Decision Trees

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- used for classification and regression tasks.
- It splits a dataset into subsets based on the value of input features.

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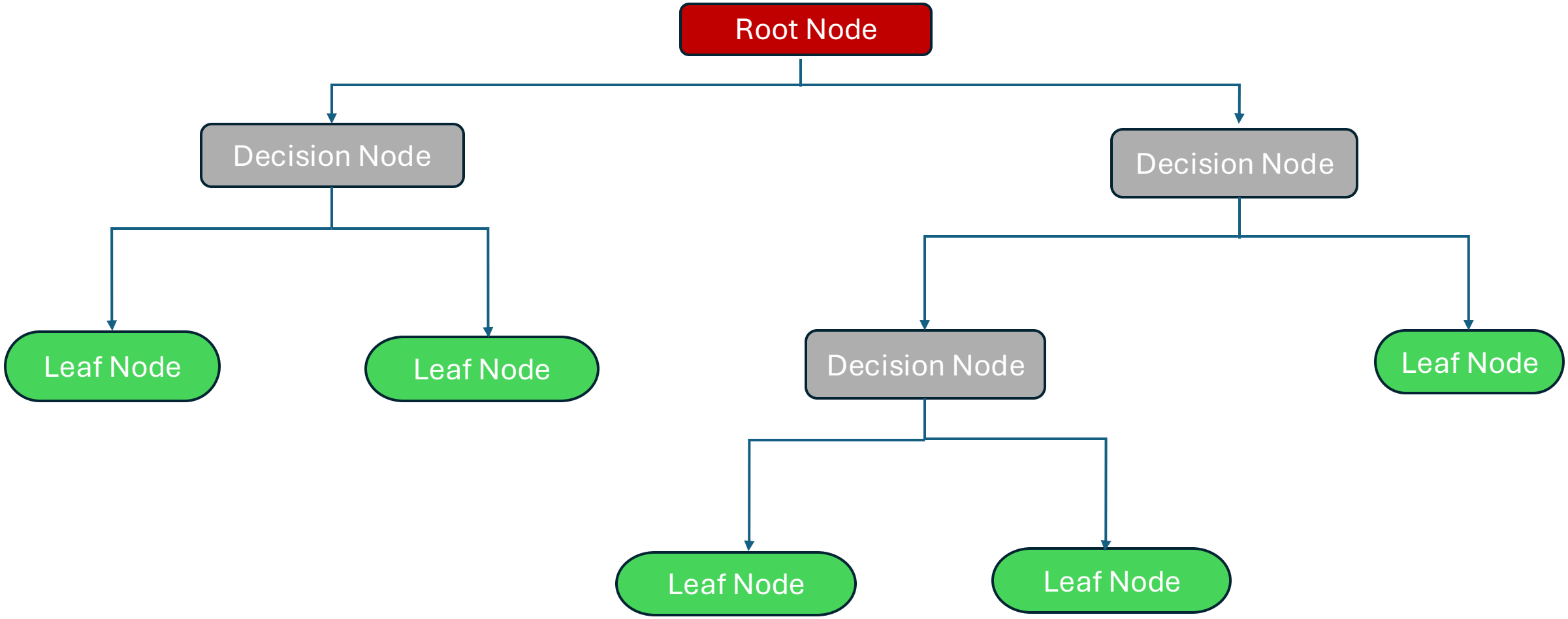


The topmost node that represents the entire dataset and initiates the first split.

An internal node that splits the data based on a feature condition.

The final node that gives the output label and does not split further.

Branch

A decision rule leading from one node to another.

Has Feathers ?

True

False

Can Fly ?

Has Fins ?

True

False

True

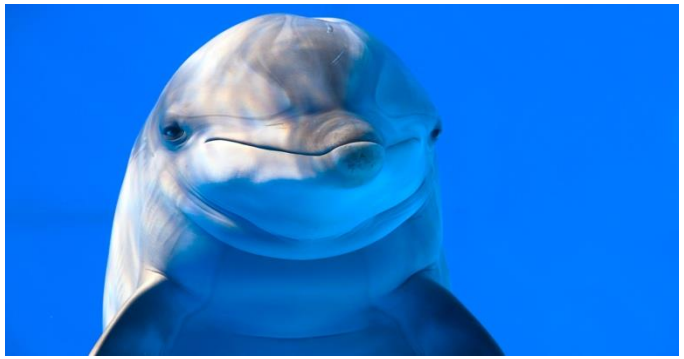
False

Hawk

Penguin

Dolphin

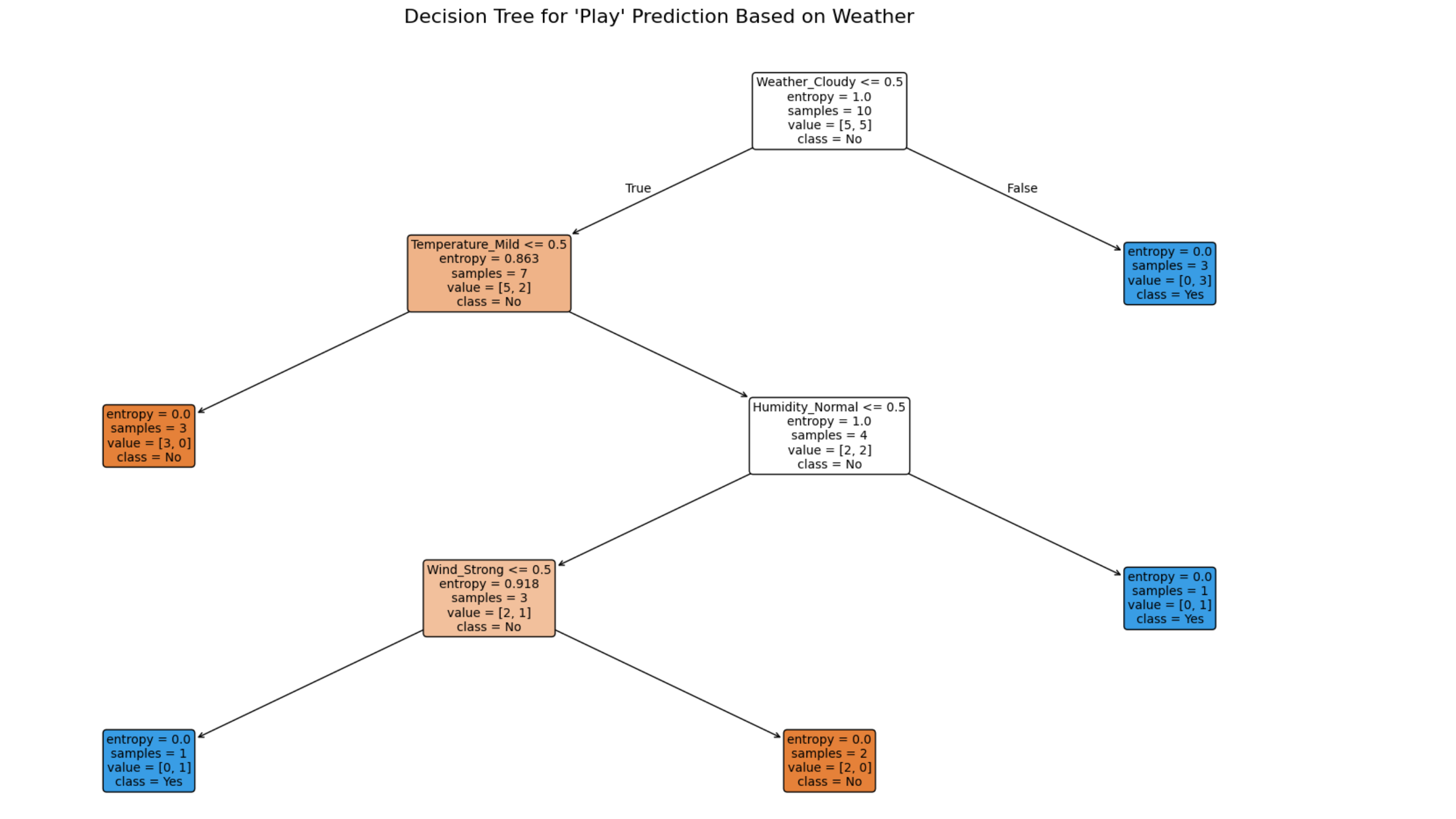
Bear



Animal	Has_Feathers	Can_Fly	Has_Fins	Class (Label)
Hawk	Yes	Yes	No	Hawk
Penguin	Yes	No	No	Penguin
Dolphin	No	No	Yes	Dolphin
Bear	No	No	No	Bear

Is the Child going to play ?

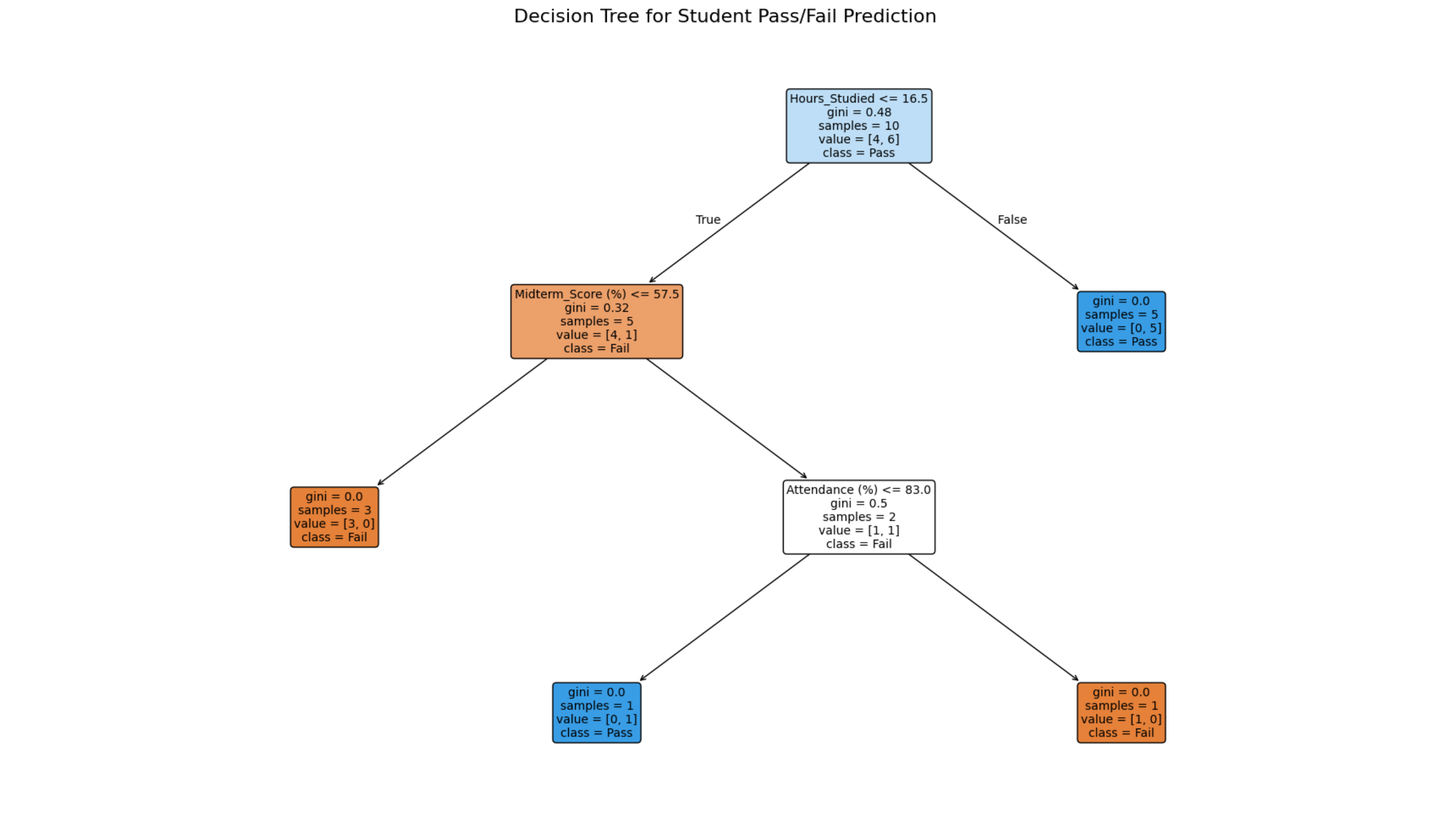
Day	Weather	Temperature	Humidity	Wind	Play?
1	Sunny	Hot	High	Weak	No
2	Cloudy	Hot	High	Weak[1]	Yes[2]
3	Sunny[4]	Mild[5]	Normal[6]	Strong[7]	Yes[8]
4	Cloudy[10]	Mild[11]	High[12]	Strong[13]	Yes[14]
5	Rainy[16]	Mild[17]	High[18]	Strong[19]	No[20]
6	Rainy[22]	Cool[23]	Normal[24]	Strong[25]	No[26]
7	Rainy[28]	Mild[29]	High[30]	Weak[31]	Yes[32]
8	Sunny[34]	Hot[35]	High[36]	Strong[37]	No[38]
9	Cloudy[40]	Hot[41]	Normal[42]	Weak[43]	Yes[44]
10	Rainy[46]	Mild[47]	High[48]	Strong[49]	N[50]o


Decision Tree for 'Play' Prediction Based on Weather
Weather_Cloudy <= 0.5
entropy = 1.0
samples = 10
value = [5, 5]
class = No
True
False
Temperature_Mild <= 0.5
entropy = 0.863
samples = 7
value = [5, 2]
class = No
entropy = 0.0
samples = 3
value = [0, 3]
class = Yes
entropy = 0.0
samples = 3
value = [3, 0]
class = No
Humidity_Normal <= 0.5
entropy = 1.0
samples = 4
value = [2, 2]
class = No
Wind_Strong <= 0.5
entropy = 0.918
samples = 3
value = [2, 1]
class = No
entropy = 0.0
samples = 1
value = [0, 1]
class = Yes
entropy = 0.0
samples = 1
value = [0, 1]
class = Yes
entropy = 0.0
samples = 2
value = [2, 0]
class = No

What is a Decision Tree?

- A supervised machine learning model used for making decisions.
- Works for both
- **classification** (e.g., Yes/No) and **regression** (e.g., price) tasks.
- It splits a large dataset into smaller, more manageable subsets based on its features

Hours_Studied	Attendance (%)	Midterm_Score (%)	Final_Exam_Status
25	95	85	Pass
10	60	45	Fail
18	80	55	Pass
5	90	40	Fail
30	98	92	Pass
12	75	65	Pass
15	50	50	Fail
22	85	78	Pass
19	70	51	Pass
9	91	75	Fail


Decision Tree for Student Pass/Fail Prediction
Hours_Studied <= 16.5
gini = 0.48
samples = 10
value = [4, 6]
class = Pass
True
False
Midterm_Score (%) <= 57.5
gini = 0.32
samples = 5
value = [4, 1]
class = Fail
gini = 0.0
samples = 5
value = [0, 5]
class = Pass
gini = 0.0
samples = 3
value = [3, 0]
class = Fail
Attendance (%) <= 83.0
gini = 0.5
samples = 2
value = [1, 1]
class = Fail
gini = 0.0
samples = 1
value = [0, 1]
class = Pass
gini = 0.0
samples = 1
value = [1, 0]
class = Fail

```python
# Import necessary libraries
import pandas as pd
from sklearn.tree import DecisionTreeClassifier, plot_tree
import matplotlib.pyplot as plt

# 1. Create a more complex dataset
# We've added two more students to make the relationships less simple.
# Now, Midterm_Score alone isn't a perfect predictor.
data = {
    'Hours_Studied': [25, 10, 18, 5, 30, 12, 15, 22, 19, 9],
    'Attendance (%)': [95, 60, 80, 90, 98, 75, 50, 85, 70, 91],
    'Midterm_Score (%)': [85, 45, 55, 40, 92, 65, 50, 78, 51, 75],
    'Final_Exam_Status': ['Pass', 'Fail', 'Pass', 'Fail', 'Pass', 'Pass', 'Fail', 'Pass', 'Pass', 'Fail']
}
df = pd.DataFrame(data)

# 2. Prepare the data for the model
# X contains the features (the factors we use to predict).
# y contains the target (what we want to predict).
features = ['Hours_Studied', 'Attendance (%)', 'Midterm_Score (%)']
X = df[features]
y = df['Final_Exam_Status']

# 3. Create and train the Decision Tree model
# The model will learn the rules from the data.
# `random_state` is set for reproducibility, so the tree looks the same every time.
model = DecisionTreeClassifier(random_state=42)
model.fit(X, y)
```

```
# 4. Visualize the Decision Tree
# This plot shows the more complex rules the model has now learned.
print("Decision Tree Rules:")
plt.figure(figsize=(20, 12))
plot_tree(model,
          feature_names=features,
          class_names=model.classes_, # Shows 'Pass' and 'Fail'
          filled=True, # Colors the nodes for clarity
          rounded=True, # Makes the nodes have rounded corners
          fontsize=10)

plt.title("Decision Tree for Student Pass/Fail Prediction ", fontsize=16)
plt.show()

# 5. Make a prediction for a new student (Example)
# Let's test a student with mixed results.
new_student_data = [[10, 70, 68]] # [Hours_Studied, Attendance, Midterm_Score]
prediction = model.predict(new_student_data)

print("\n--- New Student Prediction ---")
print(f"Data: Hours Studied=10, Attendance=70%, Midterm Score=68%")
print(f"Predicted Exam Status: {prediction[0]}")
```