```
# Step 1: Import Libraries
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.datasets import load_wine # Use load_wine for the Wine dataset
from sklearn.model_selection import train_test_split
from sklearn.tree import DecisionTreeClassifier, plot_tree
```

```
# Step 2: Load the Wine Dataset
wine = load_wine()
X = wine.data
y = wine.target

print("Feature Names:", wine.feature_names)
print("Class Names:", wine.target_names)
print("Dataset Shape:", X.shape)
```

```
Feature Names: ['alcohol', 'malic_acid', 'ash', 'alcalinity_of_ash', 'magnesium', 'total_phenols', 'flavanoids', 'nonflavanoid_phenols', 'proant
Class Names: ['class_0' 'class_1' 'class_2']
Dataset Shape: (178, 13)
```

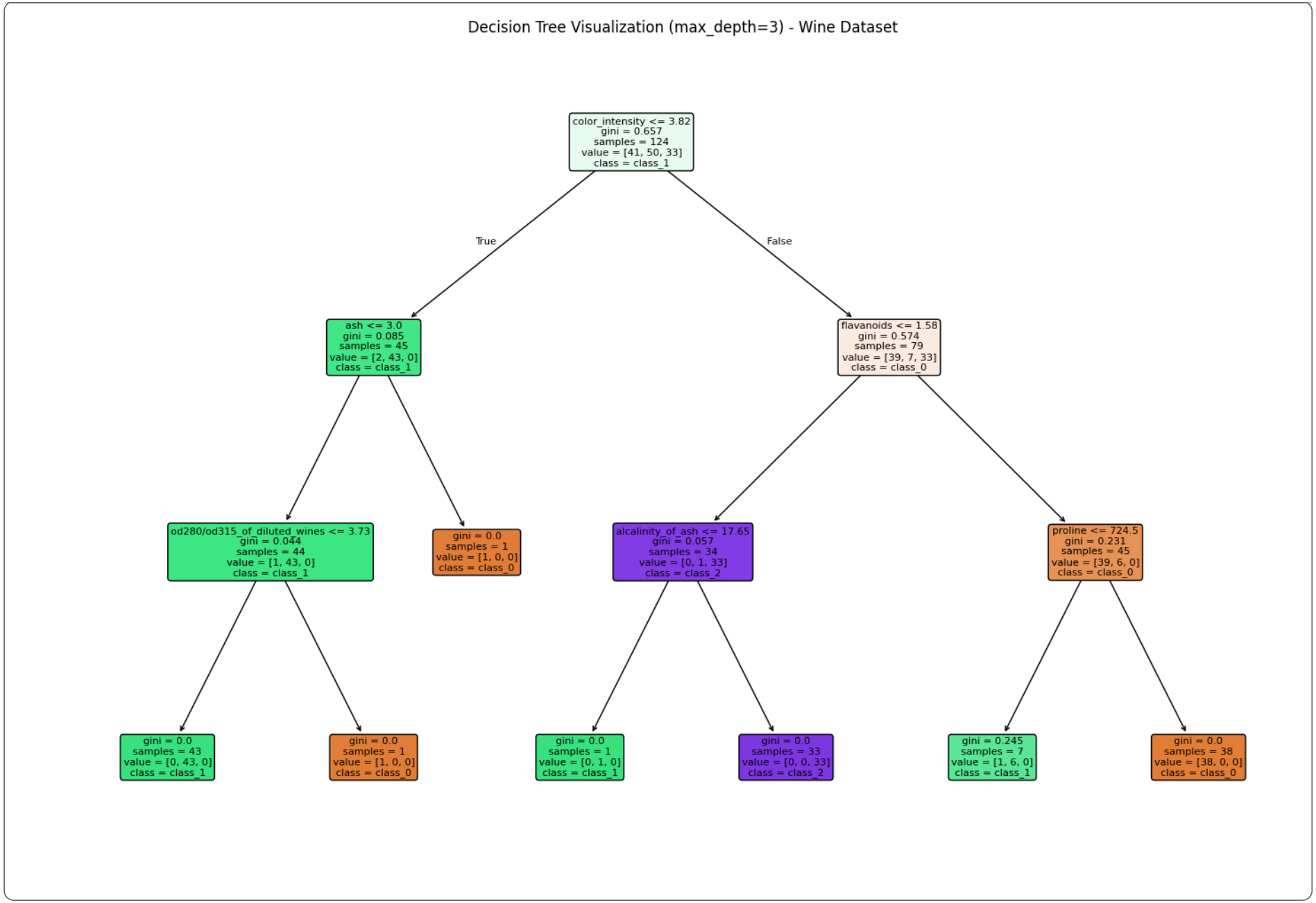
```
# Step 3: Split into Training and Testing Sets (70% Train, 30% Test)
X_train, X_test, y_train, y_test = train_test_split(
 X, y, test_size=0.3, random_state=42, stratify=y
)

print("\nTraining set size:", X_train.shape)
print("Testing set size:", X_test.shape)
```

```

Training set size: (124, 13)
Testing set size: (54, 13)
```

```
# Step 4: Train Decision Tree Classifier with max_depth = 3
clf_3 = DecisionTreeClassifier(max_depth=3, random_state=42, criterion='gini')
clf_3.fit(X_train, y_train)

# Step 5: Evaluate Model (max_depth=3)
train_acc_3 = clf_3.score(X_train, y_train)
test_acc_3 = clf_3.score(X_test, y_test)

print("\nDecision Tree (max_depth=3)")
print("Training Accuracy:", round(train_acc_3, 3))
print("Testing Accuracy:", round(test_acc_3, 3))
```

```
Decision Tree (max_depth=3)
Training Accuracy: 0.992
Testing Accuracy: 0.963
```

```
# Step 6: Visualize the Decision Tree (max_depth=3)
plt.figure(figsize=(18, 12))
plot_tree(
 clf_3,
 feature_names=wine.feature_names,
 class_names=wine.target_names,
 filled=True,
 rounded=True,
 proportion=False
)
plt.title("Decision Tree Visualization (max_depth=3) - Wine Dataset")
# Save the visualization to a file in your Colab working directory
plt.savefig('wine_tree_max_depth_3.png')
plt.show()

# NOTE: After running, you can find 'wine_tree_max_depth_3.png' in the file browser (folder icon on the left)
# and download it for your lab report.
```

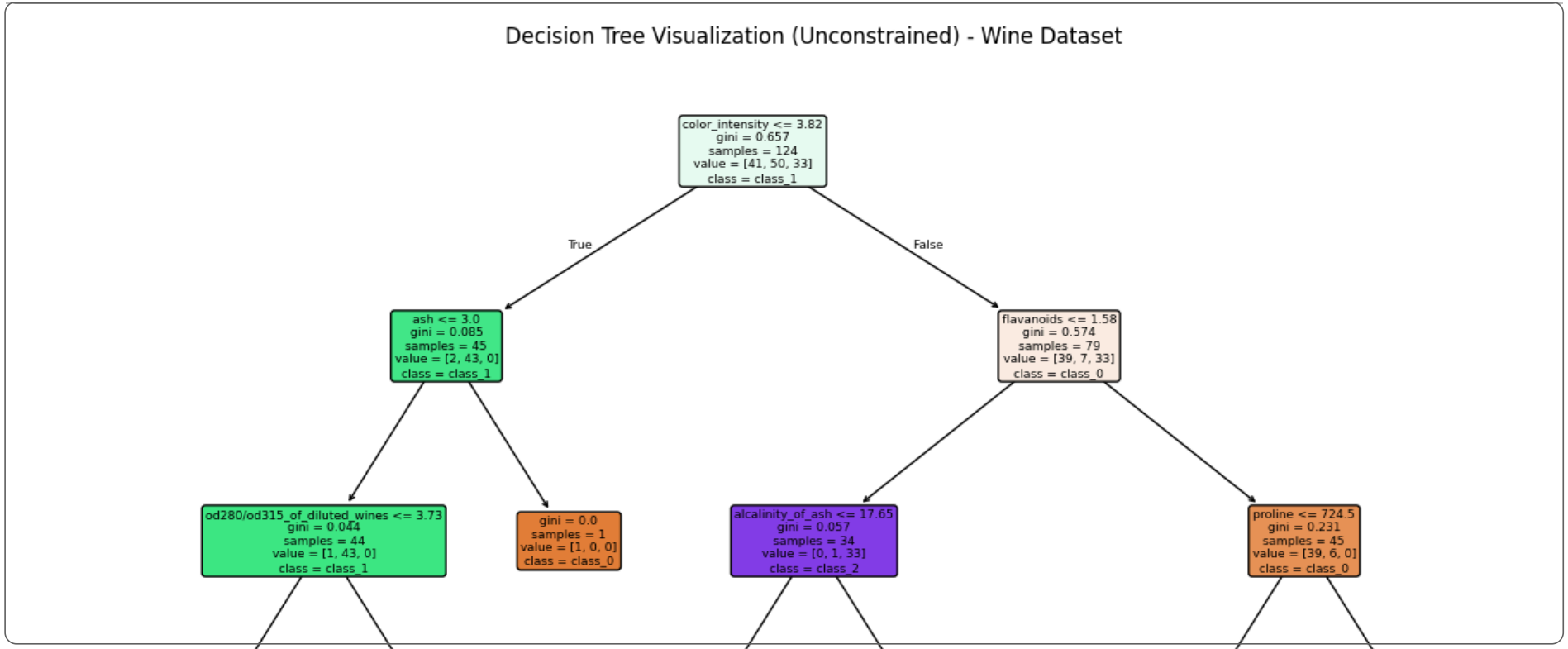



```
# Step 7: Train Unconstrained Tree (max_depth=None)
clf_un = DecisionTreeClassifier(max_depth=None, random_state=42, criterion='gini')
clf_un.fit(X_train, y_train)

```

```
# Step 8: Evaluate Model (max_depth=None)
train_acc_un = clf_un.score(X_train, y_train)
test_acc_un = clf_un.score(X_test, y_test)

print("\nDecision Tree (max_depth=None - Unconstrained)")
print("Training Accuracy:", round(train_acc_un, 3))
print("Testing Accuracy:", round(test_acc_un, 3))
```

```
Decision Tree (max_depth=None - Unconstrained)
Training Accuracy: 1.0
Testing Accuracy: 0.963
```

```
# Step 9: Visualize the Unconstrained Decision Tree
plt.figure(figsize=(15, 10)) # Use a larger figure size for the deeper tree
plot_tree(
 clf_un,
 feature_names=wine.feature_names,
 class_names=wine.target_names,
 filled=True,
 rounded=True,
 proportion=False
)

plt.title("Decision Tree Visualization (Unconstrained) - Wine Dataset")

# Save the visualization
plt.savefig('wine_tree_unconstrained.png')
plt.show()

```




```
# Step 10: Comparison Summary
print("\n--- Comparison Summary ---")
print(f"Limited Depth (max_depth=3) -> Train: {train_acc_3:.3f}, Test: {test_acc_3:.3f}")
print(f"Unconstrained (max_depth=None) -> Train: {train_acc_un:.3f}, Test: {test_acc_un:.3f}")
```

```
--- Comparison Summary ---
Limited Depth (max_depth=3) -> Train: 0.992, Test: 0.963
Unconstrained (max_depth=None) -> Train: 1.000, Test: 0.963
```

```
# Step 11: Feature Importance (max_depth=3)
importances = clf_3.feature_importances_
print("\nFeature Importances (max_depth=3):")
importance_list = list(zip(wine.feature_names, importances))
importance_list.sort(key=lambda x: x[1], reverse=True)
for name, importance in importance_list:
 print(f"{name}: {importance:.4f}")
```

```
Feature Importances (max_depth=3):
flavanoids: 0.4136
```

```
color_intensity: 0.4053
proline: 0.1089
od280/od315_of_diluted_wines: 0.0245
alcalinity_of_ash: 0.0243
ash: 0.0234
alcohol: 0.0000
malic_acid: 0.0000
magnesium: 0.0000
total_phenols: 0.0000
nonflavanoid_phenols: 0.0000
proanthocyanins: 0.0000
hue: 0.0000
```

```
# Step 12: Root Node Feature and Gini Impurity (max_depth=3)
root = clf_3.tree_
root_feature_idx = root.feature[0]
root_feature_name = wine.feature_names[root_feature_idx]
root_gini = root.impurity[0]
print("\nRoot Node Feature (max_depth=3):", root_feature_name)
print("Root Node Gini Impurity (max_depth=3):", round(root_gini, 3))
```