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Task 2: Build a decision tree classifier to predict whether a customer will purchase a product or service based on their demographic and behaviral data

IDE Used : Jupyter Notebook

```
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
import seaborn as sns
import warnings
from sklearn.preprocessing import LabelEncoder
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report
from sklearn.metrics import accuracy_score,confusion_matrix
import warnings
warnings.filterwarnings('ignore')

df=pd.read_csv('bank.csv')

df.head()
```

```
   age          job  marital  education default  balance housing loan
contact  \
0   59       admin.  married  secondary      no     2343     yes   no
unknown
1   56       admin.  married  secondary      no       45      no   no
unknown
2   41   technician  married  secondary      no     1270     yes   no
unknown
3   55     services  married  secondary      no     2476     yes   no
unknown
4   54       admin.  married   tertiary      no      184      no   no
unknown

   day month  duration  campaign  pdays  previous poutcome deposit
0    5   may      1042         1     -1         0  unknown     yes
1    5   may      1467         1     -1         0  unknown     yes
2    5   may      1389         1     -1         0  unknown     yes
3    5   may       579         1     -1         0  unknown     yes
4    5   may       673         2     -1         0  unknown     yes
```

```
df.tail()
```

```
       age          job  marital  education default  balance housing
loan  \
11157   33  blue-collar   single    primary      no        1     yes
no
11158   39     services  married  secondary      no      733      no
no
11159   32   technician   single  secondary      no       29      no
no
11160   43   technician  married  secondary      no        0      no
yes
11161   34   technician  married  secondary      no        0      no
no

        contact  day month  duration  campaign  pdays  previous
poutcome  \
11157  cellular   20   apr       257         1     -1         0
unknown
11158   unknown   16   jun        83         4     -1         0
unknown
11159  cellular   19   aug       156         2     -1         0
unknown
11160  cellular    8   may         9         2    172         5
failure
11161  cellular    9   jul       628         1     -1         0
unknown

      deposit
11157      no
11158      no
11159      no
11160      no
11161      no
```

```
df.shape
```

```
(11162, 17)
```

```
df=df.fillna(df.mean())
df=pd.get_dummies(df)
print(df.columns)
```

```
Index(['age', 'balance', 'day', 'duration', 'campaign', 'pdays',
'previous',
       'job_admin.', 'job_blue-collar', 'job_entrepreneur',
'job_housemaid',
       'job_management', 'job_retired', 'job_self-employed',
'job_services',
       'job_student', 'job_technician', 'job_unemployed',
'job_unknown',
       'marital_divorced', 'marital_married', 'marital_single',
```

```
       'education_primary', 'education_secondary',
'education_tertiary',
       'education_unknown', 'default_no', 'default_yes', 'housing_no',
       'housing_yes', 'loan_no', 'loan_yes', 'contact_cellular',
       'contact_telephone', 'contact_unknown', 'month_apr',
'month_aug',
       'month_dec', 'month_feb', 'month_jan', 'month_jul',
'month_jun',
       'month_mar', 'month_may', 'month_nov', 'month_oct',
'month_sep',
       'poutcome_failure', 'poutcome_other', 'poutcome_success',
       'poutcome_unknown', 'deposit_no', 'deposit_yes'],
      dtype='object')
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 11162 entries, 0 to 11161
Data columns (total 53 columns):
 #   Column               Non-Null Count  Dtype
---  ------               --------------  -----
 0   age                  11162 non-null  int64
 1   balance              11162 non-null  int64
 2   day                  11162 non-null  int64
 3   duration             11162 non-null  int64
 4   campaign             11162 non-null  int64
 5   pdays                11162 non-null  int64
 6   previous             11162 non-null  int64
 7   job_admin.           11162 non-null  uint8
 8   job_blue-collar      11162 non-null  uint8
 9   job_entrepreneur     11162 non-null  uint8
 10  job_housemaid        11162 non-null  uint8
 11  job_management       11162 non-null  uint8
 12  job_retired          11162 non-null  uint8
 13  job_self-employed    11162 non-null  uint8
 14  job_services         11162 non-null  uint8
 15  job_student          11162 non-null  uint8
 16  job_technician       11162 non-null  uint8
 17  job_unemployed       11162 non-null  uint8
 18  job_unknown          11162 non-null  uint8
 19  marital_divorced     11162 non-null  uint8
 20  marital_married      11162 non-null  uint8
 21  marital_single       11162 non-null  uint8
 22  education_primary    11162 non-null  uint8
 23  education_secondary  11162 non-null  uint8
 24  education_tertiary   11162 non-null  uint8
 25  education_unknown    11162 non-null  uint8
 26  default_no           11162 non-null  uint8
 27  default_yes          11162 non-null  uint8
 28  housing_no           11162 non-null  uint8
```

```
 29  housing_yes           11162 non-null  uint8
 30  loan_no               11162 non-null  uint8
 31  loan_yes              11162 non-null  uint8
 32  contact_cellular      11162 non-null  uint8
 33  contact_telephone     11162 non-null  uint8
 34  contact_unknown       11162 non-null  uint8
 35  month_apr             11162 non-null  uint8
 36  month_aug             11162 non-null  uint8
 37  month_dec             11162 non-null  uint8
 38  month_feb             11162 non-null  uint8
 39  month_jan             11162 non-null  uint8
 40  month_jul             11162 non-null  uint8
 41  month_jun             11162 non-null  uint8
 42  month_mar             11162 non-null  uint8
 43  month_may             11162 non-null  uint8
 44  month_nov             11162 non-null  uint8
 45  month_oct             11162 non-null  uint8
 46  month_sep             11162 non-null  uint8
 47  poutcome_failure      11162 non-null  uint8
 48  poutcome_other        11162 non-null  uint8
 49  poutcome_success      11162 non-null  uint8
 50  poutcome_unknown      11162 non-null  uint8
 51  deposit_no            11162 non-null  uint8
 52  deposit_yes           11162 non-null  uint8
dtypes: int64(7), uint8(46)
memory usage: 1.1 MB

df.describe()

                 age       balance            day      duration
campaign  \
count  11162.000000  11162.000000  11162.000000  11162.000000
11162.000000
mean      41.231948   1528.538524     15.658036    371.993818
2.508421
std       11.913369   3225.413326      8.420740    347.128386
2.722077
min       18.000000  -6847.000000      1.000000      2.000000
1.000000
25%       32.000000    122.000000      8.000000    138.000000
1.000000
50%       39.000000    550.000000     15.000000    255.000000
2.000000
75%       49.000000   1708.000000     22.000000    496.000000
3.000000
max       95.000000  81204.000000     31.000000   3881.000000
63.000000

              pdays      previous    job_admin.  job_blue-collar  \
count  11162.000000  11162.000000  11162.000000     11162.000000
```

```
mean      51.330407      0.832557      0.119513         0.174162
std      108.758282      2.292007      0.324405         0.379266
min       -1.000000      0.000000      0.000000         0.000000
25%       -1.000000      0.000000      0.000000         0.000000
50%       -1.000000      0.000000      0.000000         0.000000
75%       20.750000      1.000000      0.000000         0.000000
max      854.000000     58.000000      1.000000         1.000000

       job_entrepreneur  ...     month_may     month_nov     month_oct
\
count      11162.000000  ...  11162.000000  11162.000000  11162.000000

mean           0.029385  ...      0.253001      0.084483      0.035119

std            0.168892  ...      0.434751      0.278123      0.184089

min            0.000000  ...      0.000000      0.000000      0.000000

25%            0.000000  ...      0.000000      0.000000      0.000000

50%            0.000000  ...      0.000000      0.000000      0.000000

75%            0.000000  ...      1.000000      0.000000      0.000000

max            1.000000  ...      1.000000      1.000000      1.000000


          month_sep  poutcome_failure  poutcome_other
poutcome_success  \
count  11162.000000      11162.000000    11162.000000
11162.000000
mean       0.028579          0.110016        0.048110
0.095951
std        0.166628          0.312924        0.214008
0.294537
min        0.000000          0.000000        0.000000
0.000000
25%        0.000000          0.000000        0.000000
0.000000
50%        0.000000          0.000000        0.000000
0.000000
75%        0.000000          0.000000        0.000000
0.000000
max        1.000000          1.000000        1.000000
1.000000

       poutcome_unknown    deposit_no   deposit_yes
count      11162.000000  11162.000000  11162.000000
mean           0.745924      0.526160      0.473840
std            0.435360      0.499338      0.499338
```

```
min             0.000000      0.000000      0.000000
25%             0.000000      0.000000      0.000000
50%             1.000000      1.000000      0.000000
75%             1.000000      1.000000      1.000000
max             1.000000      1.000000      1.000000

[8 rows x 53 columns]
```

```
df.isnull().sum()
```

```
age                    0
balance                0
day                    0
duration               0
campaign               0
pdays                  0
previous               0
job_admin.             0
job_blue-collar        0
job_entrepreneur       0
job_housemaid          0
job_management         0
job_retired            0
job_self-employed      0
job_services           0
job_student            0
job_technician         0
job_unemployed         0
job_unknown            0
marital_divorced       0
marital_married        0
marital_single         0
education_primary      0
education_secondary    0
education_tertiary     0
education_unknown      0
default_no             0
default_yes            0
housing_no             0
housing_yes            0
loan_no                0
loan_yes               0
contact_cellular       0
contact_telephone      0
contact_unknown        0
month_apr              0
month_aug              0
month_dec              0
month_feb              0
month_jan              0
```

```
month_jul              0
month_jun              0
month_mar              0
month_may              0
month_nov              0
month_oct              0
month_sep              0
poutcome_failure       0
poutcome_other         0
poutcome_success       0
poutcome_unknown       0
deposit_no             0
deposit_yes            0
dtype: int64
```

```
x=df[['age', 'balance', 'day', 'duration', 'campaign', 'pdays',
'previous']]
y=df['deposit_yes']

# Splitting data into training and testing sets
x_train, x_test, y_train,
y_test=train_test_split(x,y,test_size=0.2,random_state=42)
```

Decision Tree Classifier

```
# Initialize and fit the DecisionTreeClassifier
dtc = DecisionTreeClassifier()
dtc.fit(x_train, y_train)
```

```
DecisionTreeClassifier()
```

```
# Make Predictions
y_pred = dtc.predict(x_test)

# Evaluate the Model
print(classification_report(y_test, y_pred))
```

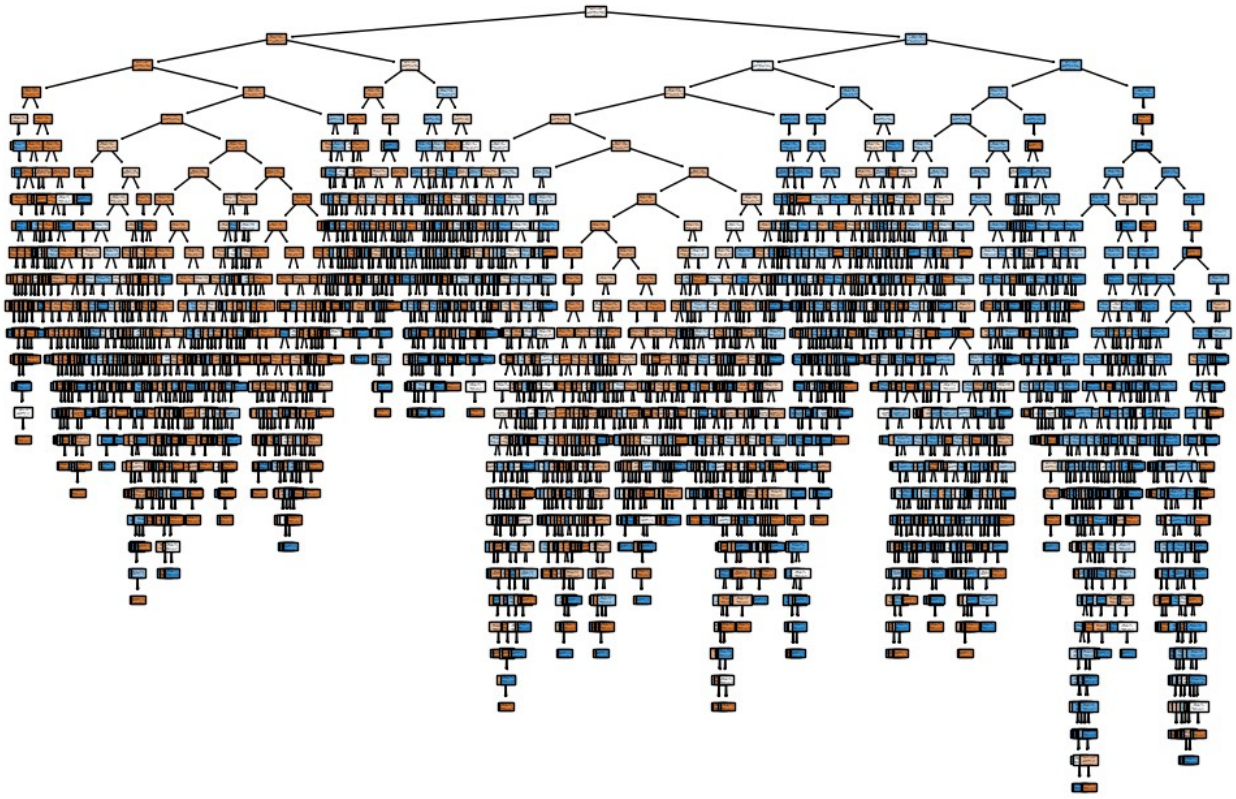
```
              precision    recall  f1-score   support

           0       0.72      0.73      0.73      1166
           1       0.70      0.69      0.70      1067

    accuracy                           0.71      2233
   macro avg       0.71      0.71      0.71      2233
weighted avg       0.71      0.71      0.71      2233
```

```
plt.figure(figsize=(12, 8))
tree.plot_tree(dtc, feature_names=x_encoded.columns,
```

```
class_names=['No', 'Yes'], filled=True)
plt.show()
```



```
# Feature Importance
importances = dtc.feature_importances_
feature_names = x.columns
feature_importance = pd.DataFrame({'Feature': feature_names,
'Importance': importances})
feature_importance = feature_importance.sort_values(by='Importance',
ascending=False)
print(feature_importance)
```

```
    Feature  Importance
3  duration    0.429095
1   balance    0.167453
0       age    0.122369
5     pdays    0.121631
2       day    0.110893
4  campaign    0.041363
6  previous    0.007196
```

```
# Hyperparameter Tuning using Grid Search
param_grid = {'max_depth': [None, 5, 10, 15],
```

```
              'min_samples_split': [2, 5, 10],
              'min_samples_leaf': [1, 2, 4]}
grid_search = GridSearchCV(estimator=dtc, param_grid=param_grid, cv=5)
grid_search.fit(x_train, y_train)
```

```
GridSearchCV(cv=5, estimator=DecisionTreeClassifier(),
             param_grid={'max_depth': [None, 5, 10, 15],
                         'min_samples_leaf': [1, 2, 4],
                         'min_samples_split': [2, 5, 10]})
```

```
best_params = grid_search.best_params_
dtc = DecisionTreeClassifier(**best_params)
dtc.fit(x_train, y_train)
```

```
DecisionTreeClassifier(max_depth=5)
```

```
y_pred = dtc.predict(x_test)
```

```
print(classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.78      0.80      0.78      1166
           1       0.77      0.75      0.76      1067

    accuracy                           0.77      2233
   macro avg       0.77      0.77      0.77      2233
weighted avg       0.77      0.77      0.77      2233
```

```
# Updated Decision Tree Classifier with Best Hyperparameters
dtc_tuned = DecisionTreeClassifier(**best_params)
dtc_tuned.fit(x_train, y_train)
y_pred_tuned = dtc_tuned.predict(x_test)
print("Classification Report (Tuned Model):")
print(classification_report(y_test, y_pred_tuned))
```

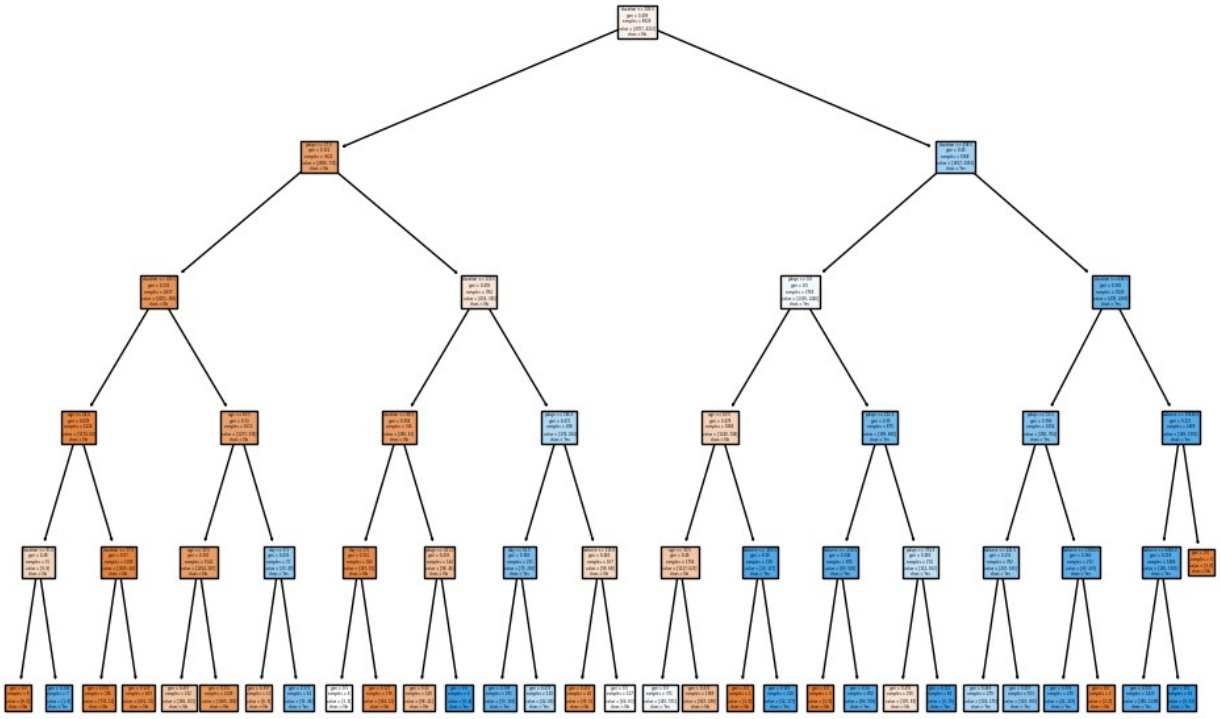
```
Classification Report (Tuned Model):
              precision    recall  f1-score   support

           0       0.78      0.80      0.78      1166
           1       0.77      0.75      0.76      1067

    accuracy                           0.77      2233
   macro avg       0.77      0.77      0.77      2233
weighted avg       0.77      0.77      0.77      2233
```

```
plt.figure(figsize=(12, 8))
plt.title("Decision Tree")
tree.plot_tree(dtc, feature_names=x_encoded.columns,
```

```
class_names=['No', 'Yes'], filled=True)
plt.show()
```



Thank You.....:)