Testing

November 6, 2024

1 COMP1801 - Machine Learning Coursework Solution

Let's start by importing the essential Python libraries for data analysis and machine learning.

[85]:
```
# Import libraries
try:
    # Importing general libraries
    import glob
    import pandas as pd

    # Importing libraries for data visualization
    import matplotlib.pyplot as plt
    import numpy as np

    # Importing libraries for model building
    from sklearn.preprocessing import LabelEncoder
    from sklearn.model_selection import train_test_split, GridSearchCV,␣
 ↪RandomizedSearchCV
    from sklearn.ensemble import RandomForestRegressor
    from sklearn.metrics import root_mean_squared_error, r2_score,␣
 ↪mean_absolute_error, mean_squared_log_error

    # Importing libraries for data preprocessing
    from scipy.stats import randint

except Exception as e:
    print(f"Error : {e}")
```

[86]:
```
# Find the CSV file in the Datasets directory
data_path = '../Datasets/*.csv'
file_list = glob.glob(data_path)

for file in file_list:
    print(f"Found file: {file}")

# Ensure there is exactly one file
if len(file_list) == 1:
    # Load the dataset
```

```
    df = pd.read_csv(file_list[0])
    print(f"Loaded dataset: {file_list[0]}")
else:
    raise FileNotFoundError("No CSV file found or multiple CSV files found in␣
 ↪the Datasets directory.")
```

```
Found file: ../Datasets/Dataset.csv
Loaded dataset: ../Datasets/Dataset.csv
```

[87]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 16 columns):
 #   Column          Non-Null Count  Dtype
---  ------          --------------  -----
 0   Lifespan        1000 non-null   float64
 1   partType        1000 non-null   object
 2   microstructure  1000 non-null   object
 3   coolingRate     1000 non-null   int64
 4   quenchTime      1000 non-null   float64
 5   forgeTime       1000 non-null   float64
 6   HeatTreatTime   1000 non-null   float64
 7   Nickel%         1000 non-null   float64
 8   Iron%           1000 non-null   float64
 9   Cobalt%         1000 non-null   float64
 10  Chromium%       1000 non-null   float64
 11  smallDefects    1000 non-null   int64
 12  largeDefects    1000 non-null   int64
 13  sliverDefects   1000 non-null   int64
 14  seedLocation    1000 non-null   object
 15  castType        1000 non-null   object
dtypes: float64(8), int64(4), object(4)
memory usage: 125.1+ KB
```

[88]:
```
# Check for missing values
df.isnull().sum()
```

[88]:
```
Lifespan          0
partType          0
microstructure    0
coolingRate       0
quenchTime        0
forgeTime         0
HeatTreatTime     0
Nickel%           0
Iron%             0
Cobalt%           0
```

```
Chromium%         0
smallDefects      0
largeDefects      0
sliverDefects     0
seedLocation      0
castType          0
dtype: int64
```

[89]:
```
df.head()
```

[89]:
```
   Lifespan partType microstructure  coolingRate  quenchTime  forgeTime  \
0   1469.17   Nozzle      equiGrain           13        3.84       6.47
1   1793.64    Block    singleGrain           19        2.62       3.48
2    700.60    Blade      equiGrain           28        0.76       1.34
3   1082.10   Nozzle       colGrain            9        2.01       2.19
4   1838.83    Blade       colGrain           16        4.13       3.87

   HeatTreatTime  Nickel%  Iron%  Cobalt%  Chromium%  smallDefects  \
0          46.87    65.73  16.52    16.82       0.93            10
1          44.70    54.22  35.38     6.14       4.26            19
2           9.54    51.83  35.95     8.81       3.41            35
3          20.29    57.03  23.33    16.86       2.78             0
4          16.13    59.62  27.37    11.45       1.56            10

   largeDefects  sliverDefects seedLocation     castType
0             0              0       Bottom          Die
1             0              0       Bottom   Investment
2             3              0       Bottom   Investment
3             1              0          Top   Continuous
4             0              0          Top          Die
```

[90]:
```
df.describe()
```

[90]:
```
          Lifespan  coolingRate   quenchTime    forgeTime  HeatTreatTime  \
count  1000.000000  1000.000000  1000.000000  1000.000000    1000.000000
mean   1298.556320    17.639000     2.764230     5.464600      30.194510
std     340.071434     7.491783     1.316979     2.604513      16.889415
min     417.990000     5.000000     0.500000     1.030000       1.030000
25%    1047.257500    11.000000     1.640000     3.170000      16.185000
50%    1266.040000    18.000000     2.755000     5.475000      29.365000
75%    1563.050000    24.000000     3.970000     7.740000      44.955000
max    2134.530000    30.000000     4.990000    10.000000      59.910000

           Nickel%        Iron%      Cobalt%    Chromium%  smallDefects  \
count  1000.000000  1000.000000  1000.000000  1000.000000   1000.000000
mean     60.243080    24.553580    12.434690     2.768650     17.311000
std       5.790475     7.371737     4.333197     1.326496     12.268365
```

```
min      50.020000    6.660000    5.020000    0.510000     0.000000
25%      55.287500   19.387500    8.597500    1.590000     7.000000
50%      60.615000   24.690000   12.585000    2.865000    18.000000
75%      65.220000   29.882500   16.080000    3.922500    26.000000
max      69.950000   43.650000   19.990000    4.990000    61.000000

       largeDefects  sliverDefects
count   1000.000000    1000.000000
mean       0.550000       0.292000
std        1.163982       1.199239
min        0.000000       0.000000
25%        0.000000       0.000000
50%        0.000000       0.000000
75%        0.000000       0.000000
max        4.000000       8.000000
```

[91]:

```
# Using nunique()
num_parts = df['partType'].nunique()
print(f"Number of unique parts types: {num_parts}")

# Or using value_counts() to see the distribution
parts_distribution = df['partType'].value_counts()
print("\nDistribution of parts types:")
print(parts_distribution)
```

```
Number of unique parts types: 4

Distribution of parts types:
partType
Valve     265
Block     253
Nozzle    245
Blade     237
Name: count, dtype: int64
```

[92]:

```
categorical_cols_unfied = ['partType', 'microstructure', 'seedLocation',␣
↪'castType']

# Create a DataFrame to display unique values and their counts
unique_values_df = pd.DataFrame({
    'Column': categorical_cols_unfied,
    'Unique Values': [df[col].unique().tolist() for col in␣
↪categorical_cols_unfied],
    'Count of Unique Values': [df[col].nunique() for col in␣
↪categorical_cols_unfied]
})
```

```python
print(unique_values_df)
```

```
          Column                      Unique Values  Count of Unique Values
0       partType       [Nozzle, Block, Blade, Valve]                      4
1  microstructure  [equiGrain, singleGrain, colGrain]                      3
2   seedLocation                       [Bottom, Top]                      2
3       castType       [Die, Investment, Continuous]                      3
```

[93]:
```python
# Creating a copy of the dataframe to ensure we maintain the original intact
df_onehot_encoded = df.copy()

# Apply one-hot encoding to the categorical columns
df_onehot_encoded = pd.get_dummies(df_onehot_encoded,␣
 ↪columns=categorical_cols_unfied, drop_first=False)

# Display the first few rows to verify
display(df_onehot_encoded.head())
```

```
   Lifespan  coolingRate  quenchTime  forgeTime  HeatTreatTime  Nickel%  \
0   1469.17           13        3.84       6.47          46.87    65.73
1   1793.64           19        2.62       3.48          44.70    54.22
2    700.60           28        0.76       1.34           9.54    51.83
3   1082.10            9        2.01       2.19          20.29    57.03
4   1838.83           16        4.13       3.87          16.13    59.62

   Iron%  Cobalt%  Chromium%  smallDefects  …  partType_Nozzle  \
0  16.52    16.82       0.93            10  …             True
1  35.38     6.14       4.26            19  …            False
2  35.95     8.81       3.41            35  …            False
3  23.33    16.86       2.78             0  …             True
4  27.37    11.45       1.56            10  …            False

   partType_Valve  microstructure_colGrain  microstructure_equiGrain  \
0           False                    False                      True
1           False                    False                     False
2           False                    False                      True
3           False                     True                     False
4           False                     True                     False

   microstructure_singleGrain  seedLocation_Bottom  seedLocation_Top  \
0                       False                 True             False
1                        True                 True             False
2                       False                 True             False
3                       False                False              True
4                       False                False              True

   castType_Continuous  castType_Die  castType_Investment
0                False          True                False
```

```
1                 False         False                 True
2                 False         False                 True
3                  True         False                False
4                 False          True                False

[5 rows x 24 columns]
```

[94]:
```python
df_onehot_encoded.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 24 columns):
 #   Column                        Non-Null Count  Dtype
---  ------                        --------------  -----
 0   Lifespan                      1000 non-null   float64
 1   coolingRate                   1000 non-null   int64
 2   quenchTime                    1000 non-null   float64
 3   forgeTime                     1000 non-null   float64
 4   HeatTreatTime                 1000 non-null   float64
 5   Nickel%                       1000 non-null   float64
 6   Iron%                         1000 non-null   float64
 7   Cobalt%                       1000 non-null   float64
 8   Chromium%                     1000 non-null   float64
 9   smallDefects                  1000 non-null   int64
 10  largeDefects                  1000 non-null   int64
 11  sliverDefects                 1000 non-null   int64
 12  partType_Blade                1000 non-null   bool
 13  partType_Block                1000 non-null   bool
 14  partType_Nozzle               1000 non-null   bool
 15  partType_Valve                1000 non-null   bool
 16  microstructure_colGrain       1000 non-null   bool
 17  microstructure_equiGrain      1000 non-null   bool
 18  microstructure_singleGrain    1000 non-null   bool
 19  seedLocation_Bottom           1000 non-null   bool
 20  seedLocation_Top              1000 non-null   bool
 21  castType_Continuous           1000 non-null   bool
 22  castType_Die                  1000 non-null   bool
 23  castType_Investment           1000 non-null   bool
dtypes: bool(12), float64(8), int64(4)
memory usage: 105.6 KB
```

[95]:
```python
# Define the target variable and feature set
X = df_onehot_encoded.drop(columns=['Lifespan'])  # Features
y = df_onehot_encoded['Lifespan']  # Target

# Split the dataset into training and testing sets (80% train, 20% test)
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,␣
↪random_state=42)
```

```python
# Display the shapes of the training and testing sets to verify
print("X_train shape:", X_train.shape)
print("X_test shape:", X_test.shape)
print("y_train shape:", y_train.shape)
print("y_test shape:", y_test.shape)
```

```
X_train shape: (800, 23)
X_test shape: (200, 23)
y_train shape: (800,)
y_test shape: (200,)
```

[96]:
```python
# Initialize the Random Forest Regressor
rf_model = RandomForestRegressor(n_estimators=100, random_state=42)

# Fit the model to the training data
rf_model.fit(X_train, y_train)

# Make predictions on the test set
y_pred = rf_model.predict(X_test)

# Evaluate the model using RMSE, R² Score, and MAE
rmse = root_mean_squared_error(y_test, y_pred)  # Root Mean Squared Error
r2 = r2_score(y_test, y_pred)  # R² Score
mae = mean_absolute_error(y_test, y_pred)  # Mean Absolute Error
msle = mean_squared_log_error(y_test, y_pred)  # Mean Squared Log Error

print(f"Root Mean Squared Error (RMSE): {rmse:.2f}")
print(f"R\u00b2 Score: {r2:.2f}")
print(f"Mean Absolute Error (MAE): {mae:.2f}")
print(f"Mean Squared Log Error (MSLE): {msle:.2f}")
```

```
Root Mean Squared Error (RMSE): 85.15
R² Score: 0.93
Mean Absolute Error (MAE): 67.46
Mean Squared Log Error (MSLE): 0.01
```

[97]:
```python
# Creating a copy of the dataframe to ensure we maintain the original intact
df_label_encoded = df.copy()

# Apply Label Encoding to each categorical column
label_encoders = {}
for col in categorical_cols_unfied:
    le = LabelEncoder()
    df_label_encoded[col] = le.fit_transform(df_label_encoded[col])
    label_encoders[col] = le  # Store the encoder for inverse transformation if␣
 ↪needed later
```

```
# Display the first few rows to verify
display(df_label_encoded.head())
```

```
   Lifespan  partType  microstructure  coolingRate  quenchTime  forgeTime  \
0   1469.17         2               1           13        3.84       6.47
1   1793.64         1               2           19        2.62       3.48
2    700.60         0               1           28        0.76       1.34
3   1082.10         2               0            9        2.01       2.19
4   1838.83         0               0           16        4.13       3.87

   HeatTreatTime  Nickel%  Iron%  Cobalt%  Chromium%  smallDefects  \
0          46.87    65.73  16.52    16.82       0.93            10
1          44.70    54.22  35.38     6.14       4.26            19
2           9.54    51.83  35.95     8.81       3.41            35
3          20.29    57.03  23.33    16.86       2.78             0
4          16.13    59.62  27.37    11.45       1.56            10

   largeDefects  sliverDefects  seedLocation  castType
0             0              0             0         1
1             0              0             0         2
2             3              0             0         2
3             1              0             1         0
4             0              0             1         1
```

[98]:
```
# Define the target variable and feature set
X = df_label_encoded.drop(columns=['Lifespan'])  # Features
y = df_label_encoded['Lifespan']  # Target

# Split the dataset into training and testing sets (80% train, 20% test)
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,␣
↪random_state=42)

# Display the shapes of the training and testing sets to verify
print("X_train shape:", X_train.shape)
print("X_test shape:", X_test.shape)
print("y_train shape:", y_train.shape)
print("y_test shape:", y_test.shape)
```

```
X_train shape: (800, 15)
X_test shape: (200, 15)
y_train shape: (800,)
y_test shape: (200,)
```

[99]:
```
# Initialize the Random Forest Regressor
rf_model = RandomForestRegressor(n_estimators=100, random_state=42)

# Fit the model to the training data
rf_model.fit(X_train, y_train)
```

```python
# Make predictions on the test set
y_pred = rf_model.predict(X_test)

# Evaluate the model using RMSE, R² Score, and MAE
rmse = root_mean_squared_error(y_test, y_pred)  # Root Mean Squared Error
r2 = r2_score(y_test, y_pred)  # R² Score
mae = mean_absolute_error(y_test, y_pred)  # Mean Absolute Error
msle = mean_squared_log_error(y_test, y_pred)  # Mean Squared Log Error

print(f"Root Mean Squared Error (RMSE): {rmse:.2f}")
print(f"R\u00b2 Score: {r2:.2f}")
print(f"Mean Absolute Error (MAE): {mae:.2f}")
print(f"Mean Squared Log Error (MSLE): {msle:.2f}")
```

```
Root Mean Squared Error (RMSE): 90.95
R² Score: 0.92
Mean Absolute Error (MAE): 72.50
Mean Squared Log Error (MSLE): 0.01
```

[100]:

```python
# Define the parameter grid for Random Forest
param_grid = {
    'n_estimators': [50, 100, 200],  # Number of trees
    'max_depth': [None, 10, 20, 30],  # Maximum depth of the tree
    'min_samples_split': [2, 5, 10],  # Minimum samples required to split a node
    'min_samples_leaf': [1, 2, 4],  # Minimum samples required at a leaf node
    'max_features': ['sqrt', 'log2', None]  # Corrected values for max_features
}

# Initialize the Random Forest Regressor
rf_model = RandomForestRegressor(random_state=42)

# Use GridSearchCV to find the best hyperparameters
grid_search = GridSearchCV(estimator=rf_model, param_grid=param_grid,
                           cv=3, n_jobs=-1, verbose=2,␣
 ↪scoring='neg_mean_squared_error')

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

# Get the best estimator and parameters
best_rf_model = grid_search.best_estimator_
print("Best parameters found by GridSearchCV:", grid_search.best_params_)
```

```
Fitting 3 folds for each of 324 candidates, totalling 972 fits
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
```

```
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=2, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=2, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=2, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=2, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=2, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=10, n_estimators=50; total time=   0.0s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=2, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=10, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=10, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=10, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=5, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=5, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
```

```
min_samples_split=5, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=2, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=2, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=2, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=1,
min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=2, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=10, n_estimators=50; total time=   0.0s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=2, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=2, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=10, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=10, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
```

```
min_samples_split=5, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=5, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=5, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=10, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=2, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=2, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=2, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=10, n_estimators=50; total time=   0.0s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=2, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=2,
min_samples_split=10, n_estimators=200; total time=   0.3s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=2, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=2, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=10, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
```

```
min_samples_split=10, n_estimators=100; total time=   0.1s
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min_samples_split=10, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=5, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=5, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=5, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=10, n_estimators=200; total time=   0.2s
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min_samples_split=2, n_estimators=100; total time=   0.1s
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min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
min_samples_split=2, n_estimators=100; total time=   0.2s
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min_samples_split=2, n_estimators=100; total time=   0.2s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=10, n_estimators=200; total time=   0.2s
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min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
min_samples_split=5, n_estimators=100; total time=   0.1s
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min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
min_samples_split=2, n_estimators=200; total time=   0.3s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
min_samples_split=2, n_estimators=200; total time=   0.3s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
```

```
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
min_samples_split=2, n_estimators=200; total time=   0.3s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=2,
min_samples_split=2, n_estimators=50; total time=   0.0s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
min_samples_split=10, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
min_samples_split=10, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=2,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
min_samples_split=5, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
min_samples_split=10, n_estimators=100; total time=   0.1s
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min_samples_split=2, n_estimators=50; total time=   0.1s
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min_samples_split=5, n_estimators=200; total time=   0.2s
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min_samples_split=5, n_estimators=200; total time=   0.2s
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min_samples_split=5, n_estimators=50; total time=   0.1s
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min_samples_split=2, n_estimators=100; total time=   0.1s
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min_samples_split=5, n_estimators=50; total time=   0.1s
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min_samples_split=2, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=2,
min_samples_split=5, n_estimators=50; total time=   0.1s
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min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=2,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=2,
min_samples_split=2, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=2,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=2,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=2,
```

```
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=2,
min_samples_split=2, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=2,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=2,
min_samples_split=2, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=2,
min_samples_split=10, n_estimators=50; total time=   0.1s
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min_samples_split=10, n_estimators=100; total time=   0.1s
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min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=2,
min_samples_split=10, n_estimators=100; total time=   0.1s
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min_samples_split=2, n_estimators=50; total time=   0.1s
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min_samples_split=10, n_estimators=100; total time=   0.1s
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[CV] END max_depth=None, max_features=log2, min_samples_leaf=2,
min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=2,
min_samples_split=5, n_estimators=200; total time=   0.3s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=4,
min_samples_split=2, n_estimators=100; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=4,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=4,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=4,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=4,
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[CV] END max_depth=None, max_features=log2, min_samples_leaf=4,
```

```
min_samples_split=2, n_estimators=200; total time=   0.2s
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[CV] END max_depth=None, max_features=log2, min_samples_leaf=4,
min_samples_split=2, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=4,
min_samples_split=5, n_estimators=100; total time=   0.1s
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min_samples_split=10, n_estimators=50; total time=   0.1s
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[CV] END max_depth=None, max_features=log2, min_samples_leaf=4,
min_samples_split=10, n_estimators=50; total time=   0.1s
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[CV] END max_depth=None, max_features=log2, min_samples_leaf=4,
min_samples_split=10, n_estimators=100; total time=   0.1s
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min_samples_split=5, n_estimators=200; total time=   0.3s
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min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=None, max_features=None, min_samples_leaf=1,
min_samples_split=2, n_estimators=50; total time=   0.2s
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min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=None, min_samples_leaf=1,
min_samples_split=5, n_estimators=50; total time=   0.2s
[CV] END max_depth=None, max_features=None, min_samples_leaf=1,
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[CV] END max_depth=None, max_features=None, min_samples_leaf=1,
min_samples_split=5, n_estimators=50; total time=   0.2s
[CV] END max_depth=None, max_features=None, min_samples_leaf=1,
min_samples_split=2, n_estimators=100; total time=   0.3s
[CV] END max_depth=None, max_features=None, min_samples_leaf=1,
```

```
min_samples_split=2, n_estimators=100; total time=   0.3s
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min_samples_split=5, n_estimators=100; total time=   0.3s
[CV] END max_depth=None, max_features=None, min_samples_leaf=1,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=None, min_samples_leaf=1,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=None, min_samples_leaf=1,
min_samples_split=5, n_estimators=100; total time=   0.3s
[CV] END max_depth=None, max_features=None, min_samples_leaf=1,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=None, min_samples_leaf=1,
min_samples_split=2, n_estimators=200; total time=   0.6s
[CV] END max_depth=None, max_features=None, min_samples_leaf=1,
min_samples_split=2, n_estimators=200; total time=   0.6s
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min_samples_split=10, n_estimators=100; total time=   0.2s
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min_samples_split=10, n_estimators=100; total time=   0.2s
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min_samples_split=2, n_estimators=200; total time=   0.7s
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min_samples_split=2, n_estimators=50; total time=   0.1s
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min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=None, min_samples_leaf=1,
min_samples_split=5, n_estimators=200; total time=   0.5s
[CV] END max_depth=None, max_features=None, min_samples_leaf=1,
min_samples_split=5, n_estimators=200; total time=   0.6s
[CV] END max_depth=None, max_features=None, min_samples_leaf=2,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=None, min_samples_leaf=2,
min_samples_split=2, n_estimators=100; total time=   0.3s
[CV] END max_depth=None, max_features=None, min_samples_leaf=1,
min_samples_split=10, n_estimators=200; total time=   0.4s
[CV] END max_depth=None, max_features=None, min_samples_leaf=1,
min_samples_split=10, n_estimators=200; total time=   0.4s
[CV] END max_depth=None, max_features=None, min_samples_leaf=2,
```

```
min_samples_split=2, n_estimators=100; total time=   0.2s
[CV] END max_depth=None, max_features=None, min_samples_leaf=2,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=None, min_samples_leaf=2,
min_samples_split=2, n_estimators=100; total time=   0.3s
[CV] END max_depth=None, max_features=None, min_samples_leaf=1,
min_samples_split=10, n_estimators=200; total time=   0.4s
[CV] END max_depth=None, max_features=None, min_samples_leaf=2,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=None, min_samples_leaf=2,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=None, max_features=None, min_samples_leaf=2,
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min_samples_split=2, n_estimators=100; total time=   0.1s
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min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=10, max_features=log2, min_samples_leaf=1,
min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=10, max_features=log2, min_samples_leaf=1,
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[CV] END max_depth=10, max_features=log2, min_samples_leaf=2,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=10, max_features=log2, min_samples_leaf=2,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=10, max_features=log2, min_samples_leaf=2,
```

```
min_samples_split=10, n_estimators=50; total time=   0.1s
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min_samples_split=10, n_estimators=50; total time=   0.0s
[CV] END max_depth=10, max_features=log2, min_samples_leaf=2,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=10, max_features=log2, min_samples_leaf=2,
min_samples_split=2, n_estimators=200; total time=   0.2s
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min_samples_split=2, n_estimators=200; total time=   0.2s
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min_samples_split=5, n_estimators=100; total time=   0.1s
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min_samples_split=2, n_estimators=200; total time=   0.2s
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min_samples_split=10, n_estimators=50; total time=   0.0s
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min_samples_split=2, n_estimators=50; total time=   0.1s
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min_samples_split=5, n_estimators=200; total time=   0.2s
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min_samples_split=5, n_estimators=200; total time=   0.2s
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min_samples_split=5, n_estimators=50; total time=   0.1s
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[CV] END max_depth=10, max_features=log2, min_samples_leaf=2,
min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=10, max_features=log2, min_samples_leaf=4,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=10, max_features=log2, min_samples_leaf=2,
```

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min_samples_split=10, n_estimators=200; total time=   0.2s
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[CV] END max_depth=10, max_features=log2, min_samples_leaf=4,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=10, max_features=log2, min_samples_leaf=4,
min_samples_split=10, n_estimators=50; total time=   0.0s
[CV] END max_depth=10, max_features=log2, min_samples_leaf=4,
min_samples_split=10, n_estimators=50; total time=   0.0s
[CV] END max_depth=10, max_features=log2, min_samples_leaf=4,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=10, max_features=log2, min_samples_leaf=4,
min_samples_split=5, n_estimators=100; total time=   0.1s
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min_samples_split=2, n_estimators=200; total time=   0.2s
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min_samples_split=2, n_estimators=200; total time=   0.2s
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min_samples_split=10, n_estimators=100; total time=   0.1s
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min_samples_split=5, n_estimators=200; total time=   0.2s
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min_samples_split=5, n_estimators=200; total time=   0.2s
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min_samples_split=5, n_estimators=200; total time=   0.2s
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min_samples_split=2, n_estimators=50; total time=   0.1s
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[CV] END max_depth=10, max_features=log2, min_samples_leaf=4,
min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=10, max_features=log2, min_samples_leaf=4,
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[CV] END max_depth=10, max_features=None, min_samples_leaf=1,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=10, max_features=None, min_samples_leaf=1,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=10, max_features=None, min_samples_leaf=1,
```

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min_samples_split=5, n_estimators=50; total time=   0.1s
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min_samples_split=2, n_estimators=100; total time=   0.3s
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min_samples_split=2, n_estimators=100; total time=   0.3s
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min_samples_split=2, n_estimators=100; total time=   0.3s
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min_samples_split=5, n_estimators=100; total time=   0.3s
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min_samples_split=5, n_estimators=100; total time=   0.3s
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min_samples_split=10, n_estimators=50; total time=   0.1s
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min_samples_split=5, n_estimators=100; total time=   0.3s
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min_samples_split=10, n_estimators=50; total time=   0.2s
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min_samples_split=2, n_estimators=200; total time=   0.5s
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min_samples_split=10, n_estimators=100; total time=   0.2s
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min_samples_split=2, n_estimators=200; total time=   0.6s
[CV] END max_depth=10, max_features=None, min_samples_leaf=1,
min_samples_split=2, n_estimators=200; total time=   0.6s
[CV] END max_depth=10, max_features=None, min_samples_leaf=1,
min_samples_split=10, n_estimators=100; total time=   0.2s
[CV] END max_depth=10, max_features=None, min_samples_leaf=1,
min_samples_split=5, n_estimators=200; total time=   0.5s
[CV] END max_depth=10, max_features=None, min_samples_leaf=2,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=10, max_features=None, min_samples_leaf=2,
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[CV] END max_depth=10, max_features=None, min_samples_leaf=2,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=10, max_features=None, min_samples_leaf=1,
min_samples_split=5, n_estimators=200; total time=   0.5s
[CV] END max_depth=10, max_features=None, min_samples_leaf=2,
min_samples_split=2, n_estimators=100; total time=   0.2s
[CV] END max_depth=10, max_features=None, min_samples_leaf=2,
```

```
min_samples_split=5, n_estimators=50; total time=   0.1s
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min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=10, max_features=None, min_samples_leaf=2,
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min_samples_split=2, n_estimators=100; total time=   0.3s
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min_samples_split=10, n_estimators=200; total time=   0.5s
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min_samples_split=10, n_estimators=200; total time=   0.5s
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min_samples_split=2, n_estimators=200; total time=   0.5s
[CV] END max_depth=10, max_features=None, min_samples_leaf=4,
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[CV] END max_depth=10, max_features=None, min_samples_leaf=4,
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min_samples_split=10, n_estimators=100; total time=   0.3s
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min_samples_split=10, n_estimators=100; total time=   0.3s
[CV] END max_depth=10, max_features=None, min_samples_leaf=2,
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```

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[CV] END max_depth=10, max_features=None, min_samples_leaf=2,
min_samples_split=10, n_estimators=200; total time=   0.4s
[CV] END max_depth=10, max_features=None, min_samples_leaf=4,
min_samples_split=5, n_estimators=50; total time=   0.1s
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[CV] END max_depth=10, max_features=None, min_samples_leaf=2,
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[CV] END max_depth=10, max_features=None, min_samples_leaf=2,
min_samples_split=10, n_estimators=200; total time=   0.5s
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min_samples_split=5, n_estimators=100; total time=   0.2s
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min_samples_split=2, n_estimators=200; total time=   0.5s
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min_samples_split=2, n_estimators=200; total time=   0.4s
[CV] END max_depth=10, max_features=None, min_samples_leaf=4,
min_samples_split=2, n_estimators=200; total time=   0.4s
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min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=20, max_features=sqrt, min_samples_leaf=1,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=10, max_features=None, min_samples_leaf=4,
min_samples_split=10, n_estimators=100; total time=   0.2s
[CV] END max_depth=10, max_features=None, min_samples_leaf=4,
min_samples_split=10, n_estimators=100; total time=   0.2s
[CV] END max_depth=10, max_features=None, min_samples_leaf=4,
```

```
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min_samples_split=5, n_estimators=200; total time=   0.4s
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min_samples_split=5, n_estimators=200; total time=   0.5s
[CV] END max_depth=10, max_features=None, min_samples_leaf=4,
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min_samples_split=5, n_estimators=100; total time=   0.1s
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min_samples_split=5, n_estimators=100; total time=   0.1s
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min_samples_split=2, n_estimators=200; total time=   0.3s
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min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=10, max_features=None, min_samples_leaf=4,
min_samples_split=10, n_estimators=200; total time=   0.4s
[CV] END max_depth=20, max_features=sqrt, min_samples_leaf=1,
min_samples_split=10, n_estimators=50; total time=   0.0s
[CV] END max_depth=20, max_features=sqrt, min_samples_leaf=1,
min_samples_split=10, n_estimators=50; total time=   0.0s
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min_samples_split=2, n_estimators=200; total time=   0.3s
[CV] END max_depth=20, max_features=sqrt, min_samples_leaf=2,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=20, max_features=sqrt, min_samples_leaf=2,
```

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[CV] END max_depth=20, max_features=sqrt, min_samples_leaf=1,
min_samples_split=10, n_estimators=100; total time=   0.1s
[CV] END max_depth=20, max_features=sqrt, min_samples_leaf=1,
min_samples_split=10, n_estimators=100; total time=   0.1s
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```

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```

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```

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min_samples_split=10, n_estimators=100; total time=   0.2s
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min_samples_split=2, n_estimators=200; total time=   0.6s
[CV] END max_depth=20, max_features=None, min_samples_leaf=1,
min_samples_split=10, n_estimators=100; total time=   0.2s
[CV] END max_depth=20, max_features=None, min_samples_leaf=1,
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min_samples_split=2, n_estimators=50; total time=   0.1s
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min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=20, max_features=None, min_samples_leaf=1,
min_samples_split=5, n_estimators=200; total time=   0.5s
```

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min_samples_split=5, n_estimators=200; total time=   0.5s
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min_samples_split=2, n_estimators=50; total time=   0.1s
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min_samples_split=5, n_estimators=50; total time=   0.1s
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min_samples_split=10, n_estimators=200; total time=   0.4s
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min_samples_split=2, n_estimators=100; total time=   0.2s
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min_samples_split=2, n_estimators=100; total time=   0.2s
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[CV] END max_depth=20, max_features=None, min_samples_leaf=2,
min_samples_split=10, n_estimators=100; total time=   0.2s
```

```
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min_samples_split=10, n_estimators=100; total time=   0.2s
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[CV] END max_depth=30, max_features=sqrt, min_samples_leaf=1,
min_samples_split=2, n_estimators=50; total time=   0.1s
```

```
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min_samples_split=10, n_estimators=100; total time=   0.2s
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min_samples_split=5, n_estimators=200; total time=   0.5s
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min_samples_split=5, n_estimators=100; total time=   0.1s
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min_samples_split=10, n_estimators=50; total time=   0.1s
```

```
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```

```
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```

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```

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min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=1,
min_samples_split=10, n_estimators=50; total time=   0.0s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=1,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=1,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=1,
min_samples_split=10, n_estimators=50; total time=   0.0s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=1,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=1,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=1,
min_samples_split=2, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=1,
min_samples_split=2, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=1,
min_samples_split=2, n_estimators=200; total time=   0.3s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=1,
min_samples_split=10, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=1,
min_samples_split=10, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=1,
min_samples_split=5, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=1,
min_samples_split=5, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=1,
min_samples_split=10, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=1,
min_samples_split=5, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
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min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=1,
min_samples_split=10, n_estimators=200; total time=   0.2s
```

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[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=2, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=2, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=1,
min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=1,
min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=2, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=2, n_estimators=200; total time=   0.3s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=10, n_estimators=50; total time=   0.0s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=2, n_estimators=200; total time=   0.3s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=10, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=10, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=5, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=10, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=5, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=5, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=5, n_estimators=50; total time=   0.1s
```

```
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=2, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=2,
min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=2, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=2, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=2, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=5, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=2, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=2, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=10, n_estimators=50; total time=   0.0s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=5, n_estimators=200; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=10, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=10, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=10, n_estimators=100; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=5, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=10, n_estimators=200; total time=   0.2s
```

```
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=10, n_estimators=200; total time=   0.2s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=2, n_estimators=50; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=4,
min_samples_split=5, n_estimators=200; total time=   0.3s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=2, n_estimators=50; total time=   0.2s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=5, n_estimators=50; total time=   0.2s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=5, n_estimators=50; total time=   0.2s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=2, n_estimators=100; total time=   0.3s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=2, n_estimators=100; total time=   0.3s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=2, n_estimators=100; total time=   0.3s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=5, n_estimators=100; total time=   0.3s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=5, n_estimators=100; total time=   0.3s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=5, n_estimators=100; total time=   0.3s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=2, n_estimators=200; total time=   0.5s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=10, n_estimators=100; total time=   0.2s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=2, n_estimators=200; total time=   0.6s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=10, n_estimators=100; total time=   0.2s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=10, n_estimators=100; total time=   0.3s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=2, n_estimators=200; total time=   0.6s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=5, n_estimators=200; total time=   0.5s
```

```
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=5, n_estimators=200; total time=   0.5s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=5, n_estimators=200; total time=   0.5s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=2, n_estimators=100; total time=   0.3s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=10, n_estimators=200; total time=   0.5s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=2, n_estimators=100; total time=   0.3s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=10, n_estimators=200; total time=   0.4s
[CV] END max_depth=30, max_features=None, min_samples_leaf=1,
min_samples_split=10, n_estimators=200; total time=   0.4s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=2, n_estimators=100; total time=   0.3s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=5, n_estimators=100; total time=   0.2s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=5, n_estimators=100; total time=   0.2s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=5, n_estimators=100; total time=   0.2s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=2, n_estimators=200; total time=   0.4s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=2, n_estimators=200; total time=   0.5s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=2, n_estimators=200; total time=   0.5s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=2, n_estimators=50; total time=   0.1s
```

```
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=10, n_estimators=100; total time=   0.3s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=10, n_estimators=100; total time=   0.3s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=10, n_estimators=100; total time=   0.3s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=5, n_estimators=200; total time=   0.5s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=5, n_estimators=200; total time=   0.5s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=5, n_estimators=200; total time=   0.5s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=2, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=2, n_estimators=100; total time=   0.2s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=2, n_estimators=100; total time=   0.2s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=10, n_estimators=200; total time=   0.4s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=5, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=2, n_estimators=100; total time=   0.2s
[CV] END max_depth=30, max_features=None, min_samples_leaf=2,
min_samples_split=10, n_estimators=200; total time=   0.5s
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min_samples_split=10, n_estimators=200; total time=   0.5s
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[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=2, n_estimators=200; total time=   0.4s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=5, n_estimators=100; total time=   0.2s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=2, n_estimators=200; total time=   0.4s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=5, n_estimators=100; total time=   0.2s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=5, n_estimators=100; total time=   0.2s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=10, n_estimators=50; total time=   0.1s
```

```
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=2, n_estimators=200; total time=   0.4s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=10, n_estimators=50; total time=   0.1s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=10, n_estimators=100; total time=   0.2s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=10, n_estimators=100; total time=   0.2s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=5, n_estimators=200; total time=   0.4s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=5, n_estimators=200; total time=   0.4s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=10, n_estimators=100; total time=   0.2s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=5, n_estimators=200; total time=   0.4s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=10, n_estimators=200; total time=   0.3s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=10, n_estimators=200; total time=   0.3s
[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=10, n_estimators=200; total time=   0.4s
Best parameters found by GridSearchCV: {'max_depth': None, 'max_features': None,
'min_samples_leaf': 2, 'min_samples_split': 2, 'n_estimators': 200}
```

[102]:

```
# Define the parameter distributions for RandomizedSearchCV
param_distributions = {
    'n_estimators': randint(100, 500),  # Randomly sample number of trees␣
 ↪between 100 and 500
    'max_depth': [None] + list(range(10, 50, 5)),  # None or range from 10 to␣
 ↪50, step 5
    'min_samples_split': randint(2, 20),  # Random split values between 2 and 20
    'min_samples_leaf': randint(1, 10),  # Random leaf values between 1 and 10
    'max_features': ['sqrt', 'log2', None]  # Use predefined feature subsets
}

# Initialize the Random Forest Regressor
rf_model = RandomForestRegressor(random_state=42)

# Use RandomizedSearchCV to find the best hyperparameters
random_search = RandomizedSearchCV(estimator=rf_model,␣
 ↪param_distributions=param_distributions,
                                   n_iter=100, cv=3, verbose=2,␣
 ↪random_state=42, n_jobs=-1,
                                   scoring='neg_mean_squared_error')

# Fit the model to the training data
```

```python
random_search.fit(X_train, y_train)

# Get the best estimator and parameters
best_rf_model = random_search.best_estimator_
print("Best parameters found by RandomizedSearchCV:", random_search.
 ↪best_params_)
```

```
Fitting 3 folds for each of 100 candidates, totalling 300 fits
[CV] END max_depth=35, max_features=sqrt, min_samples_leaf=8,
min_samples_split=8, n_estimators=221; total time=   0.2s
[CV] END max_depth=35, max_features=sqrt, min_samples_leaf=8,
min_samples_split=8, n_estimators=221; total time=   0.2s
[CV] END max_depth=35, max_features=sqrt, min_samples_leaf=8,
min_samples_split=8, n_estimators=221; total time=   0.2s
[CV] END max_depth=30, max_features=sqrt, min_samples_leaf=9,
min_samples_split=18, n_estimators=158; total time=   0.2s
[CV] END max_depth=30, max_features=sqrt, min_samples_leaf=9,
min_samples_split=18, n_estimators=158; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=5,
min_samples_split=2, n_estimators=413; total time=   0.4s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=5,
min_samples_split=2, n_estimators=413; total time=   0.4s
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min_samples_split=18, n_estimators=158; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=5,
min_samples_split=2, n_estimators=413; total time=   0.4s
[CV] END max_depth=35, max_features=sqrt, min_samples_leaf=9,
min_samples_split=8, n_estimators=373; total time=   0.3s
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min_samples_split=5, n_estimators=459; total time=   0.8s
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min_samples_split=5, n_estimators=459; total time=   0.8s
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min_samples_split=3, n_estimators=443; total time=   0.9s
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min_samples_split=3, n_estimators=443; total time=   0.9s
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[CV] END max_depth=15, max_features=log2, min_samples_leaf=1,
min_samples_split=5, n_estimators=149; total time=   0.2s
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min_samples_split=8, n_estimators=373; total time=   0.3s
[CV] END max_depth=15, max_features=None, min_samples_leaf=4,
min_samples_split=4, n_estimators=406; total time=   0.8s
```

```
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min_samples_split=16, n_estimators=363; total time=   0.4s
[CV] END max_depth=40, max_features=log2, min_samples_leaf=6,
min_samples_split=11, n_estimators=359; total time=   0.4s
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[CV] END max_depth=20, max_features=sqrt, min_samples_leaf=2,
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[CV] END max_depth=30, max_features=sqrt, min_samples_leaf=2,
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min_samples_split=10, n_estimators=443; total time=   0.4s
```

```
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[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=7,
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[CV] END max_depth=40, max_features=log2, min_samples_leaf=3,
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[CV] END max_depth=25, max_features=None, min_samples_leaf=3,
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[CV] END max_depth=45, max_features=None, min_samples_leaf=9,
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min_samples_split=18, n_estimators=491; total time=   1.1s
[CV] END max_depth=15, max_features=None, min_samples_leaf=1,
min_samples_split=6, n_estimators=330; total time=   1.0s
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[CV] END max_depth=None, max_features=None, min_samples_leaf=3,
min_samples_split=18, n_estimators=491; total time=   1.0s
[CV] END max_depth=35, max_features=None, min_samples_leaf=7,
min_samples_split=10, n_estimators=306; total time=   0.6s
[CV] END max_depth=20, max_features=sqrt, min_samples_leaf=7,
min_samples_split=3, n_estimators=269; total time=   0.2s
[CV] END max_depth=20, max_features=log2, min_samples_leaf=5,
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[CV] END max_depth=20, max_features=log2, min_samples_leaf=5,
min_samples_split=8, n_estimators=336; total time=   0.3s
[CV] END max_depth=45, max_features=sqrt, min_samples_leaf=6,
min_samples_split=13, n_estimators=143; total time=   0.1s
```

```
[CV] END max_depth=35, max_features=None, min_samples_leaf=7,
min_samples_split=10, n_estimators=306; total time=   0.6s
[CV] END max_depth=15, max_features=None, min_samples_leaf=7,
min_samples_split=18, n_estimators=151; total time=   0.3s
[CV] END max_depth=45, max_features=sqrt, min_samples_leaf=6,
min_samples_split=13, n_estimators=143; total time=   0.2s
[CV] END max_depth=20, max_features=sqrt, min_samples_leaf=7,
min_samples_split=3, n_estimators=269; total time=   0.2s
[CV] END max_depth=45, max_features=None, min_samples_leaf=9,
min_samples_split=9, n_estimators=367; total time=   0.7s
[CV] END max_depth=20, max_features=sqrt, min_samples_leaf=7,
min_samples_split=3, n_estimators=269; total time=   0.3s
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[CV] END max_depth=15, max_features=None, min_samples_leaf=7,
min_samples_split=18, n_estimators=151; total time=   0.3s
[CV] END max_depth=20, max_features=log2, min_samples_leaf=5,
min_samples_split=8, n_estimators=336; total time=   0.4s
[CV] END max_depth=20, max_features=log2, min_samples_leaf=7,
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[CV] END max_depth=35, max_features=None, min_samples_leaf=7,
min_samples_split=10, n_estimators=306; total time=   0.6s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=9,
min_samples_split=14, n_estimators=332; total time=   0.3s
[CV] END max_depth=20, max_features=log2, min_samples_leaf=7,
min_samples_split=8, n_estimators=289; total time=   0.3s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=9,
min_samples_split=14, n_estimators=332; total time=   0.3s
[CV] END max_depth=25, max_features=sqrt, min_samples_leaf=3,
min_samples_split=11, n_estimators=271; total time=   0.2s
[CV] END max_depth=25, max_features=sqrt, min_samples_leaf=3,
min_samples_split=11, n_estimators=271; total time=   0.3s
[CV] END max_depth=15, max_features=None, min_samples_leaf=1,
min_samples_split=6, n_estimators=330; total time=   0.9s
[CV] END max_depth=20, max_features=log2, min_samples_leaf=7,
min_samples_split=8, n_estimators=289; total time=   0.3s
[CV] END max_depth=15, max_features=None, min_samples_leaf=6,
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[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=9,
min_samples_split=14, n_estimators=332; total time=   0.3s
[CV] END max_depth=15, max_features=None, min_samples_leaf=1,
min_samples_split=6, n_estimators=330; total time=   0.9s
[CV] END max_depth=None, max_features=None, min_samples_leaf=3,
min_samples_split=18, n_estimators=491; total time=   1.0s
[CV] END max_depth=25, max_features=sqrt, min_samples_leaf=3,
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[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
min_samples_split=13, n_estimators=394; total time=   0.4s
```

```
[CV] END max_depth=40, max_features=None, min_samples_leaf=6,
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[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
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[CV] END max_depth=15, max_features=None, min_samples_leaf=6,
min_samples_split=9, n_estimators=236; total time=   0.5s
[CV] END max_depth=40, max_features=sqrt, min_samples_leaf=1,
min_samples_split=3, n_estimators=229; total time=   0.2s
[CV] END max_depth=40, max_features=None, min_samples_leaf=6,
min_samples_split=10, n_estimators=279; total time=   0.5s
[CV] END max_depth=40, max_features=sqrt, min_samples_leaf=1,
min_samples_split=3, n_estimators=229; total time=   0.4s
[CV] END max_depth=15, max_features=log2, min_samples_leaf=2,
min_samples_split=13, n_estimators=317; total time=   0.3s
[CV] END max_depth=10, max_features=None, min_samples_leaf=1,
min_samples_split=6, n_estimators=212; total time=   0.5s
[CV] END max_depth=15, max_features=None, min_samples_leaf=6,
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[CV] END max_depth=None, max_features=log2, min_samples_leaf=1,
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[CV] END max_depth=40, max_features=sqrt, min_samples_leaf=1,
min_samples_split=3, n_estimators=229; total time=   0.3s
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[CV] END max_depth=10, max_features=log2, min_samples_leaf=6,
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[CV] END max_depth=30, max_features=None, min_samples_leaf=4,
min_samples_split=12, n_estimators=283; total time=   0.6s
[CV] END max_depth=30, max_features=None, min_samples_leaf=5,
min_samples_split=2, n_estimators=484; total time=   1.0s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=6,
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[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=6,
min_samples_split=17, n_estimators=448; total time=   0.4s
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min_samples_split=2, n_estimators=484; total time=   1.0s
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```

```
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min_samples_split=12, n_estimators=339; total time=   0.3s
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min_samples_split=18, n_estimators=101; total time=   0.1s
[CV] END max_depth=45, max_features=sqrt, min_samples_leaf=2,
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[CV] END max_depth=15, max_features=None, min_samples_leaf=4,
min_samples_split=4, n_estimators=246; total time=   0.5s
[CV] END max_depth=35, max_features=log2, min_samples_leaf=9,
min_samples_split=18, n_estimators=101; total time=   0.1s
[CV] END max_depth=20, max_features=None, min_samples_leaf=4,
min_samples_split=10, n_estimators=227; total time=   0.5s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=5,
min_samples_split=6, n_estimators=259; total time=   0.2s
[CV] END max_depth=20, max_features=None, min_samples_leaf=4,
min_samples_split=10, n_estimators=227; total time=   0.5s
[CV] END max_depth=15, max_features=None, min_samples_leaf=4,
min_samples_split=4, n_estimators=246; total time=   0.6s
[CV] END max_depth=35, max_features=log2, min_samples_leaf=8,
min_samples_split=2, n_estimators=366; total time=   0.4s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=5,
min_samples_split=6, n_estimators=259; total time=   0.2s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=5,
min_samples_split=6, n_estimators=259; total time=   0.3s
[CV] END max_depth=35, max_features=sqrt, min_samples_leaf=9,
min_samples_split=4, n_estimators=246; total time=   0.2s
[CV] END max_depth=35, max_features=sqrt, min_samples_leaf=9,
min_samples_split=4, n_estimators=246; total time=   0.2s
```

```
[CV] END max_depth=35, max_features=sqrt, min_samples_leaf=9,
min_samples_split=4, n_estimators=246; total time=   0.2s
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[CV] END max_depth=15, max_features=log2, min_samples_leaf=8,
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[CV] END max_depth=None, max_features=log2, min_samples_leaf=8,
min_samples_split=4, n_estimators=211; total time=   0.2s
[CV] END max_depth=35, max_features=log2, min_samples_leaf=8,
min_samples_split=2, n_estimators=366; total time=   0.3s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=8,
min_samples_split=4, n_estimators=211; total time=   0.2s
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min_samples_split=2, n_estimators=215; total time=   0.2s
[CV] END max_depth=15, max_features=log2, min_samples_leaf=8,
min_samples_split=2, n_estimators=215; total time=   0.2s
[CV] END max_depth=None, max_features=log2, min_samples_leaf=8,
min_samples_split=4, n_estimators=211; total time=   0.2s
[CV] END max_depth=None, max_features=None, min_samples_leaf=6,
min_samples_split=6, n_estimators=471; total time=   0.8s
[CV] END max_depth=10, max_features=log2, min_samples_leaf=6,
min_samples_split=4, n_estimators=307; total time=   0.3s
[CV] END max_depth=10, max_features=log2, min_samples_leaf=6,
min_samples_split=4, n_estimators=307; total time=   0.3s
[CV] END max_depth=10, max_features=log2, min_samples_leaf=6,
min_samples_split=4, n_estimators=307; total time=   0.3s
[CV] END max_depth=45, max_features=sqrt, min_samples_leaf=4,
min_samples_split=2, n_estimators=497; total time=   0.4s
[CV] END max_depth=25, max_features=None, min_samples_leaf=3,
min_samples_split=18, n_estimators=227; total time=   0.4s
[CV] END max_depth=45, max_features=sqrt, min_samples_leaf=4,
min_samples_split=2, n_estimators=497; total time=   0.5s
[CV] END max_depth=25, max_features=None, min_samples_leaf=3,
min_samples_split=18, n_estimators=227; total time=   0.5s
[CV] END max_depth=45, max_features=sqrt, min_samples_leaf=4,
min_samples_split=2, n_estimators=497; total time=   0.5s
[CV] END max_depth=45, max_features=None, min_samples_leaf=9,
min_samples_split=19, n_estimators=483; total time=   0.8s
[CV] END max_depth=45, max_features=None, min_samples_leaf=9,
min_samples_split=19, n_estimators=483; total time=   0.8s
[CV] END max_depth=25, max_features=None, min_samples_leaf=3,
min_samples_split=18, n_estimators=227; total time=   0.5s
[CV] END max_depth=None, max_features=None, min_samples_leaf=3,
min_samples_split=15, n_estimators=257; total time=   0.4s
[CV] END max_depth=None, max_features=None, min_samples_leaf=3,
min_samples_split=15, n_estimators=257; total time=   0.5s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=3,
min_samples_split=9, n_estimators=382; total time=   0.4s
```

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[CV] END max_depth=30, max_features=log2, min_samples_leaf=3,
min_samples_split=9, n_estimators=382; total time=   0.4s
[CV] END max_depth=None, max_features=None, min_samples_leaf=3,
min_samples_split=15, n_estimators=257; total time=   0.5s
[CV] END max_depth=10, max_features=sqrt, min_samples_leaf=1,
min_samples_split=16, n_estimators=416; total time=   0.3s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=3,
min_samples_split=9, n_estimators=382; total time=   0.4s
[CV] END max_depth=45, max_features=None, min_samples_leaf=9,
min_samples_split=19, n_estimators=483; total time=   0.9s
[CV] END max_depth=10, max_features=sqrt, min_samples_leaf=1,
min_samples_split=16, n_estimators=416; total time=   0.3s
[CV] END max_depth=25, max_features=log2, min_samples_leaf=3,
min_samples_split=10, n_estimators=136; total time=   0.1s
[CV] END max_depth=25, max_features=log2, min_samples_leaf=3,
min_samples_split=10, n_estimators=136; total time=   0.1s
[CV] END max_depth=25, max_features=log2, min_samples_leaf=3,
min_samples_split=10, n_estimators=136; total time=   0.1s
[CV] END max_depth=10, max_features=sqrt, min_samples_leaf=1,
min_samples_split=16, n_estimators=416; total time=   0.4s
[CV] END max_depth=40, max_features=sqrt, min_samples_leaf=1,
min_samples_split=15, n_estimators=280; total time=   0.3s
[CV] END max_depth=40, max_features=sqrt, min_samples_leaf=1,
min_samples_split=15, n_estimators=280; total time=   0.2s
[CV] END max_depth=40, max_features=sqrt, min_samples_leaf=1,
min_samples_split=15, n_estimators=280; total time=   0.3s
[CV] END max_depth=15, max_features=log2, min_samples_leaf=9,
min_samples_split=11, n_estimators=322; total time=   0.3s
[CV] END max_depth=15, max_features=sqrt, min_samples_leaf=4,
min_samples_split=2, n_estimators=355; total time=   0.3s
[CV] END max_depth=15, max_features=sqrt, min_samples_leaf=4,
min_samples_split=2, n_estimators=355; total time=   0.3s
[CV] END max_depth=15, max_features=None, min_samples_leaf=1,
min_samples_split=18, n_estimators=271; total time=   0.5s
[CV] END max_depth=15, max_features=sqrt, min_samples_leaf=4,
min_samples_split=2, n_estimators=355; total time=   0.4s
[CV] END max_depth=15, max_features=log2, min_samples_leaf=9,
min_samples_split=11, n_estimators=322; total time=   0.3s
[CV] END max_depth=15, max_features=None, min_samples_leaf=1,
min_samples_split=18, n_estimators=271; total time=   0.6s
[CV] END max_depth=15, max_features=None, min_samples_leaf=1,
min_samples_split=18, n_estimators=271; total time=   0.5s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=3,
min_samples_split=9, n_estimators=273; total time=   0.3s
[CV] END max_depth=15, max_features=log2, min_samples_leaf=9,
min_samples_split=11, n_estimators=322; total time=   0.3s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=3,
min_samples_split=9, n_estimators=273; total time=   0.3s
```

```
[CV] END max_depth=40, max_features=log2, min_samples_leaf=6,
min_samples_split=3, n_estimators=226; total time=   0.2s
[CV] END max_depth=40, max_features=log2, min_samples_leaf=6,
min_samples_split=3, n_estimators=226; total time=   0.2s
[CV] END max_depth=30, max_features=log2, min_samples_leaf=3,
min_samples_split=9, n_estimators=273; total time=   0.2s
[CV] END max_depth=40, max_features=log2, min_samples_leaf=6,
min_samples_split=3, n_estimators=226; total time=   0.2s
[CV] END max_depth=45, max_features=sqrt, min_samples_leaf=7,
min_samples_split=5, n_estimators=272; total time=   0.3s
[CV] END max_depth=45, max_features=sqrt, min_samples_leaf=7,
min_samples_split=5, n_estimators=272; total time=   0.3s
[CV] END max_depth=10, max_features=log2, min_samples_leaf=1,
min_samples_split=9, n_estimators=492; total time=   0.5s
[CV] END max_depth=45, max_features=sqrt, min_samples_leaf=7,
min_samples_split=5, n_estimators=272; total time=   0.3s
[CV] END max_depth=10, max_features=log2, min_samples_leaf=1,
min_samples_split=9, n_estimators=492; total time=   0.5s
[CV] END max_depth=10, max_features=log2, min_samples_leaf=1,
min_samples_split=9, n_estimators=492; total time=   0.6s
[CV] END max_depth=20, max_features=sqrt, min_samples_leaf=8,
min_samples_split=15, n_estimators=499; total time=   0.5s
[CV] END max_depth=20, max_features=sqrt, min_samples_leaf=8,
min_samples_split=15, n_estimators=499; total time=   0.5s
[CV] END max_depth=30, max_features=None, min_samples_leaf=7,
min_samples_split=4, n_estimators=405; total time=   0.8s
[CV] END max_depth=30, max_features=None, min_samples_leaf=7,
min_samples_split=4, n_estimators=405; total time=   0.8s
[CV] END max_depth=30, max_features=None, min_samples_leaf=7,
min_samples_split=4, n_estimators=405; total time=   0.8s
[CV] END max_depth=20, max_features=sqrt, min_samples_leaf=8,
min_samples_split=15, n_estimators=499; total time=   0.6s
[CV] END max_depth=30, max_features=None, min_samples_leaf=6,
min_samples_split=12, n_estimators=200; total time=   0.4s
[CV] END max_depth=35, max_features=None, min_samples_leaf=6,
min_samples_split=18, n_estimators=279; total time=   0.6s
[CV] END max_depth=35, max_features=None, min_samples_leaf=6,
min_samples_split=18, n_estimators=279; total time=   0.6s
[CV] END max_depth=30, max_features=None, min_samples_leaf=6,
min_samples_split=12, n_estimators=200; total time=   0.3s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=5,
min_samples_split=8, n_estimators=295; total time=   0.3s
[CV] END max_depth=30, max_features=None, min_samples_leaf=6,
min_samples_split=12, n_estimators=200; total time=   0.4s
[CV] END max_depth=35, max_features=None, min_samples_leaf=6,
min_samples_split=18, n_estimators=279; total time=   0.6s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=5,
min_samples_split=8, n_estimators=295; total time=   0.3s
```

```
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=5,
min_samples_split=8, n_estimators=295; total time=   0.3s
[CV] END max_depth=15, max_features=None, min_samples_leaf=2,
min_samples_split=3, n_estimators=387; total time=   1.0s
[CV] END max_depth=15, max_features=None, min_samples_leaf=2,
min_samples_split=3, n_estimators=387; total time=   1.0s
[CV] END max_depth=35, max_features=sqrt, min_samples_leaf=2,
min_samples_split=11, n_estimators=257; total time=   0.2s
[CV] END max_depth=15, max_features=None, min_samples_leaf=2,
min_samples_split=3, n_estimators=387; total time=   1.0s
[CV] END max_depth=35, max_features=sqrt, min_samples_leaf=2,
min_samples_split=11, n_estimators=257; total time=   0.3s
[CV] END max_depth=35, max_features=sqrt, min_samples_leaf=2,
min_samples_split=11, n_estimators=257; total time=   0.3s
[CV] END max_depth=30, max_features=sqrt, min_samples_leaf=4,
min_samples_split=16, n_estimators=454; total time=   0.4s
[CV] END max_depth=15, max_features=sqrt, min_samples_leaf=8,
min_samples_split=6, n_estimators=216; total time=   0.2s
[CV] END max_depth=30, max_features=sqrt, min_samples_leaf=4,
min_samples_split=16, n_estimators=454; total time=   0.4s
[CV] END max_depth=30, max_features=sqrt, min_samples_leaf=4,
min_samples_split=16, n_estimators=454; total time=   0.4s
[CV] END max_depth=15, max_features=sqrt, min_samples_leaf=8,
min_samples_split=6, n_estimators=216; total time=   0.3s
[CV] END max_depth=15, max_features=sqrt, min_samples_leaf=8,
min_samples_split=6, n_estimators=216; total time=   0.2s
[CV] END max_depth=None, max_features=None, min_samples_leaf=2,
min_samples_split=17, n_estimators=188; total time=   0.3s
[CV] END max_depth=None, max_features=None, min_samples_leaf=2,
min_samples_split=17, n_estimators=188; total time=   0.4s
[CV] END max_depth=35, max_features=None, min_samples_leaf=9,
min_samples_split=13, n_estimators=228; total time=   0.4s
[CV] END max_depth=35, max_features=None, min_samples_leaf=9,
min_samples_split=13, n_estimators=228; total time=   0.4s
[CV] END max_depth=40, max_features=sqrt, min_samples_leaf=5,
min_samples_split=2, n_estimators=371; total time=   0.4s
[CV] END max_depth=35, max_features=None, min_samples_leaf=9,
min_samples_split=13, n_estimators=228; total time=   0.5s
[CV] END max_depth=40, max_features=sqrt, min_samples_leaf=5,
min_samples_split=2, n_estimators=371; total time=   0.3s
[CV] END max_depth=None, max_features=None, min_samples_leaf=2,
min_samples_split=17, n_estimators=188; total time=   0.4s
[CV] END max_depth=40, max_features=sqrt, min_samples_leaf=5,
min_samples_split=2, n_estimators=371; total time=   0.4s
[CV] END max_depth=35, max_features=None, min_samples_leaf=5,
min_samples_split=4, n_estimators=175; total time=   0.4s
[CV] END max_depth=35, max_features=None, min_samples_leaf=5,
min_samples_split=4, n_estimators=175; total time=   0.4s
```

```
[CV] END max_depth=35, max_features=None, min_samples_leaf=5,
min_samples_split=4, n_estimators=175; total time=   0.3s
[CV] END max_depth=15, max_features=sqrt, min_samples_leaf=6,
min_samples_split=15, n_estimators=319; total time=   0.3s
[CV] END max_depth=15, max_features=sqrt, min_samples_leaf=6,
min_samples_split=15, n_estimators=319; total time=   0.3s
[CV] END max_depth=15, max_features=sqrt, min_samples_leaf=6,
min_samples_split=15, n_estimators=319; total time=   0.4s
[CV] END max_depth=25, max_features=None, min_samples_leaf=6,
min_samples_split=6, n_estimators=199; total time=   0.4s
[CV] END max_depth=25, max_features=None, min_samples_leaf=1,
min_samples_split=15, n_estimators=303; total time=   0.6s
[CV] END max_depth=25, max_features=None, min_samples_leaf=1,
min_samples_split=15, n_estimators=303; total time=   0.7s
[CV] END max_depth=25, max_features=None, min_samples_leaf=6,
min_samples_split=6, n_estimators=199; total time=   0.4s
[CV] END max_depth=25, max_features=None, min_samples_leaf=1,
min_samples_split=15, n_estimators=303; total time=   0.7s
[CV] END max_depth=25, max_features=None, min_samples_leaf=6,
min_samples_split=6, n_estimators=199; total time=   0.4s
[CV] END max_depth=25, max_features=None, min_samples_leaf=4,
min_samples_split=2, n_estimators=353; total time=   0.8s
[CV] END max_depth=25, max_features=None, min_samples_leaf=4,
min_samples_split=2, n_estimators=353; total time=   0.8s
[CV] END max_depth=25, max_features=None, min_samples_leaf=4,
min_samples_split=2, n_estimators=353; total time=   0.8s
[CV] END max_depth=20, max_features=log2, min_samples_leaf=3,
min_samples_split=2, n_estimators=278; total time=   0.3s
[CV] END max_depth=20, max_features=log2, min_samples_leaf=3,
min_samples_split=2, n_estimators=278; total time=   0.3s
[CV] END max_depth=10, max_features=sqrt, min_samples_leaf=3,
min_samples_split=19, n_estimators=134; total time=   0.1s
[CV] END max_depth=20, max_features=log2, min_samples_leaf=3,
min_samples_split=2, n_estimators=278; total time=   0.3s
[CV] END max_depth=10, max_features=None, min_samples_leaf=3,
min_samples_split=2, n_estimators=424; total time=   0.8s
[CV] END max_depth=10, max_features=sqrt, min_samples_leaf=3,
min_samples_split=19, n_estimators=134; total time=   0.1s
[CV] END max_depth=10, max_features=None, min_samples_leaf=3,
min_samples_split=2, n_estimators=424; total time=   1.0s
[CV] END max_depth=10, max_features=sqrt, min_samples_leaf=3,
min_samples_split=19, n_estimators=134; total time=   0.1s
[CV] END max_depth=35, max_features=sqrt, min_samples_leaf=8,
min_samples_split=11, n_estimators=189; total time=   0.2s
[CV] END max_depth=35, max_features=sqrt, min_samples_leaf=8,
min_samples_split=11, n_estimators=189; total time=   0.2s
[CV] END max_depth=35, max_features=sqrt, min_samples_leaf=8,
min_samples_split=11, n_estimators=189; total time=   0.2s
```

```
[CV] END max_depth=20, max_features=None, min_samples_leaf=2,
min_samples_split=18, n_estimators=483; total time=   1.0s
[CV] END max_depth=20, max_features=None, min_samples_leaf=2,
min_samples_split=18, n_estimators=483; total time=   0.9s
[CV] END max_depth=25, max_features=None, min_samples_leaf=1,
min_samples_split=2, n_estimators=267; total time=   0.7s
[CV] END max_depth=25, max_features=None, min_samples_leaf=1,
min_samples_split=2, n_estimators=267; total time=   0.8s
[CV] END max_depth=20, max_features=None, min_samples_leaf=2,
min_samples_split=18, n_estimators=483; total time=   1.0s
[CV] END max_depth=10, max_features=None, min_samples_leaf=3,
min_samples_split=2, n_estimators=424; total time=   1.1s
[CV] END max_depth=25, max_features=log2, min_samples_leaf=8,
min_samples_split=5, n_estimators=316; total time=   0.3s
[CV] END max_depth=10, max_features=None, min_samples_leaf=9,
min_samples_split=8, n_estimators=295; total time=   0.5s
[CV] END max_depth=25, max_features=None, min_samples_leaf=1,
min_samples_split=2, n_estimators=267; total time=   0.8s
[CV] END max_depth=25, max_features=log2, min_samples_leaf=8,
min_samples_split=5, n_estimators=316; total time=   0.3s
[CV] END max_depth=25, max_features=log2, min_samples_leaf=8,
min_samples_split=5, n_estimators=316; total time=   0.3s
[CV] END max_depth=25, max_features=sqrt, min_samples_leaf=8,
min_samples_split=4, n_estimators=276; total time=   0.3s
[CV] END max_depth=10, max_features=None, min_samples_leaf=9,
min_samples_split=8, n_estimators=295; total time=   0.6s
[CV] END max_depth=25, max_features=sqrt, min_samples_leaf=8,
min_samples_split=4, n_estimators=276; total time=   0.3s
[CV] END max_depth=10, max_features=None, min_samples_leaf=9,
min_samples_split=8, n_estimators=295; total time=   0.5s
[CV] END max_depth=25, max_features=sqrt, min_samples_leaf=9,
min_samples_split=5, n_estimators=493; total time=   0.4s
[CV] END max_depth=15, max_features=log2, min_samples_leaf=1,
min_samples_split=8, n_estimators=195; total time=   0.2s
[CV] END max_depth=25, max_features=sqrt, min_samples_leaf=9,
min_samples_split=5, n_estimators=493; total time=   0.4s
[CV] END max_depth=15, max_features=log2, min_samples_leaf=1,
min_samples_split=8, n_estimators=195; total time=   0.2s
[CV] END max_depth=25, max_features=sqrt, min_samples_leaf=9,
min_samples_split=5, n_estimators=493; total time=   0.4s
[CV] END max_depth=15, max_features=log2, min_samples_leaf=1,
min_samples_split=8, n_estimators=195; total time=   0.2s
[CV] END max_depth=25, max_features=sqrt, min_samples_leaf=8,
min_samples_split=4, n_estimators=276; total time=   0.3s
[CV] END max_depth=30, max_features=sqrt, min_samples_leaf=3,
min_samples_split=18, n_estimators=199; total time=   0.2s
[CV] END max_depth=30, max_features=sqrt, min_samples_leaf=3,
min_samples_split=18, n_estimators=199; total time=   0.2s
```

```
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=17, n_estimators=316; total time=   0.3s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=17, n_estimators=316; total time=   0.3s
[CV] END max_depth=None, max_features=sqrt, min_samples_leaf=4,
min_samples_split=17, n_estimators=316; total time=   0.3s
[CV] END max_depth=35, max_features=sqrt, min_samples_leaf=7,
min_samples_split=4, n_estimators=460; total time=   0.4s
[CV] END max_depth=35, max_features=sqrt, min_samples_leaf=7,
min_samples_split=4, n_estimators=460; total time=   0.4s
[CV] END max_depth=35, max_features=sqrt, min_samples_leaf=7,
min_samples_split=4, n_estimators=460; total time=   0.4s
[CV] END max_depth=30, max_features=sqrt, min_samples_leaf=3,
min_samples_split=18, n_estimators=199; total time=   0.2s
[CV] END max_depth=20, max_features=None, min_samples_leaf=5,
min_samples_split=6, n_estimators=198; total time=   0.4s
[CV] END max_depth=20, max_features=None, min_samples_leaf=5,
min_samples_split=6, n_estimators=198; total time=   0.3s
[CV] END max_depth=40, max_features=None, min_samples_leaf=5,
min_samples_split=13, n_estimators=468; total time=   0.8s
[CV] END max_depth=20, max_features=None, min_samples_leaf=5,
min_samples_split=6, n_estimators=198; total time=   0.4s
[CV] END max_depth=40, max_features=None, min_samples_leaf=5,
min_samples_split=13, n_estimators=468; total time=   0.9s
[CV] END max_depth=40, max_features=None, min_samples_leaf=5,
min_samples_split=13, n_estimators=468; total time=   0.8s
[CV] END max_depth=45, max_features=None, min_samples_leaf=9,
min_samples_split=8, n_estimators=383; total time=   0.6s
[CV] END max_depth=45, max_features=None, min_samples_leaf=9,
min_samples_split=8, n_estimators=383; total time=   0.6s
[CV] END max_depth=45, max_features=None, min_samples_leaf=9,
min_samples_split=8, n_estimators=383; total time=   0.6s
Best parameters found by RandomizedSearchCV: {'max_depth': 15, 'max_features':
None, 'min_samples_leaf': 2, 'min_samples_split': 3, 'n_estimators': 387}
```