April 22, 2024

1 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]:
```python
import warnings
warnings.filterwarnings("ignore")

import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

sns.set_theme(context="notebook", style="whitegrid", palette="muted")
```

1.1 Understand the shape of the data

[2]:
```python
df = pd.read_csv("data/Bank.csv", sep=";")
```

[3]:
```python
df
```

[3]:
```
       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
...          ...  ...  ...   ...  ...  ...  ...  ...  ...
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]
```

[4]:
```
df.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
```

[5]:
```
df.describe()
```

[5]:
```
                age       balance           day      duration     campaign  \
count  45211.000000  45211.000000  45211.000000  45211.000000  45211.000000
mean      40.936210   1362.272058     15.806419    258.163080      2.763841
std       10.618762   3044.765829      8.322476    257.527812      3.098021
min       18.000000  -8019.000000      1.000000      0.000000      1.000000
```

```
25%      33.000000      72.000000     8.000000   103.000000     1.000000
50%      39.000000     448.000000    16.000000   180.000000     2.000000
75%      48.000000    1428.000000    21.000000   319.000000     3.000000
max      95.000000  102127.000000    31.000000  4918.000000    63.000000

              pdays      previous
count  45211.000000  45211.000000
mean      40.197828      0.580323
std      100.128746      2.303441
min       -1.000000      0.000000
25%       -1.000000      0.000000
50%       -1.000000      0.000000
75%       -1.000000      0.000000
max      871.000000    275.000000
```

[6]:
```python
df.describe(include="object")
```

[6]:
```
                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
```

[7]:
```python
df.duplicated().sum()
```

[7]: 0

1.2 Data Cleaning

[8]:
```python
df = df.rename(columns={"y": "subscribed"})
df["subscribed"] = df["subscribed"].map({"yes": "Subscribed", "no": "Not␣
↪Subscribed"})
```

[9]:
```python
categorical_cols = ["job", "marital", "education", "contact", "month",␣
↪"poutcome"]
df[categorical_cols] = (df[categorical_cols].apply(lambda x: x.str.title())
                                            .astype("category"))

binary_cols = ["default", "housing", "loan"]
df[binary_cols] = df[binary_cols] == "yes"
```

[10]:
```python
cols_with_outliers = ['age', 'balance', 'duration', 'campaign']
```

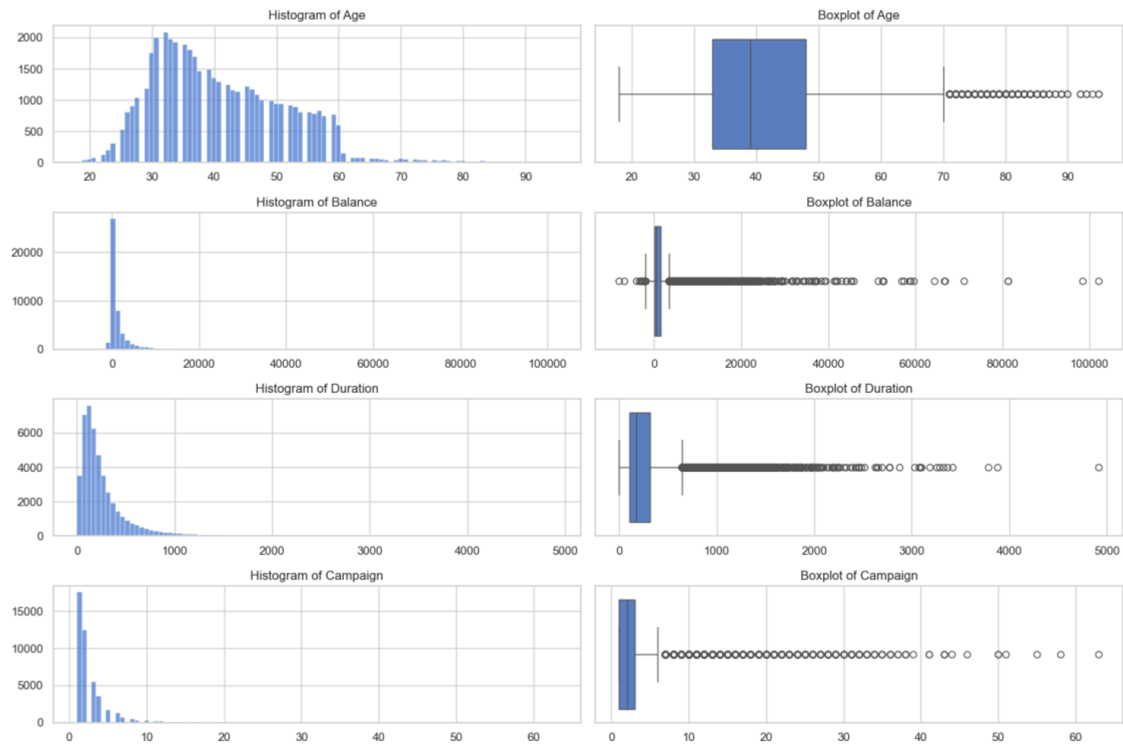
[11]:
```python
fig, axes = plt.subplots(4, 2, figsize=(15, 10))

for i, col in enumerate(cols_with_outliers):
    hist_ax, box_ax = axes[i, :]

    sns.histplot(data=df, 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=df, 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();
```



[12]:
```python
def remove_outliers(df, columns):
    df_outliers_removed = df.copy()
```

```python
    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

df = remove_outliers(df, cols_with_outliers)
```

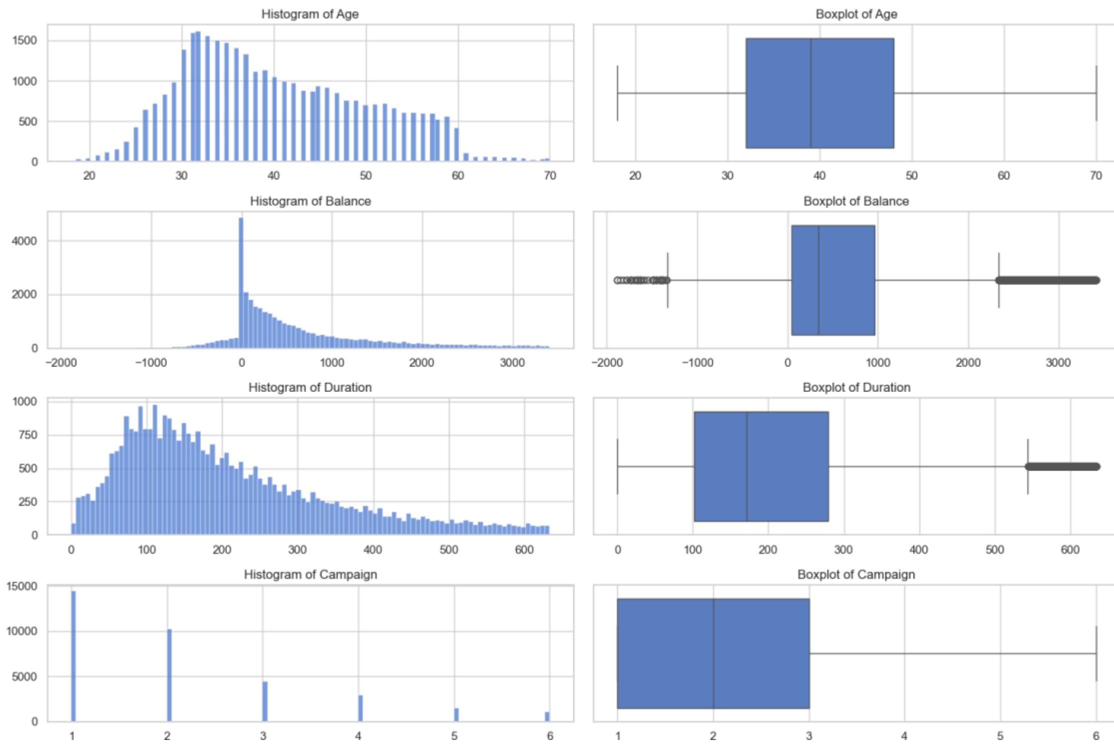
[13]:
```python
fig, axes = plt.subplots(4, 2, figsize=(15, 10))

for i, col in enumerate(cols_with_outliers):
    hist_ax, box_ax = axes[i, :]

    sns.histplot(data=df, 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=df, 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();
```



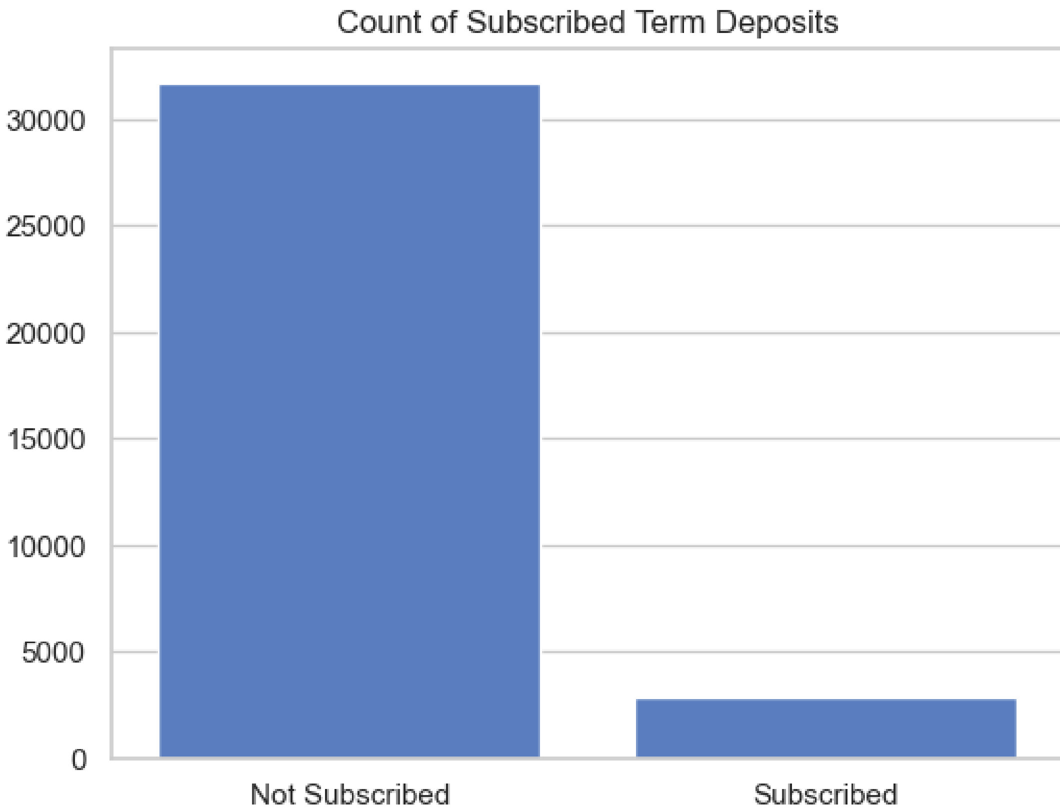
1.3 Data Exploration

[14]:
```
num_cols = df.select_dtypes('number').columns.tolist()
bool_cols = df.select_dtypes(bool).columns.tolist()
cat_cols = df.select_dtypes('category').columns.tolist()
```

[15]:
```
sns.countplot(data=df, x='subscribed');

plt.title('Count of Subscribed Term Deposits')
plt.xlabel('')
plt.ylabel('')

plt.show();
```

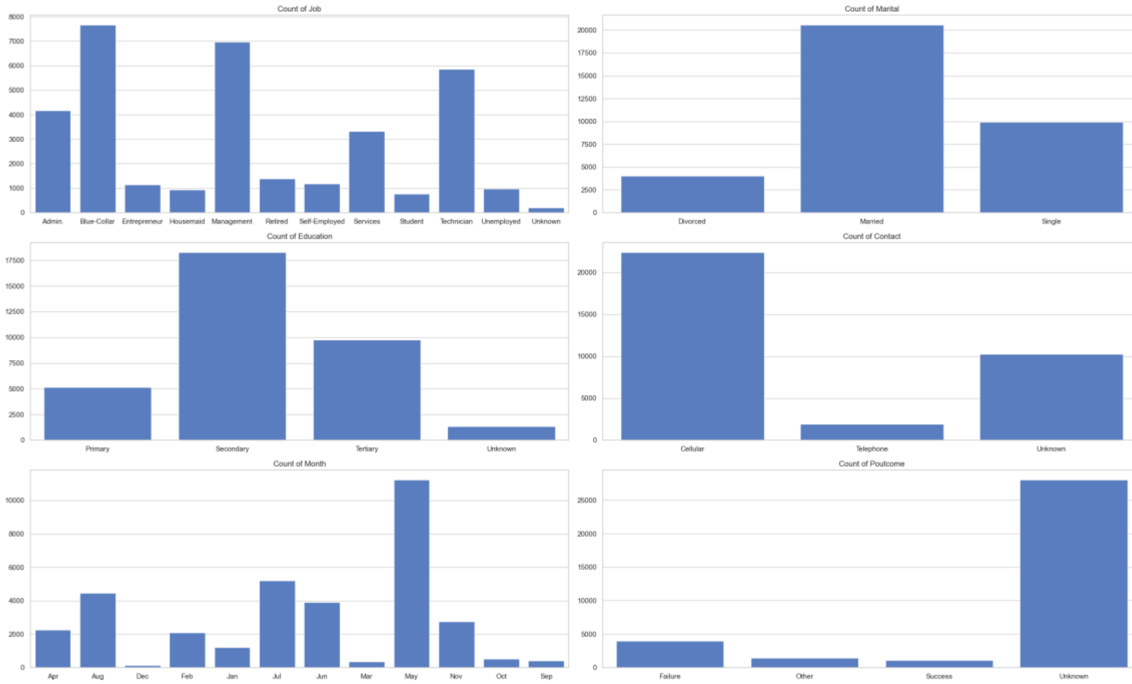


[16]:
```
fig, axes = plt.subplots(3, 2, figsize=(25, 15))

for feature, ax in zip(cat_cols, axes.flatten()):
    sns.countplot(data=df, x=feature, ax=ax)

    ax.set_title(f"Count of {feature.title()}")
    ax.set_xlabel("")
    ax.set_ylabel("")

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



1.4 Data Preprocessing for Model

[17]:
```
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
```

[18]:
```
X = df.drop(columns='subscribed')
y = df['subscribed']

X_train, X_test, y_train, y_test = train_test_split(X,
                                                    y,
                                                    test_size=0.2,
                                                    stratify=y,
                                                    random_state=42)
```

[19]:
```
num_vars = df.select_dtypes('number').columns.tolist()
cat_vars = df.select_dtypes('category').columns.tolist()
```

[20]:
```
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)
```

[21]:
```
sampler = RandomOverSampler(random_state=42)

X_train, y_train = sampler.fit_resample(X_train, y_train)
```

1.5 Basic Model Building

[22]:
```
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import classification_report
```

[23]:
```
%%time

model = DecisionTreeClassifier(random_state=42)
model.fit(X_train, y_train)
```

```
CPU times: user 1.06 s, sys: 3.91 ms, total: 1.06 s
Wall time: 1.06 s
```

[23]:
```
DecisionTreeClassifier(random_state=42)
```

[24]:
```
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: 90.09%
Classification Report:
                precision    recall  f1-score   support

Not Subscribed       0.95      0.95      0.95      6343
    Subscribed       0.40      0.41      0.40       570

      accuracy                           0.90      6913
     macro avg       0.67      0.68      0.67      6913
  weighted avg       0.90      0.90      0.90      6913
```

1.6 Model Tuning

[25]:
```
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import make_scorer, f1_score
```

[26]:
```python
param_grid = {
    'max_depth': [None, 10, 20],
    'min_samples_split': [2, 5, 10],
    'min_samples_leaf': [1, 2, 4],
}
```

[27]:
```python
scorer = make_scorer(f1_score, pos_label='Subscribed')
```

[28]:
```python
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)
```

[29]:
```python
%%time

grid_search.fit(X_train, y_train)
```

```
Fitting 5 folds for each of 27 candidates, totalling 135 fits
CPU times: user 1.8 s, sys: 196 ms, total: 2 s
Wall time: 24.6 s
```

[29]:
```
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, response_method='predict',
 pos_label=Subscribed),
             verbose=1)
```

[30]:
```python
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: 90.11%
Best Parameters:
{'max_depth': None, 'min_samples_leaf': 1, 'min_samples_split': 5}
```

[31]:
```python
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        0.40      0.41      0.41       570

      accuracy                            0.90      6913
     macro avg        0.67      0.68      0.68      6913
  weighted avg        0.90      0.90      0.90      6913
```

1.7 Results

[32]:
```python
from sklearn.metrics import confusion_matrix
```

[33]:
```python
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();
```


Confusion Matrix
True
Not Subscribed
Subscribed
5996
347
337
233
Not Subscribed
Subscribed
Predicted

Thank you