

# Decision Tree

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## Introduction

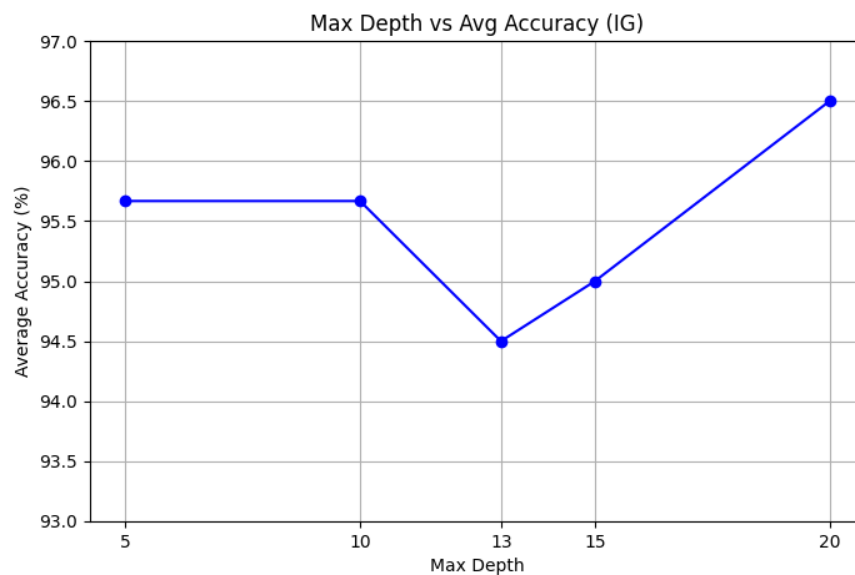
This report presents the results of decision tree learning experiments using three attribute selection criteria:

- Information Gain (IG)
- Information Gain Ratio (IGR)
- Normalized Weighted Information Gain (NWIG)

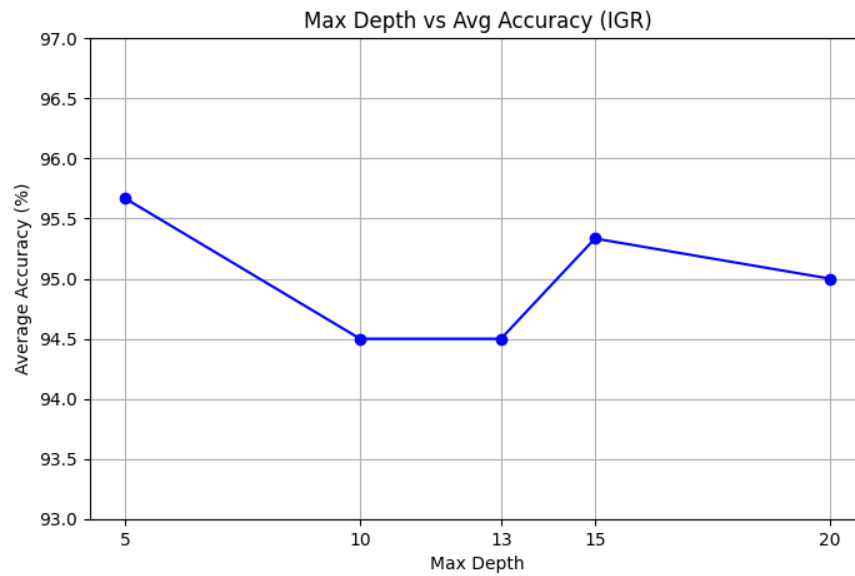
Two datasets were used. The trees were trained using 80% of the data and tested on the remaining 20%, repeated over 20 random splits. Accuracy and tree complexity were evaluated at different maximum depths.

## Results and Graphs

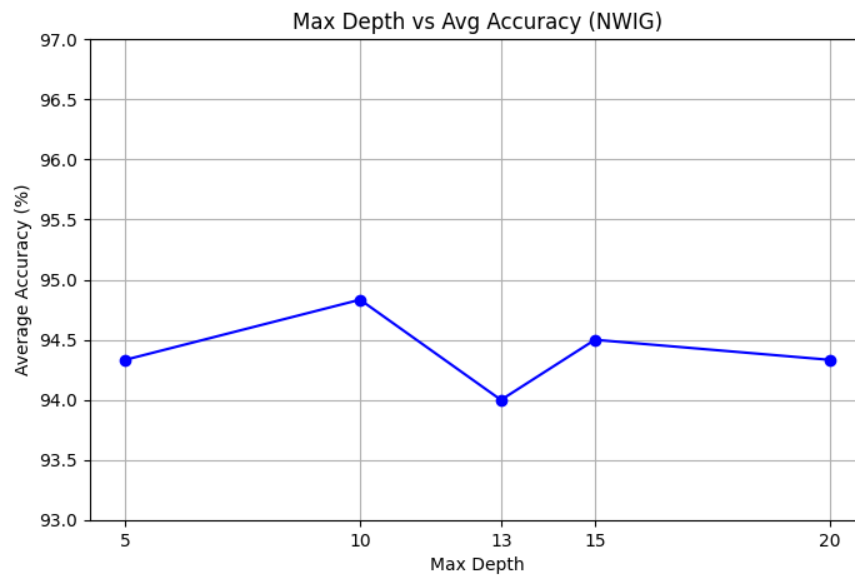
### Accuracy vs Depth – Iris Dataset(IG Criteria)



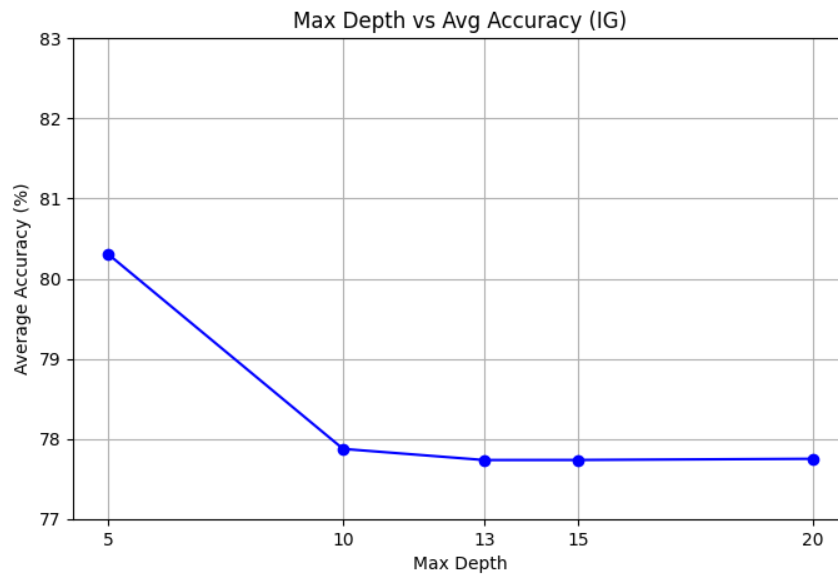
## Accuracy vs Depth – Iris Dataset(IGR Criteria)



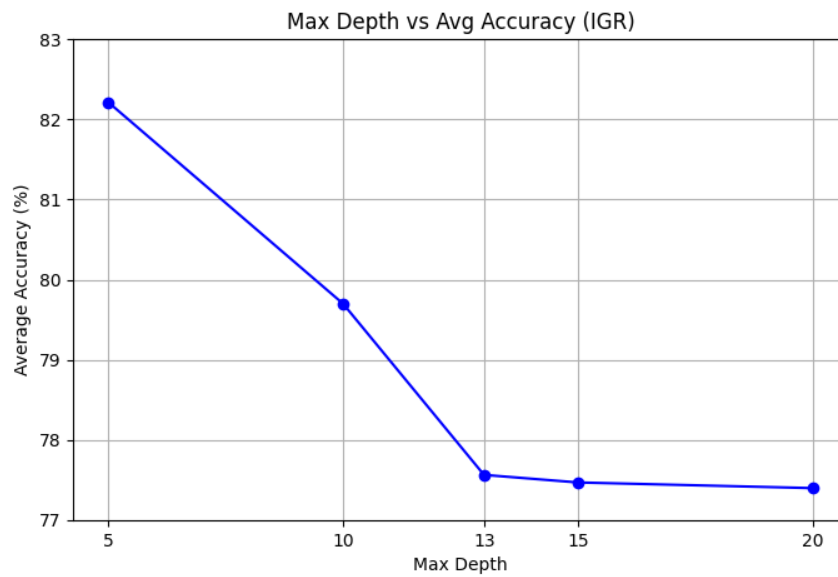
## Accuracy vs Depth – Iris Dataset(NWIG Criteria)



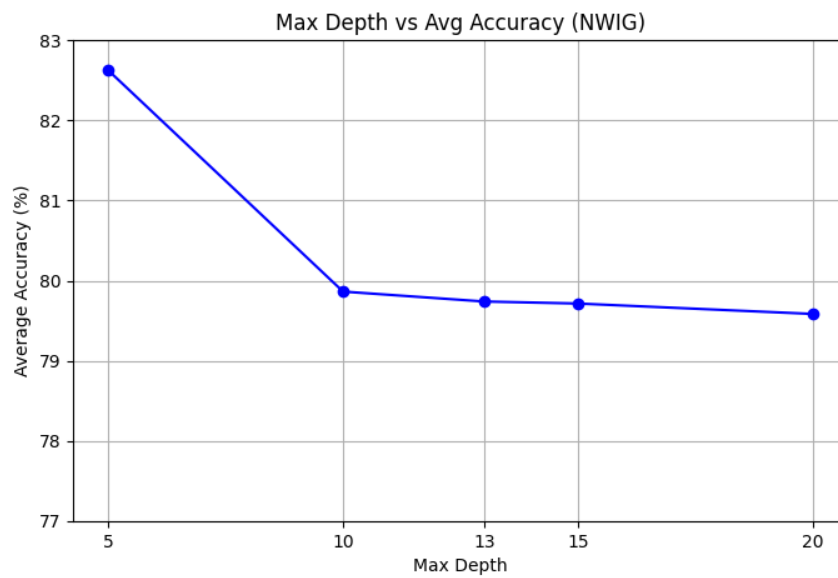
## Accuracy vs Depth – Adult Dataset(IG Criteria)



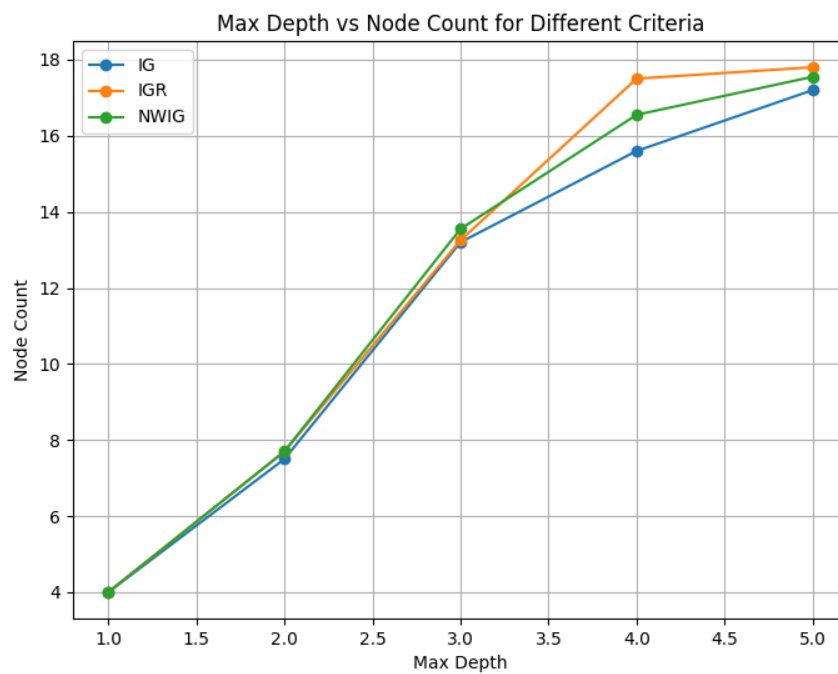
## Accuracy vs Depth – Adult Dataset(IGR Criteria)



## Accuracy vs Depth – Adult Dataset(NWIG Criteria)



## Nodes vs Depth – Iris



## Nodes vs Depth – Adult

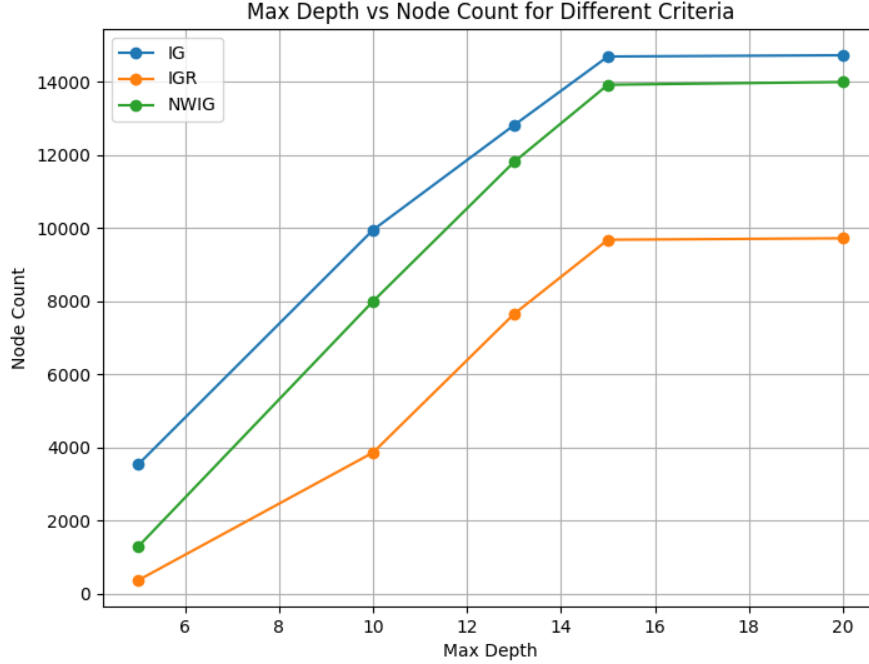


Figure 1: Number of Nodes vs Tree Depth (Dataset 2)

## 5. Observations and Analysis

### Adult Dataset

- **IG (Information Gain):** Accuracy peaked at depth 5 (80.30%), and declined as the depth increased, indicating overfitting. IG struggled with deeper trees, stabilizing around 77.7% at depth 20.
- **IGR (Information Gain Ratio):** Performed best at depth 5 (82.21%), but showed a consistent decline as tree depth increased.
- **NWIG (Normalized Weighted Information Gain):** Achieved the highest accuracy (82.62%) at depth 5. It maintained better accuracy across depths than IG and IGR, demonstrating a better balance between generalization and depth. This suggests NWIG reduced overfitting more effectively in the Adult dataset.
- **Overall:** All criteria showed best performance at shallow depths (especially depth 5), indicating that pruning is essential for generalization in the Adult dataset. NWIG performed consistently better than IG and IGR across all depths.

## Iris Dataset

- **IG:** Showed strong and stable performance across all depths, ranging from 94.5% to 96.5%, with the highest accuracy at depth 20. Overfitting was not significant in this small and clean dataset.
- **IGR:** Performance remained very close to IG, with slightly lower accuracy at some depths. It peaked at depth 5 (95.67%) and maintained comparable results.
- **NWIG:** Performed slightly worse than IG and IGR, especially at deeper depths. It peaked at depth 10 (94.83%) but declined slightly afterwards, possibly due to over-penalization of attribute splits in this smaller dataset.

## General Insights

- **Pruning Effectiveness:** For the Adult dataset, shallow trees (depth = 5) achieved the highest accuracy, showing that pruning is highly effective in noisy or high-cardinality datasets. For the Iris dataset, deeper trees did not cause overfitting.
- **Unexpected Patterns:** In the Adult dataset, both IG and IGR dropped sharply after depth 5, while NWIG maintained a consistent state. In the Iris dataset, all three methods had relatively similar performance, indicating lower sensitivity to depth.