Prodigy InfoTech Internship

Task 3

Build a decision tree classifier to predict whether a customer will purchase a product or service based on their demographic and behavioral data. Use a dataset such as the Bank Marketing dataset from the UCI Machine Learning Repository.

Sample Dataset :- Bank Marketing

1 Decision Tree Classifier of Bank Marketing Dataset

Loading Libraries and Dataset :

[2]:
```
import warnings
warnings.filterwarnings('ignore')
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
```

[3]:
```
sns.set_theme(context='notebook', style='whitegrid', palette='muted')
```

[4]:
```
data = pd.read_csv("/content/drive/MyDrive/bank-full.csv", sep=';')
```

Understanding the shape of the data :

[5]:
```
data
```

[5]:

	age	job	marital	education	default	balance	housing	loan	\
0	58	management	married	tertiary	no	2143	yes	no	
1	44	technician	single	secondary	no	29	yes	no	
2	33	entrepreneur	married	secondary	no	2	yes	yes	
3	47	blue-collar	married	unknown	no	1506	yes	no	
4	33	unknown	single	unknown	no	1	no	no	
…	…	…	…	…	…	…	…	…	
45206	51	technician	married	tertiary	no	825	no	no	
45207	71	retired	divorced	primary	no	1729	no	no	
45208	72	retired	married	secondary	no	5715	no	no	
45209	57	blue-collar	married	secondary	no	668	no	no	
45210	37	entrepreneur	married	secondary	no	2971	no	no	

	contact	day	month	duration	campaign	pdays	previous	poutcome	y
0	unknown	5	may	261	1	-1	0	unknown	no
1	unknown	5	may	151	1	-1	0	unknown	no
2	unknown	5	may	76	1	-1	0	unknown	no
3	unknown	5	may	92	1	-1	0	unknown	no
4	unknown	5	may	198	1	-1	0	unknown	no

By :- Amolak Singh
singhamolak974@gmail.com

```
...          ...  ...   ...       ...       ...  ...       ...      ...  ...
45206   cellular   17   nov       977         3   -1         0  unknown  yes
45207   cellular   17   nov       456         2   -1         0  unknown  yes
45208   cellular   17   nov      1127         5  184         3  success  yes
45209  telephone   17   nov       508         4   -1         0  unknown   no
45210   cellular   17   nov       361         2  188        11    other   no

[45211 rows x 17 columns]
```

[6]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 45211 entries, 0 to 45210
Data columns (total 17 columns):
 #   Column     Non-Null Count  Dtype 
---  ------     --------------  ----- 
 0   age        45211 non-null  int64 
 1   job        45211 non-null  object
 2   marital    45211 non-null  object
 3   education  45211 non-null  object
 4   default    45211 non-null  object
 5   balance    45211 non-null  int64 
 6   housing    45211 non-null  object
 7   loan       45211 non-null  object
 8   contact    45211 non-null  object
 9   day        45211 non-null  int64 
 10  month      45211 non-null  object
 11  duration   45211 non-null  int64 
 12  campaign   45211 non-null  int64 
 13  pdays      45211 non-null  int64 
 14  previous   45211 non-null  int64 
 15  poutcome   45211 non-null  object
 16  y          45211 non-null  object
dtypes: int64(7), object(10)
memory usage: 5.9+ MB
```

[7]:
```
data.describe(include='object')
```

[7]:
```
                job  marital  education default housing   loan   contact  \
count         45211    45211      45211   45211   45211  45211     45211   
unique           12        3          4       2       2      2         3   
top     blue-collar  married  secondary      no     yes     no  cellular   
freq           9732    27214      23202   44396   25130  37967     29285   

        month poutcome      y  
count   45211    45211  45211  
unique     12        4      2  
top       may  unknown     no  
freq    13766    36959  39922  
```

[8]:
```
data.duplicated().sum()
```

[8]:
```
0
```

By :- Amolak Singh
singhamolak974@gmail.com

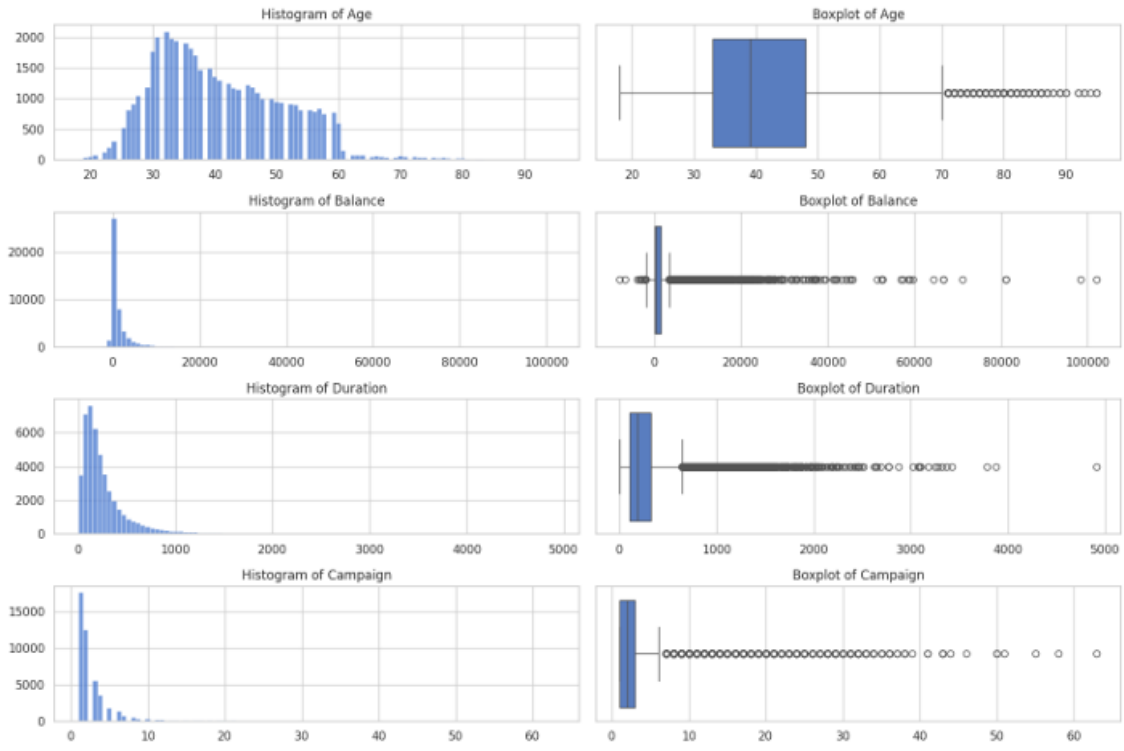
Data Cleaning :

[9]:
```
data = data.rename(columns={'y': 'subscribed'})
data['subscribed'] = data['subscribed'].map({'yes': 'Subscribed', 'no': 'Not␣
↪Subscribed'})
```

[10]:
```
categorical_cols = ['job', 'marital', 'education', 'contact',␣
↪'month','poutcome']
data[categorical_cols] = (data[categorical_cols].apply(lambda x: x.str.title())
.astype('category'))
binary_cols = ['default', 'housing', 'loan']
data[binary_cols] = data[binary_cols] == 'yes'
```

[11]:
```
cols_with_outliers = ['age', 'balance', 'duration', 'campaign']
```

[12]:
```
fig, axes = plt.subplots(4, 2, figsize=(15, 10))
for i, col in enumerate(cols_with_outliers):
  hist_ax, box_ax = axes[i, :]
  sns.histplot(data=data, x=col, bins=100, ax=hist_ax)
  hist_ax.set_title(f'Histogram of {col.title()}')
  hist_ax.set_xlabel('')
  hist_ax.set_ylabel('')
  sns.boxplot(data=data, x=col, ax=box_ax)
  box_ax.set_title(f'Boxplot of {col.title()}')
  box_ax.set_xlabel('')
  box_ax.set_ylabel('')
plt.tight_layout()
plt.show();
```



By :- Amolak Singh
singhamolak974@gmail.com

[13]:
```
def remove_outliers(df, columns):
  df_outliers_removed = data.copy()
  for col in columns:
    Q1 = df_outliers_removed[col].quantile(0.25)
    Q3 = df_outliers_removed[col].quantile(0.75)
    IQR = Q3 - Q1
    lower_bound = Q1 - 1.5 * IQR
    upper_bound = Q3 + 1.5 * IQR
    df_outliers_removed = df_outliers_removed[
    (df_outliers_removed[col] >= lower_bound) &
    (df_outliers_removed[col] <= upper_bound)
    ]
  return df_outliers_removed
data = remove_outliers(data, cols_with_outliers)
```

[14]:
```
data
```

[14]:

	age	job	marital	education	default	balance	housing	\
0	58	Management	Married	Tertiary	False	2143	True	
1	44	Technician	Single	Secondary	False	29	True	
2	33	Entrepreneur	Married	Secondary	False	2	True	
3	47	Blue-Collar	Married	Unknown	False	1506	True	
4	33	Unknown	Single	Unknown	False	1	False	
…	…	…	…	…	…	…	…	
45202	34	Admin.	Single	Secondary	False	557	False	
45203	23	Student	Single	Tertiary	False	113	False	
45205	25	Technician	Single	Secondary	False	505	False	
45209	57	Blue-Collar	Married	Secondary	False	668	False	
45210	37	Entrepreneur	Married	Secondary	False	2971	False	

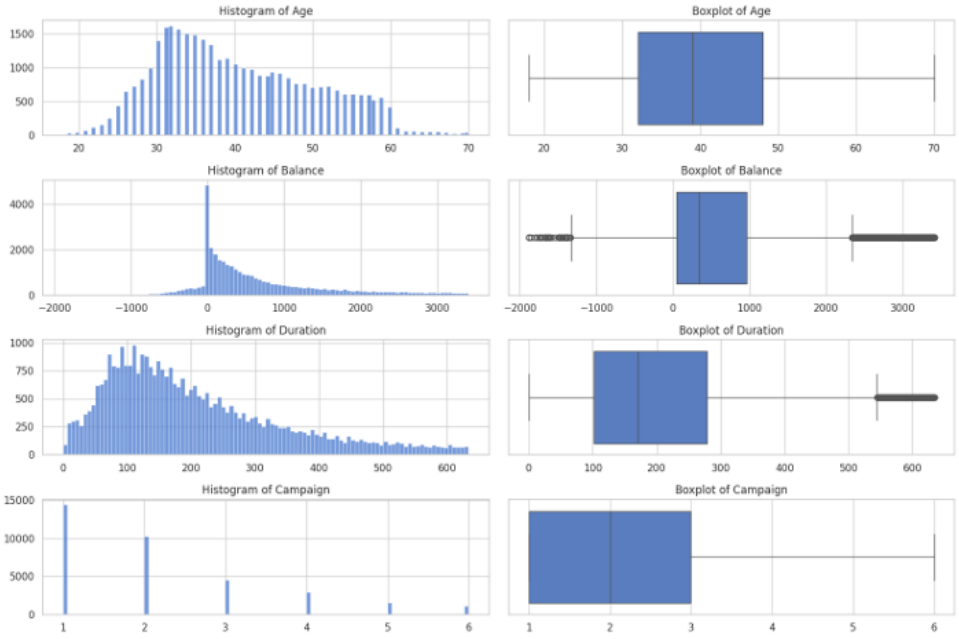
	loan	contact	day	month	duration	campaign	pdays	previous	\
0	False	Unknown	5	May	261	1	-1	0	
1	False	Unknown	5	May	151	1	-1	0	
2	True	Unknown	5	May	76	1	-1	0	
3	False	Unknown	5	May	92	1	-1	0	
4	False	Unknown	5	May	198	1	-1	0	
…	…	…	…	…	…	…	…	…	
45202	False	Cellular	17	Nov	224	1	-1	0	
45203	False	Cellular	17	Nov	266	1	-1	0	
45205	True	Cellular	17	Nov	386	2	-1	0	
45209	False	Telephone	17	Nov	508	4	-1	0	
45210	False	Cellular	17	Nov	361	2	188	11	

	poutcome	subscribed
0	Unknown	Not Subscribed
1	Unknown	Not Subscribed
2	Unknown	Not Subscribed
3	Unknown	Not Subscribed
4	Unknown	Not Subscribed
…	…	…
45202	Unknown	Subscribed
45203	Unknown	Subscribed
45205	Unknown	Subscribed
45209	Unknown	Not Subscribed
45210	Other	Not Subscribed

By :- Amolak Singh
singhamolak974@gmail.com

[15]:
```
fig, axes = plt.subplots(4, 2, figsize=(15, 10))
for i, col in enumerate(cols_with_outliers):
  hist_ax, box_ax = axes[i, :]
  sns.histplot(data=data, x=col, bins=100, ax=hist_ax)
  hist_ax.set_title(f'Histogram of {col.title()}')
  hist_ax.set_xlabel('')
  hist_ax.set_ylabel('')
  sns.boxplot(data=data, x=col, ax=box_ax)
  box_ax.set_title(f'Boxplot of {col.title()}')
  box_ax.set_xlabel('')
  box_ax.set_ylabel('')
plt.tight_layout()
```

```
plt.show();
```

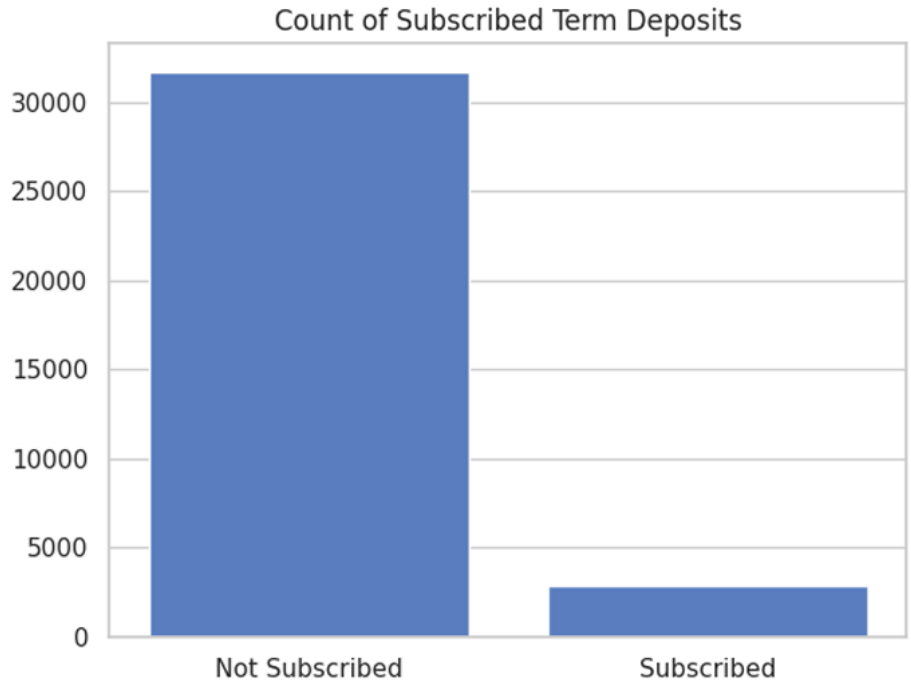


Data Exploration :

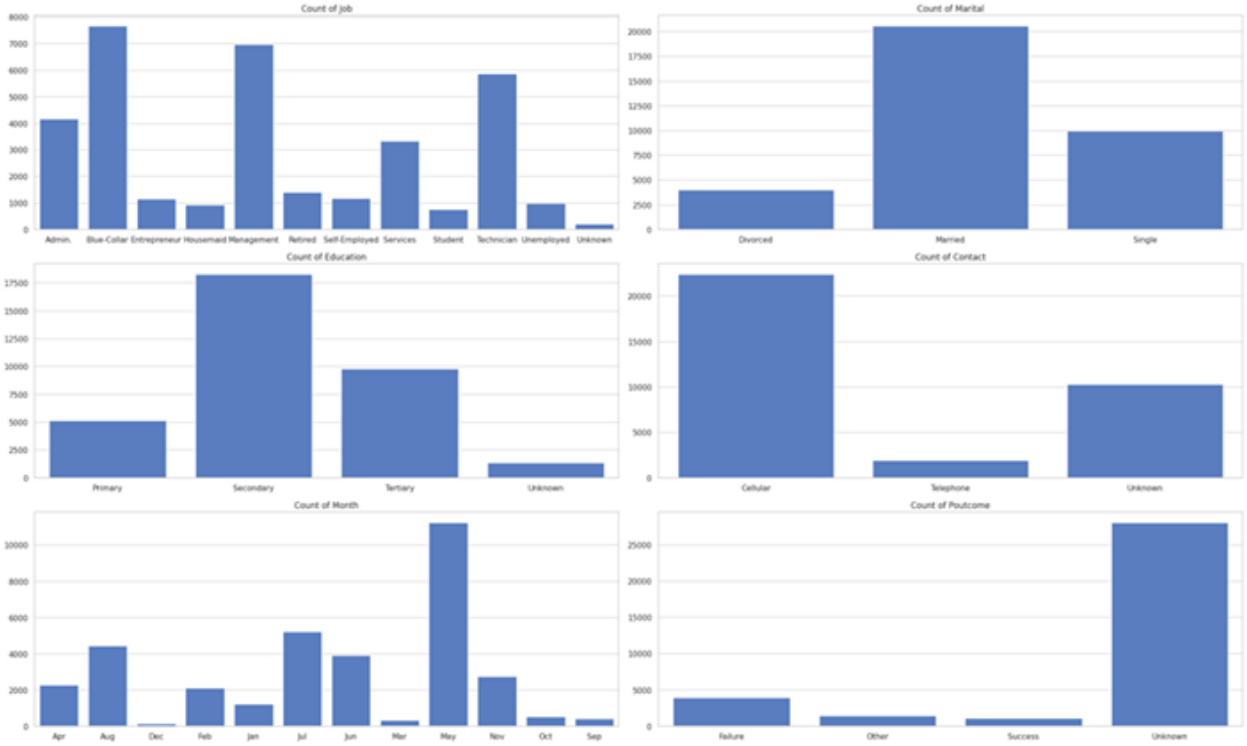
[16]:
```
num_cols = data.select_dtypes('number').columns.tolist()
bool_cols = data.select_dtypes(bool).columns.tolist()
cat_cols = data.select_dtypes('category').columns.tolist()
```

[17]:
```
sns.countplot(data=data, x='subscribed');
plt.title('Count of Subscribed Term Deposits')
plt.xlabel('')
plt.ylabel('')
plt.show();
```

By :- Amolak Singh
singhamolak974@gmail.com



[18]:
```
fig, axes = plt.subplots(3, 2, figsize=(25, 15))
for feature, ax in zip(cat_cols, axes.flatten()):
  sns.countplot(data=data, x=feature, ax=ax)
  ax.set_title(f'Count of {feature.title()}')
  ax.set_xlabel('')
  ax.set_ylabel('')
plt.tight_layout()
plt.show();
```



By :- Amolak Singh
singhamolak974@gmail.com

Data Preprocessing for Model Training :

[19]:
```
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import OneHotEncoder, StandardScaler
from sklearn.compose import ColumnTransformer
from imblearn.over_sampling import RandomOverSampler
```

[20]:
```
X = data.drop(columns='subscribed')
y = data['subscribed']
X_train, X_test, y_train, y_test = train_test_split(X,
                                                    y,
                                                    test_size=0.2,
                                                    stratify=y,
                                                    random_state=42)
```

[21]:
```
num_vars = data.select_dtypes('number').columns.tolist()
cat_vars = data.select_dtypes('category').columns.tolist()
```

[22]:
```
preprocessing_pipeline = ColumnTransformer([
  ('numerical', StandardScaler(), num_vars),
  ('categorical', OneHotEncoder(), cat_vars),
])
X_train = preprocessing_pipeline.fit_transform(X_train)
X_test = preprocessing_pipeline.transform(X_test)
```

[23]:
```
sampler = RandomOverSampler(random_state=42)
X_train, y_train = sampler.fit_resample(X_train, y_train)
```

Building Basic Model :

[24]:
```
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import classification_report
```

[25]:
```
%%time
model = DecisionTreeClassifier(random_state=42)
model.fit(X_train, y_train)
```

```
CPU times: user 2.26 s, sys: 4.38 ms, total: 2.26 s
Wall time: 2.26 s
```

[25]:
```
DecisionTreeClassifier(random_state=42)
```

[26]:
```
y_pred = model.predict(X_test)
accuracy = model.score(X_test, y_test)
report = classification_report(y_test, y_pred)
print(f'Accuracy: {accuracy:.2%}')
print(f'Classification Report:\n{report}')
```

```
Accuracy: 90.16%
Classification Report:
                precision    recall  f1-score   support

Not Subscribed       0.95      0.95      0.95      6343
    Subscribed       0.41      0.41      0.41       570

      accuracy                           0.90      6913
     macro avg       0.68      0.68      0.68      6913
  weighted avg       0.90      0.90      0.90      6913
```

By :- Amolak Singh
singhamolak974@gmail.com

Fine Tuning the Model :

[27]:
```
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import make_scorer, f1_score
```

[28]:
```
param_grid = {
  'max_depth': [None, 10, 20],
  'min_samples_split': [2, 5, 10],
  'min_samples_leaf': [1, 2, 4],
}
```

[29]:
```
scorer = make_scorer(f1_score, pos_label='Subscribed')
```

[30]:
```
base_model = DecisionTreeClassifier(random_state=42)
grid_search = GridSearchCV(estimator=base_model,
                           param_grid=param_grid,
                           cv=5,
                           scoring=scorer,
                           verbose=1,
                           n_jobs=-1)
```

[31]:
```
%%time
grid_search.fit(X_train, y_train)
```

```
Fitting 5 folds for each of 27 candidates, totalling 135 fits
CPU times: user 4.33 s, sys: 229 ms, total: 4.56 s
Wall time: 2min 18s
```

[31]:
```
GridSearchCV(cv=5, estimator=DecisionTreeClassifier(random_state=42), n_jobs=-1,
             param_grid={'max_depth': [None, 10, 20],
                         'min_samples_leaf': [1, 2, 4],
                         'min_samples_split': [2, 5, 10]},
             scoring=make_scorer(f1_score, pos_label=Subscribed), verbose=1)
```

[32]:
```
best_params = grid_search.best_params_
best_model = grid_search.best_estimator_
accuracy = best_model.score(X_test, y_test)
print(f'Best Accuracy: {accuracy:.2%}')
print(f'Best Parameters:\n{best_params}')
```

```
Best Accuracy: 90.16%
Best Parameters:
{'max_depth': None, 'min_samples_leaf': 1, 'min_samples_split': 2}
```

[33]:
```
y_pred = best_model.predict(X_test)
report = classification_report(y_test, y_pred)
print(f'Classification Report:\n{report}')
```

```
Classification Report:
                precision    recall  f1-score   support

Not Subscribed       0.95      0.95      0.95      6343
    Subscribed       0.41      0.41      0.41       570

      accuracy                           0.90      6913
     macro avg       0.68      0.68      0.68      6913
  weighted avg       0.90      0.90      0.90      6913
```

By :- Amolak Singh
singhamolak974@gmail.com

Testing the results :

[34]:
```
from sklearn.metrics import confusion_matrix
```

[35]:
```
conf_matrix = confusion_matrix(y_test, y_pred)
labels = best_model.classes_
sns.heatmap(conf_matrix,
            annot=True,
            fmt='d',
            cmap='Blues',
            cbar=False,
            xticklabels=labels,
            yticklabels=labels)
plt.title('Confusion Matrix')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show();
```

By :- Amolak Singh
singhamolak974@gmail.com