Random Forest Algorithm

The Random Forest algorithm is a powerful ensemble machine learning model used for both **classification** and **regression** tasks. It is based on the idea of combining multiple decision trees to improve the accuracy and robustness of the model.

How It Works:

1. **Random Sampling**: A random subset of data (with replacement, known as **bootstrapping**) is selected to build each individual tree.
2. **Random Feature Selection**: At each split within a tree, a random subset of features is considered rather than all features. This helps in reducing correlation among trees.
3. **Majority Voting or Averaging**: For classification, the final prediction is made by taking the majority vote from all the trees. For regression, the final prediction is the average of the predictions of all trees.

Important Parameters:

1. `n_estimators`:
   - The number of trees in the forest. A higher number of trees generally improves performance but increases computation time.
   - Default: 100
2. `max_depth`:
   - Maximum depth of the individual trees. Limiting depth helps prevent overfitting.
   - Default: `None` (fully grown trees)
3. `min_samples_split`:
   - The minimum number of samples required to split an internal node. Higher values prevent overfitting by ensuring splits are meaningful.
   - Default: 2
4. `min_samples_leaf`:
   - The minimum number of samples required to be at a leaf node. Setting this to a higher value prevents the model from learning overly specific patterns that might not generalize.
   - Default: 1
5. `max_features`:
   - The number of features to consider when looking for the best split. Smaller values of `max_features` make the trees less correlated, which improves the overall performance of the ensemble.
   - Options: `"auto"`, `"sqrt"`, `"log2"`.
6. `bootstrap`:

- Whether bootstrap samples are used when building trees. Setting this to `False` uses the entire dataset to build trees.
- Default: `True`

7. **`criterion`**:
   - The function to measure the quality of a split. For classification, it can be `"gini"` or `"entropy"`. For regression, it can be `"mse"` or `"mae"`.
   - Default: `"gini"` for classification and `"mse"` for regression.

Ensemble Technique

Ensemble learning is the process of combining multiple models to solve a problem. Random Forest is an example of **ensemble learning**, where the ensemble of decision trees work together to produce a better result than an individual tree.

The main ensemble techniques are:

1. **Bagging (Bootstrap Aggregating)**:
   Random Forest uses **bagging** to create an ensemble of trees. In bagging, multiple models are trained on random subsets of the data, and their outputs are combined for the final prediction (through majority voting in classification and averaging in regression).

2. **Boosting**:
   Boosting is another ensemble technique (not used in Random Forest) where trees are trained sequentially. Each tree tries to correct the mistakes of the previous one.

Bagging

Bagging is an ensemble technique used to improve the stability and accuracy of machine learning models. It reduces variance and helps in preventing overfitting. The key steps in bagging are:

1. **Bootstrap Sampling**: Create multiple datasets by randomly sampling with replacement from the original dataset.
2. **Training**: Train a separate model (e.g., decision tree) on each of these datasets.
3. **Aggregation**: For classification, predictions are combined using **majority voting**; for regression, they are combined using **averaging**.

Advantages of Bagging:

- Reduces variance and overfitting.
- More robust and stable than individual models.

Advantages of Random Forest:

1. **High Accuracy**:
   The ensemble of trees reduces overfitting, leading to more accurate predictions compared to a single decision tree.

2. **Handles Large Datasets**:
   Random Forest can handle large datasets with higher dimensionality.

3. **Reduces Overfitting**:
   The randomness in feature selection and bootstrapping helps in reducing the correlation between trees, which reduces the risk of overfitting.

4. **Works Well with Missing Data**:
   Random Forest can handle missing values by randomly filling them based on other data.

5. **Versatile**:
   Random Forest works well for both classification and regression tasks.

6. **Feature Importance**:
   Random Forest provides an inherent way of measuring feature importance, which helps in understanding which features are most relevant for predictions.

Disadvantages of Random Forest:

1. **Computationally Expensive**:
   Training a large number of trees requires significant computational power and memory.

2. **Less Interpretability**:
   Unlike decision trees, which are easy to interpret, Random Forest is more of a black-box model since it aggregates many trees.

3. **Slower Predictions**:
   For large datasets, the prediction phase can be slow because each tree needs to provide a prediction before the final decision is made.

4. **Bias-Variance Tradeoff**:
   While Random Forest reduces variance, it may still have a higher bias compared to more complex models like Gradient Boosting Machines (GBMs).

Feature Importance in Random Forest:

- Random Forest ranks features by their importance. Feature importance is calculated by averaging the decrease in **Gini Impurity** (or another criterion) across all trees for each feature.
- Features that contribute to large reductions in impurity (i.e., better splits) are deemed more important.

- This feature ranking helps in identifying which features have the most predictive power and can be useful for feature selection in other models.

Normalization:

Normalization is the process of scaling input data to a fixed range, which helps certain algorithms like Gradient Descent-based models to converge faster.

- **Random Forest** typically does **not require normalization** because the algorithm splits data based on thresholds, and the scale of the features doesn't affect these splits.

However, in certain cases, normalizing the data before feeding it into the model can make training more efficient, especially when Random Forest is part of a pipeline that includes other models sensitive to scaling.

Conclusion:

The Random Forest algorithm is a robust and versatile tool that leverages the power of ensemble learning and bagging. It performs well on both classification and regression tasks and provides insights into feature importance. While it has some limitations like computational expense and reduced interpretability, its advantages often outweigh these drawbacks, especially for high-dimensional and complex datasets.

Import all the required frameworks

In [1]:
```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
```

In [2]:
```
data = pd.read_csv("./WineQT.csv")
data.head()
```

Out[2]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulp
0	7.4	0.70	0.00	1.9	0.076	11.0	34.0	0.9978	3.51	
1	7.8	0.88	0.00	2.6	0.098	25.0	67.0	0.9968	3.20	
2	7.8	0.76	0.04	2.3	0.092	15.0	54.0	0.9970	3.26	
3	11.2	0.28	0.56	1.9	0.075	17.0	60.0	0.9980	3.16	
4	7.4	0.70	0.00	1.9	0.076	11.0	34.0	0.9978	3.51	

In [3]:
```
data['quality'].value_counts()
```

Out[3]:
```
quality
5    483
6    462
7    143
4     33
8     16
3      6
Name: count, dtype: int64
```

To perform the EDA on this data

In [4]:
```
X = data.drop(columns='quality', axis=1)
y = data['quality']
```

In [5]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y)
```

Data Modeling: DecisionTreeClassifier

In [6]:
```
from sklearn.tree import DecisionTreeClassifier
model = DecisionTreeClassifier()
model.fit(X_train, y_train)
```

Out[6]:
```
DecisionTreeClassifier()
```

In [7]:
```
y_pred = model.predict(X_test)
print(y_pred)
```

```
[5 5 7 5 5 7 7 6 6 6 7 5 6 6 5 6 5 5 5 7 6 6 7 5 5 6 4 5 6 6 7 5 5 7 5 5 6
 5 5 6 6 6 8 5 6 5 5 5 6 6 6 5 5 6 4 5 6 6 6 5 5 5 6 7 5 5 6 6 6 5 5 6 6 5
 8 7 5 5 6 5 6 5 5 5 5 7 6 7 5 7 6 6 6 4 7 5 4 5 6 7 6 6 5 6 6 5 5 5 7 6 6
 5 5 6 5 6 5 6 6 7 6 5 5 7 7 6 6 5 6 6 6 5 5 6 4 8 6 7 7 5 5 7 6 6 6 7 6 6
 6 6 5 6 5 7 6 6 5 4 5 5 7 6 5 5 5 6 6 5 6 4 6 7 5 6 5 5 6 5 6 8 7 5 5 7 5
 6 6 7 5 6 6 6 6 4 6 5 6 5 7 5 5 6 7 6 7 7 6 7 7 5 5 6 6 6 6 6 6 6 5 5 7
 5 5 5 5 7 6 6 6 5 6 7 6 6 6 6 6 6 7 7 6 7 5 7 5 7 4 5 5 5 6 6 4 5 5 5 5 6
 6 5 5 5 5 6 3 6 5 5 5 6 7 6 5 6 6 5 6 5 6 6 5 5 6 6 5]
```

In [8]:
```
from sklearn import tree
plt.figure(figsize=(15,15))
tree.plot_tree(model, filled=True)
```

Out[8]:
```
[Text(0.5006015472709552, 0.96875, 'x[10] <= 10.525\ngini = 0.633\nsampl
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= 522\nvalue = [4, 13, 318, 168, 18, 1]'),
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s = 255\nvalue = [2, 8, 191, 51, 3, 0]'),
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es = 130\nvalue = [1, 6, 107, 15, 1, 0]'),
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= 121\nvalue = [0, 5, 104, 11, 1, 0]'),
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= 93\nvalue = [0, 4, 77, 11, 1, 0]'),
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es = 91\nvalue = [0, 4, 77, 9, 1, 0]'),
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```

```
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```

```
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```

```
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 Text(0.15497076023391812, 0.34375, 'gini = 0.0\nsamples = 3\nvalue =
[0, 0, 3, 0, 0, 0]'),
 Text(0.15886939571150097, 0.40625, 'gini = 0.0\nsamples = 14\nvalue =
[0, 0, 14, 0, 0, 0]'),
 Text(0.1627680311890838, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.1783625730994152, 0.59375, 'x[10] <= 10.45\ngini = 0.562\nsample
s = 22\nvalue = [0, 0, 8, 12, 2, 0]'),
 Text(0.17446393762183235, 0.53125, 'x[7] <= 0.996\ngini = 0.48\nsamples
= 20\nvalue = [0, 0, 8, 12, 0, 0]'),
 Text(0.1705653021442495, 0.46875, 'gini = 0.0\nsamples = 6\nvalue = [0,
0, 0, 6, 0, 0]'),
 Text(0.1783625730994152, 0.46875, 'x[2] <= 0.25\ngini = 0.49\nsamples =
14\nvalue = [0, 0, 8, 6, 0, 0]'),
 Text(0.17446393762183235, 0.40625, 'x[6] <= 53.0\ngini = 0.48\nsamples
= 10\nvalue = [0, 0, 4, 6, 0, 0]'),
 Text(0.1705653021442495, 0.34375, 'x[8] <= 3.385\ngini = 0.444\nsamples
= 6\nvalue = [0, 0, 4, 2, 0, 0]'),
 Text(0.16666666666666666, 0.28125, 'x[5] <= 23.5\ngini = 0.444\nsamples
= 3\nvalue = [0, 0, 1, 2, 0, 0]'),
 Text(0.1627680311890838, 0.21875, 'gini = 0.0\nsamples = 2\nvalue = [0,
0, 0, 2, 0, 0]'),
 Text(0.1705653021442495, 0.21875, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.17446393762183235, 0.28125, 'gini = 0.0\nsamples = 3\nvalue =
[0, 0, 3, 0, 0, 0]'),
 Text(0.1783625730994152, 0.34375, 'gini = 0.0\nsamples = 4\nvalue = [0,
0, 0, 4, 0, 0]'),
 Text(0.18226120857699804, 0.40625, 'gini = 0.0\nsamples = 4\nvalue =
[0, 0, 4, 0, 0, 0]'),
 Text(0.18226120857699804, 0.53125, 'gini = 0.0\nsamples = 2\nvalue =
[0, 0, 0, 0, 2, 0]'),
 Text(0.42525584795321636, 0.84375, 'x[6] <= 65.5\ngini = 0.578\nsamples
= 267\nvalue = [2, 5, 127, 117, 15, 1]'),
 Text(0.36415692007797273, 0.78125, 'x[10] <= 9.85\ngini = 0.586\nsample
s = 205\nvalue = [2.0, 4.0, 81.0, 103.0, 14.0, 1.0]'),
 Text(0.29507797270955166, 0.71875, 'x[0] <= 10.85\ngini = 0.554\nsample
s = 119\nvalue = [1, 2, 60, 52, 3, 1]'),
 Text(0.25584795321637427, 0.65625, 'x[1] <= 0.545\ngini = 0.522\nsample
s = 104\nvalue = [1, 2, 59, 41, 1, 0]'),
 Text(0.22417153996101363, 0.59375, 'x[2] <= 0.445\ngini = 0.517\nsample
```

```
s = 58\nvalue = [0, 0, 28, 29, 1, 0]'),
 Text(0.20760233918128654, 0.53125, 'x[6] <= 32.5\ngini = 0.489\nsamples
= 42\nvalue = [0, 0, 15, 26, 1, 0]'),
 Text(0.19785575048732942, 0.46875, 'x[0] <= 8.9\ngini = 0.349\nsamples
= 19\nvalue = [0, 0, 3, 15, 1, 0]'),
 Text(0.19005847953216373, 0.40625, 'x[5] <= 12.5\ngini = 0.133\nsamples
= 14\nvalue = [0, 0, 0, 13, 1, 0]'),
 Text(0.1861598440545809, 0.34375, 'gini = 0.0\nsamples = 13\nvalue =
[0, 0, 0, 13, 0, 0]'),
 Text(0.19395711500974658, 0.34375, 'gini = 0.0\nsamples = 1\nvalue =
[0, 0, 0, 0, 1, 0]'),
 Text(0.20565302144249512, 0.40625, 'x[2] <= 0.415\ngini = 0.48\nsamples
= 5\nvalue = [0, 0, 3, 2, 0, 0]'),
 Text(0.20175438596491227, 0.34375, 'gini = 0.0\nsamples = 3\nvalue =
[0, 0, 3, 0, 0, 0]'),
 Text(0.20955165692007796, 0.34375, 'gini = 0.0\nsamples = 2\nvalue =
[0, 0, 0, 2, 0, 0]'),
 Text(0.21734892787524365, 0.46875, 'x[9] <= 0.63\ngini = 0.499\nsamples
= 23\nvalue = [0, 0, 12, 11, 0, 0]'),
 Text(0.2134502923976608, 0.40625, 'gini = 0.0\nsamples = 4\nvalue = [0,
0, 0, 4, 0, 0]'),
 Text(0.2212475633528265, 0.40625, 'x[7] <= 0.998\ngini = 0.465\nsamples
= 19\nvalue = [0, 0, 12, 7, 0, 0]'),
 Text(0.21734892787524365, 0.34375, 'x[5] <= 5.0\ngini = 0.32\nsamples =
15\nvalue = [0, 0, 12, 3, 0, 0]'),
 Text(0.2134502923976608, 0.28125, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.2212475633528265, 0.28125, 'x[3] <= 2.65\ngini = 0.245\nsamples
= 14\nvalue = [0, 0, 12, 2, 0, 0]'),
 Text(0.21734892787524365, 0.21875, 'x[7] <= 0.996\ngini = 0.142\nsample
s = 13\nvalue = [0, 0, 12, 1, 0, 0]'),
 Text(0.2134502923976608, 0.15625, 'x[0] <= 6.75\ngini = 0.5\nsamples =
2\nvalue = [0, 0, 1, 1, 0, 0]'),
 Text(0.20955165692007796, 0.09375, 'gini = 0.0\nsamples = 1\nvalue =
[0, 0, 1, 0, 0, 0]'),
 Text(0.21734892787524365, 0.09375, 'gini = 0.0\nsamples = 1\nvalue =
[0, 0, 0, 1, 0, 0]'),
 Text(0.2212475633528265, 0.15625, 'gini = 0.0\nsamples = 11\nvalue =
[0, 0, 11, 0, 0, 0]'),
 Text(0.22514619883040934, 0.21875, 'gini = 0.0\nsamples = 1\nvalue =
[0, 0, 0, 1, 0, 0]'),
 Text(0.22514619883040934, 0.34375, 'gini = 0.0\nsamples = 4\nvalue =
[0, 0, 0, 4, 0, 0]'),
 Text(0.24074074074074073, 0.53125, 'x[6] <= 47.0\ngini = 0.305\nsamples
= 16\nvalue = [0, 0, 13, 3, 0, 0]'),
 Text(0.23294346978557504, 0.46875, 'x[10] <= 9.15\ngini = 0.142\nsample
s = 13\nvalue = [0, 0, 12, 1, 0, 0]'),
 Text(0.2290448343079922, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.23684210526315788, 0.40625, 'gini = 0.0\nsamples = 12\nvalue =
[0, 0, 12, 0, 0, 0]'),
 Text(0.24853801169590642, 0.46875, 'x[9] <= 1.125\ngini = 0.444\nsample
s = 3\nvalue = [0, 0, 1, 2, 0, 0]'),
 Text(0.24463937621832357, 0.40625, 'gini = 0.0\nsamples = 2\nvalue =
[0, 0, 0, 2, 0, 0]'),
 Text(0.2524366471734893, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.2875243664717349, 0.59375, 'x[1] <= 0.675\ngini = 0.475\nsamples
= 46\nvalue = [1, 2, 31, 12, 0, 0]'),
 Text(0.2719298245614035, 0.53125, 'x[2] <= 0.135\ngini = 0.345\nsamples
```

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= 33\nvalue = [1, 0, 26, 6, 0, 0]'),
 Text(0.26413255360623783, 0.46875, 'x[6] <= 22.0\ngini = 0.469\nsamples
= 16\nvalue = [0, 0, 10, 6, 0, 0]'),
 Text(0.260233918128655, 0.40625, 'gini = 0.0\nsamples = 5\nvalue = [0,
0, 5, 0, 0, 0]'),
 Text(0.2680311890838207, 0.40625, 'x[10] <= 9.55\ngini = 0.496\nsamples
= 11\nvalue = [0, 0, 5, 6, 0, 0]'),
 Text(0.26413255360623783, 0.34375, 'gini = 0.0\nsamples = 5\nvalue =
[0, 0, 0, 5, 0, 0]'),
 Text(0.2719298245614035, 0.34375, 'x[6] <= 28.0\ngini = 0.278\nsamples
= 6\nvalue = [0, 0, 5, 1, 0, 0]'),
 Text(0.2680311890838207, 0.28125, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.27582846003898637, 0.28125, 'gini = 0.0\nsamples = 5\nvalue =
[0, 0, 5, 0, 0, 0]'),
 Text(0.2797270955165692, 0.46875, 'x[10] <= 8.7\ngini = 0.111\nsamples
= 17\nvalue = [1, 0, 16, 0, 0, 0]'),
 Text(0.27582846003898637, 0.40625, 'gini = 0.0\nsamples = 1\nvalue =
[1, 0, 0, 0, 0, 0]'),
 Text(0.28362573099415206, 0.40625, 'gini = 0.0\nsamples = 16\nvalue =
[0, 0, 16, 0, 0, 0]'),
 Text(0.3031189083820663, 0.53125, 'x[2] <= 0.065\ngini = 0.615\nsamples
= 13\nvalue = [0, 2, 5, 6, 0, 0]'),
 Text(0.2953216374269006, 0.46875, 'x[9] <= 0.695\ngini = 0.571\nsamples
= 7\nvalue = [0, 2, 4, 1, 0, 0]'),
 Text(0.29142300194931775, 0.40625, 'x[6] <= 16.0\ngini = 0.32\nsamples
= 5\nvalue = [0, 0, 4, 1, 0, 0]'),
 Text(0.2875243664717349, 0.34375, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.2953216374269006, 0.34375, 'gini = 0.0\nsamples = 4\nvalue = [0,
0, 4, 0, 0, 0]'),
 Text(0.29922027290448344, 0.40625, 'gini = 0.0\nsamples = 2\nvalue =
[0, 2, 0, 0, 0, 0]'),
 Text(0.310916179337232, 0.46875, 'x[7] <= 0.997\ngini = 0.278\nsamples
= 6\nvalue = [0, 0, 1, 5, 0, 0]'),
 Text(0.30701754385964913, 0.40625, 'gini = 0.0\nsamples = 1\nvalue =
[0, 0, 1, 0, 0, 0]'),
 Text(0.3148148148148148, 0.40625, 'gini = 0.0\nsamples = 5\nvalue = [0,
0, 0, 5, 0, 0]'),
 Text(0.33430799220272905, 0.65625, 'x[9] <= 0.83\ngini = 0.436\nsamples
= 15\nvalue = [0, 0, 1, 11, 2, 1]'),
 Text(0.32651072124756336, 0.59375, 'x[2] <= 0.425\ngini = 0.292\nsample
s = 12\nvalue = [0, 0, 1, 10, 0, 1]'),
 Text(0.3226120857699805, 0.53125, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.3304093567251462, 0.53125, 'x[8] <= 2.91\ngini = 0.165\nsamples
= 11\nvalue = [0, 0, 0, 10, 0, 1]'),
 Text(0.32651072124756336, 0.46875, 'x[7] <= 1.0\ngini = 0.5\nsamples =
2\nvalue = [0, 0, 0, 1, 0, 1]'),
 Text(0.3226120857699805, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 0, 0, 1]'),
 Text(0.3304093567251462, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.33430799220272905, 0.46875, 'gini = 0.0\nsamples = 9\nvalue =
[0, 0, 0, 9, 0, 0]'),
 Text(0.34210526315789475, 0.59375, 'x[7] <= 0.999\ngini = 0.444\nsample
s = 3\nvalue = [0, 0, 0, 1, 2, 0]'),
 Text(0.3382066276803119, 0.53125, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.3460038986354776, 0.53125, 'gini = 0.0\nsamples = 2\nvalue = [0,
```

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0, 0, 0, 2, 0]'),
 Text(0.43323586744639375, 0.71875, 'x[3] <= 4.8\ngini = 0.572\nsamples
= 86\nvalue = [1.0, 2.0, 21.0, 51.0, 11.0, 0.0]'),
 Text(0.41130604288499023, 0.65625, 'x[1] <= 0.705\ngini = 0.538\nsample
s = 81\nvalue = [1, 2, 19, 51, 8, 0]'),
 Text(0.3791423001949318, 0.59375, 'x[10] <= 10.15\ngini = 0.486\nsample
s = 72\nvalue = [0, 1, 14, 49, 8, 0]'),
 Text(0.3538011695906433, 0.53125, 'x[5] <= 21.5\ngini = 0.271\nsamples
= 32\nvalue = [0, 1, 0, 27, 4, 0]'),
 Text(0.3460038986354776, 0.46875, 'x[7] <= 0.995\ngini = 0.133\nsamples
= 28\nvalue = [0, 0, 0, 26, 2, 0]'),
 Text(0.34210526315789475, 0.40625, 'gini = 0.0\nsamples = 1\nvalue =
[0, 0, 0, 0, 1, 0]'),
 Text(0.34990253411306044, 0.40625, 'x[6] <= 51.0\ngini = 0.071\nsamples
= 27\nvalue = [0, 0, 0, 26, 1, 0]'),
 Text(0.3460038986354776, 0.34375, 'gini = 0.0\nsamples = 25\nvalue =
[0, 0, 0, 25, 0, 0]'),
 Text(0.3538011695906433, 0.34375, 'x[3] <= 2.4\ngini = 0.5\nsamples = 2
\nvalue = [0, 0, 0, 1, 1, 0]'),
 Text(0.34990253411306044, 0.28125, 'gini = 0.0\nsamples = 1\nvalue =
[0, 0, 0, 1, 0, 0]'),
 Text(0.35769980506822613, 0.28125, 'gini = 0.0\nsamples = 1\nvalue =
[0, 0, 0, 0, 1, 0]'),
 Text(0.361598440545809, 0.46875, 'x[9] <= 0.81\ngini = 0.625\nsamples =
4\nvalue = [0, 1, 0, 1, 2, 0]'),
 Text(0.35769980506822613, 0.40625, 'gini = 0.0\nsamples = 2\nvalue =
[0, 0, 0, 0, 2, 0]'),
 Text(0.3654970760233918, 0.40625, 'x[2] <= 0.495\ngini = 0.5\nsamples =
2\nvalue = [0, 1, 0, 1, 0, 0]'),
 Text(0.361598440545809, 0.34375, 'gini = 0.0\nsamples = 1\nvalue = [0,
1, 0, 0, 0, 0]'),
 Text(0.36939571150097467, 0.34375, 'gini = 0.0\nsamples = 1\nvalue =
[0, 0, 0, 1, 0, 0]'),
 Text(0.4044834307992203, 0.53125, 'x[3] <= 2.05\ngini = 0.565\nsamples
= 40\nvalue = [0, 0, 14, 22, 4, 0]'),
 Text(0.3888888888888889, 0.46875, 'x[4] <= 0.068\ngini = 0.544\nsamples
= 13\nvalue = [0, 0, 8, 3, 2, 0]'),
 Text(0.3810916179337232, 0.40625, 'x[3] <= 1.85\ngini = 0.444\nsamples
= 3\nvalue = [0, 0, 0, 1, 2, 0]'),
 Text(0.37719298245614036, 0.34375, 'gini = 0.0\nsamples = 2\nvalue =
[0, 0, 0, 0, 2, 0]'),
 Text(0.38499025341130605, 0.34375, 'gini = 0.0\nsamples = 1\nvalue =
[0, 0, 0, 1, 0, 0]'),
 Text(0.3966861598440546, 0.40625, 'x[6] <= 46.5\ngini = 0.32\nsamples =
10\nvalue = [0, 0, 8, 2, 0, 0]'),
 Text(0.39278752436647174, 0.34375, 'gini = 0.0\nsamples = 7\nvalue =
[0, 0, 7, 0, 0, 0]'),
 Text(0.40058479532163743, 0.34375, 'x[3] <= 1.85\ngini = 0.444\nsamples
= 3\nvalue = [0, 0, 1, 2, 0, 0]'),
 Text(0.3966861598440546, 0.28125, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.4044834307992203, 0.28125, 'gini = 0.0\nsamples = 2\nvalue = [0,
0, 0, 2, 0, 0]'),
 Text(0.42007797270955166, 0.46875, 'x[2] <= 0.205\ngini = 0.45\nsamples
= 27\nvalue = [0, 0, 6, 19, 2, 0]'),
 Text(0.4161793372319688, 0.40625, 'gini = 0.0\nsamples = 9\nvalue = [0,
0, 0, 9, 0, 0]'),
 Text(0.4239766081871345, 0.40625, 'x[1] <= 0.645\ngini = 0.568\nsamples
= 18\nvalue = [0, 0, 6, 10, 2, 0]'),
 Text(0.42007797270955166, 0.34375, 'x[3] <= 2.65\ngini = 0.531\nsamples
```

```
= 16\nvalue = [0, 0, 4, 10, 2, 0]'),
 Text(0.41228070175438597, 0.28125, 'x[7] <= 0.997\ngini = 0.314\nsample
s = 11\nvalue = [0, 0, 1, 9, 1, 0]'),
 Text(0.4083820662768031, 0.21875, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.4161793372319688, 0.21875, 'x[7] <= 1.0\ngini = 0.18\nsamples =
10\nvalue = [0, 0, 0, 9, 1, 0]'),
 Text(0.41228070175438597, 0.15625, 'gini = 0.0\nsamples = 8\nvalue =
[0, 0, 0, 8, 0, 0]'),
 Text(0.42007797270955166, 0.15625, 'x[2] <= 0.505\ngini = 0.5\nsamples
= 2\nvalue = [0, 0, 0, 1, 1, 0]'),
 Text(0.4161793372319688, 0.09375, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 0, 1, 0]'),
 Text(0.4239766081871345, 0.09375, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.42787524366471735, 0.28125, 'x[2] <= 0.265\ngini = 0.56\nsamples
= 5\nvalue = [0, 0, 3, 1, 1, 0]'),
 Text(0.4239766081871345, 0.21875, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.4317738791423002, 0.21875, 'x[2] <= 0.575\ngini = 0.375\nsamples
= 4\nvalue = [0, 0, 3, 0, 1, 0]'),
 Text(0.42787524366471735, 0.15625, 'gini = 0.0\nsamples = 3\nvalue =
[0, 0, 3, 0, 0, 0]'),
 Text(0.43567251461988304, 0.15625, 'gini = 0.0\nsamples = 1\nvalue =
[0, 0, 0, 0, 1, 0]'),
 Text(0.42787524366471735, 0.34375, 'gini = 0.0\nsamples = 2\nvalue =
[0, 0, 2, 0, 0, 0]'),
 Text(0.44346978557504874, 0.59375, 'x[7] <= 0.998\ngini = 0.617\nsample
s = 9\nvalue = [1, 1, 5, 2, 0, 0]'),
 Text(0.4395711500974659, 0.53125, 'x[5] <= 6.5\ngini = 0.449\nsamples =
7\nvalue = [1, 1, 5, 0, 0, 0]'),
 Text(0.43567251461988304, 0.46875, 'x[1] <= 0.773\ngini = 0.5\nsamples
= 2\nvalue = [1, 1, 0, 0, 0, 0]'),
 Text(0.4317738791423002, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [1,
0, 0, 0, 0, 0]'),
 Text(0.4395711500974659, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
1, 0, 0, 0, 0]'),
 Text(0.44346978557504874, 0.46875, 'gini = 0.0\nsamples = 5\nvalue =
[0, 0, 5, 0, 0, 0]'),
 Text(0.4473684210526316, 0.53125, 'gini = 0.0\nsamples = 2\nvalue = [0,
0, 0, 2, 0, 0]'),
 Text(0.4551656920077973, 0.65625, 'x[1] <= 0.627\ngini = 0.48\nsamples
= 5\nvalue = [0, 0, 2, 0, 3, 0]'),
 Text(0.4512670565302144, 0.59375, 'gini = 0.0\nsamples = 3\nvalue = [0,
0, 0, 0, 3, 0]'),
 Text(0.4590643274853801, 0.59375, 'gini = 0.0\nsamples = 2\nvalue = [0,
0, 2, 0, 0, 0]'),
 Text(0.48635477582846004, 0.78125, 'x[10] <= 9.85\ngini = 0.398\nsample
s = 62\nvalue = [0, 1, 46, 14, 1, 0]'),
 Text(0.4668615984405458, 0.71875, 'x[3] <= 1.55\ngini = 0.274\nsamples
= 44\nvalue = [0, 1, 37, 6, 0, 0]'),
 Text(0.46296296296296297, 0.65625, 'gini = 0.0\nsamples = 1\nvalue =
[0, 1, 0, 0, 0, 0]'),
 Text(0.47076023391812866, 0.65625, 'x[5] <= 7.0\ngini = 0.24\nsamples =
43\nvalue = [0, 0, 37, 6, 0, 0]'),
 Text(0.4668615984405458, 0.59375, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.4746588693957115, 0.59375, 'x[8] <= 3.32\ngini = 0.21\nsamples =
42\nvalue = [0, 0, 37, 5, 0, 0]'),
 Text(0.4668615984405458, 0.53125, 'x[9] <= 1.46\ngini = 0.069\nsamples
```

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= 28\nvalue = [0, 0, 27, 1, 0, 0]'),
 Text(0.46296296296296297, 0.46875, 'gini = 0.0\nsamples = 26\nvalue =
[0, 0, 26, 0, 0, 0]'),
 Text(0.47076023391812866, 0.46875, 'x[0] <= 8.0\ngini = 0.5\nsamples =
2\nvalue = [0, 0, 1, 1, 0, 0]'),
 Text(0.4668615984405458, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.4746588693957115, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.4824561403508772, 0.53125, 'x[4] <= 0.078\ngini = 0.408\nsamples
= 14\nvalue = [0, 0, 10, 4, 0, 0]'),
 Text(0.47855750487329435, 0.46875, 'gini = 0.0\nsamples = 5\nvalue =
[0, 0, 5, 0, 0, 0]'),
 Text(0.48635477582846004, 0.46875, 'x[7] <= 0.998\ngini = 0.494\nsample
s = 9\nvalue = [0, 0, 5, 4, 0, 0]'),
 Text(0.4824561403508772, 0.40625, 'gini = 0.0\nsamples = 3\nvalue = [0,
0, 0, 3, 0, 0]'),
 Text(0.4902534113060429, 0.40625, 'x[0] <= 8.95\ngini = 0.278\nsamples
= 6\nvalue = [0, 0, 5, 1, 0, 0]'),
 Text(0.48635477582846004, 0.34375, 'gini = 0.0\nsamples = 5\nvalue =
[0, 0, 5, 0, 0, 0]'),
 Text(0.49415204678362573, 0.34375, 'gini = 0.0\nsamples = 1\nvalue =
[0, 0, 0, 1, 0, 0]'),
 Text(0.5058479532163743, 0.71875, 'x[3] <= 3.7\ngini = 0.549\nsamples =
18\nvalue = [0, 0, 9, 8, 1, 0]'),
 Text(0.5019493177387915, 0.65625, 'x[9] <= 0.625\ngini = 0.521\nsamples
= 13\nvalue = [0, 0, 4, 8, 1, 0]'),
 Text(0.4980506822612086, 0.59375, 'gini = 0.0\nsamples = 2\nvalue = [0,
0, 2, 0, 0, 0]'),
 Text(0.5058479532163743, 0.59375, 'x[2] <= 0.525\ngini = 0.43\nsamples
= 11\nvalue = [0, 0, 2, 8, 1, 0]'),
 Text(0.4980506822612086, 0.53125, 'x[0] <= 9.75\ngini = 0.198\nsamples
= 9\nvalue = [0, 0, 1, 8, 0, 0]'),
 Text(0.49415204678362573, 0.46875, 'gini = 0.0\nsamples = 7\nvalue =
[0, 0, 0, 7, 0, 0]'),
 Text(0.5019493177387915, 0.46875, 'x[10] <= 10.25\ngini = 0.5\nsamples
= 2\nvalue = [0, 0, 1, 1, 0, 0]'),
 Text(0.4980506822612086, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.5058479532163743, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.51364522417154, 0.53125, 'x[9] <= 0.74\ngini = 0.5\nsamples = 2
\nvalue = [0, 0, 1, 0, 1, 0]'),
 Text(0.5097465886939572, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.5175438596491229, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 0, 1, 0]'),
 Text(0.5097465886939572, 0.65625, 'gini = 0.0\nsamples = 5\nvalue = [0,
0, 5, 0, 0, 0]'),
 Text(0.7563505116959064, 0.90625, 'x[1] <= 0.445\ngini = 0.638\nsamples
= 335\nvalue = [1.0, 10.0, 59.0, 174.0, 82.0, 9.0]'),
 Text(0.6284760294834308, 0.9375, '  False'),
 Text(0.6381578947368421, 0.84375, 'x[9] <= 0.725\ngini = 0.631\nsamples
= 154\nvalue = [0, 2, 15, 69, 61, 7]'),
 Text(0.598196881091618, 0.78125, 'x[3] <= 2.9\ngini = 0.625\nsamples =
80\nvalue = [0, 2, 9, 43, 21, 5]'),
 Text(0.5735867446393762, 0.71875, 'x[1] <= 0.345\ngini = 0.569\nsamples
= 65\nvalue = [0, 1, 7, 40, 12, 5]'),
 Text(0.5497076023391813, 0.65625, 'x[4] <= 0.081\ngini = 0.643\nsamples
= 31\nvalue = [0, 0, 6, 15, 9, 1]'),
```

```
 Text(0.5389863547758285, 0.59375, 'x[4] <= 0.064\ngini = 0.577\nsamples
= 26\nvalue = [0.0, 0.0, 5.0, 15.0, 6.0, 0.0]'),
 Text(0.5292397660818714, 0.53125, 'x[9] <= 0.705\ngini = 0.664\nsamples
= 16\nvalue = [0, 0, 5, 6, 5, 0]'),
 Text(0.5253411306042886, 0.46875, 'x[1] <= 0.225\ngini = 0.651\nsamples
= 13\nvalue = [0, 0, 5, 3, 5, 0]'),
 Text(0.5175438596491229, 0.40625, 'x[4] <= 0.059\ngini = 0.375\nsamples
= 4\nvalue = [0, 0, 1, 3, 0, 0]'),
 Text(0.51364522417154, 0.34375, 'gini = 0.0\nsamples = 3\nvalue = [0,
0, 0, 3, 0, 0]'),
 Text(0.5214424951267057, 0.34375, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.5331384015594542, 0.40625, 'x[8] <= 3.33\ngini = 0.494\nsamples
= 9\nvalue = [0, 0, 4, 0, 5, 0]'),
 Text(0.5292397660818714, 0.34375, 'x[1] <= 0.325\ngini = 0.278\nsamples
= 6\nvalue = [0, 0, 1, 0, 5, 0]'),
 Text(0.5253411306042886, 0.28125, 'gini = 0.0\nsamples = 5\nvalue = [0,
0, 0, 0, 5, 0]'),
 Text(0.5331384015594542, 0.28125, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.5370370370370371, 0.34375, 'gini = 0.0\nsamples = 3\nvalue = [0,
0, 3, 0, 0, 0]'),
 Text(0.5331384015594542, 0.46875, 'gini = 0.0\nsamples = 3\nvalue = [0,
0, 0, 3, 0, 0]'),
 Text(0.5487329434697856, 0.53125, 'x[7] <= 0.994\ngini = 0.18\nsamples
= 10\nvalue = [0, 0, 0, 9, 1, 0]'),
 Text(0.5448343079922028, 0.46875, 'x[6] <= 88.5\ngini = 0.5\nsamples =
2\nvalue = [0, 0, 0, 1, 1, 0]'),
 Text(0.5409356725146199, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 0, 1, 0]'),
 Text(0.5487329434697856, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.5526315789473685, 0.46875, 'gini = 0.0\nsamples = 8\nvalue = [0,
0, 0, 8, 0, 0]'),
 Text(0.5604288499025342, 0.59375, 'x[6] <= 45.0\ngini = 0.56\nsamples =
5\nvalue = [0, 0, 1, 0, 3, 1]'),
 Text(0.5565302144249513, 0.53125, 'gini = 0.0\nsamples = 3\nvalue = [0,
0, 0, 0, 3, 0]'),
 Text(0.564327485380117, 0.53125, 'x[7] <= 0.997\ngini = 0.5\nsamples =
2\nvalue = [0, 0, 1, 0, 0, 1]'),
 Text(0.5604288499025342, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 0, 0, 1]'),
 Text(0.5682261208576999, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.5974658869395711, 0.65625, 'x[6] <= 17.5\ngini = 0.436\nsamples
= 34\nvalue = [0, 1, 1, 25, 3, 4]'),
 Text(0.5877192982456141, 0.59375, 'x[2] <= 0.365\ngini = 0.653\nsamples
= 14\nvalue = [0, 1, 0, 7, 3, 3]'),
 Text(0.5799220272904484, 0.53125, 'x[2] <= 0.27\ngini = 0.375\nsamples
= 4\nvalue = [0, 1, 0, 0, 3, 0]'),
 Text(0.5760233918128655, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [0,
1, 0, 0, 0, 0]'),
 Text(0.5838206627680312, 0.46875, 'gini = 0.0\nsamples = 3\nvalue = [0,
0, 0, 0, 3, 0]'),
 Text(0.5955165692007798, 0.53125, 'x[9] <= 0.645\ngini = 0.42\nsamples
= 10\nvalue = [0, 0, 0, 7, 0, 3]'),
 Text(0.5916179337231969, 0.46875, 'gini = 0.0\nsamples = 6\nvalue = [0,
0, 0, 6, 0, 0]'),
 Text(0.5994152046783626, 0.46875, 'x[4] <= 0.06\ngini = 0.375\nsamples
= 4\nvalue = [0, 0, 0, 1, 0, 3]'),
```

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 Text(0.5955165692007798, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.6033138401559455, 0.40625, 'gini = 0.0\nsamples = 3\nvalue = [0,
0, 0, 0, 0, 3]'),
 Text(0.6072124756335283, 0.59375, 'x[8] <= 3.095\ngini = 0.185\nsamples
= 20\nvalue = [0, 0, 1, 18, 0, 1]'),
 Text(0.6033138401559455, 0.53125, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.6111111111111112, 0.53125, 'x[9] <= 0.695\ngini = 0.1\nsamples =
19\nvalue = [0, 0, 0, 18, 0, 1]'),
 Text(0.6072124756335283, 0.46875, 'gini = 0.0\nsamples = 15\nvalue =
[0, 0, 0, 15, 0, 0]'),
 Text(0.615009746588694, 0.46875, 'x[0] <= 7.9\ngini = 0.375\nsamples =
4\nvalue = [0, 0, 0, 3, 0, 1]'),
 Text(0.6111111111111112, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 0, 0, 1]'),
 Text(0.6189083820662769, 0.40625, 'gini = 0.0\nsamples = 3\nvalue = [0,
0, 0, 3, 0, 0]'),
 Text(0.6228070175438597, 0.71875, 'x[10] <= 10.7\ngini = 0.578\nsamples
= 15\nvalue = [0, 1, 2, 3, 9, 0]'),
 Text(0.6189083820662769, 0.65625, 'gini = 0.0\nsamples = 2\nvalue = [0,
0, 2, 0, 0, 0]'),
 Text(0.6267056530214425, 0.65625, 'x[10] <= 13.1\ngini = 0.462\nsamples
= 13\nvalue = [0, 1, 0, 3, 9, 0]'),
 Text(0.6228070175438597, 0.59375, 'x[0] <= 6.85\ngini = 0.314\nsamples
= 11\nvalue = [0, 1, 0, 1, 9, 0]'),
 Text(0.6189083820662769, 0.53125, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.6267056530214425, 0.53125, 'x[6] <= 12.0\ngini = 0.18\nsamples =
10\nvalue = [0, 1, 0, 0, 9, 0]'),
 Text(0.6228070175438597, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [0,
1, 0, 0, 0, 0]'),
 Text(0.6306042884990254, 0.46875, 'gini = 0.0\nsamples = 9\nvalue = [0,
0, 0, 0, 9, 0]'),
 Text(0.6306042884990254, 0.59375, 'gini = 0.0\nsamples = 2\nvalue = [0,
0, 0, 2, 0, 0]'),
 Text(0.6781189083820662, 0.78125, 'x[7] <= 0.996\ngini = 0.577\nsamples
= 74\nvalue = [0, 0, 6, 26, 40, 2]'),
 Text(0.6500974658869396, 0.71875, 'x[6] <= 56.5\ngini = 0.35\nsamples =
31\nvalue = [0, 0, 0, 7, 24, 0]'),
 Text(0.6423001949317739, 0.65625, 'x[4] <= 0.079\ngini = 0.211\nsamples
= 25\nvalue = [0, 0, 0, 3, 22, 0]'),
 Text(0.6384015594541911, 0.59375, 'x[6] <= 9.0\ngini = 0.083\nsamples =
23\nvalue = [0, 0, 0, 1, 22, 0]'),
 Text(0.6345029239766082, 0.53125, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.6423001949317739, 0.53125, 'gini = 0.0\nsamples = 22\nvalue =
[0, 0, 0, 0, 22, 0]'),
 Text(0.6461988304093568, 0.59375, 'gini = 0.0\nsamples = 2\nvalue = [0,
0, 0, 2, 0, 0]'),
 Text(0.6578947368421053, 0.65625, 'x[6] <= 82.5\ngini = 0.444\nsamples
= 6\nvalue = [0, 0, 0, 4, 2, 0]'),
 Text(0.6539961013645225, 0.59375, 'gini = 0.0\nsamples = 4\nvalue = [0,
0, 0, 4, 0, 0]'),
 Text(0.6617933723196882, 0.59375, 'gini = 0.0\nsamples = 2\nvalue = [0,
0, 0, 0, 2, 0]'),
 Text(0.706140350877193, 0.71875, 'x[2] <= 0.615\ngini = 0.645\nsamples
= 43\nvalue = [0, 0, 6, 19, 16, 2]'),
 Text(0.6900584795321637, 0.65625, 'x[1] <= 0.275\ngini = 0.622\nsamples
= 36\nvalue = [0, 0, 5, 19, 10, 2]'),
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 Text(0.6695906432748538, 0.59375, 'x[4] <= 0.063\ngini = 0.512\nsamples
= 11\nvalue = [0, 0, 1, 3, 7, 0]'),
 Text(0.6617933723196882, 0.53125, 'x[7] <= 0.997\ngini = 0.5\nsamples =
2\nvalue = [0, 0, 1, 1, 0, 0]'),
 Text(0.6578947368421053, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.665692007797271, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.6773879142300195, 0.53125, 'x[6] <= 20.5\ngini = 0.346\nsamples
= 9\nvalue = [0, 0, 0, 2, 7, 0]'),
 Text(0.6734892787524367, 0.46875, 'x[2] <= 0.51\ngini = 0.444\nsamples
= 3\nvalue = [0, 0, 0, 2, 1, 0]'),
 Text(0.6695906432748538, 0.40625, 'gini = 0.0\nsamples = 2\nvalue = [0,
0, 0, 2, 0, 0]'),
 Text(0.6773879142300195, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 0, 1, 0]'),
 Text(0.6812865497076024, 0.46875, 'gini = 0.0\nsamples = 6\nvalue = [0,
0, 0, 0, 6, 0]'),
 Text(0.7105263157894737, 0.59375, 'x[3] <= 3.7\ngini = 0.544\nsamples =
25\nvalue = [0, 0, 4, 16, 3, 2]'),
 Text(0.6968810916179338, 0.53125, 'x[0] <= 7.4\ngini = 0.395\nsamples =
21\nvalue = [0, 0, 3, 16, 1, 1]'),
 Text(0.6890838206627681, 0.46875, 'x[10] <= 11.25\ngini = 0.444\nsample
s = 3\nvalue = [0, 0, 2, 1, 0, 0]'),
 Text(0.6851851851851852, 0.40625, 'gini = 0.0\nsamples = 2\nvalue = [0,
0, 2, 0, 0, 0]'),
 Text(0.6929824561403509, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.7046783625730995, 0.46875, 'x[9] <= 0.855\ngini = 0.296\nsamples
= 18\nvalue = [0, 0, 1, 15, 1, 1]'),
 Text(0.7007797270955166, 0.40625, 'gini = 0.0\nsamples = 11\nvalue =
[0, 0, 0, 11, 0, 0]'),
 Text(0.7085769980506823, 0.40625, 'x[4] <= 0.075\ngini = 0.612\nsamples
= 7\nvalue = [0, 0, 1, 4, 1, 1]'),
 Text(0.7046783625730995, 0.34375, 'gini = 0.0\nsamples = 4\nvalue = [0,
0, 0, 4, 0, 0]'),
 Text(0.7124756335282652, 0.34375, 'x[9] <= 0.87\ngini = 0.667\nsamples
= 3\nvalue = [0, 0, 1, 0, 1, 1]'),
 Text(0.7085769980506823, 0.28125, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 0, 1, 0]'),
 Text(0.716374269005848, 0.28125, 'x[1] <= 0.355\ngini = 0.5\nsamples =
2\nvalue = [0, 0, 1, 0, 0, 1]'),
 Text(0.7124756335282652, 0.21875, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 0, 0, 1]'),
 Text(0.7202729044834308, 0.21875, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.7241715399610137, 0.53125, 'x[6] <= 16.0\ngini = 0.625\nsamples
= 4\nvalue = [0, 0, 1, 0, 2, 1]'),
 Text(0.7202729044834308, 0.46875, 'x[1] <= 0.38\ngini = 0.5\nsamples =
2\nvalue = [0, 0, 1, 0, 0, 1]'),
 Text(0.716374269005848, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 0, 0, 1]'),
 Text(0.7241715399610137, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.7280701754385965, 0.46875, 'gini = 0.0\nsamples = 2\nvalue = [0,
0, 0, 0, 2, 0]'),
 Text(0.7222222222222222, 0.65625, 'x[8] <= 3.075\ngini = 0.245\nsamples
= 7\nvalue = [0, 0, 1, 0, 6, 0]'),
 Text(0.7183235867446394, 0.59375, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
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 Text(0.7261208576998051, 0.59375, 'gini = 0.0\nsamples = 6\nvalue = [0,
0, 0, 0, 6, 0]'),
 Text(0.8745431286549707, 0.84375, 'x[9] <= 0.585\ngini = 0.589\nsamples
= 181\nvalue = [1, 8, 44, 105, 21, 2]'),
 Text(0.7982456140350878, 0.78125, 'x[7] <= 0.996\ngini = 0.624\nsamples
= 60\nvalue = [1, 7, 26, 25, 1, 0]'),
 Text(0.7690058479532164, 0.71875, 'x[0] <= 6.25\ngini = 0.598\nsamples
= 38\nvalue = [1.0, 4.0, 11.0, 21.0, 1.0, 0.0]'),
 Text(0.7514619883040936, 0.65625, 'x[4] <= 0.078\ngini = 0.521\nsamples
= 13\nvalue = [0, 1, 8, 4, 0, 0]'),
 Text(0.7475633528265108, 0.59375, 'x[8] <= 3.49\ngini = 0.43\nsamples =
11\nvalue = [0, 1, 8, 2, 0, 0]'),
 Text(0.7397660818713451, 0.53125, 'x[9] <= 0.55\ngini = 0.444\nsamples
= 3\nvalue = [0, 0, 1, 2, 0, 0]'),
 Text(0.7358674463937622, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.7436647173489279, 0.46875, 'gini = 0.0\nsamples = 2\nvalue = [0,
0, 0, 2, 0, 0]'),
 Text(0.7553606237816765, 0.53125, 'x[8] <= 3.81\ngini = 0.219\nsamples
= 8\nvalue = [0, 1, 7, 0, 0, 0]'),
 Text(0.7514619883040936, 0.46875, 'gini = 0.0\nsamples = 7\nvalue = [0,
0, 7, 0, 0, 0]'),
 Text(0.7592592592592593, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [0,
1, 0, 0, 0, 0]'),
 Text(0.7553606237816765, 0.59375, 'gini = 0.0\nsamples = 2\nvalue = [0,
0, 0, 2, 0, 0]'),
 Text(0.7865497076023392, 0.65625, 'x[1] <= 1.0\ngini = 0.506\nsamples =
25\nvalue = [1, 3, 3, 17, 1, 0]'),
 Text(0.7787524366471735, 0.59375, 'x[2] <= 0.18\ngini = 0.38\nsamples =
22\nvalue = [0, 1, 3, 17, 1, 0]'),
 Text(0.7748538011695907, 0.53125, 'x[5] <= 31.5\ngini = 0.27\nsamples =
20\nvalue = [0, 1, 1, 17, 1, 0]'),
 Text(0.767056530214425, 0.46875, 'x[3] <= 3.75\ngini = 0.105\nsamples =
18\nvalue = [0, 1, 0, 17, 0, 0]'),
 Text(0.7631578947368421, 0.40625, 'gini = 0.0\nsamples = 17\nvalue =
[0, 0, 0, 17, 0, 0]'),
 Text(0.7709551656920078, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
1, 0, 0, 0, 0]'),
 Text(0.7826510721247564, 0.46875, 'x[0] <= 6.75\ngini = 0.5\nsamples =
2\nvalue = [0, 0, 1, 0, 1, 0]'),
 Text(0.7787524366471735, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 0, 1, 0]'),
 Text(0.7865497076023392, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.7826510721247564, 0.53125, 'gini = 0.0\nsamples = 2\nvalue = [0,
0, 2, 0, 0, 0]'),
 Text(0.7943469785575049, 0.59375, 'x[10] <= 11.05\ngini = 0.444\nsample
s = 3\nvalue = [1, 2, 0, 0, 0, 0]'),
 Text(0.7904483430799221, 0.53125, 'gini = 0.0\nsamples = 1\nvalue = [1,
0, 0, 0, 0, 0]'),
 Text(0.7982456140350878, 0.53125, 'gini = 0.0\nsamples = 2\nvalue = [0,
2, 0, 0, 0, 0]'),
 Text(0.827485380116959, 0.71875, 'x[5] <= 17.5\ngini = 0.483\nsamples =
22\nvalue = [0.0, 3.0, 15.0, 4.0, 0.0, 0.0]'),
 Text(0.817738791423002, 0.65625, 'x[8] <= 3.355\ngini = 0.405\nsamples
= 20\nvalue = [0, 2, 15, 3, 0, 0]'),
 Text(0.8099415204678363, 0.59375, 'x[8] <= 3.215\ngini = 0.612\nsamples
= 7\nvalue = [0, 1, 3, 3, 0, 0]'),
 Text(0.8060428849902534, 0.53125, 'gini = 0.0\nsamples = 3\nvalue = [0,
0, 3, 0, 0, 0]'),
```

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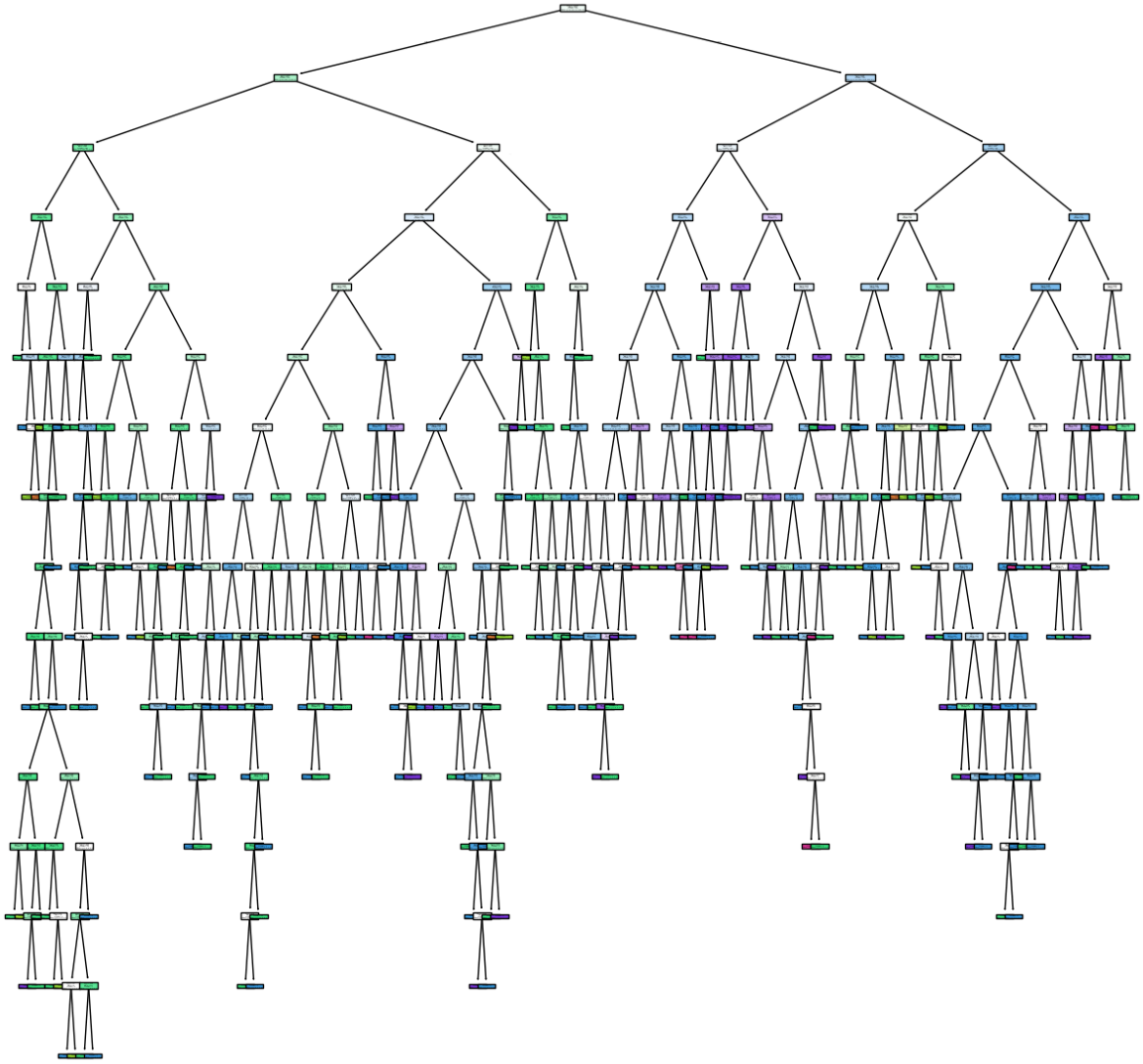
 Text(0.8138401559454191, 0.53125, 'x[2] <= 0.05\ngini = 0.375\nsamples
= 4\nvalue = [0, 1, 0, 3, 0, 0]'),
 Text(0.8099415204678363, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [0,
1, 0, 0, 0, 0]'),
 Text(0.817738791423002, 0.46875, 'gini = 0.0\nsamples = 3\nvalue = [0,
0, 0, 3, 0, 0]'),
 Text(0.8255360623781677, 0.59375, 'x[6] <= 10.0\ngini = 0.142\nsamples
= 13\nvalue = [0, 1, 12, 0, 0, 0]'),
 Text(0.8216374269005848, 0.53125, 'gini = 0.0\nsamples = 1\nvalue = [0,
1, 0, 0, 0, 0]'),
 Text(0.8294346978557505, 0.53125, 'gini = 0.0\nsamples = 12\nvalue =
[0, 0, 12, 0, 0, 0]'),
 Text(0.8372319688109162, 0.65625, 'x[4] <= 0.068\ngini = 0.5\nsamples =
2\nvalue = [0, 1, 0, 1, 0, 0]'),
 Text(0.8333333333333334, 0.59375, 'gini = 0.0\nsamples = 1\nvalue = [0,
1, 0, 0, 0, 0]'),
 Text(0.8411306042884991, 0.59375, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.9508406432748538, 0.78125, 'x[6] <= 83.5\ngini = 0.513\nsamples
= 121\nvalue = [0, 1, 18, 80, 20, 2]'),
 Text(0.9211744639376218, 0.71875, 'x[4] <= 0.089\ngini = 0.447\nsamples
= 110\nvalue = [0.0, 0.0, 14.0, 79.0, 16.0, 1.0]'),
 Text(0.8891325536062378, 0.65625, 'x[8] <= 3.565\ngini = 0.371\nsamples
= 86\nvalue = [0, 0, 10, 67, 8, 1]'),
 Text(0.8640350877192983, 0.59375, 'x[4] <= 0.067\ngini = 0.312\nsamples
= 78\nvalue = [0, 0, 8, 64, 5, 1]'),
 Text(0.8372319688109162, 0.53125, 'x[10] <= 10.65\ngini = 0.512\nsample
s = 26\nvalue = [0, 0, 5, 17, 4, 0]'),
 Text(0.8265107212475633, 0.46875, 'x[1] <= 0.6\ngini = 0.5\nsamples = 2
\nvalue = [0, 0, 1, 0, 1, 0]'),
 Text(0.8226120857699805, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 0, 1, 0]'),
 Text(0.8304093567251462, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.847953216374269, 0.46875, 'x[6] <= 25.0\ngini = 0.455\nsamples =
24\nvalue = [0, 0, 4, 17, 3, 0]'),
 Text(0.8382066276803118, 0.40625, 'x[10] <= 10.85\ngini = 0.165\nsample
s = 11\nvalue = [0, 0, 0, 10, 1, 0]'),
 Text(0.834307992202729, 0.34375, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 0, 1, 0]'),
 Text(0.8421052631578947, 0.34375, 'gini = 0.0\nsamples = 10\nvalue =
[0, 0, 0, 10, 0, 0]'),
 Text(0.8576998050682261, 0.40625, 'x[5] <= 14.5\ngini = 0.592\nsamples
= 13\nvalue = [0, 0, 4, 7, 2, 0]'),
 Text(0.8499025341130604, 0.34375, 'x[4] <= 0.065\ngini = 0.32\nsamples
= 5\nvalue = [0, 0, 4, 0, 1, 0]'),
 Text(0.8460038986354775, 0.28125, 'gini = 0.0\nsamples = 4\nvalue = [0,
0, 4, 0, 0, 0]'),
 Text(0.8538011695906432, 0.28125, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 0, 1, 0]'),
 Text(0.8654970760233918, 0.34375, 'x[7] <= 0.994\ngini = 0.219\nsamples
= 8\nvalue = [0, 0, 0, 7, 1, 0]'),
 Text(0.8615984405458089, 0.28125, 'x[3] <= 2.05\ngini = 0.444\nsamples
= 3\nvalue = [0, 0, 0, 2, 1, 0]'),
 Text(0.8576998050682261, 0.21875, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 0, 1, 0]'),
 Text(0.8654970760233918, 0.21875, 'gini = 0.0\nsamples = 2\nvalue = [0,
0, 0, 2, 0, 0]'),
 Text(0.8693957115009746, 0.28125, 'gini = 0.0\nsamples = 5\nvalue = [0,
0, 0, 5, 0, 0]'),
```

```
 Text(0.8908382066276803, 0.53125, 'x[3] <= 5.15\ngini = 0.179\nsamples
= 52\nvalue = [0, 0, 3, 47, 1, 1]'),
 Text(0.8869395711500975, 0.46875, 'x[7] <= 0.994\ngini = 0.147\nsamples
= 51\nvalue = [0, 0, 3, 47, 1, 0]'),
 Text(0.8771929824561403, 0.40625, 'x[8] <= 3.36\ngini = 0.5\nsamples =
2\nvalue = [0, 0, 0, 1, 1, 0]'),
 Text(0.8732943469785575, 0.34375, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.8810916179337231, 0.34375, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 0, 1, 0]'),
 Text(0.8966861598440545, 0.40625, 'x[6] <= 54.0\ngini = 0.115\nsamples
= 49\nvalue = [0, 0, 3, 46, 0, 0]'),
 Text(0.8888888888888888, 0.34375, 'x[1] <= 0.685\ngini = 0.049\nsamples
= 40\nvalue = [0, 0, 1, 39, 0, 0]'),
 Text(0.884990253411306, 0.28125, 'gini = 0.0\nsamples = 32\nvalue = [0,
0, 0, 32, 0, 0]'),
 Text(0.8927875243664717, 0.28125, 'x[1] <= 0.707\ngini = 0.219\nsamples
= 8\nvalue = [0, 0, 1, 7, 0, 0]'),
 Text(0.8888888888888888, 0.21875, 'x[8] <= 3.47\ngini = 0.5\nsamples =
2\nvalue = [0, 0, 1, 1, 0, 0]'),
 Text(0.884990253411306, 0.15625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.8927875243664717, 0.15625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.8966861598440545, 0.21875, 'gini = 0.0\nsamples = 6\nvalue = [0,
0, 0, 6, 0, 0]'),
 Text(0.9044834307992202, 0.34375, 'x[3] <= 2.0\ngini = 0.346\nsamples =
9\nvalue = [0, 0, 2, 7, 0, 0]'),
 Text(0.9005847953216374, 0.28125, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.9083820662768031, 0.28125, 'x[5] <= 17.5\ngini = 0.219\nsamples
= 8\nvalue = [0, 0, 1, 7, 0, 0]'),
 Text(0.9044834307992202, 0.21875, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.9122807017543859, 0.21875, 'gini = 0.0\nsamples = 7\nvalue = [0,
0, 0, 7, 0, 0]'),
 Text(0.8947368421052632, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 0, 0, 1]'),
 Text(0.9142300194931774, 0.59375, 'x[9] <= 0.68\ngini = 0.656\nsamples
= 8\nvalue = [0, 0, 2, 3, 3, 0]'),
 Text(0.9064327485380117, 0.53125, 'x[7] <= 0.995\ngini = 0.375\nsamples
= 4\nvalue = [0, 0, 1, 3, 0, 0]'),
 Text(0.9025341130604289, 0.46875, 'gini = 0.0\nsamples = 3\nvalue = [0,
0, 0, 3, 0, 0]'),
 Text(0.9103313840155945, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.9220272904483431, 0.53125, 'x[2] <= 0.005\ngini = 0.375\nsamples
= 4\nvalue = [0, 0, 1, 0, 3, 0]'),
 Text(0.9181286549707602, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.9259259259259259, 0.46875, 'gini = 0.0\nsamples = 3\nvalue = [0,
0, 0, 0, 3, 0]'),
 Text(0.9532163742690059, 0.65625, 'x[8] <= 3.225\ngini = 0.611\nsamples
= 24\nvalue = [0, 0, 4, 12, 8, 0]'),
 Text(0.9454191033138402, 0.59375, 'x[8] <= 3.215\ngini = 0.595\nsamples
= 11\nvalue = [0, 0, 3, 2, 6, 0]'),
 Text(0.9415204678362573, 0.53125, 'x[10] <= 11.15\ngini = 0.494\nsample
s = 9\nvalue = [0, 0, 1, 2, 6, 0]'),
 Text(0.9337231968810916, 0.46875, 'x[10] <= 11.0\ngini = 0.5\nsamples =
2\nvalue = [0, 0, 1, 1, 0, 0]'),
```

```
 Text(0.9298245614035088, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.9376218323586745, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.949317738791423, 0.46875, 'x[4] <= 0.097\ngini = 0.245\nsamples
= 7\nvalue = [0, 0, 0, 1, 6, 0]'),
 Text(0.9454191033138402, 0.40625, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.9532163742690059, 0.40625, 'gini = 0.0\nsamples = 6\nvalue = [0,
0, 0, 0, 6, 0]'),
 Text(0.949317738791423, 0.53125, 'gini = 0.0\nsamples = 2\nvalue = [0,
0, 2, 0, 0, 0]'),
 Text(0.9610136452241715, 0.59375, 'x[10] <= 10.65\ngini = 0.379\nsample
s = 13\nvalue = [0, 0, 1, 10, 2, 0]'),
 Text(0.9571150097465887, 0.53125, 'gini = 0.0\nsamples = 2\nvalue = [0,
0, 0, 0, 2, 0]'),
 Text(0.9649122807017544, 0.53125, 'x[7] <= 0.995\ngini = 0.165\nsamples
= 11\nvalue = [0, 0, 1, 10, 0, 0]'),
 Text(0.9610136452241715, 0.46875, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 1, 0, 0, 0]'),
 Text(0.9688109161793372, 0.46875, 'gini = 0.0\nsamples = 10\nvalue =
[0, 0, 0, 10, 0, 0]'),
 Text(0.9805068226120858, 0.71875, 'x[7] <= 0.993\ngini = 0.711\nsamples
= 11\nvalue = [0, 1, 4, 1, 4, 1]'),
 Text(0.9727095516569201, 0.65625, 'x[3] <= 1.5\ngini = 0.32\nsamples =
5\nvalue = [0, 0, 0, 0, 4, 1]'),
 Text(0.9688109161793372, 0.59375, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 0, 0, 1]'),
 Text(0.9766081871345029, 0.59375, 'gini = 0.0\nsamples = 4\nvalue = [0,
0, 0, 0, 4, 0]'),
 Text(0.9883040935672515, 0.65625, 'x[6] <= 88.0\ngini = 0.5\nsamples =
6\nvalue = [0, 1, 4, 1, 0, 0]'),
 Text(0.9844054580896686, 0.59375, 'gini = 0.0\nsamples = 1\nvalue = [0,
1, 0, 0, 0, 0]'),
 Text(0.9922027290448343, 0.59375, 'x[8] <= 3.34\ngini = 0.32\nsamples =
5\nvalue = [0, 0, 4, 1, 0, 0]'),
 Text(0.9883040935672515, 0.53125, 'gini = 0.0\nsamples = 1\nvalue = [0,
0, 0, 1, 0, 0]'),
 Text(0.9961013645224172, 0.53125, 'gini = 0.0\nsamples = 4\nvalue = [0,
0, 4, 0, 0, 0]')]
```



In [9]:
```
data.shape
```

Out[9]: (1143, 12)

In [10]:
```
sampleData = data.head(20)
sampleData
```

Out[10]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sul
0	7.4	0.700	0.00	1.9	0.076	11.0	34.0	0.9978	3.51	
1	7.8	0.880	0.00	2.6	0.098	25.0	67.0	0.9968	3.20	
2	7.8	0.760	0.04	2.3	0.092	15.0	54.0	0.9970	3.26	
3	11.2	0.280	0.56	1.9	0.075	17.0	60.0	0.9980	3.16	
4	7.4	0.700	0.00	1.9	0.076	11.0	34.0	0.9978	3.51	
5	7.4	0.660	0.00	1.8	0.075	13.0	40.0	0.9978	3.51	
6	7.9	0.600	0.06	1.6	0.069	15.0	59.0	0.9964	3.30	
7	7.3	0.650	0.00	1.2	0.065	15.0	21.0	0.9946	3.39	
8	7.8	0.580	0.02	2.0	0.073	9.0	18.0	0.9968	3.36	
9	6.7	0.580	0.08	1.8	0.097	15.0	65.0	0.9959	3.28	
10	5.6	0.615	0.00	1.6	0.089	16.0	59.0	0.9943	3.58	
11	7.8	0.610	0.29	1.6	0.114	9.0	29.0	0.9974	3.26	
12	8.5	0.280	0.56	1.8	0.092	35.0	103.0	0.9969	3.30	
13	7.9	0.320	0.51	1.8	0.341	17.0	56.0	0.9969	3.04	
14	7.6	0.390	0.31	2.3	0.082	23.0	71.0	0.9982	3.52	
15	7.9	0.430	0.21	1.6	0.106	10.0	37.0	0.9966	3.17	
16	8.5	0.490	0.11	2.3	0.084	9.0	67.0	0.9968	3.17	
17	6.9	0.400	0.14	2.4	0.085	21.0	40.0	0.9968	3.43	
18	6.3	0.390	0.16	1.4	0.080	11.0	23.0	0.9955	3.34	
19	7.6	0.410	0.24	1.8	0.080	4.0	11.0	0.9962	3.28	

In [11]:
```
X_sample = sampleData.drop(columns='quality', axis=1)
y_sample = sampleData['quality']
sampleModel = DecisionTreeClassifier()
sampleModel.fit(X_sample, y_sample)
```

Out[11]:
```
DecisionTreeClassifier()
```

In [12]:
```
y_sample.value_counts()
```

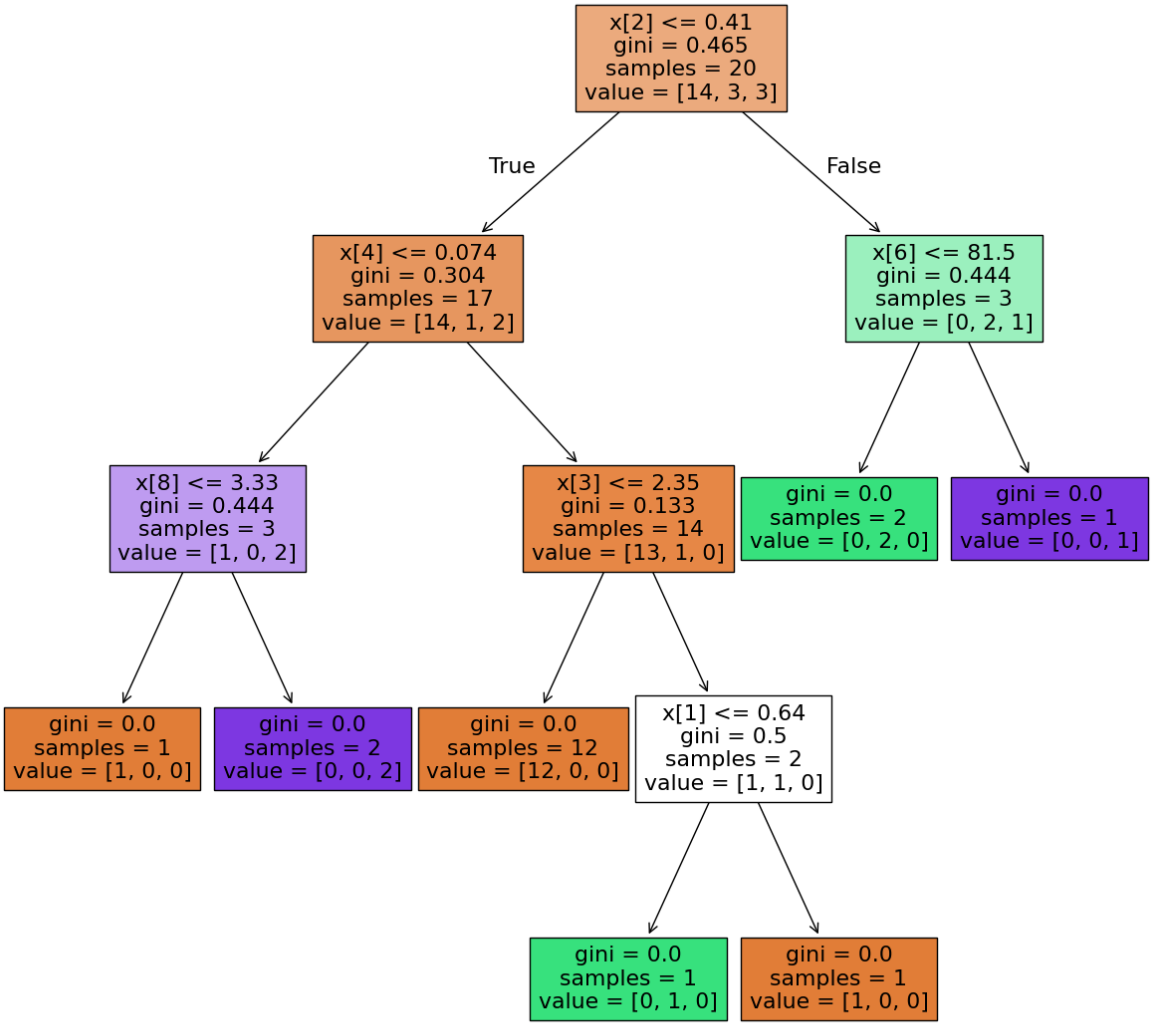
Out[12]:
```
quality
5    14
6     3
7     3
Name: count, dtype: int64
```

In [13]:
```
X_sample.columns
```

Out[13]:
```
Index(['fixed acidity', 'volatile acidity', 'citric acid', 'residual sug
ar',
       'chlorides', 'free sulfur dioxide', 'total sulfur dioxide', 'dens
ity',
       'pH', 'sulphates', 'alcohol'],
      dtype='object')
```

In [14]:
```
from sklearn import tree
plt.figure(figsize=(15,15))
tree.plot_tree(sampleModel, filled=True)
```

Out[14]:
```
[Text(0.5909090909090909, 0.9, 'x[2] <= 0.41\ngini = 0.465\nsamples = 20
\nvalue = [14, 3, 3]'),
 Text(0.36363636363636365, 0.7, 'x[4] <= 0.074\ngini = 0.304\nsamples =
17\nvalue = [14, 1, 2]'),
 Text(0.4772727272727273, 0.8, 'True  '),
 Text(0.18181818181818182, 0.5, 'x[8] <= 3.33\ngini = 0.444\nsamples = 3
\nvalue = [1, 0, 2]'),
 Text(0.09090909090909091, 0.3, 'gini = 0.0\nsamples = 1\nvalue = [1, 0,
0]'),
 Text(0.2727272727272727, 0.3, 'gini = 0.0\nsamples = 2\nvalue = [0, 0,
2]'),
 Text(0.5454545454545454, 0.5, 'x[3] <= 2.35\ngini = 0.133\nsamples = 14
\nvalue = [13, 1, 0]'),
 Text(0.45454545454545453, 0.3, 'gini = 0.0\nsamples = 12\nvalue = [12,
0, 0]'),
 Text(0.6363636363636364, 0.3, 'x[1] <= 0.64\ngini = 0.5\nsamples = 2\nv
alue = [1, 1, 0]'),
 Text(0.5454545454545454, 0.1, 'gini = 0.0\nsamples = 1\nvalue = [0, 1,
0]'),
 Text(0.7272727272727273, 0.1, 'gini = 0.0\nsamples = 1\nvalue = [1, 0,
0]'),
 Text(0.8181818181818182, 0.7, 'x[6] <= 81.5\ngini = 0.444\nsamples = 3
\nvalue = [0, 2, 1]'),
 Text(0.7045454545454546, 0.8, '  False'),
 Text(0.7272727272727273, 0.5, 'gini = 0.0\nsamples = 2\nvalue = [0, 2,
0]'),
 Text(0.9090909090909091, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0, 0,
1]')]
```



`make_classification()` is a function in the **Scikit-learn** library used to generate synthetic classification datasets. It is useful for testing and prototyping machine learning algorithms by providing customizable, randomly generated data.

Functionality

The `make_classification()` function allows you to create a dataset with specified characteristics such as the number of classes, features, informative features, redundant features, clusters per class, and noise. You can use this data for training and testing classification models, or for experimenting with different algorithms.

Syntax

```
from sklearn.datasets import make_classification

X, y = make_classification(n_samples=100, n_features=20,
n_informative=2, n_redundant=2, n_classes=2, random_state=42)
```

Parameters

Some of the key parameters are:

- `n_samples`:
  The total number of samples (data points) in the dataset.
  Default: 100

- `n_features`:
  The total number of features (columns) in the dataset. This includes informative, redundant, and noise features.
  Default: 20

- `n_informative`:
  The number of features that actually carry information useful for classification.
  Default: 2

- `n_redundant`:
  The number of features that are generated as random linear combinations of the informative features.
  Default: 2

- `n_classes`:
  The number of classes (or target labels) in the classification problem.
  Default: 2

- `n_clusters_per_class`:
  The number of clusters per class. Controls the separability of the classes.
  Default: 2

- `flip_y`:
  The fraction of samples whose class labels are randomly flipped to introduce noise.
  Default: 0.01

- `random_state`:
  Sets a seed for reproducibility so that the same dataset is generated every time the function is called with the same parameters.

Return Values

- `X`:
  An array of shape `(n_samples, n_features)` containing the features of the dataset.

- `y`:
  An array of shape `(n_samples,)` containing the labels (target values) of the dataset.

Example Usage

```
from sklearn.datasets import make_classification
import matplotlib.pyplot as plt

# Create synthetic dataset
X, y = make_classification(n_samples=1000, n_features=2,
n_informative=2, n_redundant=0, n_classes=2, random_state=42)

# Plot the dataset
plt.scatter(X[:, 0], X[:, 1], c=y, cmap='coolwarm')
plt.xlabel("Feature 1")
plt.ylabel("Feature 2")
plt.title("Synthetic Classification Data")
plt.show()
```

In this example:

- `n_samples=1000` : 1000 data points.
- `n_features=2` : Two features (so it can be easily plotted in 2D).
- `n_informative=2` : Both features are informative for classification.
- `n_redundant=0` : No redundant features.

Use Cases

- **Algorithm Testing**: You can quickly generate datasets to test classification algorithms like Logistic Regression, Decision Trees, Random Forests, etc.
- **Debugging**: It helps to diagnose and debug models on synthetic data before using real-world datasets.
- **Benchmarking**: You can use it to compare the performance of different algorithms on controlled datasets.

Advantages

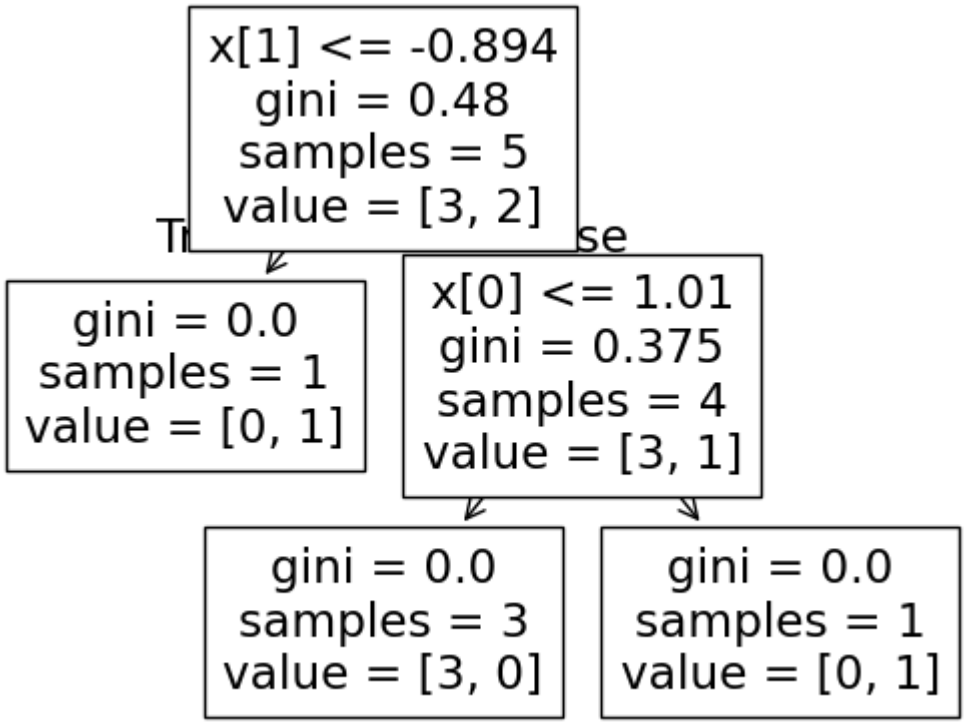
- Flexibility to create datasets with different levels of complexity.
- Provides a simple and efficient way to generate labeled data for testing.
- Helps understand how different algorithms behave with certain data characteristics.

In [15]:
```
from sklearn.datasets import make_classification
X, y = make_classification(n_samples = 5, n_classes = 2, n_features = 2,
clf = DecisionTreeClassifier()
clf.fit(X,y)
```

Out[15]:
```
▾ DecisionTreeClassifier
DecisionTreeClassifier()
```

In [16]:
```
from sklearn.tree import plot_tree
plot_tree(clf)
```

Out[16]:
```
[Text(0.4, 0.8333333333333334, 'x[1] <= -0.894\ngini = 0.48\nsamples = 5
\nvalue = [3, 2]'),
 Text(0.2, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0, 1]'),
 Text(0.30000000000000004, 0.6666666666666667, 'True  '),
 Text(0.6, 0.5, 'x[0] <= 1.01\ngini = 0.375\nsamples = 4\nvalue = [3,
1]'),
 Text(0.5, 0.6666666666666667, '  False'),
 Text(0.4, 0.16666666666666666, 'gini = 0.0\nsamples = 3\nvalue = [3,
0]'),
 Text(0.8, 0.16666666666666666, 'gini = 0.0\nsamples = 1\nvalue = [0,
1]')]
```



In [17]:
```
clf.feature_importances_
```

Out[17]:
```
array([0.625, 0.375])
```

In [18]:
```
from sklearn.ensemble import RandomForestClassifier, RandomForestRegresso
rf = RandomForestClassifier()
rf.fit(X_train, y_train)
```

Out[18]:
```
RandomForestClassifier
RandomForestClassifier()
```

In [19]:
```
rf.score(X_test, y_test)
```

Out[19]:
```
0.6433566433566433
```

In [20]:
```
y_predict_rf = rf.predict(X_test)
print(y_predict_rf)
```

```
[5 5 7 5 5 6 6 6 5 6 7 5 6 6 5 6 5 5 6 5 5 5 7 5 5 6 5 5 6 6 7 6 5 7 5 6 6
 5 7 6 6 6 6 6 6 5 7 5 6 6 7 5 5 6 5 5 6 6 6 5 5 5 6 7 5 5 6 6 6 5 5 6 6 5
 7 7 5 6 7 6 6 5 5 5 5 7 6 7 5 7 6 5 6 5 7 5 6 5 6 6 6 6 5 5 6 5 6 5 7 5 5
 6 6 6 5 5 5 5 5 6 5 5 5 7 6 6 6 5 6 6 6 5 5 5 6 6 6 7 7 6 5 6 6 6 6 6 6 6
 5 6 5 6 5 7 6 6 5 5 5 6 6 5 5 5 5 6 6 5 6 5 6 6 5 6 5 6 6 5 6 8 7 5 5 5 5
 5 7 5 6 6 6 6 6 5 6 5 6 5 7 5 5 6 7 5 7 7 6 7 6 5 5 6 6 5 6 5 5 6 5 6 5 6
 5 5 5 5 7 6 6 7 5 6 5 6 6 6 6 6 7 6 6 6 6 5 7 5 5 5 6 5 5 5 6 7 5 5 6 5 6
 6 5 5 5 5 6 5 6 5 5 5 5 6 7 6 5 6 5 6 6 5 6 5 5 6 6 5]
```

In [21]:
```
rf.estimators_
```

Out[21]:
```
[DecisionTreeClassifier(max_features='sqrt', random_state=1768586963),
 DecisionTreeClassifier(max_features='sqrt', random_state=1872176275),
 DecisionTreeClassifier(max_features='sqrt', random_state=1711640999),
 DecisionTreeClassifier(max_features='sqrt', random_state=1793105295),
 DecisionTreeClassifier(max_features='sqrt', random_state=1170093486),
 DecisionTreeClassifier(max_features='sqrt', random_state=894529526),
 DecisionTreeClassifier(max_features='sqrt', random_state=235381435),
 DecisionTreeClassifier(max_features='sqrt', random_state=769482771),
 DecisionTreeClassifier(max_features='sqrt', random_state=1477317242),
 DecisionTreeClassifier(max_features='sqrt', random_state=1298942943),
 DecisionTreeClassifier(max_features='sqrt', random_state=1067337936),
 DecisionTreeClassifier(max_features='sqrt', random_state=1207108604),
 DecisionTreeClassifier(max_features='sqrt', random_state=2138409278),
 DecisionTreeClassifier(max_features='sqrt', random_state=1880949735),
 DecisionTreeClassifier(max_features='sqrt', random_state=415690394),
 DecisionTreeClassifier(max_features='sqrt', random_state=297879643),
 DecisionTreeClassifier(max_features='sqrt', random_state=282842588),
 DecisionTreeClassifier(max_features='sqrt', random_state=723461479),
 DecisionTreeClassifier(max_features='sqrt', random_state=806825407),
 DecisionTreeClassifier(max_features='sqrt', random_state=1092505004),
 DecisionTreeClassifier(max_features='sqrt', random_state=1231633052),
 DecisionTreeClassifier(max_features='sqrt', random_state=550657162),
 DecisionTreeClassifier(max_features='sqrt', random_state=785273328),
 DecisionTreeClassifier(max_features='sqrt', random_state=1393918303),
 DecisionTreeClassifier(max_features='sqrt', random_state=1252083942),
 DecisionTreeClassifier(max_features='sqrt', random_state=1559408927),
 DecisionTreeClassifier(max_features='sqrt', random_state=1906251757),
 DecisionTreeClassifier(max_features='sqrt', random_state=693228499),
 DecisionTreeClassifier(max_features='sqrt', random_state=894471471),
 DecisionTreeClassifier(max_features='sqrt', random_state=1387695504),
 DecisionTreeClassifier(max_features='sqrt', random_state=1550723821),
 DecisionTreeClassifier(max_features='sqrt', random_state=1613758865),
 DecisionTreeClassifier(max_features='sqrt', random_state=410398877),
 DecisionTreeClassifier(max_features='sqrt', random_state=1458265845),
 DecisionTreeClassifier(max_features='sqrt', random_state=1477171368),
 DecisionTreeClassifier(max_features='sqrt', random_state=2125666959),
 DecisionTreeClassifier(max_features='sqrt', random_state=110734887),
 DecisionTreeClassifier(max_features='sqrt', random_state=1191256699),
 DecisionTreeClassifier(max_features='sqrt', random_state=276760253),
 DecisionTreeClassifier(max_features='sqrt', random_state=1799609628),
 DecisionTreeClassifier(max_features='sqrt', random_state=2095253897),
 DecisionTreeClassifier(max_features='sqrt', random_state=1960819424),
 DecisionTreeClassifier(max_features='sqrt', random_state=1710719138),
 DecisionTreeClassifier(max_features='sqrt', random_state=1571994975),
 DecisionTreeClassifier(max_features='sqrt', random_state=2040361933),
 DecisionTreeClassifier(max_features='sqrt', random_state=987215623),
 DecisionTreeClassifier(max_features='sqrt', random_state=1374679652),
 DecisionTreeClassifier(max_features='sqrt', random_state=134268365),
 DecisionTreeClassifier(max_features='sqrt', random_state=131498388),
 DecisionTreeClassifier(max_features='sqrt', random_state=236004693),
 DecisionTreeClassifier(max_features='sqrt', random_state=398684886),
 DecisionTreeClassifier(max_features='sqrt', random_state=994243512),
 DecisionTreeClassifier(max_features='sqrt', random_state=1962704766),
 DecisionTreeClassifier(max_features='sqrt', random_state=700871724),
 DecisionTreeClassifier(max_features='sqrt', random_state=52199589),
 DecisionTreeClassifier(max_features='sqrt', random_state=895922810),
 DecisionTreeClassifier(max_features='sqrt', random_state=1205398147),
 DecisionTreeClassifier(max_features='sqrt', random_state=1893660663),
 DecisionTreeClassifier(max_features='sqrt', random_state=238527260),
 DecisionTreeClassifier(max_features='sqrt', random_state=1173525156),
```

```
 DecisionTreeClassifier(max_features='sqrt', random_state=1216318754),
 DecisionTreeClassifier(max_features='sqrt', random_state=711091595),
 DecisionTreeClassifier(max_features='sqrt', random_state=1249988786),
 DecisionTreeClassifier(max_features='sqrt', random_state=1450637179),
 DecisionTreeClassifier(max_features='sqrt', random_state=1881794210),
 DecisionTreeClassifier(max_features='sqrt', random_state=851677744),
 DecisionTreeClassifier(max_features='sqrt', random_state=810866529),
 DecisionTreeClassifier(max_features='sqrt', random_state=77910333),
 DecisionTreeClassifier(max_features='sqrt', random_state=681457591),
 DecisionTreeClassifier(max_features='sqrt', random_state=1370847883),
 DecisionTreeClassifier(max_features='sqrt', random_state=1025876449),
 DecisionTreeClassifier(max_features='sqrt', random_state=179733480),
 DecisionTreeClassifier(max_features='sqrt', random_state=1745587802),
 DecisionTreeClassifier(max_features='sqrt', random_state=1990029026),
 DecisionTreeClassifier(max_features='sqrt', random_state=373041047),
 DecisionTreeClassifier(max_features='sqrt', random_state=35748294),
 DecisionTreeClassifier(max_features='sqrt', random_state=1621339025),
 DecisionTreeClassifier(max_features='sqrt', random_state=159370877),
 DecisionTreeClassifier(max_features='sqrt', random_state=1263041684),
 DecisionTreeClassifier(max_features='sqrt', random_state=375085118),
 DecisionTreeClassifier(max_features='sqrt', random_state=1969069661),
 DecisionTreeClassifier(max_features='sqrt', random_state=410868075),
 DecisionTreeClassifier(max_features='sqrt', random_state=1857648461),
 DecisionTreeClassifier(max_features='sqrt', random_state=1082836260),
 DecisionTreeClassifier(max_features='sqrt', random_state=1273658301),
 DecisionTreeClassifier(max_features='sqrt', random_state=465217083),
 DecisionTreeClassifier(max_features='sqrt', random_state=1701650653),
 DecisionTreeClassifier(max_features='sqrt', random_state=1666408990),
 DecisionTreeClassifier(max_features='sqrt', random_state=102670256),
 DecisionTreeClassifier(max_features='sqrt', random_state=1282943470),
 DecisionTreeClassifier(max_features='sqrt', random_state=951654375),
 DecisionTreeClassifier(max_features='sqrt', random_state=386518653),
 DecisionTreeClassifier(max_features='sqrt', random_state=1507258386),
 DecisionTreeClassifier(max_features='sqrt', random_state=348915311),
 DecisionTreeClassifier(max_features='sqrt', random_state=1658722003),
 DecisionTreeClassifier(max_features='sqrt', random_state=386291841),
 DecisionTreeClassifier(max_features='sqrt', random_state=1419138073),
 DecisionTreeClassifier(max_features='sqrt', random_state=551446177),
 DecisionTreeClassifier(max_features='sqrt', random_state=1987554377),
 DecisionTreeClassifier(max_features='sqrt', random_state=1122236314)]
```

In [22]:
```
plt.figure(figsize= (20,20))
tree.plot_tree(rf.estimators_[0],filled=True)
```

Out[22]:
```
[Text(0.7225783327792553, 0.9705882352941176, 'x[6] <= 81.5\ngini = 0.63
6\nsamples = 526\nvalue = [4.0, 26.0, 384.0, 329.0, 106.0, 8.0]'),
 Text(0.4943587932180851, 0.9117647058823529, 'x[2] <= 0.305\ngini = 0.6
4\nsamples = 454\nvalue = [4.0, 23.0, 293.0, 314.0, 91.0, 8.0]'),
 Text(0.6084685629986702, 0.9411764705882353, 'True  '),
 Text(0.23071808510638298, 0.8529411764705882, 'x[9] <= 0.595\ngini = 0.
573\nsamples = 262\nvalue = [4.0, 19.0, 226.0, 162.0, 15.0, 1.0]'),
 Text(0.0789561170212766, 0.7941176470588235, 'x[8] <= 3.205\ngini = 0.5
16\nsamples = 137\nvalue = [2.0, 16.0, 150.0, 61.0, 5.0, 0.0]'),
 Text(0.010638297872340425, 0.7352941176470589, 'x[3] <= 2.15\ngini = 0.
124\nsamples = 24\nvalue = [0, 0, 42, 3, 0, 0]'),
 Text(0.005319148936170213, 0.6764705882352942, 'gini = 0.0\nsamples = 1
3\nvalue = [0, 0, 26, 0, 0, 0]'),
 Text(0.015957446808510637, 0.6764705882352942, 'x[10] <= 9.65\ngini =
0.266\nsamples = 11\nvalue = [0, 0, 16, 3, 0, 0]'),
 Text(0.010638297872340425, 0.6176470588235294, 'gini = 0.0\nsamples = 8
\nvalue = [0, 0, 15, 0, 0, 0]'),
 Text(0.02127659574468085, 0.6176470588235294, 'x[6] <= 43.0\ngini = 0.3
75\nsamples = 3\nvalue = [0, 0, 1, 3, 0, 0]'),
 Text(0.015957446808510637, 0.5588235294117647, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 1, 0, 0, 0]'),
 Text(0.026595744680851064, 0.5588235294117647, 'gini = 0.0\nsamples = 2
\nvalue = [0, 0, 0, 3, 0, 0]'),
 Text(0.14727393617021275, 0.7352941176470589, 'x[10] <= 11.15\ngini =
0.571\nsamples = 113\nvalue = [2, 16, 108, 58, 5, 0]'),
 Text(0.07380319148936171, 0.6764705882352942, 'x[5] <= 8.5\ngini = 0.48
7\nsamples = 84\nvalue = [2, 7, 95, 31, 5, 0]'),
 Text(0.0425531914893617, 0.6176470588235294, 'x[9] <= 0.36\ngini = 0.19
4\nsamples = 23\nvalue = [0, 2, 34, 2, 0, 0]'),
 Text(0.03723404255319149, 0.5588235294117647, 'gini = 0.0\nsamples = 1
\nvalue = [0, 2, 0, 0, 0, 0]'),
 Text(0.047872340425531915, 0.5588235294117647, 'x[2] <= 0.005\ngini =
0.105\nsamples = 22\nvalue = [0, 0, 34, 2, 0, 0]'),
 Text(0.0425531914893617, 0.5, 'x[4] <= 0.091\ngini = 0.26\nsamples = 8
\nvalue = [0, 0, 11, 2, 0, 0]'),
 Text(0.03723404255319149, 0.4411764705882353, 'x[5] <= 4.0\ngini = 0.48
\nsamples = 4\nvalue = [0, 0, 3, 2, 0, 0]'),
 Text(0.031914893617021274, 0.38235294117647056, 'gini = 0.0\nsamples =
3\nvalue = [0, 0, 3, 0, 0, 0]'),
 Text(0.0425531914893617, 0.38235294117647056, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 2, 0, 0]'),
 Text(0.047872340425531915, 0.4411764705882353, 'gini = 0.0\nsamples = 4
\nvalue = [0, 0, 8, 0, 0, 0]'),
 Text(0.05319148936170213, 0.5, 'gini = 0.0\nsamples = 14\nvalue = [0,
0, 23, 0, 0, 0]'),
 Text(0.10505319148936171, 0.6176470588235294, 'x[4] <= 0.079\ngini = 0.
556\nsamples = 61\nvalue = [2, 5, 61, 29, 5, 0]'),
 Text(0.06914893617021277, 0.5588235294117647, 'x[5] <= 9.5\ngini = 0.42
\nsamples = 26\nvalue = [2, 0, 32, 6, 3, 0]'),
 Text(0.06382978723404255, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0, 0,
0, 0, 3, 0]'),
 Text(0.07446808510638298, 0.5, 'x[9] <= 0.435\ngini = 0.335\nsamples =
25\nvalue = [2, 0, 32, 6, 0, 0]'),
 Text(0.06914893617021277, 0.4411764705882353, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 1, 0, 0]'),
 Text(0.0797872340425532, 0.4411764705882353, 'x[8] <= 3.26\ngini = 0.30
8\nsamples = 24\nvalue = [2, 0, 32, 5, 0, 0]'),
 Text(0.07446808510638298, 0.38235294117647056, 'gini = 0.0\nsamples = 2
\nvalue = [0, 0, 0, 4, 0, 0]'),
 Text(0.0851063829787234, 0.38235294117647056, 'x[1] <= 0.97\ngini = 0.1
```

```
6\nsamples = 22\nvalue = [2, 0, 32, 1, 0, 0]'),
 Text(0.07446808510638298, 0.3235294117647059, 'x[0] <= 7.9\ngini = 0.06
1\nsamples = 20\nvalue = [0, 0, 31, 1, 0, 0]'),
 Text(0.06914893617021277, 0.2647058823529412, 'gini = 0.0\nsamples = 16
\nvalue = [0, 0, 26, 0, 0, 0]'),
 Text(0.0797872340425532, 0.2647058823529412, 'x[9] <= 0.515\ngini = 0.2
78\nsamples = 4\nvalue = [0, 0, 5, 1, 0, 0]'),
 Text(0.07446808510638298, 0.20588235294117646, 'gini = 0.0\nsamples = 2
\nvalue = [0, 0, 4, 0, 0, 0]'),
 Text(0.0851063829787234, 0.20588235294117646, 'x[7] <= 0.996\ngini = 0.
5\nsamples = 2\nvalue = [0, 0, 1, 1, 0, 0]'),
 Text(0.0797872340425532, 0.14705882352941177, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 1, 0, 0, 0]'),
 Text(0.09042553191489362, 0.14705882352941177, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 1, 0, 0]'),
 Text(0.09574468085106383, 0.3235294117647059, 'x[3] <= 4.05\ngini = 0.4
44\nsamples = 2\nvalue = [2, 0, 1, 0, 0, 0]'),
 Text(0.09042553191489362, 0.2647058823529412, 'gini = 0.0\nsamples = 1
\nvalue = [2, 0, 0, 0, 0, 0]'),
 Text(0.10106382978723404, 0.2647058823529412, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 1, 0, 0, 0]'),
 Text(0.14095744680851063, 0.5588235294117647, 'x[6] <= 44.5\ngini = 0.5
98\nsamples = 35\nvalue = [0, 5, 29, 23, 2, 0]'),
 Text(0.12234042553191489, 0.5, 'x[2] <= 0.005\ngini = 0.592\nsamples =
20\nvalue = [0, 3, 9, 18, 2, 0]'),
 Text(0.11170212765957446, 0.4411764705882353, 'x[9] <= 0.5\ngini = 0.49
\nsamples = 3\nvalue = [0, 3, 4, 0, 0, 0]'),
 Text(0.10638297872340426, 0.38235294117647056, 'gini = 0.0\nsamples = 1
\nvalue = [0, 3, 0, 0, 0, 0]'),
 Text(0.11702127659574468, 0.38235294117647056, 'gini = 0.0\nsamples = 2
\nvalue = [0, 0, 4, 0, 0, 0]'),
 Text(0.13297872340425532, 0.4411764705882353, 'x[5] <= 12.5\ngini = 0.4
35\nsamples = 17\nvalue = [0, 0, 5, 18, 2, 0]'),
 Text(0.1276595744680851, 0.38235294117647056, 'x[4] <= 0.089\ngini = 0.
625\nsamples = 8\nvalue = [0, 0, 5, 5, 2, 0]'),
 Text(0.11702127659574468, 0.3235294117647059, 'x[6] <= 20.5\ngini = 0.4
8\nsamples = 3\nvalue = [0, 0, 3, 0, 2, 0]'),
 Text(0.11170212765957446, 0.2647058823529412, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 0, 2, 0]'),
 Text(0.12234042553191489, 0.2647058823529412, 'gini = 0.0\nsamples = 2
\nvalue = [0, 0, 3, 0, 0, 0]'),
 Text(0.13829787234042554, 0.3235294117647059, 'x[4] <= 0.098\ngini = 0.
408\nsamples = 5\nvalue = [0, 0, 2, 5, 0, 0]'),
 Text(0.13297872340425532, 0.2647058823529412, 'gini = 0.0\nsamples = 2
\nvalue = [0, 0, 0, 3, 0, 0]'),
 Text(0.14361702127659576, 0.2647058823529412, 'x[3] <= 3.8\ngini = 0.5
\nsamples = 3\nvalue = [0, 0, 2, 2, 0, 0]'),
 Text(0.13829787234042554, 0.20588235294117646, 'gini = 0.0\nsamples = 2
\nvalue = [0, 0, 2, 0, 0, 0]'),
 Text(0.14893617021276595, 0.20588235294117646, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 2, 0, 0]'),
 Text(0.13829787234042554, 0.38235294117647056, 'gini = 0.0\nsamples = 9
\nvalue = [0, 0, 0, 13, 0, 0]'),
 Text(0.1595744680851064, 0.5, 'x[0] <= 7.9\ngini = 0.412\nsamples = 15
\nvalue = [0, 2, 20, 5, 0, 0]'),
 Text(0.15425531914893617, 0.4411764705882353, 'gini = 0.0\nsamples = 8
\nvalue = [0, 0, 15, 0, 0, 0]'),
 Text(0.16489361702127658, 0.4411764705882353, 'x[6] <= 47.0\ngini = 0.6
25\nsamples = 7\nvalue = [0, 2, 5, 5, 0, 0]'),
 Text(0.1595744680851064, 0.38235294117647056, 'gini = 0.0\nsamples = 1
```

```
\nvalue = [0, 2, 0, 0, 0, 0]'),
 Text(0.1702127659574468, 0.38235294117647056, 'x[0] <= 9.0\ngini = 0.5
\nsamples = 6\nvalue = [0, 0, 5, 5, 0, 0]'),
 Text(0.1595744680851064, 0.3235294117647059, 'x[0] <= 8.15\ngini = 0.32
\nsamples = 3\nvalue = [0, 0, 1, 4, 0, 0]'),
 Text(0.15425531914893617, 0.2647058823529412, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 2, 0, 0]'),
 Text(0.16489361702127658, 0.2647058823529412, 'x[9] <= 0.52\ngini = 0.4
44\nsamples = 2\nvalue = [0, 0, 1, 2, 0, 0]'),
 Text(0.1595744680851064, 0.20588235294117646, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 2, 0, 0]'),
 Text(0.1702127659574468, 0.20588235294117646, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 1, 0, 0, 0]'),
 Text(0.18085106382978725, 0.3235294117647059, 'x[4] <= 0.089\ngini = 0.
32\nsamples = 3\nvalue = [0, 0, 4, 1, 0, 0]'),
 Text(0.17553191489361702, 0.2647058823529412, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 2, 0, 0, 0]'),
 Text(0.18617021276595744, 0.2647058823529412, 'x[1] <= 0.65\ngini = 0.4
44\nsamples = 2\nvalue = [0, 0, 2, 1, 0, 0]'),
 Text(0.18085106382978725, 0.20588235294117646, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 2, 0, 0, 0]'),
 Text(0.19148936170212766, 0.20588235294117646, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 1, 0, 0]'),
 Text(0.22074468085106383, 0.6764705882352942, 'x[5] <= 14.0\ngini = 0.5
92\nsamples = 29\nvalue = [0.0, 9.0, 13.0, 27.0, 0.0, 0.0]'),
 Text(0.2074468085106383, 0.6176470588235294, 'x[1] <= 0.53\ngini = 0.64
3\nsamples = 21\nvalue = [0, 8, 13, 16, 0, 0]'),
 Text(0.19680851063829788, 0.5588235294117647, 'x[2] <= 0.255\ngini = 0.
278\nsamples = 3\nvalue = [0, 5, 0, 1, 0, 0]'),
 Text(0.19148936170212766, 0.5, 'gini = 0.0\nsamples = 2\nvalue = [0, 5,
0, 0, 0, 0]'),
 Text(0.20212765957446807, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0, 0,
0, 1, 0, 0]'),
 Text(0.21808510638297873, 0.5588235294117647, 'x[2] <= 0.18\ngini = 0.5
81\nsamples = 18\nvalue = [0, 3, 13, 15, 0, 0]'),
 Text(0.2127659574468085, 0.5, 'x[0] <= 6.25\ngini = 0.547\nsamples = 15
\nvalue = [0.0, 3.0, 7.0, 15.0, 0.0, 0.0]'),
 Text(0.20212765957446807, 0.4411764705882353, 'x[1] <= 0.575\ngini = 0.
278\nsamples = 5\nvalue = [0, 0, 5, 1, 0, 0]'),
 Text(0.19680851063829788, 0.38235294117647056, 'x[9] <= 0.56\ngini = 0.
5\nsamples = 2\nvalue = [0, 0, 1, 1, 0, 0]'),
 Text(0.19148936170212766, 0.3235294117647059, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 1, 0, 0]'),
 Text(0.20212765957446807, 0.3235294117647059, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 1, 0, 0, 0]'),
 Text(0.2074468085106383, 0.38235294117647056, 'gini = 0.0\nsamples = 3
\nvalue = [0, 0, 4, 0, 0, 0]'),
 Text(0.22340425531914893, 0.4411764705882353, 'x[7] <= 0.997\ngini = 0.
421\nsamples = 10\nvalue = [0, 3, 2, 14, 0, 0]'),
 Text(0.21808510638297873, 0.38235294117647056, 'x[8] <= 3.505\ngini =
0.291\nsamples = 9\nvalue = [0, 3, 0, 14, 0, 0]'),
 Text(0.2127659574468085, 0.3235294117647059, 'x[5] <= 10.5\ngini = 0.12
4\nsamples = 8\nvalue = [0, 1, 0, 14, 0, 0]'),
 Text(0.2074468085106383, 0.2647058823529412, 'gini = 0.0\nsamples = 6\n
value = [0, 0, 0, 12, 0, 0]'),
 Text(0.21808510638297873, 0.2647058823529412, 'x[8] <= 3.42\ngini = 0.4
44\nsamples = 2\nvalue = [0, 1, 0, 2, 0, 0]'),
 Text(0.2127659574468085, 0.20588235294117646, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 2, 0, 0]'),
 Text(0.22340425531914893, 0.20588235294117646, 'gini = 0.0\nsamples = 1
```

```
\nvalue = [0, 1, 0, 0, 0, 0]'),
 Text(0.22340425531914893, 0.3235294117647059, 'gini = 0.0\nsamples = 1
\nvalue = [0, 2, 0, 0, 0, 0]'),
 Text(0.22872340425531915, 0.38235294117647056, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 2, 0, 0, 0]'),
 Text(0.22340425531914893, 0.5, 'gini = 0.0\nsamples = 3\nvalue = [0, 0,
6, 0, 0, 0]'),
 Text(0.23404255319148937, 0.6176470588235294, 'x[1] <= 1.0\ngini = 0.15
3\nsamples = 8\nvalue = [0, 1, 0, 11, 0, 0]'),
 Text(0.22872340425531915, 0.5588235294117647, 'gini = 0.0\nsamples = 7
\nvalue = [0, 0, 0, 11, 0, 0]'),
 Text(0.2393617021276596, 0.5588235294117647, 'gini = 0.0\nsamples = 1\n
value = [0, 1, 0, 0, 0, 0]'),
 Text(0.38248005319148937, 0.7941176470588235, 'x[10] <= 10.65\ngini =
0.568\nsamples = 125\nvalue = [2, 3, 76, 101, 10, 1]'),
 Text(0.3248005319148936, 0.7352941176470589, 'x[0] <= 8.5\ngini = 0.547
\nsamples = 82\nvalue = [2, 3, 65, 50, 2, 0]'),
 Text(0.28257978723404253, 0.6764705882352942, 'x[2] <= 0.015\ngini = 0.
532\nsamples = 67\nvalue = [2.0, 3.0, 59.0, 33.0, 2.0, 0.0]'),
 Text(0.2553191489361702, 0.6176470588235294, 'x[6] <= 15.5\ngini = 0.34
9\nsamples = 12\nvalue = [0, 3, 15, 1, 0, 0]'),
 Text(0.25, 0.5588235294117647, 'gini = 0.0\nsamples = 1\nvalue = [0, 2,
0, 0, 0, 0]'),
 Text(0.26063829787234044, 0.5588235294117647, 'x[7] <= 1.0\ngini = 0.21
5\nsamples = 11\nvalue = [0, 1, 15, 1, 0, 0]'),
 Text(0.2553191489361702, 0.5, 'x[8] <= 3.585\ngini = 0.117\nsamples = 1
0\nvalue = [0, 0, 15, 1, 0, 0]'),
 Text(0.25, 0.4411764705882353, 'gini = 0.0\nsamples = 7\nvalue = [0, 0,
12, 0, 0, 0]'),
 Text(0.26063829787234044, 0.4411764705882353, 'x[7] <= 0.998\ngini = 0.
375\nsamples = 3\nvalue = [0, 0, 3, 1, 0, 0]'),
 Text(0.2553191489361702, 0.38235294117647056, 'gini = 0.0\nsamples = 2
\nvalue = [0, 0, 3, 0, 0, 0]'),
 Text(0.26595744680851063, 0.38235294117647056, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 1, 0, 0]'),
 Text(0.26595744680851063, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0, 1,
0, 0, 0, 0]'),
 Text(0.3098404255319149, 0.6176470588235294, 'x[1] <= 0.445\ngini = 0.5
36\nsamples = 55\nvalue = [2, 0, 44, 32, 2, 0]'),
 Text(0.28191489361702127, 0.5588235294117647, 'x[2] <= 0.13\ngini = 0.3
04\nsamples = 11\nvalue = [0, 0, 14, 2, 1, 0]'),
 Text(0.2765957446808511, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0, 0,
0, 0, 1, 0]'),
 Text(0.2872340425531915, 0.5, 'x[5] <= 4.0\ngini = 0.219\nsamples = 10
\nvalue = [0, 0, 14, 2, 0, 0]'),
 Text(0.28191489361702127, 0.4411764705882353, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 1, 0, 0]'),
 Text(0.2925531914893617, 0.4411764705882353, 'x[4] <= 0.078\ngini = 0.1
24\nsamples = 9\nvalue = [0, 0, 14, 1, 0, 0]'),
 Text(0.2872340425531915, 0.38235294117647056, 'gini = 0.0\nsamples = 5
\nvalue = [0, 0, 7, 0, 0, 0]'),
 Text(0.2978723404255319, 0.38235294117647056, 'x[0] <= 6.65\ngini = 0.2
19\nsamples = 4\nvalue = [0, 0, 7, 1, 0, 0]'),
 Text(0.2925531914893617, 0.3235294117647059, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 1, 0, 0]'),
 Text(0.30319148936170215, 0.3235294117647059, 'gini = 0.0\nsamples = 3
\nvalue = [0, 0, 7, 0, 0, 0]'),
 Text(0.3377659574468085, 0.5588235294117647, 'x[1] <= 0.545\ngini = 0.5
45\nsamples = 44\nvalue = [2, 0, 30, 30, 1, 0]'),
 Text(0.3191489361702128, 0.5, 'x[0] <= 6.55\ngini = 0.308\nsamples = 16
```

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\nvalue = [0, 0, 4, 17, 0, 0]'),
 Text(0.31382978723404253, 0.4411764705882353, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 1, 0, 0, 0]'),
 Text(0.324468085106383, 0.4411764705882353, 'x[2] <= 0.145\ngini = 0.25
5\nsamples = 15\nvalue = [0, 0, 3, 17, 0, 0]'),
 Text(0.3191489361702128, 0.38235294117647056, 'x[10] <= 9.45\ngini = 0.
375\nsamples = 8\nvalue = [0, 0, 3, 9, 0, 0]'),
 Text(0.31382978723404253, 0.3235294117647059, 'gini = 0.0\nsamples = 3
\nvalue = [0, 0, 0, 7, 0, 0]'),
 Text(0.324468085106383, 0.3235294117647059, 'x[9] <= 0.66\ngini = 0.48
\nsamples = 5\nvalue = [0, 0, 3, 2, 0, 0]'),
 Text(0.3191489361702128, 0.2647058823529412, 'gini = 0.0\nsamples = 2\n
value = [0, 0, 2, 0, 0, 0]'),
 Text(0.32978723404255317, 0.2647058823529412, 'x[10] <= 9.65\ngini = 0.
444\nsamples = 3\nvalue = [0, 0, 1, 2, 0, 0]'),
 Text(0.324468085106383, 0.20588235294117646, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 1, 0, 0, 0]'),
 Text(0.3351063829787234, 0.20588235294117646, 'gini = 0.0\nsamples = 2
\nvalue = [0, 0, 0, 2, 0, 0]'),
 Text(0.32978723404255317, 0.38235294117647056, 'gini = 0.0\nsamples = 7
\nvalue = [0, 0, 0, 8, 0, 0]'),
 Text(0.35638297872340424, 0.5, 'x[10] <= 9.275\ngini = 0.518\nsamples =
28\nvalue = [2, 0, 26, 13, 1, 0]'),
 Text(0.35106382978723405, 0.4411764705882353, 'gini = 0.0\nsamples = 3
\nvalue = [0, 0, 0, 5, 0, 0]'),
 Text(0.3617021276595745, 0.4411764705882353, 'x[3] <= 2.05\ngini = 0.45
6\nsamples = 25\nvalue = [2, 0, 26, 8, 1, 0]'),
 Text(0.3404255319148936, 0.38235294117647056, 'x[0] <= 6.55\ngini = 0.3
24\nsamples = 17\nvalue = [2, 0, 22, 2, 1, 0]'),
 Text(0.3351063829787234, 0.3235294117647059, 'gini = 0.0\nsamples = 4\n
value = [0, 0, 8, 0, 0, 0]'),
 Text(0.34574468085106386, 0.3235294117647059, 'x[0] <= 6.75\ngini = 0.4
32\nsamples = 13\nvalue = [2, 0, 14, 2, 1, 0]'),
 Text(0.3404255319148936, 0.2647058823529412, 'gini = 0.0\nsamples = 1\n
value = [2, 0, 0, 0, 0, 0]'),
 Text(0.35106382978723405, 0.2647058823529412, 'x[8] <= 3.495\ngini = 0.
304\nsamples = 12\nvalue = [0, 0, 14, 2, 1, 0]'),
 Text(0.34574468085106386, 0.20588235294117646, 'x[10] <= 10.525\ngini =
0.227\nsamples = 11\nvalue = [0, 0, 14, 1, 1, 0]'),
 Text(0.3404255319148936, 0.14705882352941177, 'x[7] <= 0.997\ngini = 0.
124\nsamples = 10\nvalue = [0, 0, 14, 1, 0, 0]'),
 Text(0.3351063829787234, 0.08823529411764706, 'gini = 0.0\nsamples = 8
\nvalue = [0, 0, 12, 0, 0, 0]'),
 Text(0.34574468085106386, 0.08823529411764706, 'x[5] <= 13.5\ngini = 0.
444\nsamples = 2\nvalue = [0, 0, 2, 1, 0, 0]'),
 Text(0.3404255319148936, 0.029411764705882353, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 2, 0, 0, 0]'),
 Text(0.35106382978723405, 0.029411764705882353, 'gini = 0.0\nsamples =
1\nvalue = [0, 0, 0, 1, 0, 0]'),
 Text(0.35106382978723405, 0.14705882352941177, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 0, 1, 0]'),
 Text(0.35638297872340424, 0.20588235294117646, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 1, 0, 0]'),
 Text(0.3829787234042553, 0.38235294117647056, 'x[3] <= 2.5\ngini = 0.48
\nsamples = 8\nvalue = [0, 0, 4, 6, 0, 0]'),
 Text(0.3776595744680851, 0.3235294117647059, 'x[3] <= 2.35\ngini = 0.44
4\nsamples = 7\nvalue = [0, 0, 3, 6, 0, 0]'),
 Text(0.3723404255319149, 0.2647058823529412, 'x[6] <= 19.0\ngini = 0.5
\nsamples = 5\nvalue = [0, 0, 3, 3, 0, 0]'),
 Text(0.3670212765957447, 0.20588235294117646, 'gini = 0.0\nsamples = 1
```

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\nvalue = [0, 0, 0, 1, 0, 0]'),
 Text(0.3776595744680851, 0.20588235294117646, 'x[2] <= 0.145\ngini = 0.
48\nsamples = 4\nvalue = [0, 0, 3, 2, 0, 0]'),
 Text(0.3723404255319149, 0.14705882352941177, 'x[10] <= 10.0\ngini = 0.
444\nsamples = 3\nvalue = [0, 0, 1, 2, 0, 0]'),
 Text(0.3670212765957447, 0.08823529411764706, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 1, 0, 0, 0]'),
 Text(0.3776595744680851, 0.08823529411764706, 'gini = 0.0\nsamples = 2
\nvalue = [0, 0, 0, 2, 0, 0]'),
 Text(0.3829787234042553, 0.14705882352941177, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 2, 0, 0, 0]'),
 Text(0.3829787234042553, 0.2647058823529412, 'gini = 0.0\nsamples = 2\n
value = [0, 0, 0, 3, 0, 0]'),
 Text(0.3882978723404255, 0.3235294117647059, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 1, 0, 0, 0]'),
 Text(0.3670212765957447, 0.6764705882352942, 'x[7] <= 0.998\ngini = 0.3
86\nsamples = 15\nvalue = [0, 0, 6, 17, 0, 0]'),
 Text(0.35638297872340424, 0.6176470588235294, 'x[10] <= 9.45\ngini = 0.
469\nsamples = 5\nvalue = [0, 0, 5, 3, 0, 0]'),
 Text(0.35106382978723405, 0.5588235294117647, 'gini = 0.0\nsamples = 2
\nvalue = [0, 0, 0, 3, 0, 0]'),
 Text(0.3617021276595745, 0.5588235294117647, 'gini = 0.0\nsamples = 3\n
value = [0, 0, 5, 0, 0, 0]'),
 Text(0.3776595744680851, 0.6176470588235294, 'x[7] <= 0.998\ngini = 0.1
24\nsamples = 10\nvalue = [0, 0, 1, 14, 0, 0]'),
 Text(0.3723404255319149, 0.5588235294117647, 'x[2] <= 0.19\ngini = 0.32
\nsamples = 4\nvalue = [0, 0, 1, 4, 0, 0]'),
 Text(0.3670212765957447, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0, 0,
1, 0, 0, 0]'),
 Text(0.3776595744680851, 0.5, 'gini = 0.0\nsamples = 3\nvalue = [0, 0,
0, 4, 0, 0]'),
 Text(0.3829787234042553, 0.5588235294117647, 'gini = 0.0\nsamples = 6\n
value = [0, 0, 0, 10, 0, 0]'),
 Text(0.4401595744680851, 0.7352941176470589, 'x[5] <= 6.5\ngini = 0.447
\nsamples = 43\nvalue = [0, 0, 11, 51, 8, 1]'),
 Text(0.4295212765957447, 0.6764705882352942, 'x[8] <= 3.33\ngini = 0.48
\nsamples = 3\nvalue = [0, 0, 2, 0, 3, 0]'),
 Text(0.4242021276595745, 0.6176470588235294, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 2, 0, 0, 0]'),
 Text(0.4348404255319149, 0.6176470588235294, 'gini = 0.0\nsamples = 2\n
value = [0, 0, 0, 0, 3, 0]'),
 Text(0.4507978723404255, 0.6764705882352942, 'x[0] <= 5.05\ngini = 0.37
8\nsamples = 40\nvalue = [0, 0, 9, 51, 5, 1]'),
 Text(0.4454787234042553, 0.6176470588235294, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 0, 2, 0]'),
 Text(0.45611702127659576, 0.6176470588235294, 'x[2] <= 0.255\ngini = 0.
343\nsamples = 39\nvalue = [0, 0, 9, 51, 3, 1]'),
 Text(0.43882978723404253, 0.5588235294117647, 'x[7] <= 0.997\ngini = 0.
2\nsamples = 35\nvalue = [0, 0, 3, 49, 3, 0]'),
 Text(0.42021276595744683, 0.5, 'x[9] <= 0.685\ngini = 0.144\nsamples =
32\nvalue = [0, 0, 3, 48, 1, 0]'),
 Text(0.39893617021276595, 0.4411764705882353, 'x[3] <= 2.45\ngini = 0.0
51\nsamples = 23\nvalue = [0, 0, 1, 37, 0, 0]'),
 Text(0.39361702127659576, 0.38235294117647056, 'gini = 0.0\nsamples = 1
3\nvalue = [0, 0, 0, 20, 0, 0]'),
 Text(0.40425531914893614, 0.38235294117647056, 'x[10] <= 11.95\ngini =
0.105\nsamples = 10\nvalue = [0, 0, 1, 17, 0, 0]'),
 Text(0.39893617021276595, 0.3235294117647059, 'gini = 0.0\nsamples = 8
\nvalue = [0, 0, 0, 16, 0, 0]'),
 Text(0.4095744680851064, 0.3235294117647059, 'x[9] <= 0.64\ngini = 0.5
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\nsamples = 2\nvalue = [0, 0, 1, 1, 0, 0]'),
 Text(0.40425531914893614, 0.2647058823529412, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 1, 0, 0, 0]'),
 Text(0.4148936170212766, 0.2647058823529412, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 1, 0, 0]'),
 Text(0.44148936170212766, 0.4411764705882353, 'x[9] <= 0.775\ngini = 0.
357\nsamples = 9\nvalue = [0, 0, 2, 11, 1, 0]'),
 Text(0.43617021276595747, 0.38235294117647056, 'x[3] <= 2.15\ngini = 0.
625\nsamples = 4\nvalue = [0, 0, 2, 1, 1, 0]'),
 Text(0.4308510638297872, 0.3235294117647059, 'x[9] <= 0.745\ngini = 0.4
44\nsamples = 3\nvalue = [0, 0, 2, 0, 1, 0]'),
 Text(0.425531914893617, 0.2647058823529412, 'gini = 0.0\nsamples = 2\nv
alue = [0, 0, 2, 0, 0, 0]'),
 Text(0.43617021276595747, 0.2647058823529412, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 0, 1, 0]'),
 Text(0.44148936170212766, 0.3235294117647059, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 1, 0, 0]'),
 Text(0.44680851063829785, 0.38235294117647056, 'gini = 0.0\nsamples = 5
\nvalue = [0, 0, 0, 10, 0, 0]'),
 Text(0.4574468085106383, 0.5, 'x[8] <= 3.32\ngini = 0.444\nsamples = 3
\nvalue = [0, 0, 0, 1, 2, 0]'),
 Text(0.4521276595744681, 0.4411764705882353, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 1, 0, 0]'),
 Text(0.4627659574468085, 0.4411764705882353, 'gini = 0.0\nsamples = 2\n
value = [0, 0, 0, 0, 2, 0]'),
 Text(0.4734042553191489, 0.5588235294117647, 'x[4] <= 0.056\ngini = 0.4
94\nsamples = 4\nvalue = [0, 0, 6, 2, 0, 1]'),
 Text(0.46808510638297873, 0.5, 'gini = 0.0\nsamples = 2\nvalue = [0, 0,
6, 0, 0, 0]'),
 Text(0.4787234042553192, 0.5, 'x[6] <= 31.0\ngini = 0.444\nsamples = 2
\nvalue = [0, 0, 0, 2, 0, 1]'),
 Text(0.4734042553191489, 0.4411764705882353, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 0, 0, 1]'),
 Text(0.48404255319148937, 0.4411764705882353, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 2, 0, 0]'),
 Text(0.7579995013297872, 0.8529411764705882, 'x[3] <= 3.625\ngini = 0.6
43\nsamples = 192\nvalue = [0.0, 4.0, 67.0, 152.0, 76.0, 7.0]'),
 Text(0.6343500664893617, 0.7941176470588235, 'x[7] <= 0.996\ngini = 0.6
12\nsamples = 172\nvalue = [0.0, 1.0, 61.0, 147.0, 63.0, 3.0]'),
 Text(0.5545212765957447, 0.7352941176470589, 'x[9] <= 0.735\ngini = 0.5
91\nsamples = 54\nvalue = [0, 0, 8, 37, 45, 2]'),
 Text(0.5186170212765957, 0.6764705882352942, 'x[8] <= 3.145\ngini = 0.5
61\nsamples = 28\nvalue = [0, 0, 6, 27, 9, 2]'),
 Text(0.5079787234042553, 0.6176470588235294, 'x[2] <= 0.465\ngini = 0.4
44\nsamples = 3\nvalue = [0, 0, 0, 0, 4, 2]'),
 Text(0.5026595744680851, 0.5588235294117647, 'gini = 0.0\nsamples = 2\n
value = [0, 0, 0, 0, 4, 0]'),
 Text(0.5132978723404256, 0.5588235294117647, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 0, 0, 2]'),
 Text(0.5292553191489362, 0.6176470588235294, 'x[8] <= 3.445\ngini = 0.4
53\nsamples = 25\nvalue = [0, 0, 6, 27, 5, 0]'),
 Text(0.523936170212766, 0.5588235294117647, 'x[8] <= 3.285\ngini = 0.40
6\nsamples = 24\nvalue = [0, 0, 4, 27, 5, 0]'),
 Text(0.5053191489361702, 0.5, 'x[0] <= 8.45\ngini = 0.571\nsamples = 12
\nvalue = [0, 0, 3, 11, 5, 0]'),
 Text(0.4946808510638298, 0.4411764705882353, 'x[9] <= 0.66\ngini = 0.48
\nsamples = 4\nvalue = [0, 0, 2, 0, 3, 0]'),
 Text(0.48936170212765956, 0.38235294117647056, 'gini = 0.0\nsamples = 3
\nvalue = [0, 0, 0, 0, 3, 0]'),
 Text(0.5, 0.38235294117647056, 'gini = 0.0\nsamples = 1\nvalue = [0, 0,
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2, 0, 0, 0]'),
 Text(0.5159574468085106, 0.4411764705882353, 'x[5] <= 8.0\ngini = 0.357
\nsamples = 8\nvalue = [0, 0, 1, 11, 2, 0]'),
 Text(0.5106382978723404, 0.38235294117647056, 'gini = 0.0\nsamples = 5
\nvalue = [0, 0, 0, 10, 0, 0]'),
 Text(0.5212765957446809, 0.38235294117647056, 'x[10] <= 11.7\ngini = 0.
625\nsamples = 3\nvalue = [0, 0, 1, 1, 2, 0]'),
 Text(0.5159574468085106, 0.3235294117647059, 'x[5] <= 10.5\ngini = 0.5
\nsamples = 2\nvalue = [0, 0, 1, 1, 0, 0]'),
 Text(0.5106382978723404, 0.2647058823529412, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 1, 0, 0, 0]'),
 Text(0.5212765957446809, 0.2647058823529412, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 1, 0, 0]'),
 Text(0.526595744680851, 0.3235294117647059, 'gini = 0.0\nsamples = 1\nv
alue = [0, 0, 0, 0, 2, 0]'),
 Text(0.5425531914893617, 0.5, 'x[3] <= 1.55\ngini = 0.111\nsamples = 12
\nvalue = [0, 0, 1, 16, 0, 0]'),
 Text(0.5372340425531915, 0.4411764705882353, 'x[10] <= 10.85\ngini = 0.
5\nsamples = 2\nvalue = [0, 0, 1, 1, 0, 0]'),
 Text(0.5319148936170213, 0.38235294117647056, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 1, 0, 0, 0]'),
 Text(0.5425531914893617, 0.38235294117647056, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 1, 0, 0]'),
 Text(0.5478723404255319, 0.4411764705882353, 'gini = 0.0\nsamples = 10
\nvalue = [0, 0, 0, 15, 0, 0]'),
 Text(0.5345744680851063, 0.5588235294117647, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 2, 0, 0, 0]'),
 Text(0.5904255319148937, 0.6764705882352942, 'x[1] <= 0.345\ngini = 0.3
92\nsamples = 26\nvalue = [0, 0, 2, 10, 36, 0]'),
 Text(0.5691489361702128, 0.6176470588235294, 'x[5] <= 36.5\ngini = 0.16
9\nsamples = 16\nvalue = [0, 0, 2, 1, 30, 0]'),
 Text(0.5585106382978723, 0.5588235294117647, 'x[5] <= 29.0\ngini = 0.06
7\nsamples = 14\nvalue = [0, 0, 0, 1, 28, 0]'),
 Text(0.5531914893617021, 0.5, 'gini = 0.0\nsamples = 12\nvalue = [0, 0,
0, 0, 26, 0]'),
 Text(0.5638297872340425, 0.5, 'x[1] <= 0.3\ngini = 0.444\nsamples = 2\n
value = [0, 0, 0, 1, 2, 0]'),
 Text(0.5585106382978723, 0.4411764705882353, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 0, 2, 0]'),
 Text(0.5691489361702128, 0.4411764705882353, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 1, 0, 0]'),
 Text(0.5797872340425532, 0.5588235294117647, 'x[1] <= 0.2\ngini = 0.5\n
samples = 2\nvalue = [0, 0, 2, 0, 2, 0]'),
 Text(0.574468085106383, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0, 0,
2, 0, 0, 0]'),
 Text(0.5851063829787234, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0, 0,
0, 0, 2, 0]'),
 Text(0.6117021276595744, 0.6176470588235294, 'x[6] <= 31.5\ngini = 0.48
\nsamples = 10\nvalue = [0, 0, 0, 9, 6, 0]'),
 Text(0.601063829787234, 0.5588235294117647, 'x[1] <= 0.425\ngini = 0.40
8\nsamples = 5\nvalue = [0, 0, 0, 2, 5, 0]'),
 Text(0.5957446808510638, 0.5, 'gini = 0.0\nsamples = 3\nvalue = [0, 0,
0, 0, 5, 0]'),
 Text(0.6063829787234043, 0.5, 'gini = 0.0\nsamples = 2\nvalue = [0, 0,
0, 2, 0, 0]'),
 Text(0.6223404255319149, 0.5588235294117647, 'x[10] <= 10.9\ngini = 0.2
19\nsamples = 5\nvalue = [0, 0, 0, 7, 1, 0]'),
 Text(0.6170212765957447, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0, 0,
0, 0, 1, 0]'),
 Text(0.6276595744680851, 0.5, 'gini = 0.0\nsamples = 4\nvalue = [0, 0,
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0, 7, 0, 0]'),
 Text(0.7141788563829787, 0.7352941176470589, 'x[9] <= 0.585\ngini = 0.5
45\nsamples = 118\nvalue = [0, 1, 53, 110, 18, 1]'),
 Text(0.648936170212766, 0.6764705882352942, 'x[7] <= 0.997\ngini = 0.38
9\nsamples = 24\nvalue = [0, 0, 25, 9, 0, 0]'),
 Text(0.6436170212765957, 0.6176470588235294, 'gini = 0.0\nsamples = 4\n
value = [0, 0, 0, 5, 0, 0]'),
 Text(0.6542553191489362, 0.6176470588235294, 'x[10] <= 10.6\ngini = 0.2
38\nsamples = 20\nvalue = [0, 0, 25, 4, 0, 0]'),
 Text(0.6436170212765957, 0.5588235294117647, 'x[2] <= 0.365\ngini = 0.1
53\nsamples = 16\nvalue = [0, 0, 22, 2, 0, 0]'),
 Text(0.6382978723404256, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0, 0,
0, 1, 0, 0]'),
 Text(0.648936170212766, 0.5, 'x[1] <= 0.345\ngini = 0.083\nsamples = 15
\nvalue = [0, 0, 22, 1, 0, 0]'),
 Text(0.6436170212765957, 0.4411764705882353, 'x[4] <= 0.061\ngini = 0.5
\nsamples = 2\nvalue = [0, 0, 1, 1, 0, 0]'),
 Text(0.6382978723404256, 0.38235294117647056, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 1, 0, 0, 0]'),
 Text(0.648936170212766, 0.38235294117647056, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 1, 0, 0]'),
 Text(0.6542553191489362, 0.4411764705882353, 'gini = 0.0\nsamples = 13
\nvalue = [0, 0, 21, 0, 0, 0]'),
 Text(0.6648936170212766, 0.5588235294117647, 'x[8] <= 3.215\ngini = 0.4
8\nsamples = 4\nvalue = [0, 0, 3, 2, 0, 0]'),
 Text(0.6595744680851063, 0.5, 'gini = 0.0\nsamples = 2\nvalue = [0, 0,
3, 0, 0, 0]'),
 Text(0.6702127659574468, 0.5, 'gini = 0.0\nsamples = 2\nvalue = [0, 0,
0, 2, 0, 0]'),
 Text(0.7794215425531915, 0.6764705882352942, 'x[4] <= 0.441\ngini = 0.4
91\nsamples = 94\nvalue = [0, 1, 28, 101, 18, 1]'),
 Text(0.7741023936170213, 0.6176470588235294, 'x[10] <= 10.65\ngini = 0.
472\nsamples = 92\nvalue = [0.0, 1.0, 24.0, 101.0, 18.0, 1.0]'),
 Text(0.7157579787234043, 0.5588235294117647, 'x[5] <= 8.5\ngini = 0.546
\nsamples = 61\nvalue = [0, 1, 24, 54, 10, 0]'),
 Text(0.6808510638297872, 0.5, 'x[5] <= 4.5\ngini = 0.278\nsamples = 19
\nvalue = [0, 0, 5, 25, 0, 0]'),
 Text(0.675531914893617, 0.4411764705882353, 'gini = 0.0\nsamples = 2\nv
alue = [0, 0, 2, 0, 0, 0]'),
 Text(0.6861702127659575, 0.4411764705882353, 'x[4] <= 0.087\ngini = 0.1
91\nsamples = 17\nvalue = [0, 0, 3, 25, 0, 0]'),
 Text(0.6808510638297872, 0.38235294117647056, 'gini = 0.0\nsamples = 7
\nvalue = [0, 0, 0, 13, 0, 0]'),
 Text(0.6914893617021277, 0.38235294117647056, 'x[1] <= 0.38\ngini = 0.3
2\nsamples = 10\nvalue = [0, 0, 3, 12, 0, 0]'),
 Text(0.6861702127659575, 0.3235294117647059, 'x[7] <= 0.999\ngini = 0.3
75\nsamples = 4\nvalue = [0, 0, 3, 1, 0, 0]'),
 Text(0.6808510638297872, 0.2647058823529412, 'gini = 0.0\nsamples = 3\n
value = [0, 0, 3, 0, 0, 0]'),
 Text(0.6914893617021277, 0.2647058823529412, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 1, 0, 0]'),
 Text(0.6968085106382979, 0.3235294117647059, 'gini = 0.0\nsamples = 6\n
value = [0, 0, 0, 11, 0, 0]'),
 Text(0.7506648936170213, 0.5, 'x[5] <= 13.5\ngini = 0.626\nsamples = 42
\nvalue = [0, 1, 19, 29, 10, 0]'),
 Text(0.7180851063829787, 0.4411764705882353, 'x[10] <= 10.55\ngini = 0.
649\nsamples = 13\nvalue = [0, 0, 9, 5, 8, 0]'),
 Text(0.7127659574468085, 0.38235294117647056, 'x[5] <= 9.5\ngini = 0.64
8\nsamples = 11\nvalue = [0, 0, 5, 5, 8, 0]'),
 Text(0.7074468085106383, 0.3235294117647059, 'gini = 0.0\nsamples = 2\n
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value = [0, 0, 3, 0, 0, 0]'),
 Text(0.7180851063829787, 0.3235294117647059, 'x[6] <= 25.0\ngini = 0.58
7\nsamples = 9\nvalue = [0, 0, 2, 5, 8, 0]'),
 Text(0.7074468085106383, 0.2647058823529412, 'x[9] <= 0.765\ngini = 0.2
45\nsamples = 3\nvalue = [0, 0, 1, 0, 6, 0]'),
 Text(0.7021276595744681, 0.20588235294117646, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 1, 0, 0, 0]'),
 Text(0.7127659574468085, 0.20588235294117646, 'gini = 0.0\nsamples = 2
\nvalue = [0, 0, 0, 0, 6, 0]'),
 Text(0.7287234042553191, 0.2647058823529412, 'x[5] <= 12.0\ngini = 0.53
1\nsamples = 6\nvalue = [0, 0, 1, 5, 2, 0]'),
 Text(0.723404255319149, 0.20588235294117646, 'gini = 0.0\nsamples = 3\n
value = [0, 0, 0, 4, 0, 0]'),
 Text(0.7340425531914894, 0.20588235294117646, 'x[2] <= 0.38\ngini = 0.6
25\nsamples = 3\nvalue = [0, 0, 1, 1, 2, 0]'),
 Text(0.7287234042553191, 0.14705882352941177, 'x[9] <= 0.635\ngini = 0.
5\nsamples = 2\nvalue = [0, 0, 1, 1, 0, 0]'),
 Text(0.723404255319149, 0.08823529411764706, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 1, 0, 0]'),
 Text(0.7340425531914894, 0.08823529411764706, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 1, 0, 0, 0]'),
 Text(0.7393617021276596, 0.14705882352941177, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 0, 2, 0]'),
 Text(0.723404255319149, 0.38235294117647056, 'gini = 0.0\nsamples = 2\n
value = [0, 0, 4, 0, 0, 0]'),
 Text(0.7832446808510638, 0.4411764705882353, 'x[0] <= 12.45\ngini = 0.5
03\nsamples = 29\nvalue = [0, 1, 10, 24, 2, 0]'),
 Text(0.7686170212765957, 0.38235294117647056, 'x[9] <= 0.655\ngini = 0.
429\nsamples = 25\nvalue = [0, 1, 5, 22, 2, 0]'),
 Text(0.7553191489361702, 0.3235294117647059, 'x[9] <= 0.63\ngini = 0.49
\nsamples = 7\nvalue = [0, 0, 4, 3, 0, 0]'),
 Text(0.75, 0.2647058823529412, 'x[1] <= 0.51\ngini = 0.375\nsamples = 4
\nvalue = [0, 0, 1, 3, 0, 0]'),
 Text(0.7446808510638298, 0.20588235294117646, 'gini = 0.0\nsamples = 3
\nvalue = [0, 0, 0, 3, 0, 0]'),
 Text(0.7553191489361702, 0.20588235294117646, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 1, 0, 0, 0]'),
 Text(0.7606382978723404, 0.2647058823529412, 'gini = 0.0\nsamples = 3\n
value = [0, 0, 3, 0, 0, 0]'),
 Text(0.7819148936170213, 0.3235294117647059, 'x[0] <= 11.55\ngini = 0.3
06\nsamples = 18\nvalue = [0, 1, 1, 19, 2, 0]'),
 Text(0.7712765957446809, 0.2647058823529412, 'x[0] <= 9.85\ngini = 0.1
\nsamples = 14\nvalue = [0, 0, 1, 18, 0, 0]'),
 Text(0.7659574468085106, 0.20588235294117646, 'gini = 0.0\nsamples = 10
\nvalue = [0, 0, 0, 14, 0, 0]'),
 Text(0.776595744680851, 0.20588235294117646, 'x[2] <= 0.53\ngini = 0.32
\nsamples = 4\nvalue = [0, 0, 1, 4, 0, 0]'),
 Text(0.7712765957446809, 0.14705882352941177, 'gini = 0.0\nsamples = 3
\nvalue = [0, 0, 0, 4, 0, 0]'),
 Text(0.7819148936170213, 0.14705882352941177, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 1, 0, 0, 0]'),
 Text(0.7925531914893617, 0.2647058823529412, 'x[7] <= 0.998\ngini = 0.6
25\nsamples = 4\nvalue = [0, 1, 0, 1, 2, 0]'),
 Text(0.7872340425531915, 0.20588235294117646, 'gini = 0.0\nsamples = 2
\nvalue = [0, 0, 0, 0, 2, 0]'),
 Text(0.7978723404255319, 0.20588235294117646, 'x[4] <= 0.113\ngini = 0.
5\nsamples = 2\nvalue = [0, 1, 0, 1, 0, 0]'),
 Text(0.7925531914893617, 0.14705882352941177, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 1, 0, 0]'),
 Text(0.8031914893617021, 0.14705882352941177, 'gini = 0.0\nsamples = 1
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\nvalue = [0, 1, 0, 0, 0, 0]'),
 Text(0.7978723404255319, 0.38235294117647056, 'x[9] <= 0.765\ngini = 0.
408\nsamples = 4\nvalue = [0, 0, 5, 2, 0, 0]'),
 Text(0.7925531914893617, 0.3235294117647059, 'gini = 0.0\nsamples = 2\n
value = [0, 0, 5, 0, 0, 0]'),
 Text(0.8031914893617021, 0.3235294117647059, 'gini = 0.0\nsamples = 2\n
value = [0, 0, 0, 2, 0, 0]'),
 Text(0.8324468085106383, 0.5588235294117647, 'x[8] <= 3.165\ngini = 0.2
75\nsamples = 31\nvalue = [0, 0, 0, 47, 8, 1]'),
 Text(0.8191489361702128, 0.5, 'x[7] <= 0.998\ngini = 0.524\nsamples = 9
\nvalue = [0, 0, 0, 9, 5, 1]'),
 Text(0.8138297872340425, 0.4411764705882353, 'x[4] <= 0.068\ngini = 0.2
78\nsamples = 4\nvalue = [0, 0, 0, 0, 5, 1]'),
 Text(0.8085106382978723, 0.38235294117647056, 'gini = 0.0\nsamples = 2
\nvalue = [0, 0, 0, 0, 3, 0]'),
 Text(0.8191489361702128, 0.38235294117647056, 'x[2] <= 0.585\ngini = 0.
444\nsamples = 2\nvalue = [0, 0, 0, 0, 2, 1]'),
 Text(0.8138297872340425, 0.3235294117647059, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 0, 0, 1]'),
 Text(0.824468085106383, 0.3235294117647059, 'gini = 0.0\nsamples = 1\nv
alue = [0, 0, 0, 0, 2, 0]'),
 Text(0.824468085106383, 0.4411764705882353, 'gini = 0.0\nsamples = 5\nv
alue = [0, 0, 0, 9, 0, 0]'),
 Text(0.8457446808510638, 0.5, 'x[9] <= 0.98\ngini = 0.136\nsamples = 22
\nvalue = [0, 0, 0, 38, 3, 0]'),
 Text(0.8351063829787234, 0.4411764705882353, 'x[3] <= 2.7\ngini = 0.097
\nsamples = 20\nvalue = [0, 0, 0, 37, 2, 0]'),
 Text(0.8297872340425532, 0.38235294117647056, 'gini = 0.0\nsamples = 15
\nvalue = [0, 0, 0, 32, 0, 0]'),
 Text(0.8404255319148937, 0.38235294117647056, 'x[3] <= 2.975\ngini = 0.
408\nsamples = 5\nvalue = [0, 0, 0, 5, 2, 0]'),
 Text(0.8351063829787234, 0.3235294117647059, 'x[5] <= 15.5\ngini = 0.44
4\nsamples = 3\nvalue = [0, 0, 0, 1, 2, 0]'),
 Text(0.8297872340425532, 0.2647058823529412, 'gini = 0.0\nsamples = 2\n
value = [0, 0, 0, 0, 2, 0]'),
 Text(0.8404255319148937, 0.2647058823529412, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 1, 0, 0]'),
 Text(0.8457446808510638, 0.3235294117647059, 'gini = 0.0\nsamples = 2\n
value = [0, 0, 0, 4, 0, 0]'),
 Text(0.8563829787234043, 0.4411764705882353, 'x[6] <= 34.5\ngini = 0.5
\nsamples = 2\nvalue = [0, 0, 0, 1, 1, 0]'),
 Text(0.851063829787234, 0.38235294117647056, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 0, 1, 0]'),
 Text(0.8617021276595744, 0.38235294117647056, 'gini = 0.0\nsamples = 1
\nvalue = [0, 0, 0, 1, 0, 0]'),
 Text(0.7847406914893617, 0.6176470588235294, 'gini = 0.0\nsamples = 2\n
value = [0, 0, 4, 0, 0, 0]'),
 Text(0.8816489361702128, 0.7941176470588235, 'x[8] <= 3.215\ngini = 0.7
35\nsamples = 20\nvalue = [0, 3, 6, 5, 13, 4]'),
 Text(0.8643617021276596, 0.7352941176470589, 'x[7] <= 1.001\ngini = 0.3
79\nsamples = 8\nvalue = [0, 0, 2, 1, 10, 0]'),
 Text(0.8537234042553191, 0.6764705882352942, 'x[5] <= 5.5\ngini = 0.18
\nsamples = 6\nvalue = [0, 0, 0, 1, 9, 0]'),
 Text(0.848404255319149, 0.6176470588235294, 'x[3] <= 5.15\ngini = 0.444
\nsamples = 2\nvalue = [0, 0, 0, 1, 2, 0]'),
 Text(0.8430851063829787, 0.5588235294117647, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 0, 2, 0]'),
 Text(0.8537234042553191, 0.5588235294117647, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 1, 0, 0]'),
 Text(0.8590425531914894, 0.6176470588235294, 'gini = 0.0\nsamples = 4\n
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value = [0, 0, 0, 0, 7, 0]'),
 Text(0.875, 0.6764705882352942, 'x[2] <= 0.575\ngini = 0.444\nsamples =
2\nvalue = [0, 0, 2, 0, 1, 0]'),
 Text(0.8696808510638298, 0.6176470588235294, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 2, 0, 0, 0]'),
 Text(0.8803191489361702, 0.6176470588235294, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 0, 1, 0]'),
 Text(0.898936170212766, 0.7352941176470589, 'x[6] <= 10.5\ngini = 0.796
\nsamples = 12\nvalue = [0, 3, 4, 4, 3, 4]'),
 Text(0.8936170212765957, 0.6764705882352942, 'gini = 0.0\nsamples = 1\n
value = [0, 3, 0, 0, 0, 0]'),
 Text(0.9042553191489362, 0.6764705882352942, 'x[10] <= 11.6\ngini = 0.7
47\nsamples = 11\nvalue = [0, 0, 4, 4, 3, 4]'),
 Text(0.8909574468085106, 0.6176470588235294, 'x[9] <= 0.9\ngini = 0.32
\nsamples = 3\nvalue = [0, 0, 4, 1, 0, 0]'),
 Text(0.8856382978723404, 0.5588235294117647, 'gini = 0.0\nsamples = 2\n
value = [0, 0, 4, 0, 0, 0]'),
 Text(0.8962765957446809, 0.5588235294117647, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 1, 0, 0]'),
 Text(0.9175531914893617, 0.6176470588235294, 'x[3] <= 4.75\ngini = 0.66
\nsamples = 8\nvalue = [0, 0, 0, 3, 3, 4]'),
 Text(0.9069148936170213, 0.5588235294117647, 'x[1] <= 0.375\ngini = 0.4
8\nsamples = 5\nvalue = [0, 0, 0, 3, 2, 0]'),
 Text(0.901595744680851, 0.5, 'gini = 0.0\nsamples = 2\nvalue = [0, 0,
0, 0, 2, 0]'),
 Text(0.9122340425531915, 0.5, 'gini = 0.0\nsamples = 3\nvalue = [0, 0,
0, 3, 0, 0]'),
 Text(0.9281914893617021, 0.5588235294117647, 'x[8] <= 3.25\ngini = 0.32
\nsamples = 3\nvalue = [0, 0, 0, 0, 1, 4]'),
 Text(0.9228723404255319, 0.5, 'gini = 0.0\nsamples = 2\nvalue = [0, 0,
0, 0, 0, 4]'),
 Text(0.9335106382978723, 0.5, 'gini = 0.0\nsamples = 1\nvalue = [0, 0,
0, 0, 1, 0]'),
 Text(0.9507978723404256, 0.9117647058823529, 'x[7] <= 0.993\ngini = 0.4
32\nsamples = 72\nvalue = [0, 3, 91, 15, 15, 0]'),
 Text(0.8366881025598405, 0.9411764705882353, '  False'),
 Text(0.9361702127659575, 0.8529411764705882, 'x[2] <= 0.255\ngini = 0.1
53\nsamples = 6\nvalue = [0, 0, 0, 1, 11, 0]'),
 Text(0.9308510638297872, 0.7941176470588235, 'gini = 0.0\nsamples = 3\n
value = [0, 0, 0, 0, 7, 0]'),
 Text(0.9414893617021277, 0.7941176470588235, 'x[9] <= 0.55\ngini = 0.32
\nsamples = 3\nvalue = [0, 0, 0, 1, 4, 0]'),
 Text(0.9361702127659575, 0.7352941176470589, 'gini = 0.0\nsamples = 2\n
value = [0, 0, 0, 0, 4, 0]'),
 Text(0.9468085106382979, 0.7352941176470589, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 1, 0, 0]'),
 Text(0.9654255319148937, 0.8529411764705882, 'x[1] <= 0.295\ngini = 0.3
22\nsamples = 66\nvalue = [0, 3, 91, 14, 4, 0]'),
 Text(0.9601063829787234, 0.7941176470588235, 'gini = 0.0\nsamples = 2\n
value = [0, 0, 0, 0, 4, 0]'),
 Text(0.9707446808510638, 0.7941176470588235, 'x[8] <= 3.545\ngini = 0.2
72\nsamples = 64\nvalue = [0, 3, 91, 14, 0, 0]'),
 Text(0.9574468085106383, 0.7352941176470589, 'x[2] <= 0.025\ngini = 0.1
83\nsamples = 59\nvalue = [0, 1, 89, 9, 0, 0]'),
 Text(0.9468085106382979, 0.6764705882352942, 'x[1] <= 0.675\ngini = 0.4
8\nsamples = 5\nvalue = [0, 0, 6, 4, 0, 0]'),
 Text(0.9414893617021277, 0.6176470588235294, 'gini = 0.0\nsamples = 2\n
value = [0, 0, 0, 4, 0, 0]'),
 Text(0.9521276595744681, 0.6176470588235294, 'gini = 0.0\nsamples = 3\n
value = [0, 0, 6, 0, 0, 0]'),
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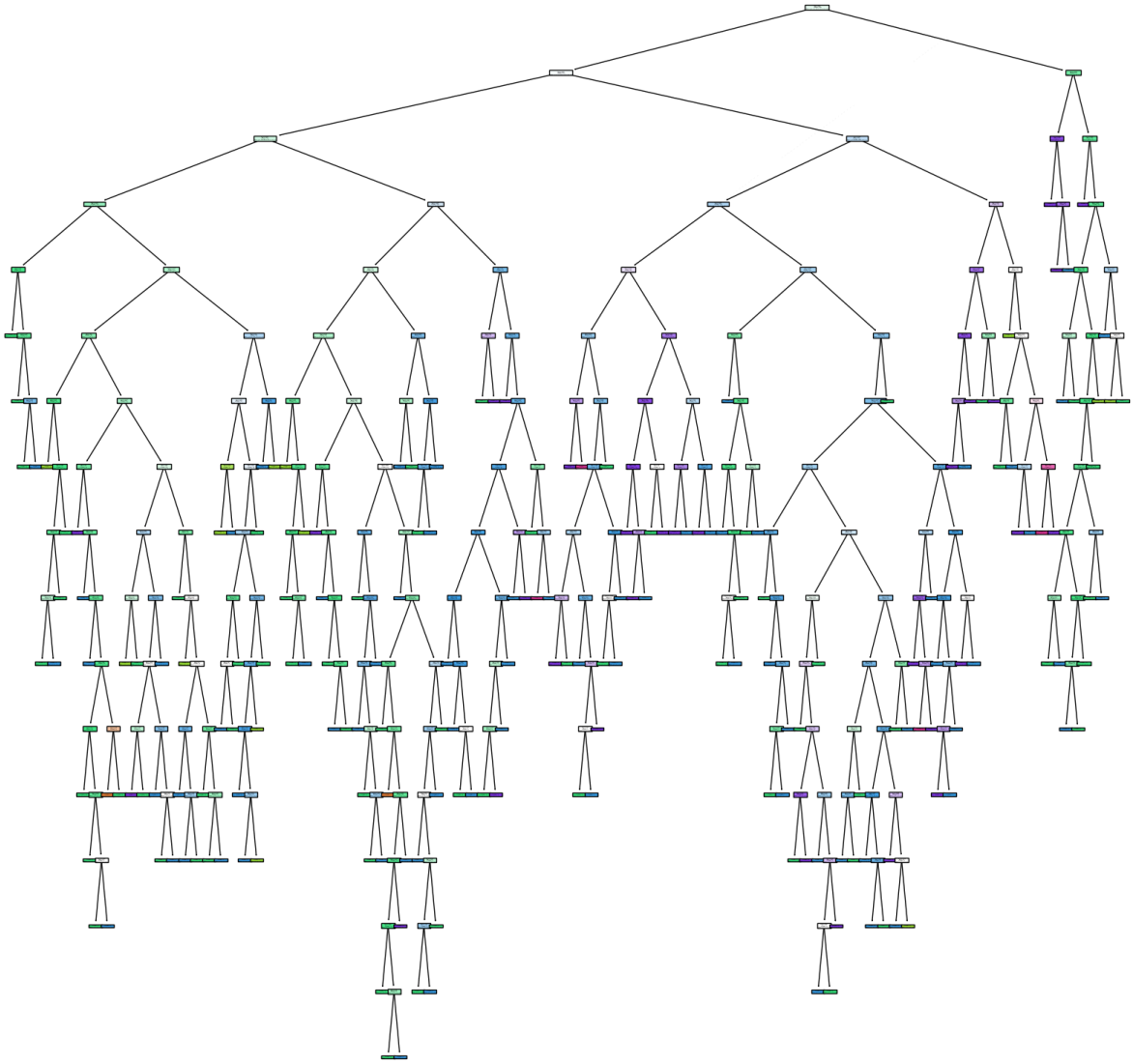
 Text(0.9680851063829787, 0.6764705882352942, 'x[10] <= 11.2\ngini = 0.1
27\nsamples = 54\nvalue = [0, 1, 83, 5, 0, 0]'),
 Text(0.9627659574468085, 0.6176470588235294, 'x[3] <= 2.25\ngini = 0.10
7\nsamples = 53\nvalue = [0, 0, 83, 5, 0, 0]'),
 Text(0.9574468085106383, 0.5588235294117647, 'x[7] <= 0.997\ngini = 0.2
57\nsamples = 23\nvalue = [0, 0, 28, 5, 0, 0]'),
 Text(0.9441489361702128, 0.5, 'x[6] <= 91.5\ngini = 0.18\nsamples = 20
\nvalue = [0, 0, 27, 3, 0, 0]'),
 Text(0.9335106382978723, 0.4411764705882353, 'x[3] <= 1.95\ngini = 0.44
4\nsamples = 5\nvalue = [0, 0, 4, 2, 0, 0]'),
 Text(0.9281914893617021, 0.38235294117647056, 'gini = 0.0\nsamples = 3
\nvalue = [0, 0, 4, 0, 0, 0]'),
 Text(0.9388297872340425, 0.38235294117647056, 'gini = 0.0\nsamples = 2
\nvalue = [0, 0, 0, 2, 0, 0]'),
 Text(0.9547872340425532, 0.4411764705882353, 'x[9] <= 0.505\ngini = 0.0
8\nsamples = 15\nvalue = [0, 0, 23, 1, 0, 0]'),
 Text(0.949468085106383, 0.38235294117647056, 'x[5] <= 30.0\ngini = 0.37
5\nsamples = 3\nvalue = [0, 0, 3, 1, 0, 0]'),
 Text(0.9441489361702128, 0.3235294117647059, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 0, 1, 0, 0]'),
 Text(0.9547872340425532, 0.3235294117647059, 'gini = 0.0\nsamples = 2\n
value = [0, 0, 3, 0, 0, 0]'),
 Text(0.9601063829787234, 0.38235294117647056, 'gini = 0.0\nsamples = 12
\nvalue = [0, 0, 20, 0, 0, 0]'),
 Text(0.9707446808510638, 0.5, 'x[8] <= 3.19\ngini = 0.444\nsamples = 3
\nvalue = [0, 0, 1, 2, 0, 0]'),
 Text(0.9654255319148937, 0.4411764705882353, 'gini = 0.0\nsamples = 1\n
value = [0, 0, 1, 0, 0, 0]'),
 Text(0.976063829787234, 0.4411764705882353, 'gini = 0.0\nsamples = 2\nv
alue = [0, 0, 0, 2, 0, 0]'),
 Text(0.9680851063829787, 0.5588235294117647, 'gini = 0.0\nsamples = 30
\nvalue = [0, 0, 55, 0, 0, 0]'),
 Text(0.973404255319149, 0.6176470588235294, 'gini = 0.0\nsamples = 1\nv
alue = [0, 1, 0, 0, 0, 0]'),
 Text(0.9840425531914894, 0.7352941176470589, 'x[10] <= 10.1\ngini = 0.5
93\nsamples = 5\nvalue = [0, 2, 2, 5, 0, 0]'),
 Text(0.9787234042553191, 0.6764705882352942, 'gini = 0.0\nsamples = 2\n
value = [0, 0, 0, 5, 0, 0]'),
 Text(0.9893617021276596, 0.6764705882352942, 'x[2] <= 0.065\ngini = 0.5
\nsamples = 3\nvalue = [0, 2, 2, 0, 0, 0]'),
 Text(0.9840425531914894, 0.6176470588235294, 'gini = 0.0\nsamples = 1\n
value = [0, 2, 0, 0, 0, 0]'),
 Text(0.9946808510638298, 0.6176470588235294, 'gini = 0.0\nsamples = 2\n
value = [0, 0, 2, 0, 0, 0]')]
```



In [23]:
```
lst = [DecisionTreeClassifier(max_features='sqrt', random_state=120722165
 DecisionTreeClassifier(max_features='sqrt', random_state=271498305),
 DecisionTreeClassifier(max_features='sqrt', random_state=1520572380),
 DecisionTreeClassifier(max_features='sqrt', random_state=1084035594),
 DecisionTreeClassifier(max_features='sqrt', random_state=1600634660),
 DecisionTreeClassifier(max_features='sqrt', random_state=1771429680),
 DecisionTreeClassifier(max_features='sqrt', random_state=1616302164),
 DecisionTreeClassifier(max_features='sqrt', random_state=210688443),
 DecisionTreeClassifier(max_features='sqrt', random_state=211285308),
 DecisionTreeClassifier(max_features='sqrt', random_state=369716156),
 DecisionTreeClassifier(max_features='sqrt', random_state=1448064097),
 DecisionTreeClassifier(max_features='sqrt', random_state=1751221911),
 DecisionTreeClassifier(max_features='sqrt', random_state=2065746137),
 DecisionTreeClassifier(max_features='sqrt', random_state=1661677090),
 DecisionTreeClassifier(max_features='sqrt', random_state=1204059923),
 DecisionTreeClassifier(max_features='sqrt', random_state=243791502),
 DecisionTreeClassifier(max_features='sqrt', random_state=1524266902),
 DecisionTreeClassifier(max_features='sqrt', random_state=883654068),
 DecisionTreeClassifier(max_features='sqrt', random_state=576919577),
 DecisionTreeClassifier(max_features='sqrt', random_state=1013041113),
 DecisionTreeClassifier(max_features='sqrt', random_state=1011446518),
 DecisionTreeClassifier(max_features='sqrt', random_state=2105498496),
 DecisionTreeClassifier(max_features='sqrt', random_state=1867116866),
 DecisionTreeClassifier(max_features='sqrt', random_state=1765774877),
```

```
DecisionTreeClassifier(max_features='sqrt', random_state=332723627),
DecisionTreeClassifier(max_features='sqrt', random_state=2122328370),
DecisionTreeClassifier(max_features='sqrt', random_state=497780875),
DecisionTreeClassifier(max_features='sqrt', random_state=1055811522),
DecisionTreeClassifier(max_features='sqrt', random_state=973649372),
DecisionTreeClassifier(max_features='sqrt', random_state=1698401594),
DecisionTreeClassifier(max_features='sqrt', random_state=370916769),
DecisionTreeClassifier(max_features='sqrt', random_state=173983428),
DecisionTreeClassifier(max_features='sqrt', random_state=1541050848),
DecisionTreeClassifier(max_features='sqrt', random_state=1981734719),
DecisionTreeClassifier(max_features='sqrt', random_state=1289180502),
DecisionTreeClassifier(max_features='sqrt', random_state=1417764894),
DecisionTreeClassifier(max_features='sqrt', random_state=1958054169),
DecisionTreeClassifier(max_features='sqrt', random_state=266371829),
DecisionTreeClassifier(max_features='sqrt', random_state=583880494),
DecisionTreeClassifier(max_features='sqrt', random_state=694053796),
DecisionTreeClassifier(max_features='sqrt', random_state=508394461),
DecisionTreeClassifier(max_features='sqrt', random_state=1350988980),
DecisionTreeClassifier(max_features='sqrt', random_state=2013731033),
DecisionTreeClassifier(max_features='sqrt', random_state=978876927),
DecisionTreeClassifier(max_features='sqrt', random_state=1620292421),
DecisionTreeClassifier(max_features='sqrt', random_state=1595105460),
DecisionTreeClassifier(max_features='sqrt', random_state=995615733),
DecisionTreeClassifier(max_features='sqrt', random_state=833740744),
DecisionTreeClassifier(max_features='sqrt', random_state=2132716536),
DecisionTreeClassifier(max_features='sqrt', random_state=1696784032),
DecisionTreeClassifier(max_features='sqrt', random_state=816488511),
DecisionTreeClassifier(max_features='sqrt', random_state=238796200),
DecisionTreeClassifier(max_features='sqrt', random_state=1945040390),
DecisionTreeClassifier(max_features='sqrt', random_state=267920396),
DecisionTreeClassifier(max_features='sqrt', random_state=1375254394),
DecisionTreeClassifier(max_features='sqrt', random_state=338884359),
DecisionTreeClassifier(max_features='sqrt', random_state=496445008),
DecisionTreeClassifier(max_features='sqrt', random_state=17083671),
DecisionTreeClassifier(max_features='sqrt', random_state=117854860),
DecisionTreeClassifier(max_features='sqrt', random_state=1628821326),
DecisionTreeClassifier(max_features='sqrt', random_state=1083921928),
DecisionTreeClassifier(max_features='sqrt', random_state=819447854),
DecisionTreeClassifier(max_features='sqrt', random_state=967831533),
DecisionTreeClassifier(max_features='sqrt', random_state=1148838646),
DecisionTreeClassifier(max_features='sqrt', random_state=248104915),
DecisionTreeClassifier(max_features='sqrt', random_state=330080872),
DecisionTreeClassifier(max_features='sqrt', random_state=2087654822),
DecisionTreeClassifier(max_features='sqrt', random_state=1043560881),
DecisionTreeClassifier(max_features='sqrt', random_state=1497404603),
DecisionTreeClassifier(max_features='sqrt', random_state=1628300778),
DecisionTreeClassifier(max_features='sqrt', random_state=1416264479),
DecisionTreeClassifier(max_features='sqrt', random_state=1651230503),
DecisionTreeClassifier(max_features='sqrt', random_state=213211602),
DecisionTreeClassifier(max_features='sqrt', random_state=1491716064),
DecisionTreeClassifier(max_features='sqrt', random_state=1416735533),
DecisionTreeClassifier(max_features='sqrt', random_state=352142613),
DecisionTreeClassifier(max_features='sqrt', random_state=332246973),
DecisionTreeClassifier(max_features='sqrt', random_state=2064188223),
DecisionTreeClassifier(max_features='sqrt', random_state=1720959578),
DecisionTreeClassifier(max_features='sqrt', random_state=938319536),
DecisionTreeClassifier(max_features='sqrt', random_state=1216677341),
DecisionTreeClassifier(max_features='sqrt', random_state=1020211174),
DecisionTreeClassifier(max_features='sqrt', random_state=941561685),
DecisionTreeClassifier(max_features='sqrt', random_state=1455116870),
```

```
 DecisionTreeClassifier(max_features='sqrt', random_state=48899324),
 DecisionTreeClassifier(max_features='sqrt', random_state=564214121),
 DecisionTreeClassifier(max_features='sqrt', random_state=978576042),
 DecisionTreeClassifier(max_features='sqrt', random_state=1496416686),
 DecisionTreeClassifier(max_features='sqrt', random_state=780965169),
 DecisionTreeClassifier(max_features='sqrt', random_state=134743595),
 DecisionTreeClassifier(max_features='sqrt', random_state=1828665050),
 DecisionTreeClassifier(max_features='sqrt', random_state=489082406),
 DecisionTreeClassifier(max_features='sqrt', random_state=639051190),
 DecisionTreeClassifier(max_features='sqrt', random_state=560204224),
 DecisionTreeClassifier(max_features='sqrt', random_state=121450284),
 DecisionTreeClassifier(max_features='sqrt', random_state=1990872082),
 DecisionTreeClassifier(max_features='sqrt', random_state=1921873150),
 DecisionTreeClassifier(max_features='sqrt', random_state=474293923),
 DecisionTreeClassifier(max_features='sqrt', random_state=1414423120),
 DecisionTreeClassifier(max_features='sqrt', random_state=912234182)]
```

In [24]:
```
print(len(lst))
```

```
100
```

Hyperparameter Tuning: GridSearchCV and RandomSearchCV

Both `GridSearchCV` and `RandomizedSearchCV` are methods from the **Scikit-learn** library used for hyperparameter tuning. Hyperparameter tuning is the process of finding the best set of hyperparameters for a machine learning model to maximize performance.

1. GridSearchCV

`GridSearchCV` performs an exhaustive search over a specified parameter grid by trying all possible combinations of hyperparameters. It evaluates the performance of each combination and returns the best-performing model.

How it works:

- A list of hyperparameters and their possible values are defined in a dictionary.
- `GridSearchCV` tries **every combination** of hyperparameters in the grid.
- For each combination, cross-validation is performed (hence the "CV" part in `GridSearchCV`), meaning the model is trained on various subsets of the data and tested on the remaining portions.
- The combination of hyperparameters with the best performance (e.g., highest accuracy) across cross-validation folds is selected as the optimal set.

Example:

```
from sklearn.model_selection import GridSearchCV
from sklearn.ensemble import RandomForestClassifier

# Define the model
model = RandomForestClassifier()

# Define the parameter grid
```

```
param_grid = {
    'n_estimators': [100, 200, 300],
    'max_depth': [None, 10, 20],
    'min_samples_split': [2, 5, 10]
}

# Initialize GridSearchCV
grid_search = GridSearchCV(estimator=model,
param_grid=param_grid, cv=5)

# Fit the model
grid_search.fit(X_train, y_train)

# Best parameters and best score
print(grid_search.best_params_)
print(grid_search.best_score_)
```

Pros:

- **Exhaustive**: All possible combinations of parameters are tried.
- **Guaranteed optimal**: Given that it tests all combinations, it will find the best hyperparameters within the provided grid.

Cons:

- **Computationally expensive**: It can be slow, especially when the number of hyperparameters and their ranges is large.
- **Not scalable**: As the search space grows, the time to run `GridSearchCV` increases exponentially.

---

2. RandomizedSearchCV

`RandomizedSearchCV` tries a random combination of hyperparameters from the specified parameter grid. Instead of trying every possible combination, it randomly samples a fixed number of hyperparameter combinations and evaluates their performance.

How it works:

- A parameter grid is defined, but instead of trying all combinations, `RandomizedSearchCV` randomly selects a fixed number of combinations.
- The number of combinations to try is set by the user (e.g., `n_iter`).
- For each random combination, cross-validation is performed.
- The combination of hyperparameters with the best performance across cross-validation folds is selected as the optimal set.

Example:

```
from sklearn.model_selection import RandomizedSearchCV
from sklearn.ensemble import RandomForestClassifier

# Define the model
```

```
model = RandomForestClassifier()

# Define the parameter grid
param_grid = {
    'n_estimators': [100, 200, 300, 400, 500],
    'max_depth': [None, 10, 20, 30],
    'min_samples_split': [2, 5, 10],
    'min_samples_leaf': [1, 2, 4]
}

# Initialize RandomizedSearchCV
random_search = RandomizedSearchCV(estimator=model,
param_distributions=param_grid, n_iter=10, cv=5, random_state=42)

# Fit the model
random_search.fit(X_train, y_train)

# Best parameters and best score
print(random_search.best_params_)
print(random_search.best_score_)
```

Pros:

- **Faster**: Since it randomly samples the parameter space, it's faster than `GridSearchCV`, especially when there are many hyperparameters.
- **Scalable**: It can be used for larger search spaces where trying every combination would be infeasible.
- **Good results with fewer iterations**: Random sampling often finds good hyperparameters even without exploring the entire search space.

Cons:

- **Not exhaustive**: Since it only samples random combinations, it may miss the optimal set of hyperparameters.
- **Randomness**: The results may vary with different random seeds.

GridSearchCV vs RandomizedSearchCV

Feature	GridSearchCV	RandomizedSearchCV
Search Strategy	Exhaustive search over all combinations	Random search over specified number of combinations
Computational Cost	Expensive for large hyperparameter spaces	Cheaper, as it searches a subset of combinations
Best Use Case	Small hyperparameter space	Large hyperparameter space
Guarantees	Guarantees finding the best hyperparameters	Does not guarantee finding the optimal parameters
Control	Full control over which combinations are tested	Randomly samples combinations, less control

Conclusion:

- Use **GridSearchCV** when the parameter grid is small and computational resources are not a limiting factor. It guarantees the best combination within the provided grid.
- Use **RandomizedSearchCV** when dealing with larger hyperparameter spaces and when computational efficiency is important. It offers a good trade-off between search space exploration and speed.

In [25]:
```
grid_param =  {
    "n_estimators" : [50 , 100 , 120],
    'criterion' :['gini' ,'entropy'],
    'max_depth' :range(5)
}
```

In [26]:
```
from sklearn.model_selection import GridSearchCV
grid_serach_rf = GridSearchCV(param_grid= grid_param, cv = 10 , n_jobs=6,
grid_serach_rf.fit(X_train, y_train)
```

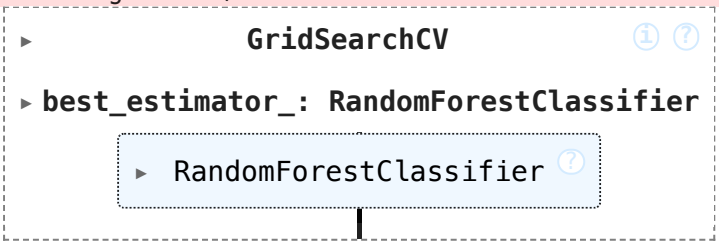
```
Fitting 10 folds for each of 30 candidates, totalling 300 fits
```

```
/Users/vaibhavarde/Desktop/DATASCIENCE/ChaiCode/MLNotes/MLNotes/lib/python
3.10/site-packages/sklearn/model_selection/_split.py:776: UserWarning: The
least populated class in y has only 5 members, which is less than n_splits
=10.
  warnings.warn(
/Users/vaibhavarde/Desktop/DATASCIENCE/ChaiCode/MLNotes/MLNotes/lib/python
3.10/site-packages/sklearn/model_selection/_validation.py:540: FitFailedWa
rning:
60 fits failed out of a total of 300.
The score on these train-test partitions for these parameters will be set
to nan.
If these failures are not expected, you can try to debug them by setting e
rror_score='raise'.

Below are more details about the failures:
--------------------------------------------------------------------------
------
60 fits failed with the following error:
Traceback (most recent call last):
  File "/Users/vaibhavarde/Desktop/DATASCIENCE/ChaiCode/MLNotes/MLNotes/li
b/python3.10/site-packages/sklearn/model_selection/_validation.py", line 8
88, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "/Users/vaibhavarde/Desktop/DATASCIENCE/ChaiCode/MLNotes/MLNotes/li
b/python3.10/site-packages/sklearn/base.py", line 1466, in wrapper
    estimator._validate_params()
  File "/Users/vaibhavarde/Desktop/DATASCIENCE/ChaiCode/MLNotes/MLNotes/li
b/python3.10/site-packages/sklearn/base.py", line 666, in _validate_params
    validate_parameter_constraints(
  File "/Users/vaibhavarde/Desktop/DATASCIENCE/ChaiCode/MLNotes/MLNotes/li
b/python3.10/site-packages/sklearn/utils/_param_validation.py", line 95, i
n validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'max_depth' par
ameter of RandomForestClassifier must be an int in the range [1, inf) or N
one. Got 0 instead.

  warnings.warn(some_fits_failed_message, FitFailedWarning)
/Users/vaibhavarde/Desktop/DATASCIENCE/ChaiCode/MLNotes/MLNotes/lib/python
3.10/site-packages/sklearn/model_selection/_search.py:1102: UserWarning: O
ne or more of the test scores are non-finite: [       nan        nan
nan 0.57878249 0.57994528 0.58805746
 0.60444596 0.61030096 0.61032832 0.60679891 0.61259918 0.61380301
 0.62433653 0.61963064 0.6149658         nan        nan        nan
 0.57989056 0.57878249 0.57526676 0.58218878 0.59742818 0.59744186
 0.59391245 0.60321477 0.59980848 0.60913817 0.61730506 0.61380301]
  warnings.warn(
```

Out[26]:



In [27]:
```
grid_serach_rf.best_params_
```

Out[27]:
```
{'criterion': 'gini', 'max_depth': 4, 'n_estimators': 50}
```

In [28]:
```
rf_new = RandomForestClassifier(n_estimators=120, criterion='entropy', ma
rf_new.fit(X_train, y_train)
```

Out[28]:
```
RandomForestClassifier(criterion='entropy', max_depth=4, n_estima
tors=120)
```

In [29]:
```
rf_new.score(X_test, y_test)
```

Out[29]:
```
0.5594405594405595
```

In [30]:
```
from sklearn.model_selection import GridSearchCV, RandomizedSearchCV
from sklearn.ensemble import RandomForestClassifier

# GridSearchCV
param_grid = {
    'n_estimators': [100, 200, 300],
    'max_depth': [None, 5, 10],
    'min_samples_split': [2, 5, 10]
}
grid_search = GridSearchCV(RandomForestClassifier(), param_grid, cv=5)
grid_search.fit(X_train, y_train)
best_params = grid_search.best_params_

print("GridSearchCV best_params_: ", best_params)

# RandomSearchCV
param_dist = {
    'n_estimators': np.arange(100, 500),
    'max_depth': np.random.randint(5, 20, size=10),
    'min_samples_split': np.random.randint(2, 10, size=10)
}
random_search = RandomizedSearchCV(RandomForestClassifier(), param_dist,
random_search.fit(X_train, y_train)
best_params = random_search.best_params_
print("RandomSearchCV best_params_: ", best_params)
```

```
GridSearchCV best_params_:  {'max_depth': None, 'min_samples_split': 5, 'n
_estimators': 200}
RandomSearchCV best_params_:  {'n_estimators': 226, 'min_samples_split':
3, 'max_depth': 11}
```

In [31]:
```
rf_GridSearch = RandomForestClassifier(max_depth=None, min_samples_split=
rf_GridSearch.fit(X_train, y_train)
```

Out[31]:
```
RandomForestClassifier(n_estimators=200)
```

In [32]:
```
rf_GridSearch.score(X_test, y_test)
```

Out[32]:
```
0.6503496503496503
```

In [33]:
```
rf_random_search = RandomForestClassifier(n_estimators=267, min_samples_s
rf_random_search.fit(X_train, y_train)
```

Out[33]:

RandomForestClassifier

```
RandomForestClassifier(max_depth=12, min_samples_split=5, n_estimators=267)
```

In [34]:
```
rf_random_search.score(X_test, y_test)
```

Out[34]:
```
0.6223776223776224
```