```
!pip install imbalanced-learn
```

```
Requirement already satisfied: imbalanced-learn in
/usr/local/lib/python3.11/dist-packages (0.13.0)
Requirement already satisfied: numpy<3,>=1.24.3 in
/usr/local/lib/python3.11/dist-packages (from imbalanced-learn)
(2.0.2)
Requirement already satisfied: scipy<2,>=1.10.1 in
/usr/local/lib/python3.11/dist-packages (from imbalanced-learn)
(1.15.3)
Requirement already satisfied: scikit-learn<2,>=1.3.2 in
/usr/local/lib/python3.11/dist-packages (from imbalanced-learn)
(1.6.1)
Requirement already satisfied: sklearn-compat<1,>=0.1 in
/usr/local/lib/python3.11/dist-packages (from imbalanced-learn)
(0.1.3)
Requirement already satisfied: joblib<2,>=1.1.1 in
/usr/local/lib/python3.11/dist-packages (from imbalanced-learn)
(1.5.1)
Requirement already satisfied: threadpoolctl<4,>=2.0.0 in
/usr/local/lib/python3.11/dist-packages (from imbalanced-learn)
(3.6.0)
```

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

from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from imblearn.over_sampling import SMOTE

from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier
from sklearn.neural_network import MLPClassifier
from sklearn.metrics import confusion_matrix, classification_report

df = pd.read_csv('Telco_Customer_Churn.csv')
df.head()
```

{"type":"dataframe","variable_name":"df"}

```
df.drop(['customerID'], axis=1, inplace=True)


df['TotalCharges'] = pd.to_numeric(df['TotalCharges'],
errors='coerce')
df.dropna(inplace=True)
```

```
df['Churn'] = df['Churn'].map({'Yes': 1, 'No': 0})


df = pd.get_dummies(df, drop_first=True)

print("customerID column exists?", 'customerID' in df.columns)

print("TotalCharges type:", df['TotalCharges'].dtype)
print("Missing values in TotalCharges:",
df['TotalCharges'].isnull().sum())

print("Total missing values in dataset:", df.isnull().sum().sum())

print("Unique values in Churn column:", df['Churn'].unique())

print("\nFirst 5 rows of dataframe:")
print(df.head())
```

```
customerID column exists? False
TotalCharges type: float64
Missing values in TotalCharges: 0
Total missing values in dataset: 0
Unique values in Churn column: [0 1]

First 5 rows of dataframe:
   SeniorCitizen  tenure  MonthlyCharges  TotalCharges  Churn
gender_Male  \
0              0       1           29.85         29.85      0
False
1              0      34           56.95       1889.50      0
True
2              0       2           53.85        108.15      1
True
3              0      45           42.30       1840.75      0
True
4              0       2           70.70        151.65      1
False

   Partner_Yes  Dependents_Yes  PhoneService_Yes  \
0         True           False             False
1        False           False              True
2        False           False              True
3        False           False             False
4        False           False              True

   MultipleLines_No phone service  ...  StreamingTV_No internet
service  \
0                            True  ...
False
1                           False  ...
```

```
False
2                            False  ...
False
3                             True  ...
False
4                            False  ...
False

   StreamingTV_Yes  StreamingMovies_No internet service
StreamingMovies_Yes  \
0            False                                False
False
1            False                                False
False
2            False                                False
False
3            False                                False
False
4            False                                False
False

   Contract_One year  Contract_Two year  PaperlessBilling_Yes  \
0              False              False                  True
1               True              False                 False
2              False              False                  True
3               True              False                 False
4              False              False                  True

   PaymentMethod_Credit card (automatic)  PaymentMethod_Electronic
check  \
0                                  False
True
1                                  False
False
2                                  False
False
3                                  False
False
4                                  False
True

   PaymentMethod_Mailed check
0                        False
1                         True
2                         True
3                        False
4                        False

[5 rows x 31 columns]
```

```
X = df.drop('Churn', axis=1)
y = df['Churn']

print("Shape of X (features):", X.shape)
print("Shape of y (target):", y.shape)

print("\nFirst 5 rows of X:")
print(X.head())

print("\nFirst 10 values of y:")
print(y.head(10))

print("\nUnique values in y:", y.unique())
```

```
Shape of X (features): (7032, 30)
Shape of y (target): (7032,)

First 5 rows of X:
   SeniorCitizen  tenure  MonthlyCharges  TotalCharges  gender_Male  \
0              0       1           29.85         29.85        False
1              0      34           56.95       1889.50         True
2              0       2           53.85        108.15         True
3              0      45           42.30       1840.75         True
4              0       2           70.70        151.65        False

   Partner_Yes  Dependents_Yes  PhoneService_Yes  \
0         True           False             False
1        False           False              True
2        False           False              True
3        False           False             False
4        False           False              True

   MultipleLines_No phone service  MultipleLines_Yes  ...  \
0                            True              False  ...
1                           False              False  ...
2                           False              False  ...
3                            True              False  ...
4                           False              False  ...

   StreamingTV_No internet service  StreamingTV_Yes  \
0                            False            False
1                            False            False
2                            False            False
3                            False            False
4                            False            False

   StreamingMovies_No internet service  StreamingMovies_Yes  \
0                                False                False
1                                False                False
2                                False                False
```

```
3                                  False                False
4                                  False                False

   Contract_One year  Contract_Two year  PaperlessBilling_Yes  \
0              False              False                  True
1               True              False                 False
2              False              False                  True
3               True              False                 False
4              False              False                  True

   PaymentMethod_Credit card (automatic)  PaymentMethod_Electronic
check  \
0                                  False
True
1                                  False
False
2                                  False
False
3                                  False
False
4                                  False
True

   PaymentMethod_Mailed check
0                      False
1                       True
2                       True
3                      False
4                      False

[5 rows x 30 columns]

First 10 values of y:
0    0
1    0
2    1
3    0
4    1
5    1
6    0
7    0
8    1
9    0
Name: Churn, dtype: int64

Unique values in y: [0 1]

scaler = StandardScaler()
X_scaled = scaler.fit_transform(X)
```

```
print("Original shape:", X.shape)
print("Scaled shape:", X_scaled.shape)
```

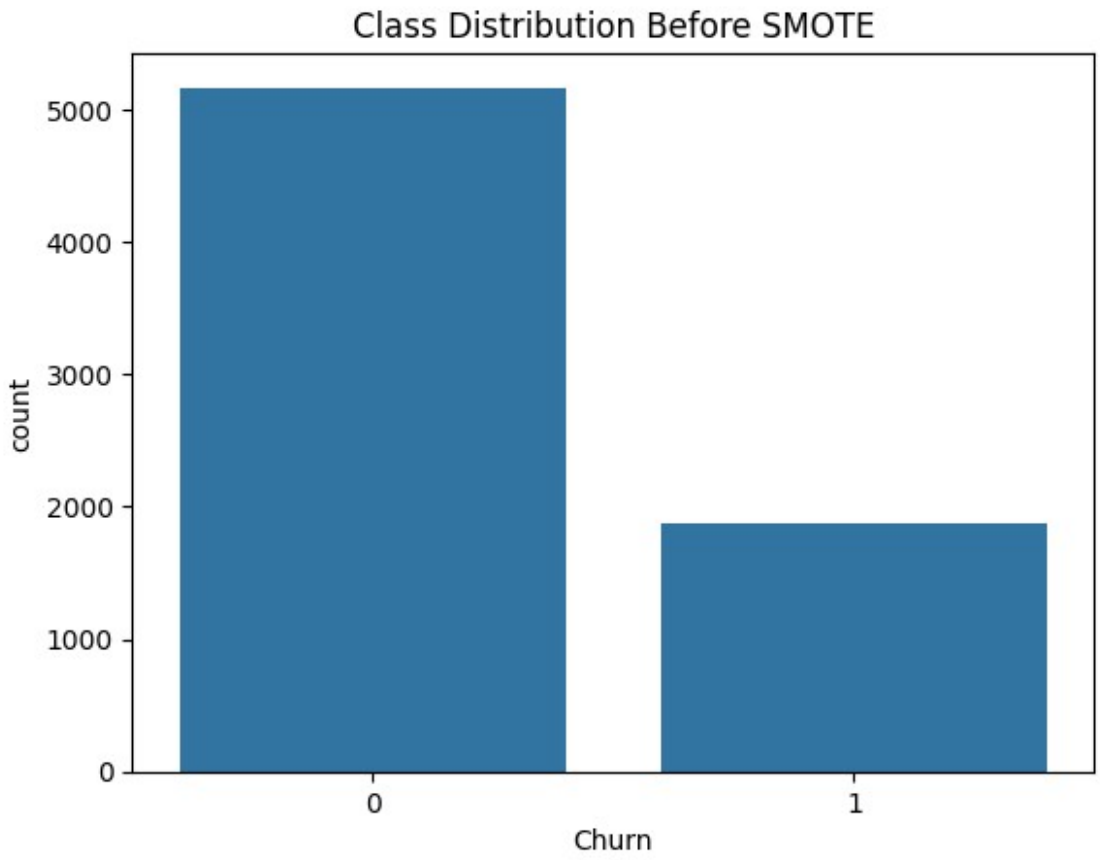
```
Original shape: (7032, 30)
Scaled shape: (7032, 30)
```

```
print("Mean of each column (should be ~0):")
print(np.mean(X_scaled, axis=0))

print("\nStandard deviation of each column (should be ~1):")
print(np.std(X_scaled, axis=0))
```

```
Mean of each column (should be ~0):
[ 2.62714891e-17 -1.12664271e-16  6.06265133e-17 -1.11906439e-16
 -7.67935835e-17  6.26473971e-17  6.46682808e-17  1.37420097e-16
 -7.27518159e-17  3.63759080e-17  1.97036168e-17 -4.29437802e-18
 -4.29437802e-18 -1.50303231e-17 -4.29437802e-18 -4.40805274e-17
 -4.29437802e-18  7.42674788e-17 -4.29437802e-18  2.72819310e-17
 -4.29437802e-18  8.48771186e-17 -4.29437802e-18  6.66891646e-17
  1.03317683e-16 -1.86931749e-17 -4.06702860e-17 -8.36140662e-17
  5.98686819e-17  4.39542221e-17]

Standard deviation of each column (should be ~1):
[1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
1.
 1. 1. 1. 1. 1. 1.]
```

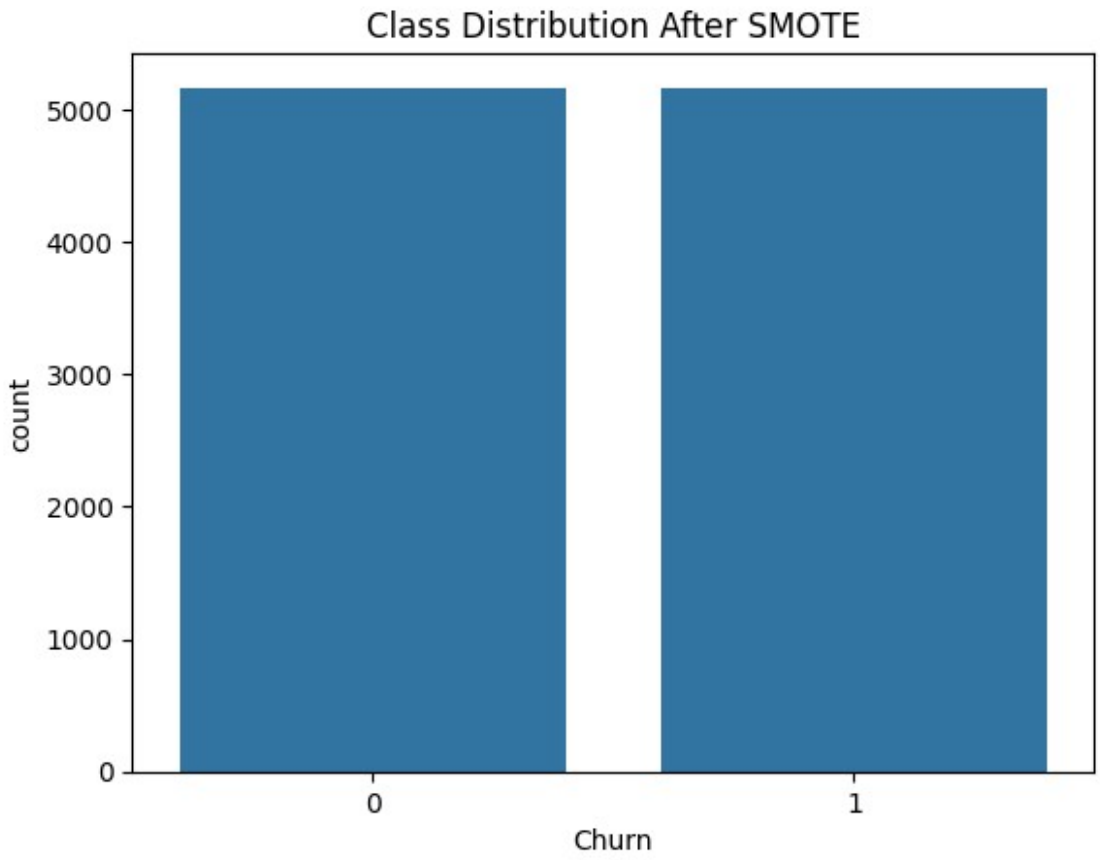
```
print("Before SMOTE:")
print(y.value_counts())
sns.countplot(x=y)
plt.title("Class Distribution Before SMOTE")
plt.show()
```

```
Before SMOTE:
Churn
0    5163
1    1869
Name: count, dtype: int64
```




```
smote = SMOTE(random_state=42)
X_resampled, y_resampled = smote.fit_resample(X_scaled, y)

print("After SMOTE:")
print(pd.Series(y_resampled).value_counts())
sns.countplot(x=y_resampled)
plt.title("Class Distribution After SMOTE")
plt.show()
```

```
After SMOTE:
Churn
0    5163
1    5163
Name: count, dtype: int64
```




```
X_train, X_test, y_train, y_test = train_test_split(X_resampled,
y_resampled, test_size=0.2, random_state=42)

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: (8260, 30)
X_test shape: (2066, 30)
y_train shape: (8260,)
y_test shape: (2066,)
```

```
lr = LogisticRegression(max_iter=1000)
lr.fit(X_train, y_train)
lr_pred = lr.predict(X_test)

print("□ Logistic Regression Report:\n")
print(confusion_matrix(y_test, lr_pred))
print(classification_report(y_test, lr_pred))
```

```
□ Logistic Regression Report:

[[778 259]
```

```
 [176 853]]
              precision    recall  f1-score   support

           0       0.82      0.75      0.78      1037
           1       0.77      0.83      0.80      1029

    accuracy                           0.79      2066
   macro avg       0.79      0.79      0.79      2066
weighted avg       0.79      0.79      0.79      2066
```

```
dt = DecisionTreeClassifier(random_state=42)
dt.fit(X_train, y_train)
dt_pred = dt.predict(X_test)

print("🌳 Decision Tree Report:\n")
print(confusion_matrix(y_test, dt_pred))
print(classification_report(y_test, dt_pred))
```

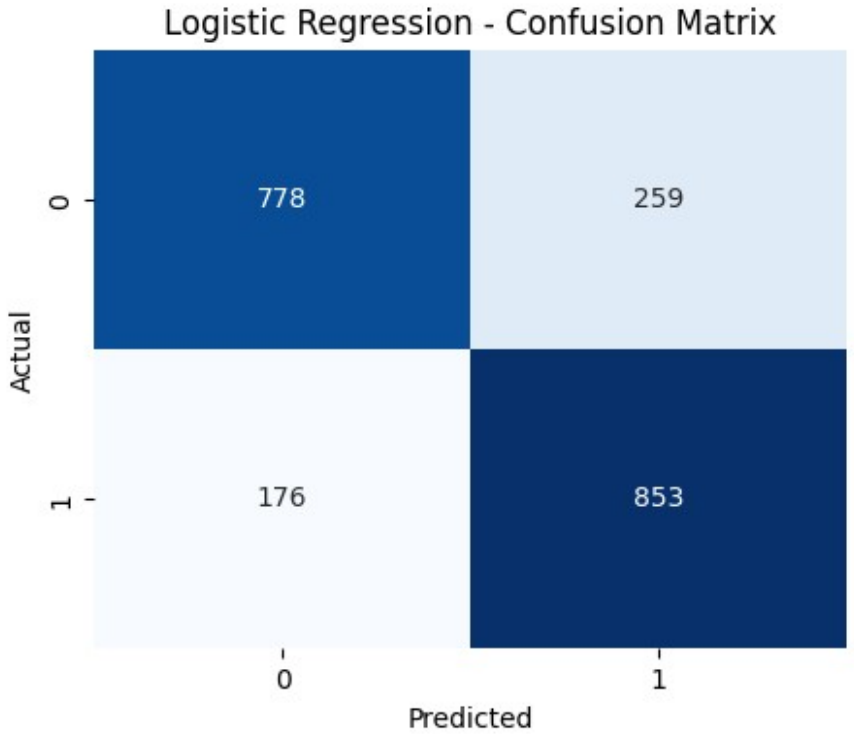
```
🌳 Decision Tree Report:

[[813 224]
 [221 808]]
              precision    recall  f1-score   support

           0       0.79      0.78      0.79      1037
           1       0.78      0.79      0.78      1029

    accuracy                           0.78      2066
   macro avg       0.78      0.78      0.78      2066
weighted avg       0.78      0.78      0.78      2066
```

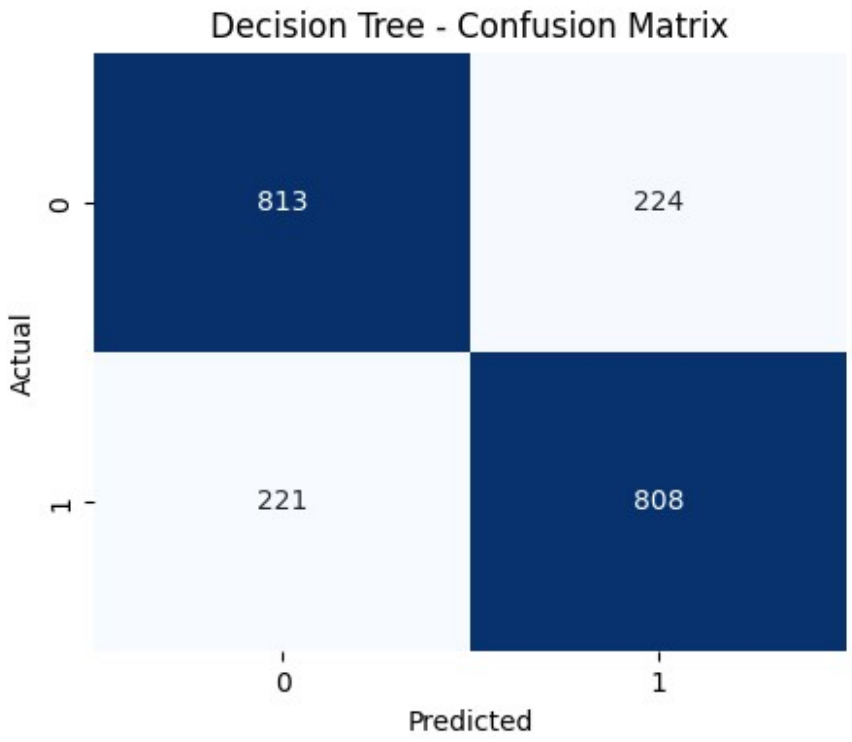
```
mlp = MLPClassifier(hidden_layer_sizes=(100,), max_iter=300,
random_state=42)
mlp.fit(X_train, y_train)
mlp_pred = mlp.predict(X_test)

print("🧠 Neural Network Report:\n")
print(confusion_matrix(y_test, mlp_pred))
print(classification_report(y_test, mlp_pred))
```

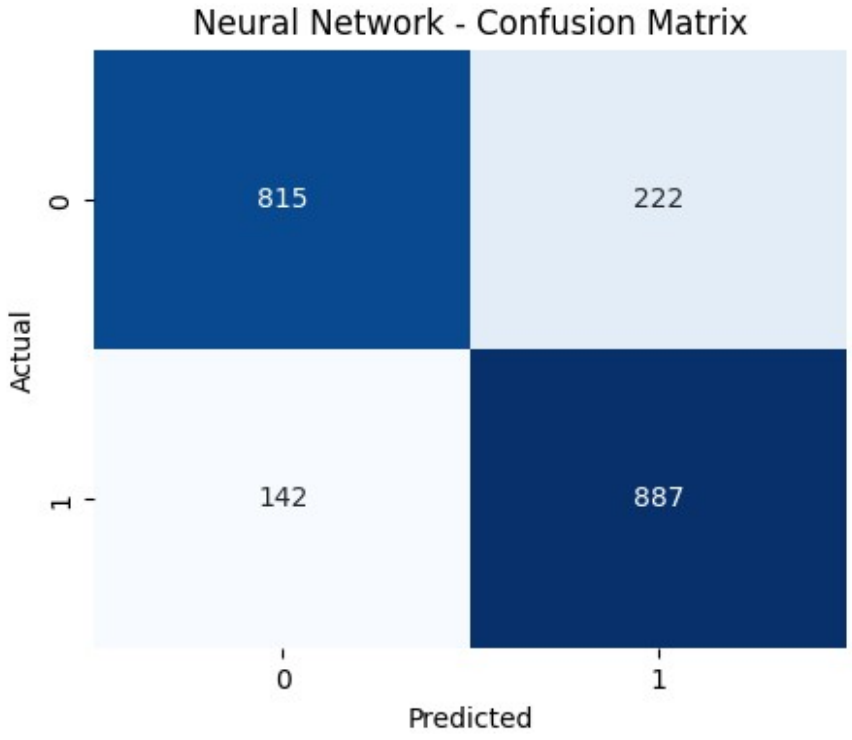
```
🧠 Neural Network Report:

[[815 222]
 [142 887]]
              precision    recall  f1-score   support

           0       0.85      0.79      0.82      1037
           1       0.80      0.86      0.83      1029
```

```
    accuracy                           0.82      2066
   macro avg       0.83      0.82      0.82      2066
weighted avg       0.83      0.82      0.82      2066


/usr/local/lib/python3.11/dist-packages/sklearn/neural_network/
_multilayer_perceptron.py:691: ConvergenceWarning: Stochastic
Optimizer: Maximum iterations (300) reached and the optimization
hasn't converged yet.
  warnings.warn(
```

```python
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.metrics import confusion_matrix

def plot_confusion(model_name, y_true, y_pred):
    cm = confusion_matrix(y_true, y_pred)
    plt.figure(figsize=(5, 4))
    sns.heatmap(cm, annot=True, fmt='d', cmap='Blues', cbar=False)
    plt.title(f"{model_name} - Confusion Matrix")
    plt.xlabel("Predicted")
    plt.ylabel("Actual")
    plt.show()

plot_confusion("Logistic Regression", y_test, lr_pred)
plot_confusion("Decision Tree", y_test, dt_pred)
plot_confusion("Neural Network", y_test, mlp_pred)
```



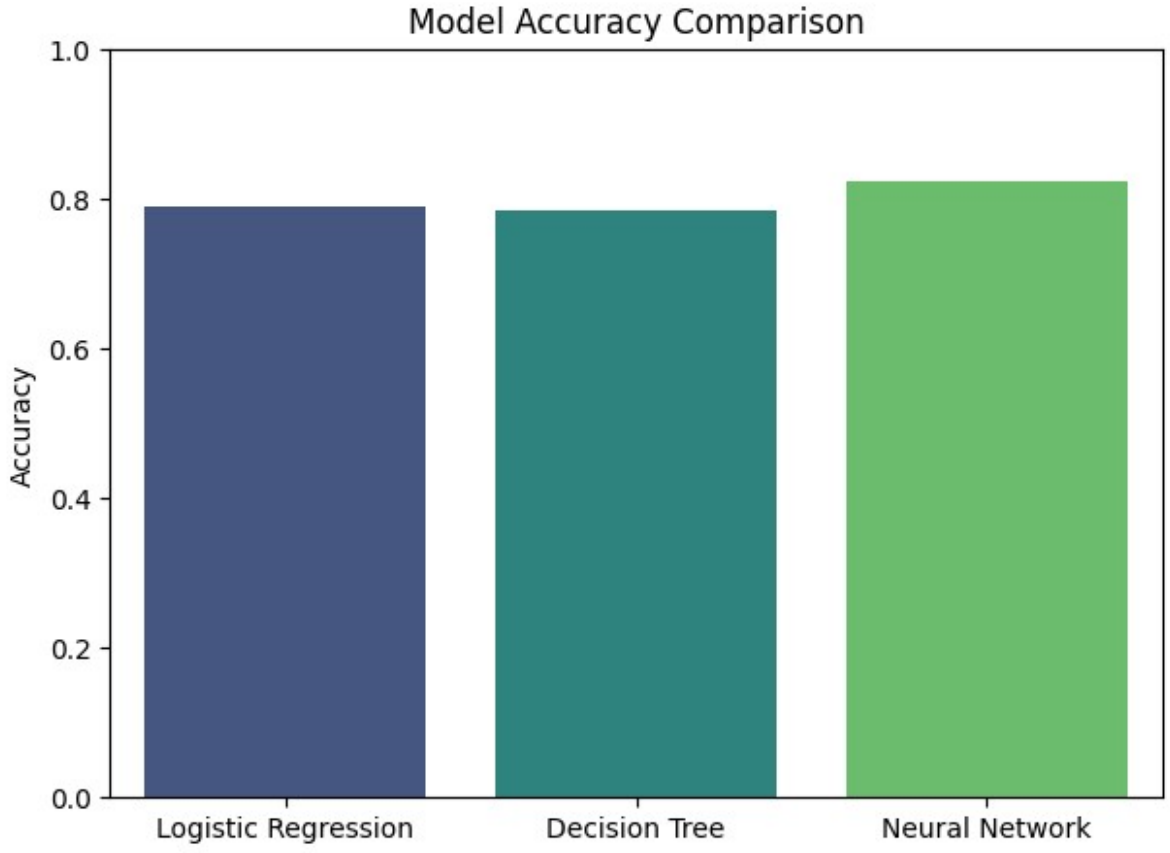





```
from sklearn.metrics import accuracy_score

models = ['Logistic Regression', 'Decision Tree', 'Neural Network']
```

```
accuracies = [
    accuracy_score(y_test, lr_pred),
    accuracy_score(y_test, dt_pred),
    accuracy_score(y_test, mlp_pred)
]

plt.figure(figsize=(7, 5))
sns.barplot(x=models, y=accuracies, palette="viridis")
plt.title("Model Accuracy Comparison")
plt.ylabel("Accuracy")
plt.ylim(0, 1)
plt.show()
```

```
<ipython-input-30-84ae9695587d>:11: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable to `hue` and set `legend=False` for the same effect.

  sns.barplot(x=models, y=accuracies, palette="viridis")
```




```
labels = ['Not Churned', 'Churned']
sizes = y.value_counts()
```

```
plt.figure(figsize=(5, 5))
plt.pie(sizes, labels=labels, autopct='%1.1f%%', startangle=90,
colors=['#66b3ff', '#ff9999'])
plt.title("Original Churn Distribution")
plt.axis('equal')
plt.show()
```