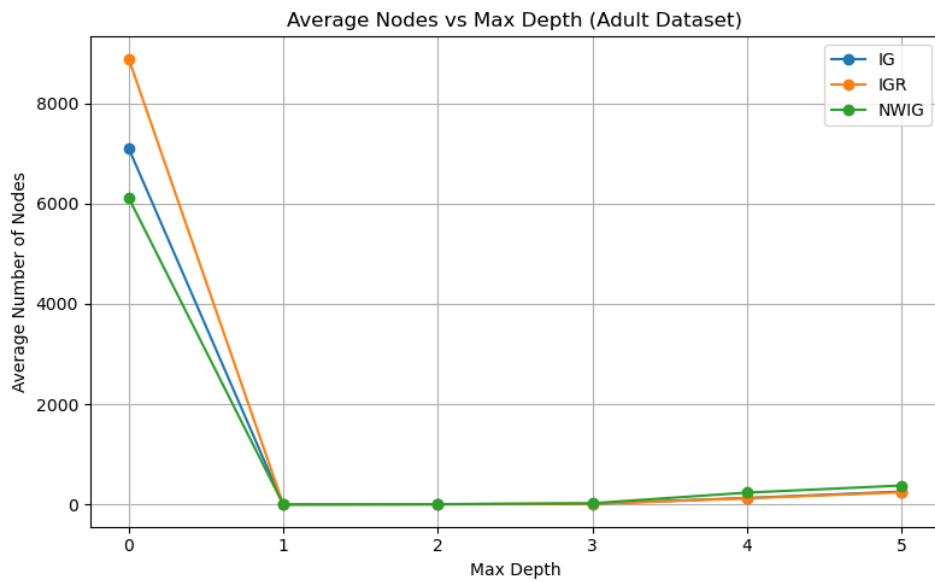


Figure 4: Adult Dataset: Tree Size vs Max Depth

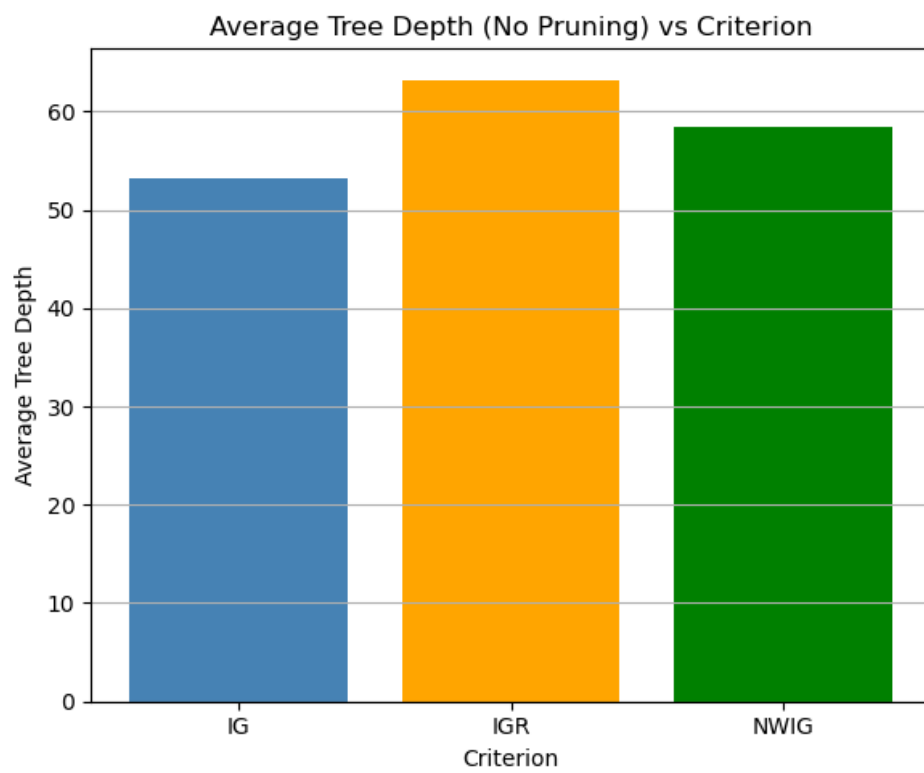


Figure 5: Comparison of Criteria at No Pruning (Depth 0)