```
import pandas as pd
import seaborn as sns
import numpy as np
import matplotlib.pyplot as plt
sns.set_theme(color_codes=True)
pd.set_option('display.max_columns', None)
```

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

	_category	joining_date	joined_through_referral	referral_id	preferred_offer_type
	Membership	2017-08-17	No	xxxxxxxx	Gift Vouchers/Coupor
	Membership	2017-08-28	?	CID21329	Gift Vouchers/Coupor
	Membership	2016-11-11	Yes	CID12313	Gift Vouchers/Coupor
	Membership	2016-10-29	Yes	CID3793	Gift Vouchers/Coupor
	Membership	2017-09-12	No	xxxxxxxx	Credit/Debit Card Offe

Data Preprocessing Part 1

```
# Drop identifier columns
df.drop(columns = ['customer_id', 'Name', 'security_no', 'referral_id'], inplace=True)
```

```
df.head()
```

	age	gender	region_category	membership_category	joining_date	joined_through
0	18	F	Village	Platinum Membership	2017-08-17	
1	32	F	City	Premium Membership	2017-08-28	
2	44	F	Town	No Membership	2016-11-11	
3	37	M	City	No Membership	2016-10-29	
4	31	F	City	No Membership	2017-09-12	

```
df.shape
```

```
(36992, 21)
```

```
#Check the number of unique value from all of the object datatype
df.select_dtypes(include='object').nunique()
```

```
gender                          3
region_category                 3
membership_category             6
joining_date                 1096
joined_through_referral         3
preferred_offer_types           3
medium_of_operation             4
internet_option                 3
last_visit_time             30101
avg_frequency_login_days     1654
```

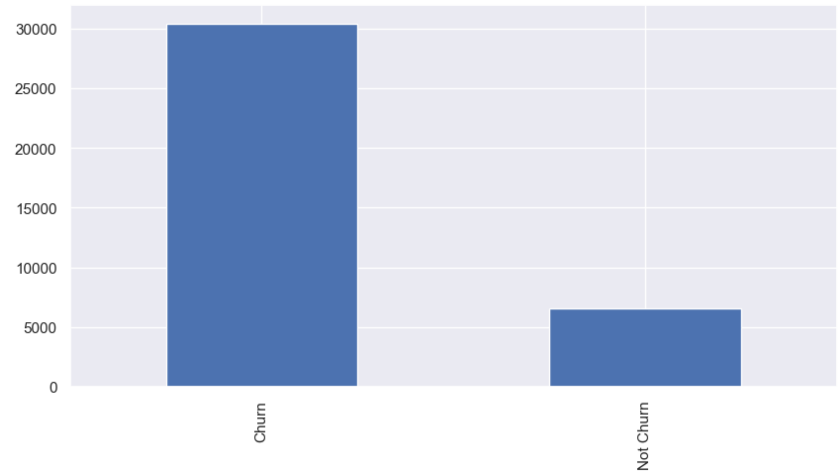
```
used_special_discount              2
offer_application_preference       2
past_complaint                     2
complaint_status                   5
feedback                           9
dtype: int64
```

```
# Drop last_visit_time
df.drop(columns = 'last_visit_time', inplace=True)

# Only extreact year from joining_date
df['joining_date'] = df['joining_date'].str[:4].astype(int)

# Change error from avg_frequency_login_days into null value
df['avg_frequency_login_days'] = df['avg_frequency_login_days'].replace('Error', np.nan).astype(float)


#Check the number of unique value from all of the object datatype
df.select_dtypes(include='object').nunique()
```

```
gender                          3
region_category                 3
membership_category             6
joined_through_referral         3
preferred_offer_types           3
medium_of_operation             4
internet_option                 3
used_special_discount           2
offer_application_preference    2
past_complaint                  2
complaint_status                5
feedback                        9
dtype: int64
```

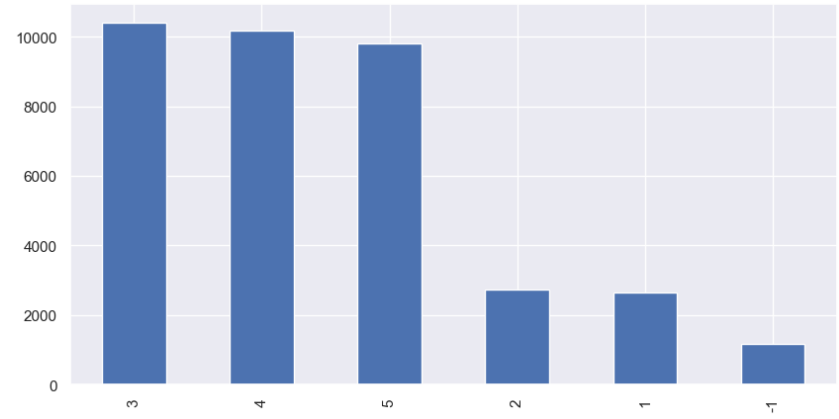
```
# Categorize churn_risk_score into 2 types
def categorize_churn(score):
    if score in (-1, 1, 2):
        return 'Not Churn'
    elif score in (3, 4, 5):
        return 'Churn'
    else:
        return 'Unknown'

df['churn_category'] = df['churn_risk_score'].apply(categorize_churn)
df['churn_category'] = df['churn_category'].astype(str)


plt.figure(figsize=(10,5))
df['churn_category'].value_counts().plot(kind='bar')
```

```
<AxesSubplot:>
```



```
plt.figure(figsize=(10,5))
df['churn_risk_score'].value_counts().plot(kind='bar')
```

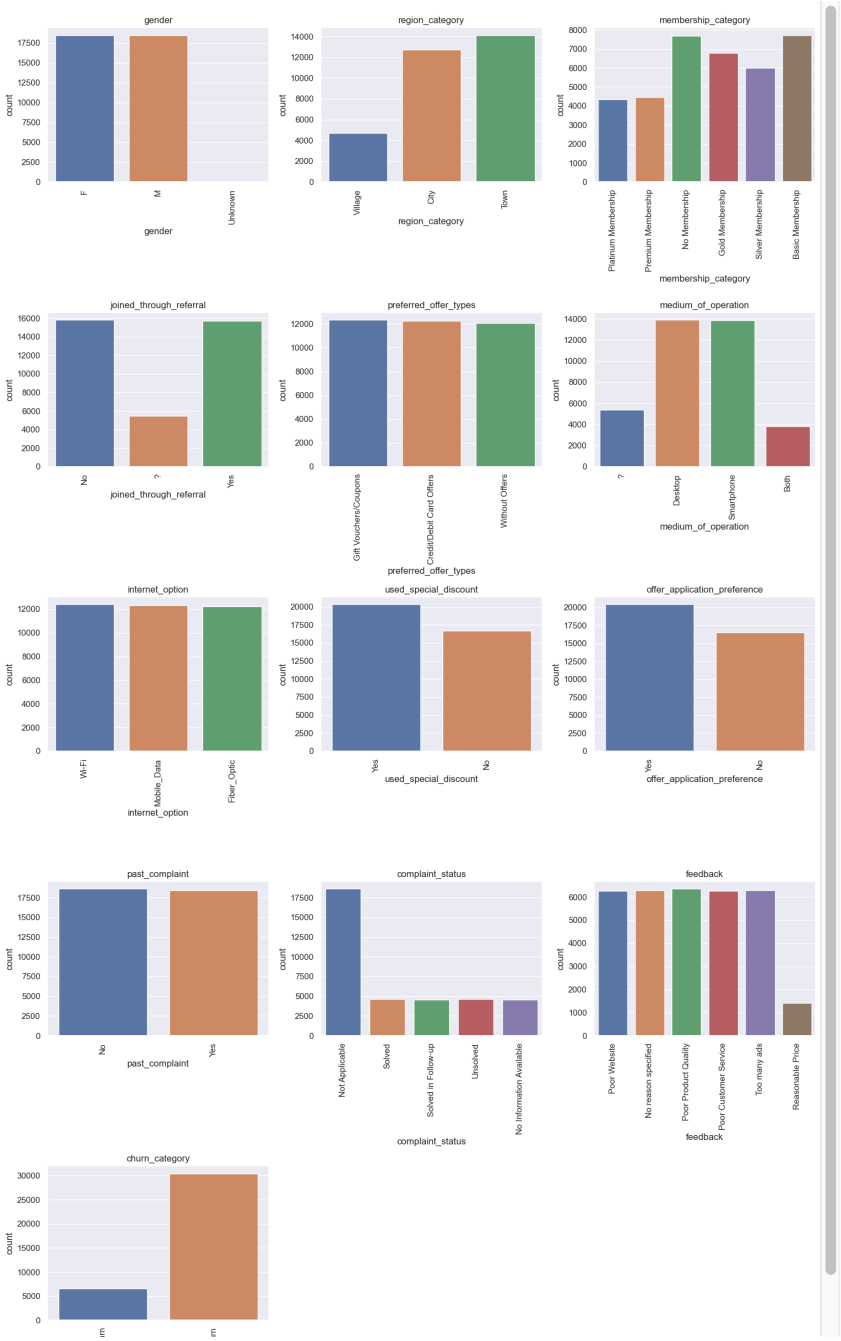
```
<AxesSubplot:>
```



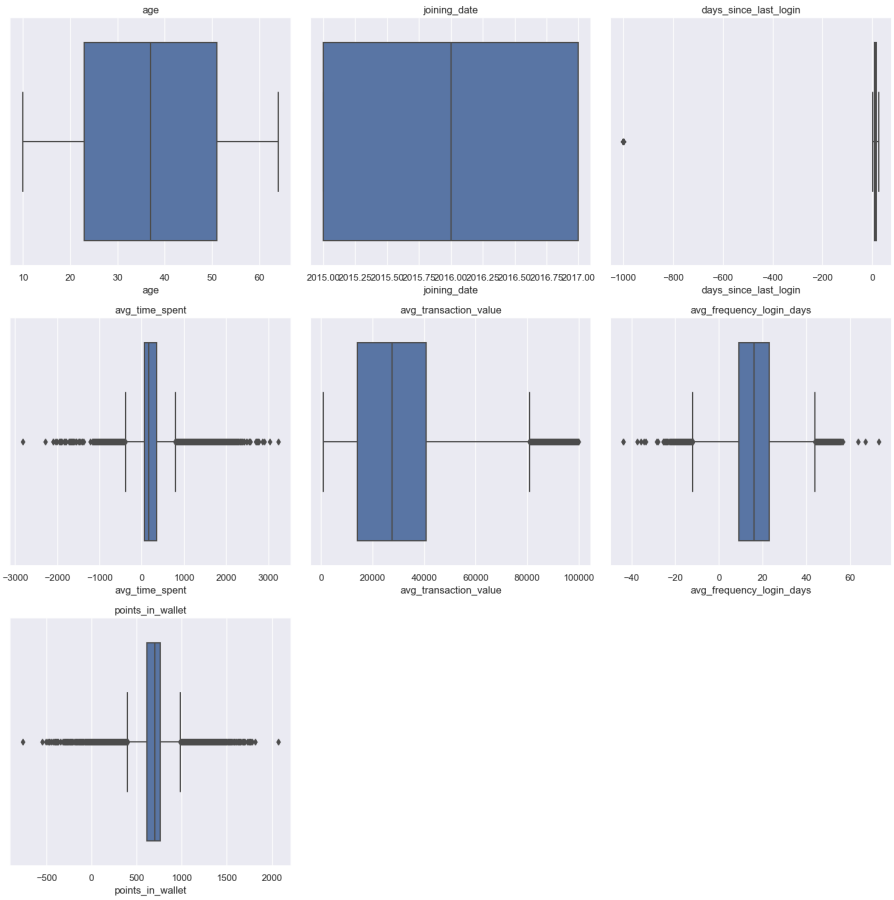

```
df.drop(columns = 'churn_risk_score', inplace=True)
```

Exploratory Data Analysis

```
# Get the names of all columns with data type 'object' (categorical columns)
cat_vars = df.select_dtypes(include='object').columns.tolist()

# Create a figure with subplots
num_cols = len(cat_vars)
num_rows = (num_cols + 2) // 3
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(15, 5*num_rows))
axs = axs.flatten()

# Create a countplot for the top 6 values of each categorical variable using Seaborn
for i, var in enumerate(cat_vars):
    top_values = df[var].value_counts().nlargest(6).index
    filtered_df = df[df[var].isin(top_values)]
    sns.countplot(x=var, data=filtered_df, ax=axs[i])
    axs[i].set_title(var)
    axs[i].tick_params(axis='x', rotation=90)

# Remove any extra empty subplots if needed
if num_cols < len(axs):
    for i in range(num_cols, len(axs)):
        fig.delaxes(axs[i])

# Adjust spacing between subplots
fig.tight_layout()

# Show plot
plt.show()
```

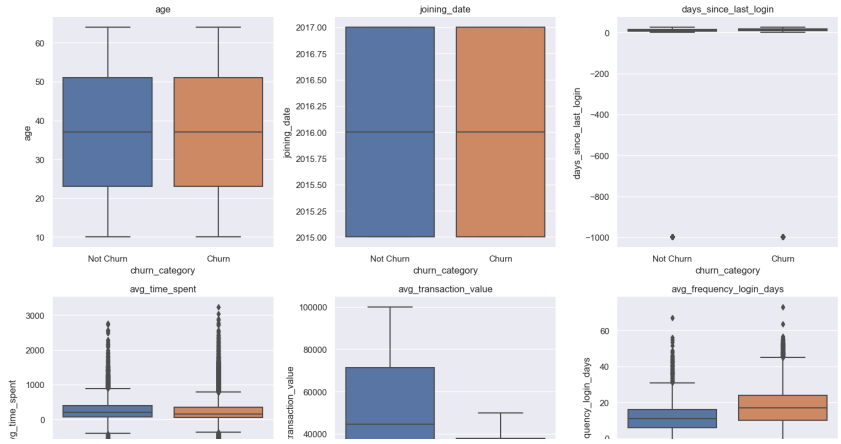

gender
count
F
M
Unknown
gender
region_category
Village
City
Town
region_category
membership_category
Platinum Membership
Premium Membership
No Membership
Gold Membership
Silver Membership
Basic Membership
membership_category
joined_through_referral
No
?
Yes
joined_through_referral
preferred_offer_types
Gift Vouchers/Coupons
Credit/Debit Card Offers
Without Offers
preferred_offer_types
medium_of_operation
?
Desktop
Smartphone
Both
medium_of_operation
internet_option
Wi-Fi
Mobile_Data
Fiber_Optic
internet_option
used_special_discount
Yes
No
used_special_discount
offer_application_preference
Yes
No
offer_application_preference
past_complaint
No
Yes
past_complaint
complaint_status
Not Applicable
Solved
Solved in Follow-up
Unsolved
No Information Available
complaint_status
feedback
Poor Website
No reason specified
Poor Product Quality
Poor Customer Service
Too many ads
Reasonable Price
feedback
churn_category
0
1
churn_category

```
# Get the names of all columns with data type 'int' or 'float'
num_vars = df.select_dtypes(include=['int', 'float']).columns.tolist()

# Create a figure with subplots
num_cols = len(num_vars)
num_rows = (num_cols + 2) // 3
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(15, 5*num_rows))
axs = axs.flatten()

# Create a box plot for each numerical variable using Seaborn
for i, var in enumerate(num_vars):
    sns.boxplot(x=df[var], ax=axs[i])
    axs[i].set_title(var)

# Remove any extra empty subplots if needed
if num_cols < len(axs):
    for i in range(num_cols, len(axs)):
        fig.delaxes(axs[i])

# Adjust spacing between subplots
fig.tight_layout()

# Show plot
plt.show()
```

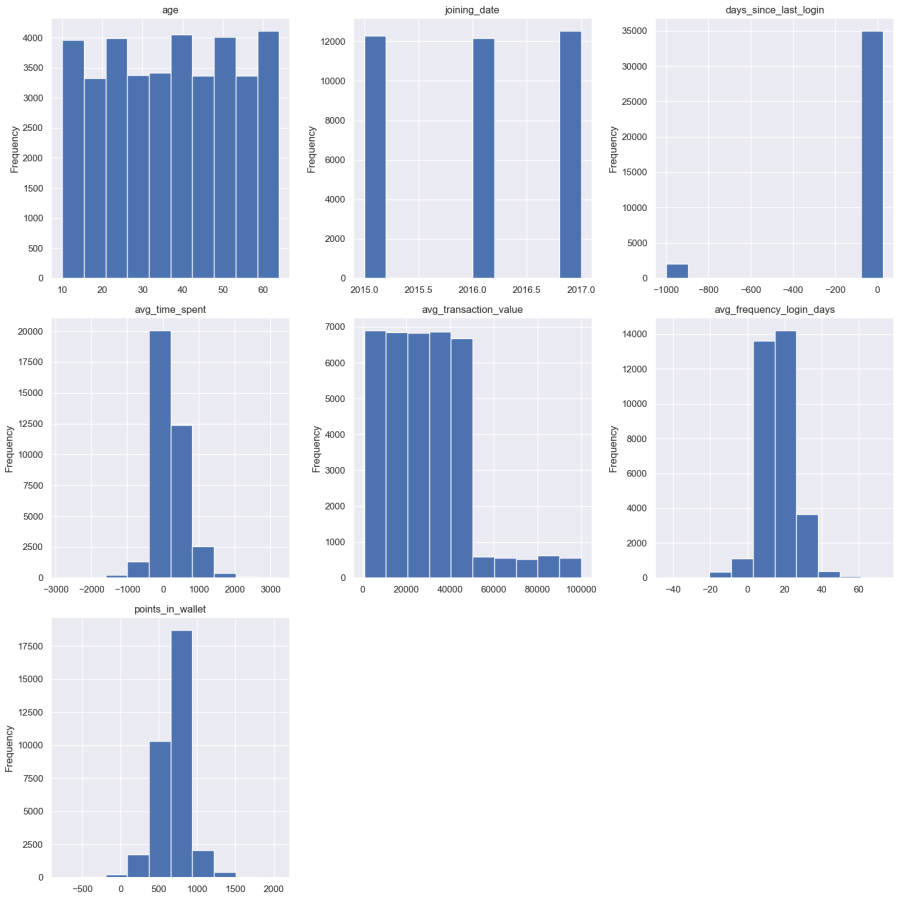



```
# Get the names of all columns with data type 'int'
int_vars = df.select_dtypes(include=['int', 'float']).columns.tolist()

# Create a figure with subplots
num_cols = len(int_vars)
num_rows = (num_cols + 2) // 3  # To make sure there are enough rows for the subplots
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(15, 5*num_rows))
axs = axs.flatten()
```

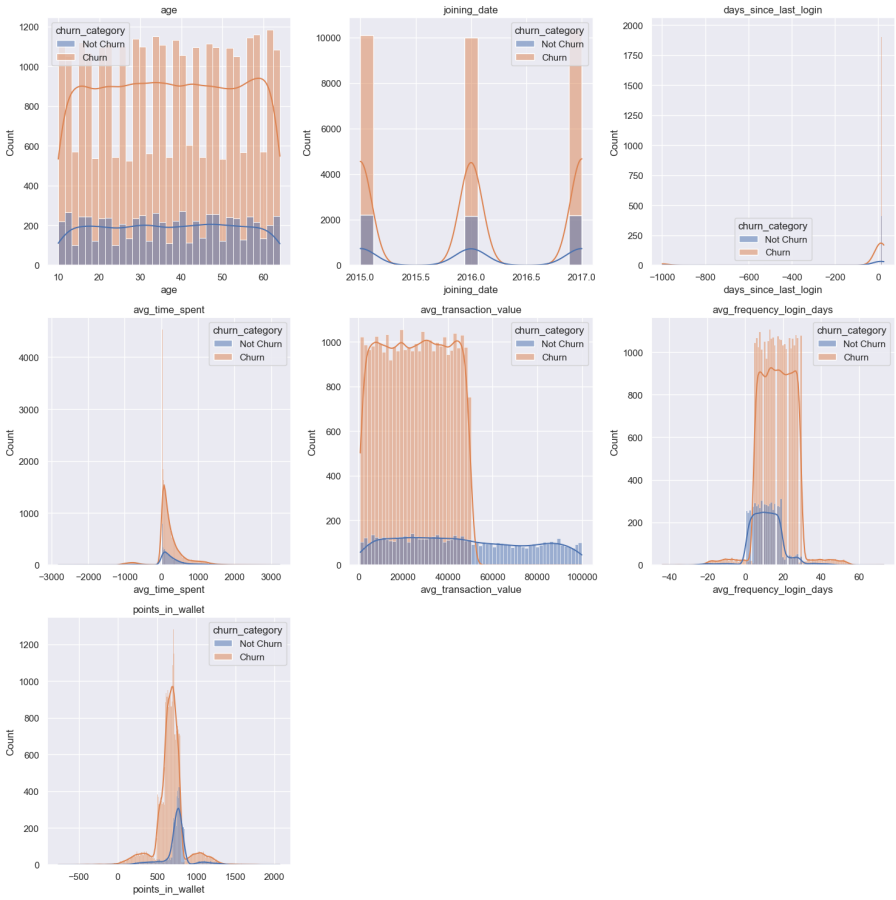
```
# Create a box plot for each integer variable using Seaborn with hue='attrition'
for i, var in enumerate(int_vars):
    sns.boxplot(y=var, x='churn_category', data=df, ax=axs[i])
    axs[i].set_title(var)

# Remove any extra empty subplots if needed
if num_cols < len(axs):
    for i in range(num_cols, len(axs)):
        fig.delaxes(axs[i])

# Adjust spacing between subplots
fig.tight_layout()

# Show plot
plt.show()
```




```
# Get the names of all columns with data type 'int'
int_vars = df.select_dtypes(include=['int', 'float']).columns.tolist()

# Create a figure with subplots
num_cols = len(int_vars)
num_rows = (num_cols + 2) // 3  # To make sure there are enough rows for the subplots
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(15, 5*num_rows))
axs = axs.flatten()

# Create a histogram for each integer variable
for i, var in enumerate(int_vars):
    df[var].plot.hist(ax=axs[i])
    axs[i].set_title(var)

# Remove any extra empty subplots if needed
if num_cols < len(axs):
    for i in range(num_cols, len(axs)):
        fig.delaxes(axs[i])

# Adjust spacing between subplots
fig.tight_layout()

# Show plot
plt.show()
```

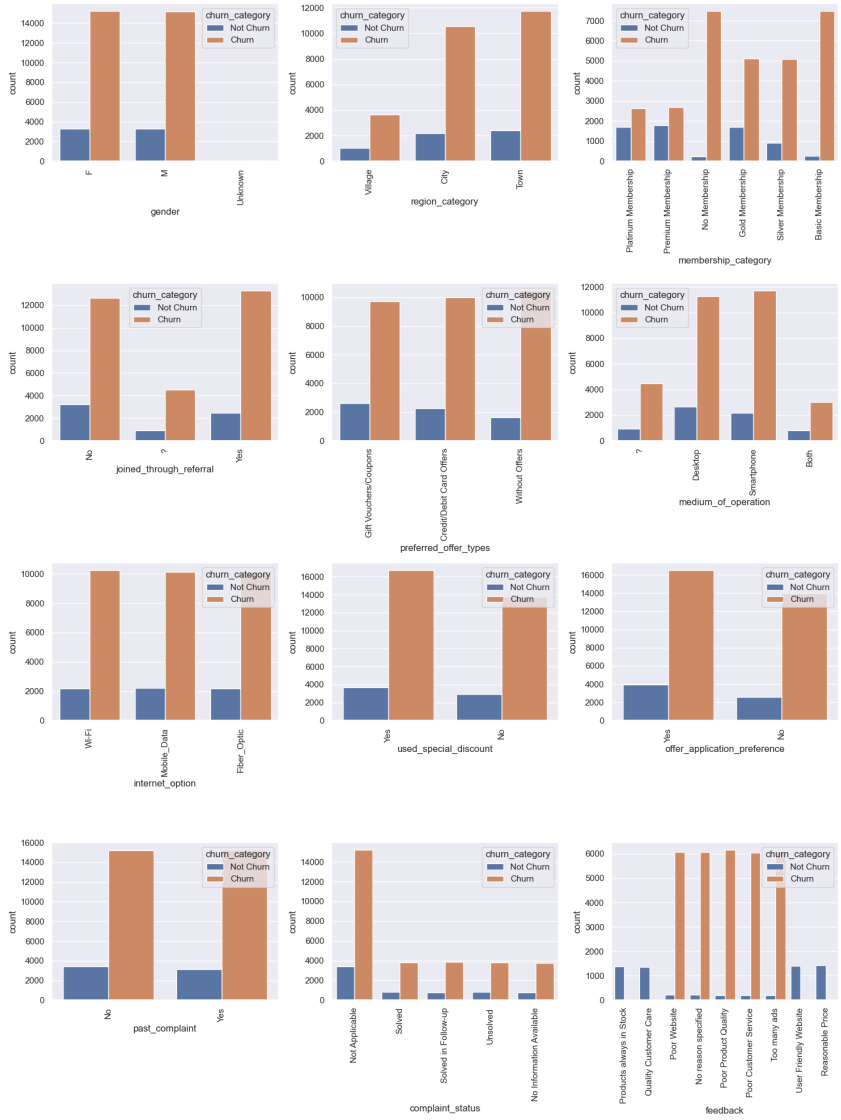



```
# Get the names of all columns with data type 'int'
int_vars = df.select_dtypes(include=['int', 'float']).columns.tolist()

# Create a figure with subplots
num_cols = len(int_vars)
num_rows = (num_cols + 2) // 3  # To make sure there are enough rows for the subplots
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(15, 5*num_rows))
axs = axs.flatten()

# Create a histogram for each integer variable with hue='Attrition'
for i, var in enumerate(int_vars):
    sns.histplot(data=df, x=var, hue='churn_category', kde=True, ax=axs[i])
    axs[i].set_title(var)

# Remove any extra empty subplots if needed
if num_cols < len(axs):
    for i in range(num_cols, len(axs)):
        fig.delaxes(axs[i])

# Adjust spacing between subplots
fig.tight_layout()

# Show plot
plt.show()
```




```
# Get the names of all columns with data type 'object' (categorical variables)
cat_vars = df.select_dtypes(include=['object']).columns.tolist()

# Exclude 'Attrition' from the list if it exists in cat_vars
```

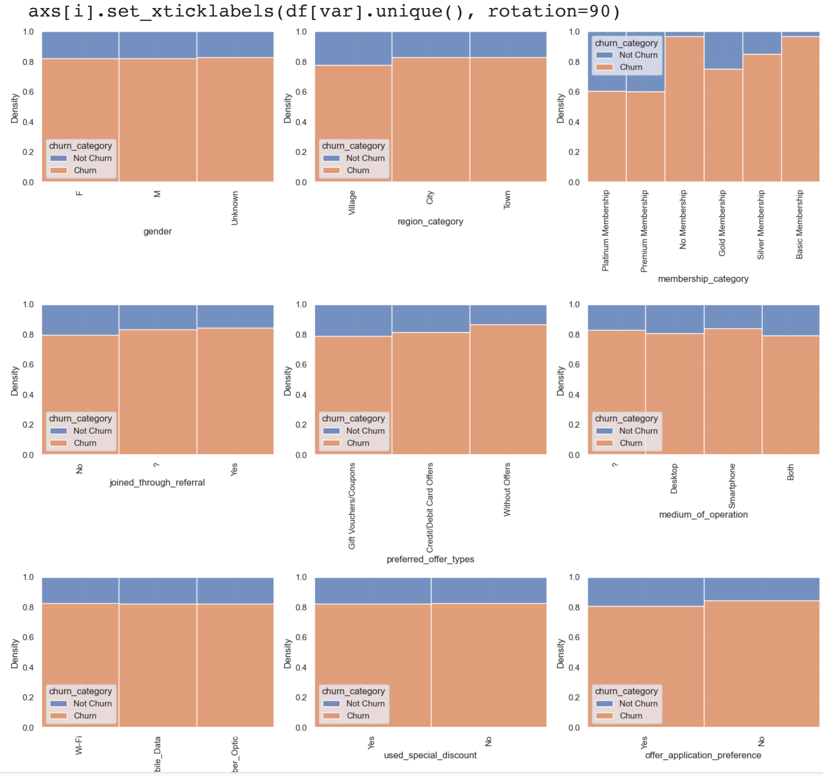
```
if 'churn_category' in cat_vars:
    cat_vars.remove('churn_category')

# Create a figure with subplots, but only include the required number of subplots
num_cols = len(cat_vars)
num_rows = (num_cols + 2) // 3  # To make sure there are enough rows for the subplots
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(15, 5*num_rows))
axs = axs.flatten()

# Create a count plot for each categorical variable
for i, var in enumerate(cat_vars):
    sns.countplot(x=var, hue='churn_category', data=df, ax=axs[i])
    axs[i].set_xticklabels(axs[i].get_xticklabels(), rotation=90)

# Remove any remaining blank subplots
for i in range(num_cols, len(axs)):
    fig.delaxes(axs[i])

# Adjust spacing between subplots
fig.tight_layout()

# Show the plot
plt.show()
```




```
# Get the names of all columns with data type 'object' (categorical variables)
cat_vars = df.select_dtypes(include=['object']).columns.tolist()

# Exclude 'Attrition' from the list if it exists in cat_vars
if 'churn_category' in cat_vars:
    cat_vars.remove('churn_category')

# Create a figure with subplots, but only include the required number of subplots
num_cols = len(cat_vars)
num_rows = (num_cols + 2) // 3  # To make sure there are enough rows for the subplots
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(15, 5*num_rows))
axs = axs.flatten()

# Create a count plot for each categorical variable
for i, var in enumerate(cat_vars):
    sns.histplot(x=var, hue='churn_category', data=df, ax=axs[i], multiple="fill", kde=False, element="bars", fill=True, stat='der
    axs[i].set_xticklabels(df[var].unique(), rotation=90)
    axs[i].set_xlabel(var)

# Remove any remaining blank subplots
for i in range(num_cols, len(axs)):
    fig.delaxes(axs[i])

# Adjust spacing between subplots
```

```
fig.tight_layout()

# Show the plot
plt.show()
```

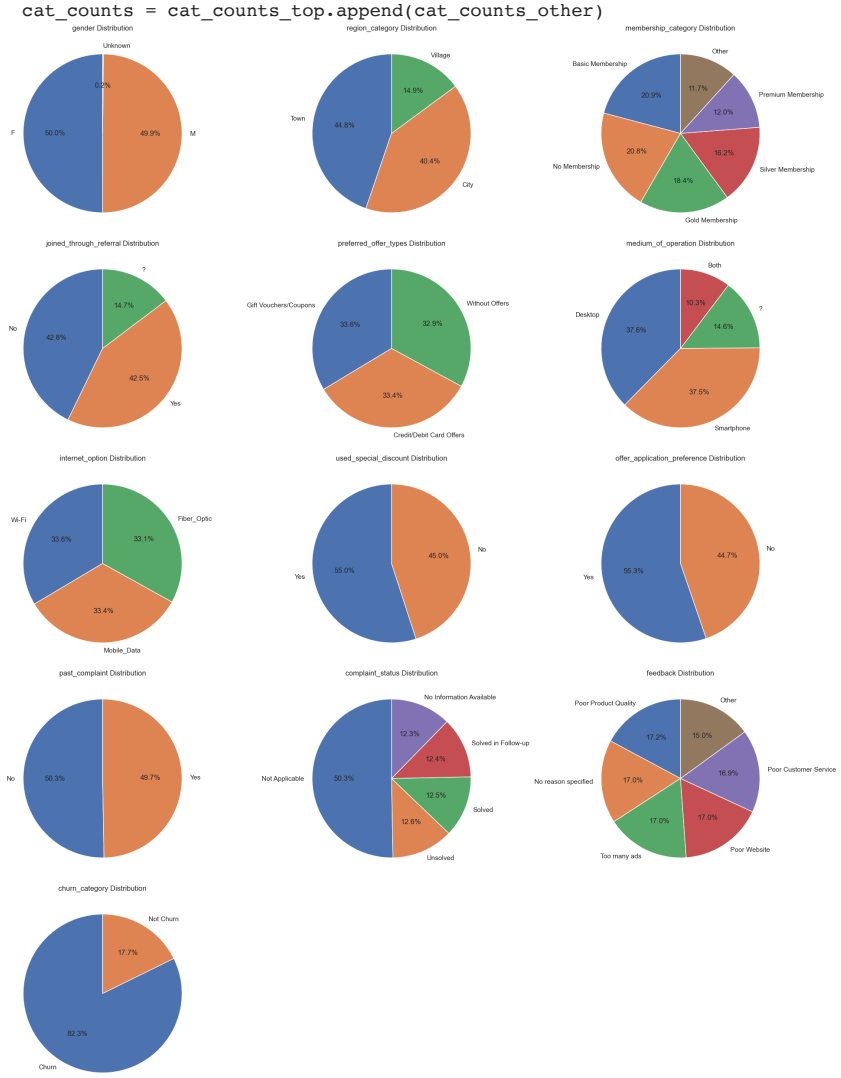
```
C:\Users\Michael\AppData\Local\Temp\ipykernel_3508\2500184484.py:17: User
  axs[i].set_xticklabels(df[var].unique(), rotation=90)
C:\Users\Michael\AppData\Local\Temp\ipykernel_3508\2500184484.py:17: User
  axs[i].set_xticklabels(df[var].unique(), rotation=90)
C:\Users\Michael\AppData\Local\Temp\ipykernel_3508\2500184484.py:17: User
  axs[i].set_xticklabels(df[var].unique(), rotation=90)
C:\Users\Michael\AppData\Local\Temp\ipykernel_3508\2500184484.py:17: User
  axs[i].set_xticklabels(df[var].unique(), rotation=90)
C:\Users\Michael\AppData\Local\Temp\ipykernel_3508\2500184484.py:17: User
  axs[i].set_xticklabels(df[var].unique(), rotation=90)
C:\Users\Michael\AppData\Local\Temp\ipykernel_3508\2500184484.py:17: User
  axs[i].set_xticklabels(df[var].unique(), rotation=90)
C:\Users\Michael\AppData\Local\Temp\ipykernel_3508\2500184484.py:17: User
  axs[i].set_xticklabels(df[var].unique(), rotation=90)
C:\Users\Michael\AppData\Local\Temp\ipykernel_3508\2500184484.py:17: User
  axs[i].set_xticklabels(df[var].unique(), rotation=90)
C:\Users\Michael\AppData\Local\Temp\ipykernel_3508\2500184484.py:17: User
  axs[i].set_xticklabels(df[var].unique(), rotation=90)
C:\Users\Michael\AppData\Local\Temp\ipykernel_3508\2500184484.py:17: User
  axs[i].set_xticklabels(df[var].unique(), rotation=90)
C:\Users\Michael\AppData\Local\Temp\ipykernel_3508\2500184484.py:17: User
  axs[i].set_xticklabels(df[var].unique(), rotation=90)
C:\Users\Michael\AppData\Local\Temp\ipykernel_3508\2500184484.py:17: User
  axs[i].set_xticklabels(df[var].unique(), rotation=90)
```




```
# Specify the maximum number of categories to show individually
max_categories = 5

# Filter categorical columns with 'object' data type
cat_cols = [col for col in df.columns if col != 'y' and df[col].dtype == 'object']

# Create a figure with subplots
num_cols = len(cat_cols)
num_rows = (num_cols + 2) // 3
fig, axs = plt.subplots(nrows=num_rows, ncols=3, figsize=(20, 5*num_rows))

# Flatten the axs array for easier indexing
axs = axs.flatten()

# Create a pie chart for each categorical column
for i, col in enumerate(cat_cols):
    if i < len(axs):  # Ensure we don't exceed the number of subplots
        # Count the number of occurrences for each category
        cat_counts = df[col].value_counts()

        # Group categories beyond the top max_categories as 'Other'
```

```
            if len(cat_counts) > max_categories:
                cat_counts_top = cat_counts[:max_categories]
                cat_counts_other = pd.Series(cat_counts[max_categories:].sum(), index=['Other'])
                cat_counts = cat_counts_top.append(cat_counts_other)

            # Create a pie chart
            axs[i].pie(cat_counts, labels=cat_counts.index, autopct='%1.1f%%', startangle=90)
            axs[i].set_title(f'{col} Distribution')

    # Remove any extra empty subplots if needed
    if num_cols < len(axs):
        for i in range(num_cols, len(axs)):
            fig.delaxes(axs[i])

    # Adjust spacing between subplots
    fig.tight_layout()

    # Show plot
    plt.show()
```

```
C:\Users\Michael\AppData\Local\Temp\ipykernel_3508\943223290.py:25: FutureW
  cat_counts = cat_counts_top.append(cat_counts_other)
C:\Users\Michael\AppData\Local\Temp\ipykernel_3508\943223290.py:25: FutureW
  cat_counts = cat_counts_top.append(cat_counts_other)
```



Data Preprocessing Part 2

```
# Check the amounnt of missing value
check_missing = df.isnull().sum() * 100 / df.shape[0]
check_missing[check_missing > 0].sort_values(ascending=False)
```

```
region_category            14.673443
avg_frequency_login_days    9.520978
points_in_wallet            9.307418
preferred_offer_types       0.778547
dtype: float64
```

```
# Drop rows with null values in categorical columns
df = df.dropna(subset=['region_category', 'preferred_offer_types'])

# Fill null values with median for numerical columns
df['avg_frequency_login_days'].fillna(df['avg_frequency_login_days'].median(), inplace=True)
df['points_in_wallet'].fillna(df['points_in_wallet'].median(), inplace=True)
```

```
# Check the amounnt of missing value
check_missing = df.isnull().sum() * 100 / df.shape[0]
check_missing[check_missing > 0].sort_values(ascending=False)
```

```
Series([], dtype: float64)
```

Label Encoding for Object Datatypes

```
# Loop over each column in the DataFrame where dtype is 'object'
for col in df.select_dtypes(include=['object']).columns:

    # Print the column name and the unique values
    print(f"{col}: {df[col].unique()}")
```

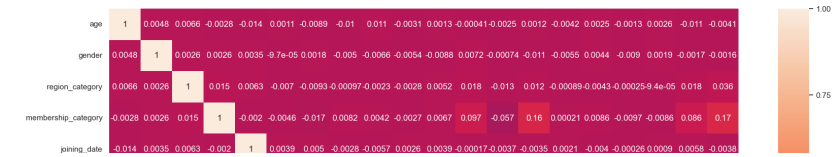
```
gender: ['F' 'M' 'Unknown']
region_category: ['Village' 'City' 'Town']
membership_category: ['Platinum Membership' 'Premium Membership' 'No Membership'
 'Gold Membership' 'Silver Membership' 'Basic Membership']
joined_through_referral: ['No' '?' 'Yes']
preferred_offer_types: ['Gift Vouchers/Coupons' 'Credit/Debit Card Offers' 'Without Offers']
medium_of_operation: ['?' 'Desktop' 'Smartphone' 'Both']
internet_option: ['Wi-Fi' 'Mobile_Data' 'Fiber_Optic']
used_special_discount: ['Yes' 'No']
offer_application_preference: ['Yes' 'No']
past_complaint: ['No' 'Yes']
complaint_status: ['Not Applicable' 'Solved' 'Solved in Follow-up' 'Unsolved'
 'No Information Available']
feedback: ['Products always in Stock' 'Quality Customer Care' 'Poor Website'
 'No reason specified' 'Poor Customer Service' 'Poor Product Quality'
 'Too many ads' 'User Friendly Website' 'Reasonable Price']
churn_category: ['Not Churn' 'Churn']
```

```
from sklearn import preprocessing

# Loop over each column in the DataFrame where dtype is 'object'
for col in df.select_dtypes(include=['object']).columns:

    # Initialize a LabelEncoder object
    label_encoder = preprocessing.LabelEncoder()

    # Fit the encoder to the unique values in the column
    label_encoder.fit(df[col].unique())

    # Transform the column using the encoder
    df[col] = label_encoder.transform(df[col])

    # Print the column name and the unique encoded values
    print(f"{col}: {df[col].unique()}")
```

```
gender: [0 1 2]
region_category: [2 0 1]
membership_category: [3 4 2 1 5 0]
joined_through_referral: [1 0 2]
preferred_offer_types: [1 0 2]
medium_of_operation: [0 2 3 1]
internet_option: [2 1 0]
used_special_discount: [1 0]
offer_application_preference: [1 0]
past_complaint: [0 1]
complaint_status: [1 2 3 4 0]
feedback: [4 5 3 0 1 2 7 8 6]
churn_category: [1 0]
```

```
# Correlation Heatmap
plt.figure(figsize=(20, 16))
sns.heatmap(df.corr(), fmt='.2g', annot=True)
```

```
<AxesSubplot:>
```



Train Test Split

```
X = df.drop('churn_category', axis=1)
y = df['churn_category']
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score
X_train, X_test, y_train, y_test = train_test_split(X,y, test_size=0.2,random_state=0)
```

Remove Outlier from Train Data using Z-Score

```
from scipy import stats

# Define the columns for which you want to remove outliers
selected_columns = ['days_since_last_login', 'avg_time_spent', 'avg_transaction_value',
                    'avg_frequency_login_days', 'points_in_wallet']

# Calculate the Z-scores for the selected columns in the training data
z_scores = np.abs(stats.zscore(X_train[selected_columns]))

# Set a threshold value for outlier detection (e.g., 3)
threshold = 3

# Find the indices of outliers based on the threshold
outlier_indices = np.where(z_scores > threshold)[0]

# Remove the outliers from the training data
X_train = X_train.drop(X_train.index[outlier_indices])
y_train = y_train.drop(y_train.index[outlier_indices])
```

Decision Tree Classifier

```
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import GridSearchCV
dtree = DecisionTreeClassifier(class_weight='balanced')
param_grid = {
    'max_depth': [3, 4, 5, 6, 7, 8],
    'min_samples_split': [2, 3, 4],
    'min_samples_leaf': [1, 2, 3, 4],
    'random_state': [0, 42]
}

# Perform a grid search with cross-validation to find the best hyperparameters
grid_search = GridSearchCV(dtree, param_grid, cv=5)
grid_search.fit(X_train, y_train)

# Print the best hyperparameters
print(grid_search.best_params_)
```

```
{'max_depth': 4, 'min_samples_leaf': 3, 'min_samples_split': 2, 'random_state': 0}
```

```
from sklearn.tree import DecisionTreeClassifier
dtree = DecisionTreeClassifier(random_state=0, max_depth=4, min_samples_leaf=3, min_samples_split=2, class_weight='balanced')
dtree.fit(X_train, y_train)
```

```
DecisionTreeClassifier(class_weight='balanced', max_depth=4, min_samples_leaf=3,
                       random_state=0)
```

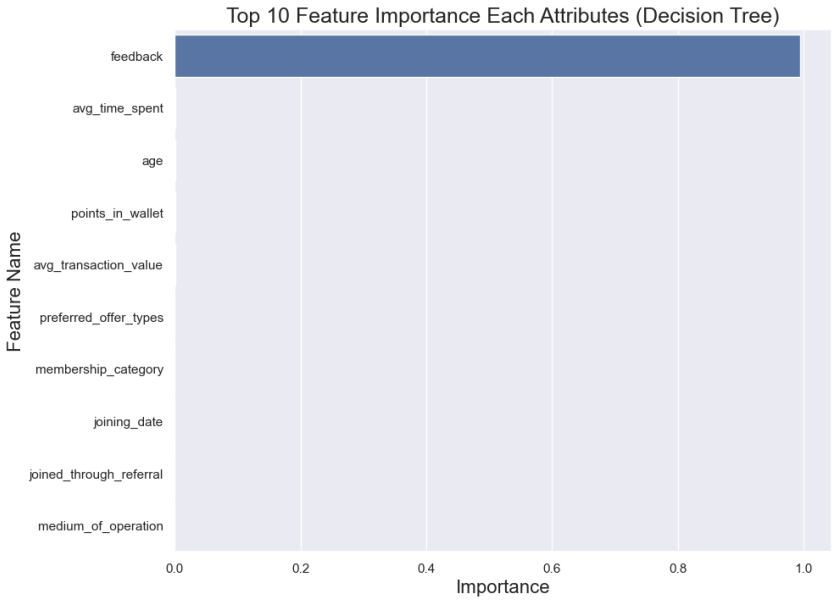
```
from sklearn.metrics import accuracy_score
y_pred = dtree.predict(X_test)
print("Accuracy Score :", round(accuracy_score(y_test, y_pred)*100 ,2), "%")
```

```
Accuracy Score : 97.02 %
```

```
from sklearn.metrics import accuracy_score, f1_score, precision_score, recall_score, jaccard_score, log_loss
print('F-1 Score : ',(f1_score(y_test, y_pred, average='micro')))
print('Precision Score : ',(precision_score(y_test, y_pred, average='micro')))
print('Recall Score : ',(recall_score(y_test, y_pred, average='micro')))
print('Jaccard Score : ',(jaccard_score(y_test, y_pred, average='micro')))
print('Log Loss : ',(log_loss(y_test, y_pred)))
```

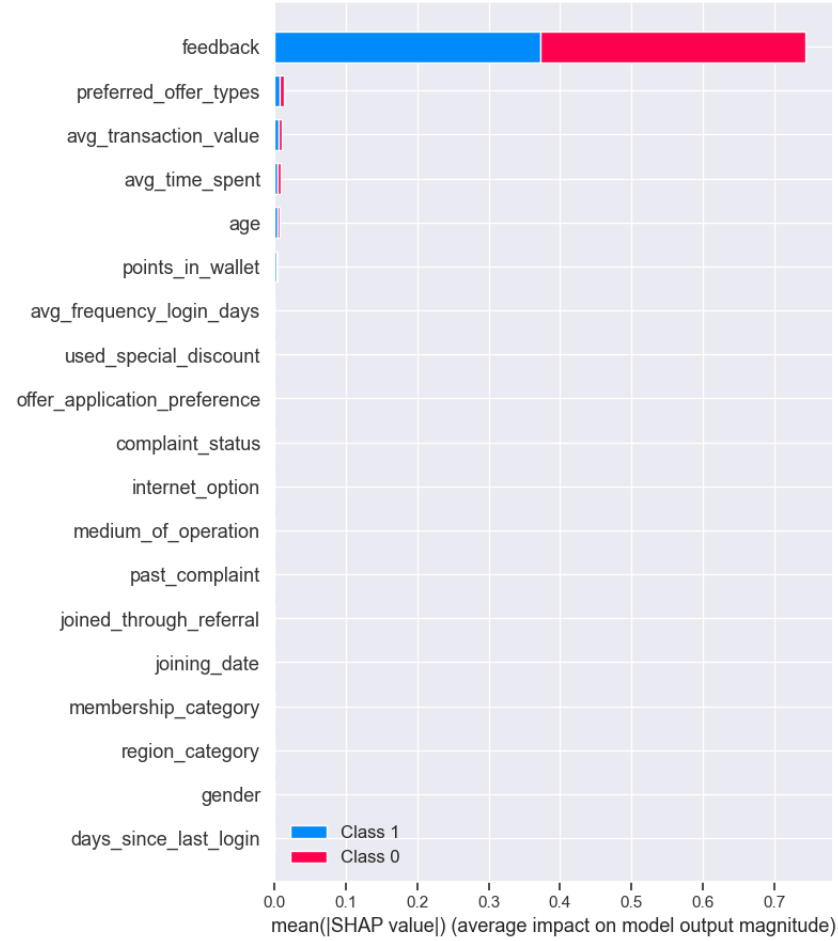
```
F-1 Score :  0.9701516360734238
Precision Score :  0.9701516360734238
Recall Score :  0.9701516360734238
Jaccard Score :  0.9420334779913205
Log Loss :  1.0309292857751775
```

```
imp_df = pd.DataFrame({
    "Feature Name": X_train.columns,
    "Importance": dtree.feature_importances_
})
fi = imp_df.sort_values(by="Importance", ascending=False)

fi2 = fi.head(10)
plt.figure(figsize=(10,8))
sns.barplot(data=fi2, x='Importance', y='Feature Name')
plt.title('Top 10 Feature Importance Each Attributes (Decision Tree)', fontsize=18)
plt.xlabel ('Importance', fontsize=16)
plt.ylabel ('Feature Name', fontsize=16)
plt.show()
```

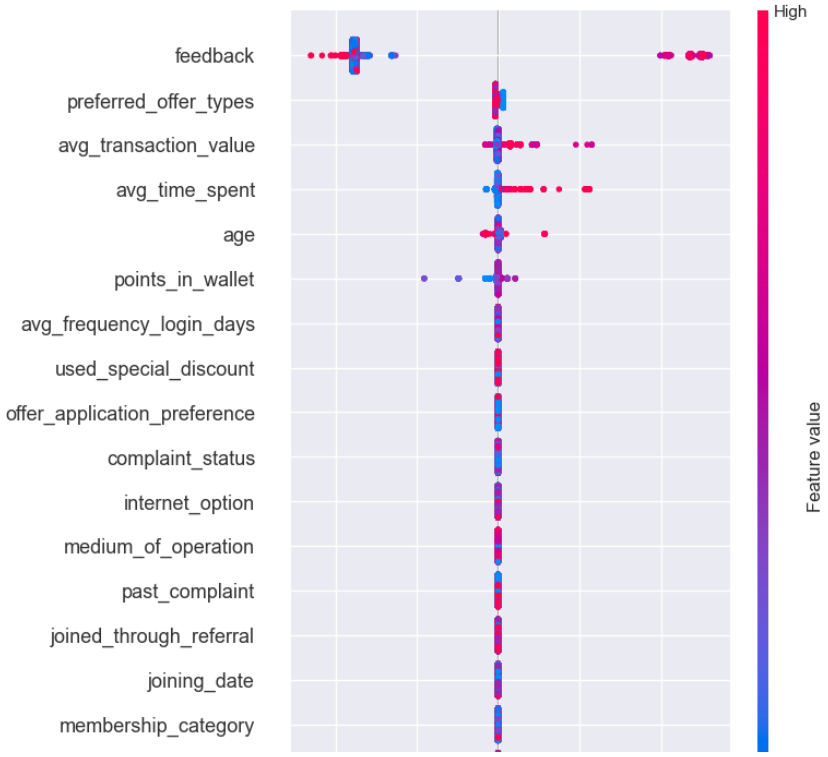


```
import shap
explainer = shap.TreeExplainer(dtree)
shap_values = explainer.shap_values(X_test)
shap.summary_plot(shap_values, X_test)
```

```
Using `tqdm.autonotebook.tqdm` in notebook mode. Use `tqdm.tqdm` instead to
```

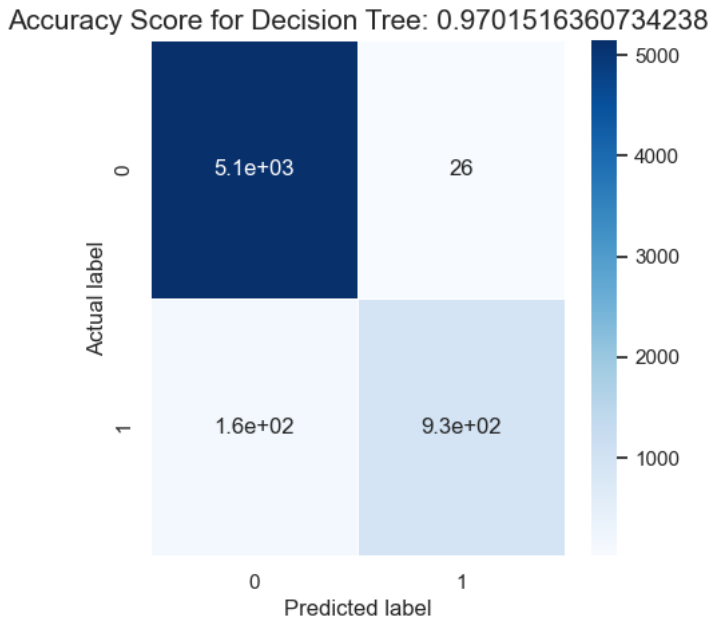



```
# compute SHAP values
explainer = shap.TreeExplainer(dtree)
shap_values = explainer.shap_values(X_test)
shap.summary_plot(shap_values[1], X_test.values, feature_names = X_test.columns)
```




```
from sklearn.metrics import confusion_matrix
cm = confusion_matrix(y_test, y_pred)
plt.figure(figsize=(5,5))
sns.heatmap(data=cm,linewidths=.5, annot=True,  cmap = 'Blues')
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
all_sample_title = 'Accuracy Score for Decision Tree: {0}'.format(dtree.score(X_test, y_test))
plt.title(all_sample_title, size = 15)
```

```
Text(0.5, 1.0, 'Accuracy Score for Decision Tree: 0.9701516360734238')
```




```
from sklearn.metrics import roc_curve, roc_auc_score
y_pred_proba = dtree.predict_proba(X_test)[:][:,1]

df_actual_predicted = pd.concat([pd.DataFrame(np.array(y_test), columns=['y_actual']), pd.DataFrame(y_pred_proba, columns=['y_prec
df_actual_predicted.index = y_test.index

fpr, tpr, tr = roc_curve(df_actual_predicted['y_actual'], df_actual_predicted['y_pred_proba'])
auc = roc_auc_score(df_actual_predicted['y_actual'], df_actual_predicted['y_pred_proba'])

plt.plot(fpr, tpr, label='AUC = %0.4f' %auc)
```