employe-turnover-analysis-2

July 1, 2024

[1]:

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

[ ]:

```

```

[2]:

```
# Import the dataset
data = pd.read_excel('1673873196_hr_comma_sep.xlsx')
```

[3]:

```
# Display the dataset
data
```

[3]:

```
       satisfaction_level  last_evaluation  number_project  \
0                    0.38             0.53               2
1                    0.80             0.86               5
2                    0.11             0.88               7
3                    0.72             0.87               5
4                    0.37             0.52               2
…                   …              …             …
14994                0.40             0.57               2
14995                0.37             0.48               2
14996                0.37             0.53               2
14997                0.11             0.96               6
14998                0.37             0.52               2

       average_montly_hours  time_spend_company  Work_accident  left  \
0                       157                   3              0     1
1                       262                   6              0     1
2                       272                   4              0     1
3                       223                   5              0     1
4                       159                   3              0     1
…                     …                 …            …   …
14994                   151                   3              0     1
14995                   160                   3              0     1
14996                   143                   3              0     1
14997                   280                   4              0     1
```

```
14998                   158                  3              0     1

       promotion_last_5years    sales  salary
0                          0    sales     low
1                          0    sales  medium
2                          0    sales  medium
3                          0    sales     low
4                          0    sales     low
…                       …       …     …
14994                      0  support     low
14995                      0  support     low
14996                      0  support     low
14997                      0  support     low
14998                      0  support     low

[14999 rows x 10 columns]
```

[4]:

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 14999 entries, 0 to 14998
Data columns (total 10 columns):
 #   Column                 Non-Null Count  Dtype
---  ------                 --------------  -----
 0   satisfaction_level     14999 non-null  float64
 1   last_evaluation        14999 non-null  float64
 2   number_project         14999 non-null  int64
 3   average_montly_hours   14999 non-null  int64
 4   time_spend_company     14999 non-null  int64
 5   Work_accident          14999 non-null  int64
 6   left                   14999 non-null  int64
 7   promotion_last_5years  14999 non-null  int64
 8   sales                  14999 non-null  object
 9   salary                 14999 non-null  object
dtypes: float64(2), int64(6), object(2)
memory usage: 1.1+ MB
```

[ ]:

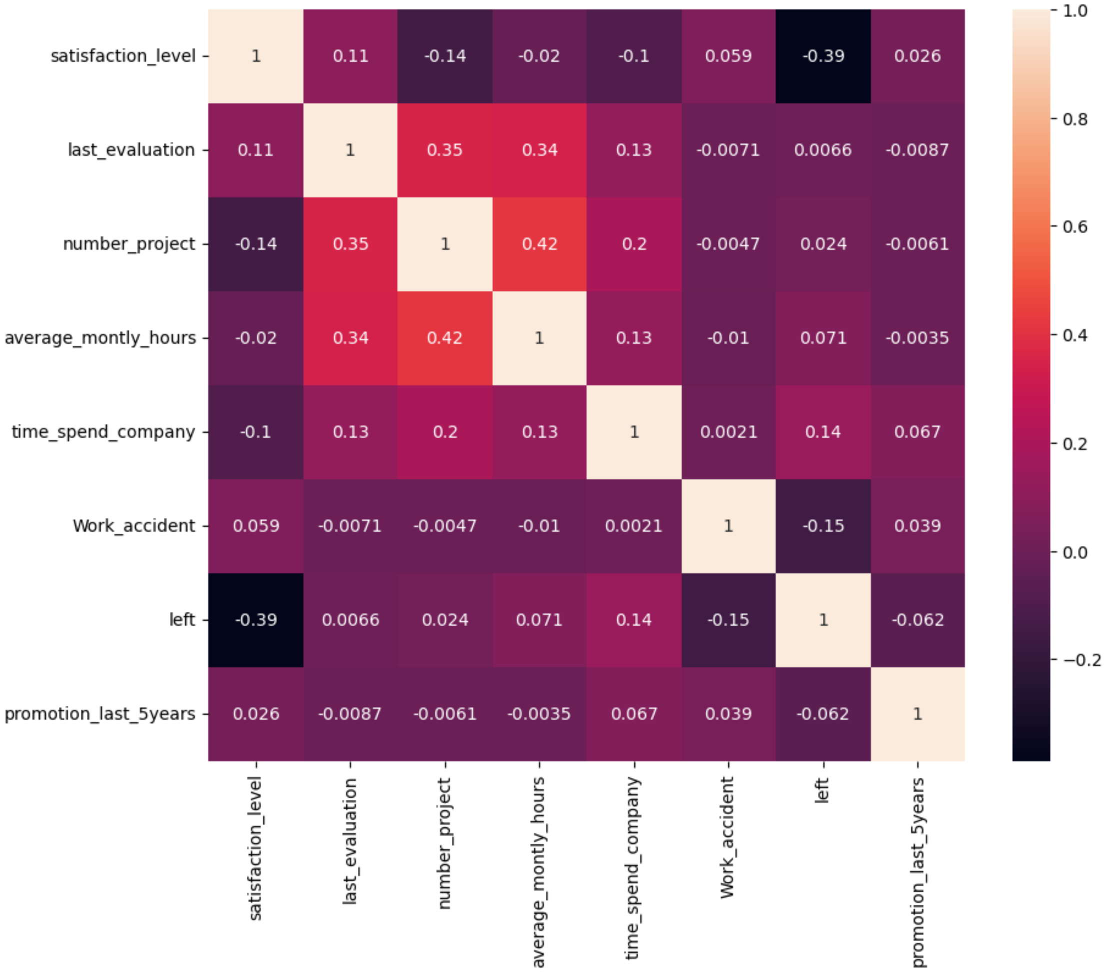
```
Perform the following steps:
1.        Perform data quality checks by checking for missing values, if any
2.        Understand what factors contributed most to employee turnover by EDA
2.1.        Draw a heatmap of the Correlation Matrix between all numerical␣
 ↪features/columns in the data
2.2.        Draw the distribution plot of
         Employee Satisfaction (use column satisfaction_level)
         Employee Evaluation (use column last_evaluation)
         Employee Average Monthly Hours (use column average_montly_hours)
```

```
2.3.        Draw the bar plot of the Employee Project Count of both employees␣
 ↪who left and stayed in the organization
(use column number_project and hue column left), and give your inferences from␣
 ↪the plot
```

[6]:
```
# missing values
data.isnull().sum().any()
```

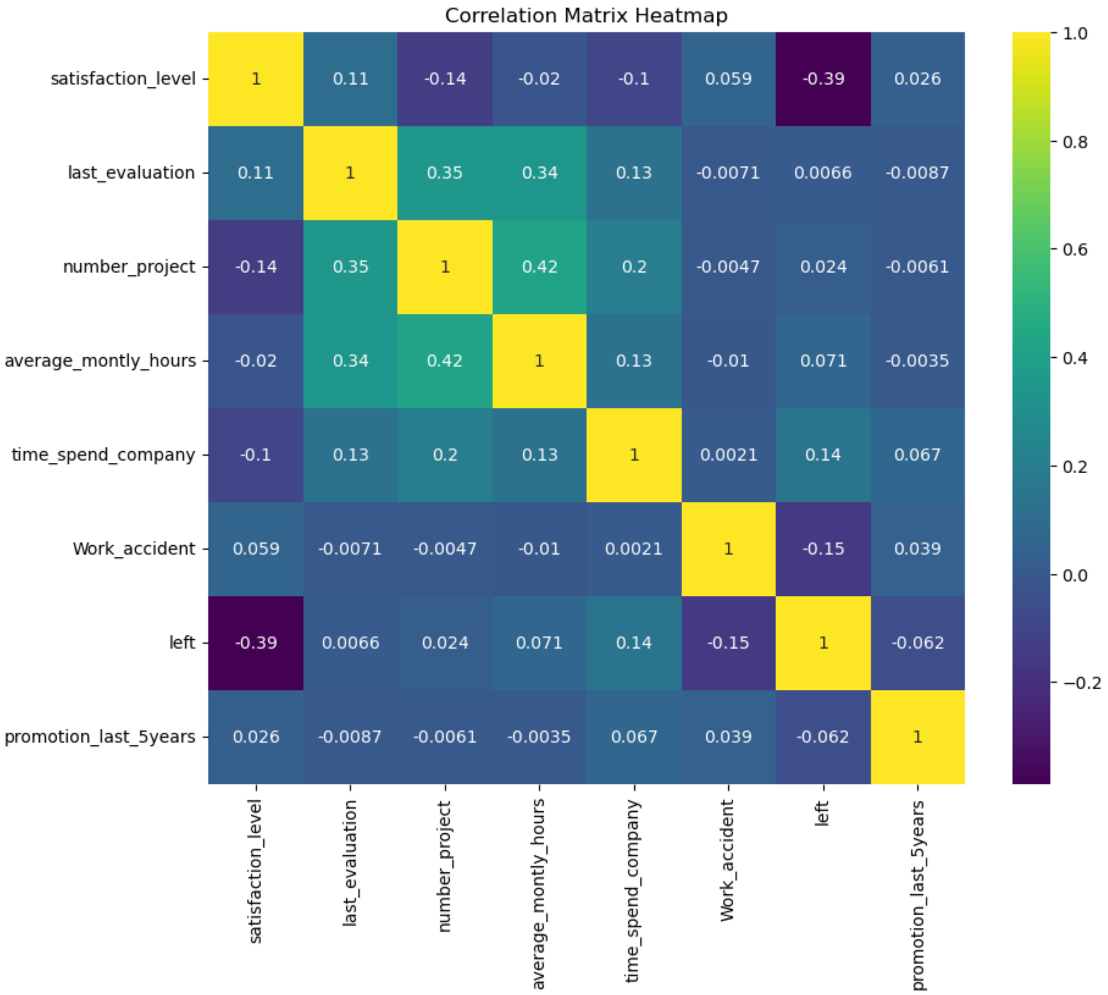
[6]:
```
False
```

[7]:
```
# correlation matrix
plt.figure(figsize=(10,8))
sns.heatmap(data.corr(numeric_only=True),annot=True)
plt.show()
```



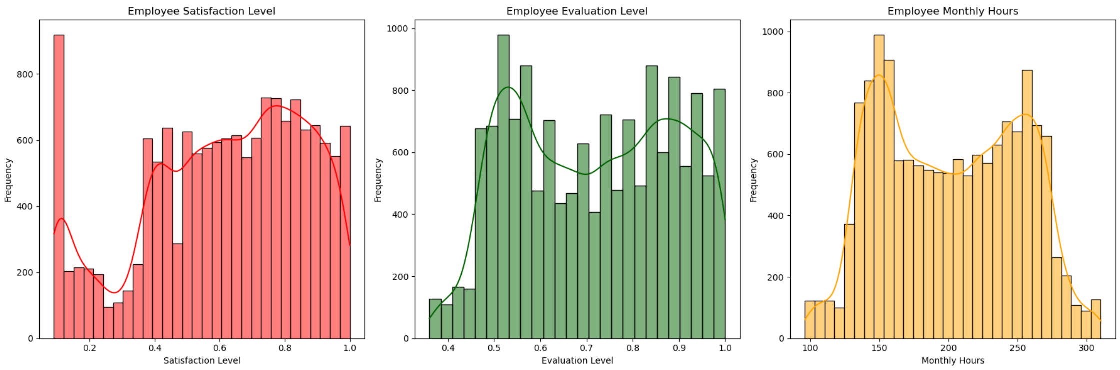
[9]:

```
# Generate the correlation matrix
corr_matrix = data.corr(numeric_only=True)

# Plot the heatmap with a specific color map
plt.figure(figsize=(10,8))
sns.heatmap(corr_matrix, annot=True, cmap='viridis')
plt.title('Correlation Matrix Heatmap')
plt.show()
```



[15]:

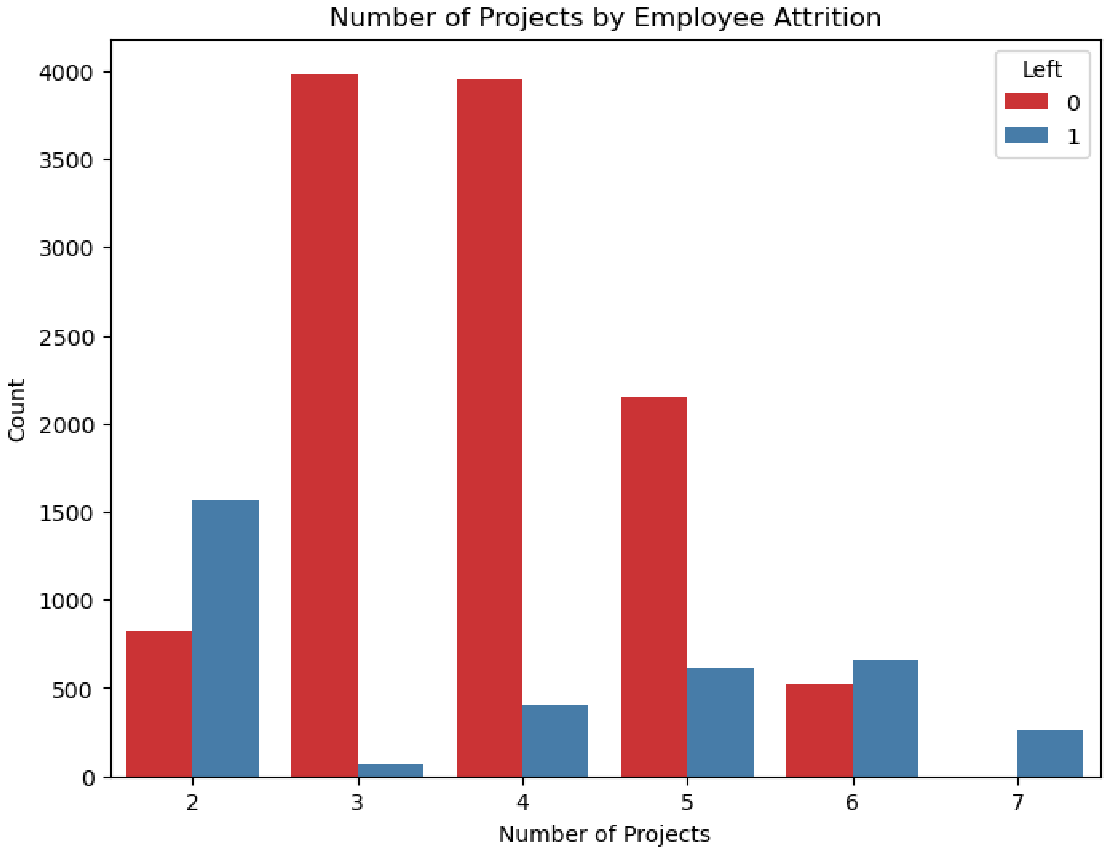
```
# Create a figure with subplots
plt.figure(figsize=(18,6))

# Satisfaction level histogram
plt.subplot(1,3,1)
sns.histplot(data['satisfaction_level'], kde=True, color='red')
plt.title('Employee Satisfaction Level')
plt.xlabel('Satisfaction Level')
plt.ylabel('Frequency')

# Last evaluation histogram
plt.subplot(1,3,2)
sns.histplot(data['last_evaluation'], kde=True, color='darkgreen')
plt.title('Employee Evaluation Level')
plt.xlabel('Evaluation Level')
plt.ylabel('Frequency')

# Average monthly hours histogram
plt.subplot(1,3,3)
sns.histplot(data['average_montly_hours'], kde=True, color='orange')
plt.title('Employee Monthly Hours')
plt.xlabel('Monthly Hours')
plt.ylabel('Frequency')

# Adjust layout for better spacing
plt.tight_layout()

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



[ ]:
```
Draw the bar plot of the Employee Project Count of both employees who left and␣
 ↪stayed in the organization
(use column number_project and hue column left), and give your inferences from␣
 ↪the plot
```

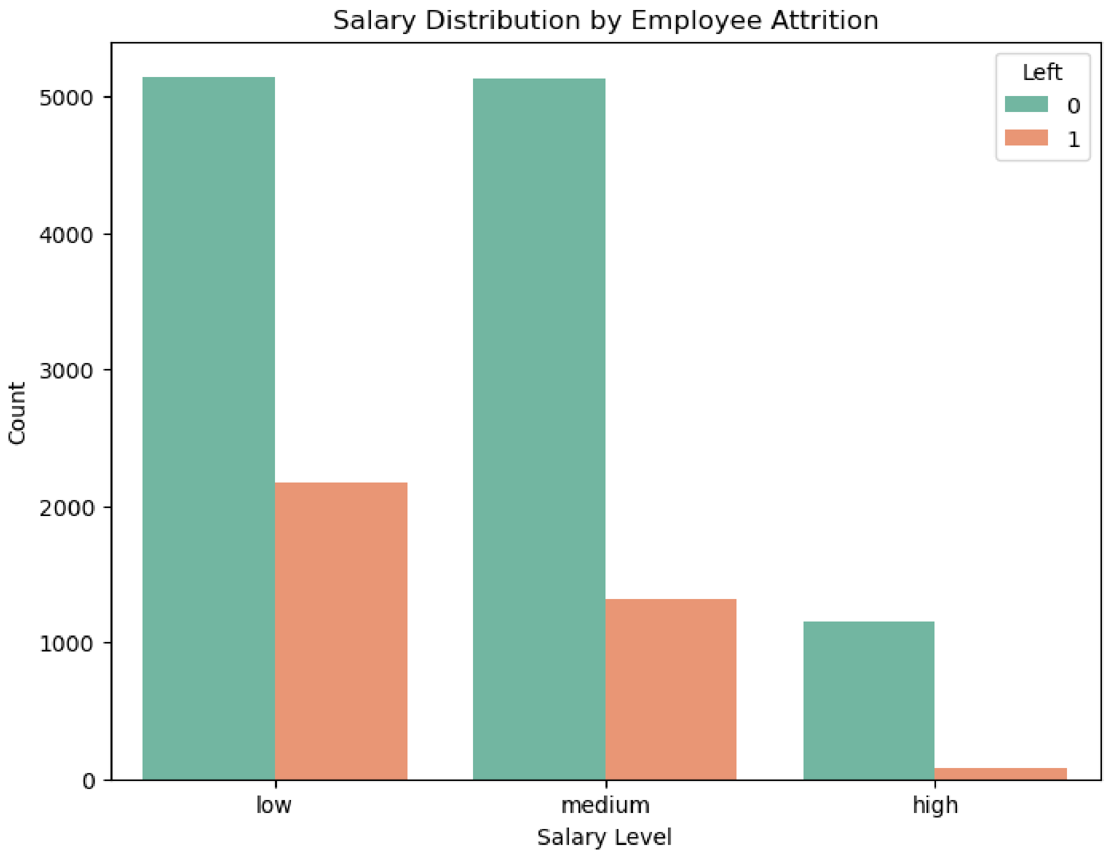
[16]:
```
plt.figure(figsize=(8,6))
sns.countplot(x='number_project', hue='left', data=data, palette='Set1')
plt.title('Number of Projects by Employee Attrition')
plt.xlabel('Number of Projects')
plt.ylabel('Count')
```

```python
plt.legend(title='Left', loc='upper right')
plt.show()
```

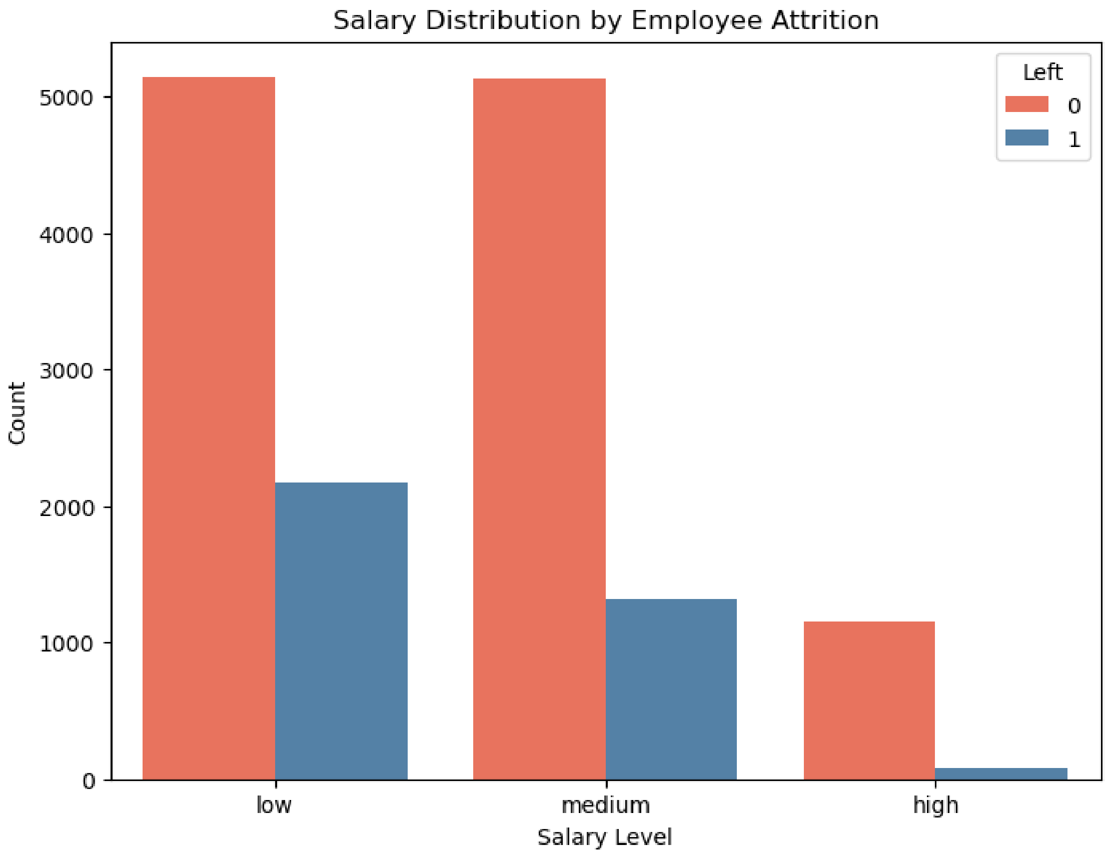


[17]:

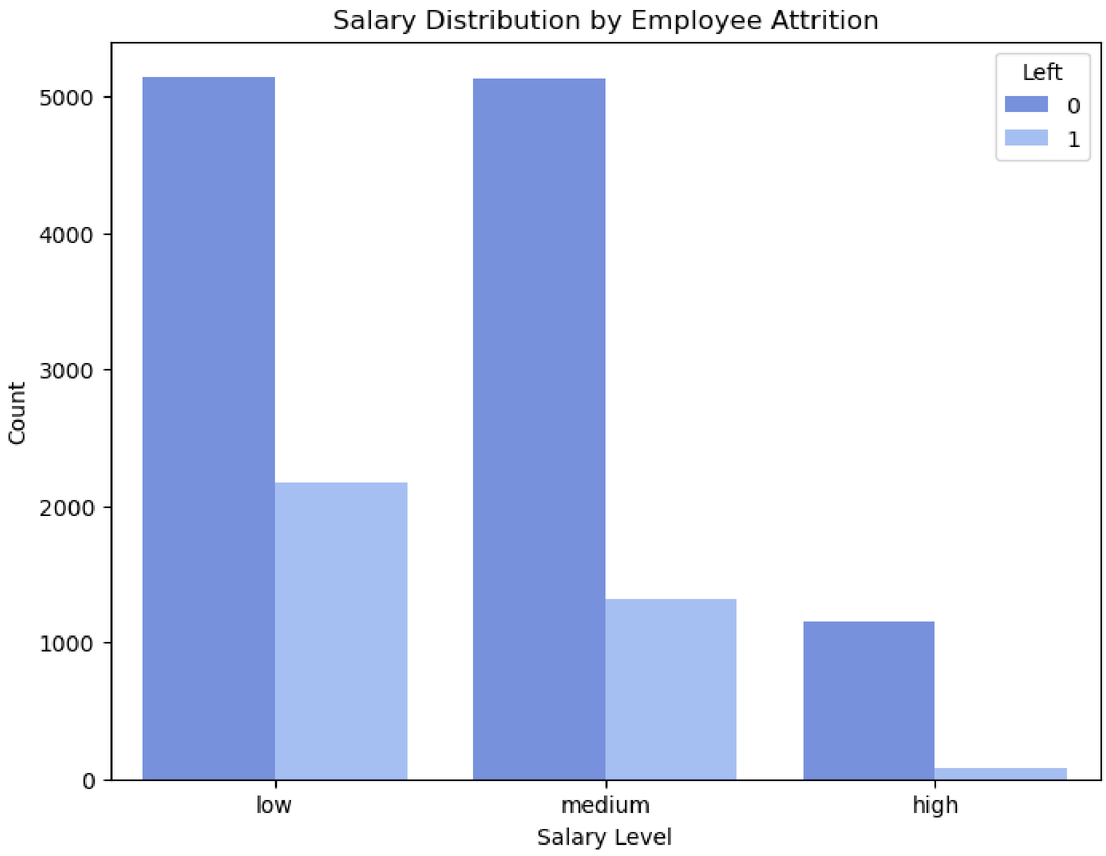
```python
# Create the count plot with a custom color palette
plt.figure(figsize=(8,6))
sns.countplot(x='salary', hue='left', data=data, palette='Set2')
plt.title('Salary Distribution by Employee Attrition')
plt.xlabel('Salary Level')
plt.ylabel('Count')
plt.legend(title='Left', loc='upper right')
plt.show()
```



[18]:
```
plt.figure(figsize=(8,6))
sns.countplot(x='salary', hue='left', data=data, palette=['#FF6347', '#4682B4'])
plt.title('Salary Distribution by Employee Attrition')
plt.xlabel('Salary Level')
plt.ylabel('Count')
plt.legend(title='Left', loc='upper right')
plt.show()
```

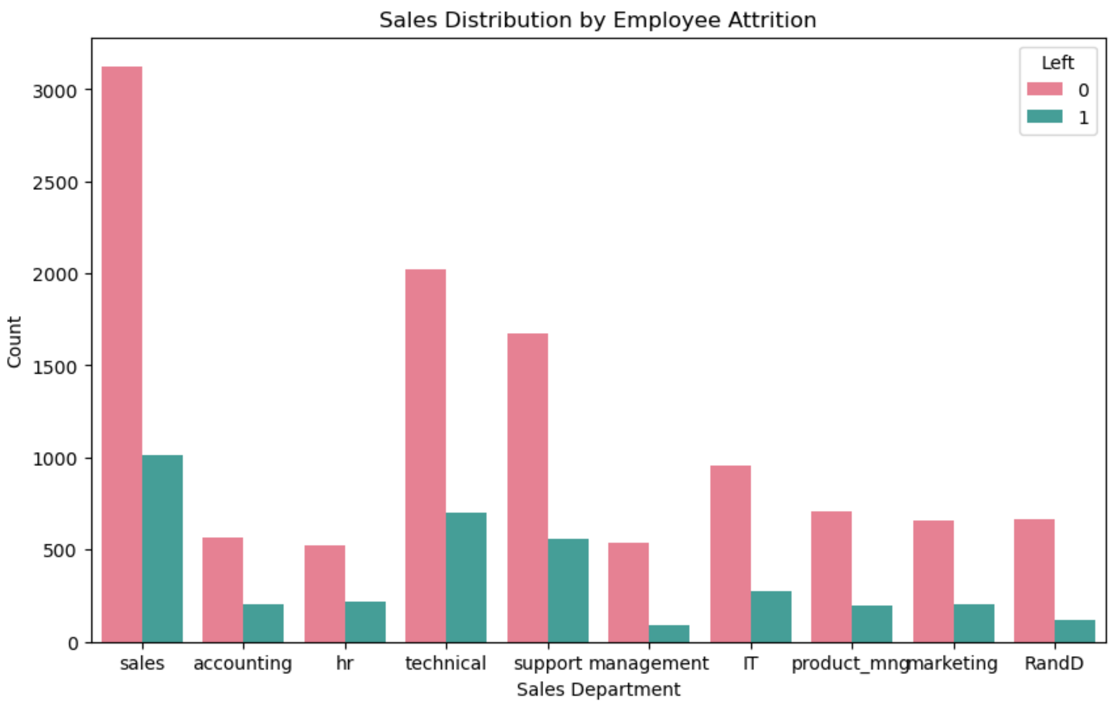


[19]:
```
plt.figure(figsize=(8,6))
sns.countplot(x='salary', hue='left', data=data, palette=sns.
  ↪color_palette("coolwarm"))
plt.title('Salary Distribution by Employee Attrition')
plt.xlabel('Salary Level')
plt.ylabel('Count')
plt.legend(title='Left', loc='upper right')
plt.show()
```



[20]:

```
plt.figure(figsize=(10,6))
sns.countplot(x='sales', hue='left', data=data, palette='husl')
plt.title('Sales Distribution by Employee Attrition')
plt.xlabel('Sales Department')
plt.ylabel('Count')
plt.legend(title='Left', loc='upper right')
plt.show()
```



[ ]:

```
3.Perform clustering of employees who left based on their satisfaction and␣
 ↪evaluation
3.1. Choose columns satisfaction_level, last_evaluation and left
3.2. Do K-Means clustering of employees who left the company into 3 clusters?
3.3. Based on the satisfaction and evaluation factors, give your thoughts on␣
 ↪the employee clusters
```

[21]:

```
# Display the column names
print(data.columns)
```

```
Index(['satisfaction_level', 'last_evaluation', 'number_project',
       'average_montly_hours', 'time_spend_company', 'Work_accident', 'left',
       'promotion_last_5years', 'sales', 'salary'],
      dtype='object')
```

[22]:

```
# select the relevant columns
cluster_data=data[['satisfaction_level', 'last_evaluation','left']]
left_emp_data=cluster_data[cluster_data['left']==1]
```

[23]:

```
left_emp_data
```

[23]:

```
       satisfaction_level  last_evaluation  left
0                    0.38             0.53     1
1                    0.80             0.86     1
```

```
2                      0.11             0.88     1
3                      0.72             0.87     1
4                      0.37             0.52     1
…                    …                …    …
14994                  0.40             0.57     1
14995                  0.37             0.48     1
14996                  0.37             0.53     1
14997                  0.11             0.96     1
14998                  0.37             0.52     1

[3571 rows x 3 columns]
```

```
[ ]: # drop left label
     left_emp_data.drop('left',axis=1,inplace=True)
```

```
[29]: left_emp_data
```

```
[29]:        satisfaction_level  last_evaluation
      0                      0.38             0.53
      1                      0.80             0.86
      2                      0.11             0.88
      3                      0.72             0.87
      4                      0.37             0.52
      …                    …                …
      14994                  0.40             0.57
      14995                  0.37             0.48
      14996                  0.37             0.53
      14997                  0.11             0.96
      14998                  0.37             0.52

      [3571 rows x 2 columns]
```

```
[30]: import warnings
      warnings.filterwarnings('ignore')
```

```
[31]: from sklearn.cluster import KMeans
```

```
[32]: # perform K means
      kmeans=KMeans(n_clusters=3,random_state=42)
      kmeans.fit(left_emp_data)
```

```
[32]: KMeans(n_clusters=3, random_state=42)
```

```
[33]: kmeans.labels_
```

```
[33]: array([0, 1, 2, …, 0, 2, 0])
```

[56]:

```
# Assuming you have already performed K-means clustering and have cluster labels
# Replace 'kmeans.labels_' with your actual cluster labels

# Check the length of cluster labels
print("Length of cluster labels:", len(kmeans.labels_))

# Check the length of the DataFrame
print("Length of DataFrame:", len(left_emp_data))

# Add cluster labels to the DataFrame if the lengths match
if len(kmeans.labels_) == len(left_emp_data):
    left_emp_data['cluster'] = kmeans.labels_
    print("Cluster labels added successfully.")
else:
    print("Length of cluster labels does not match length of DataFrame.")

# Display the DataFrame
left_emp_data.head()
```

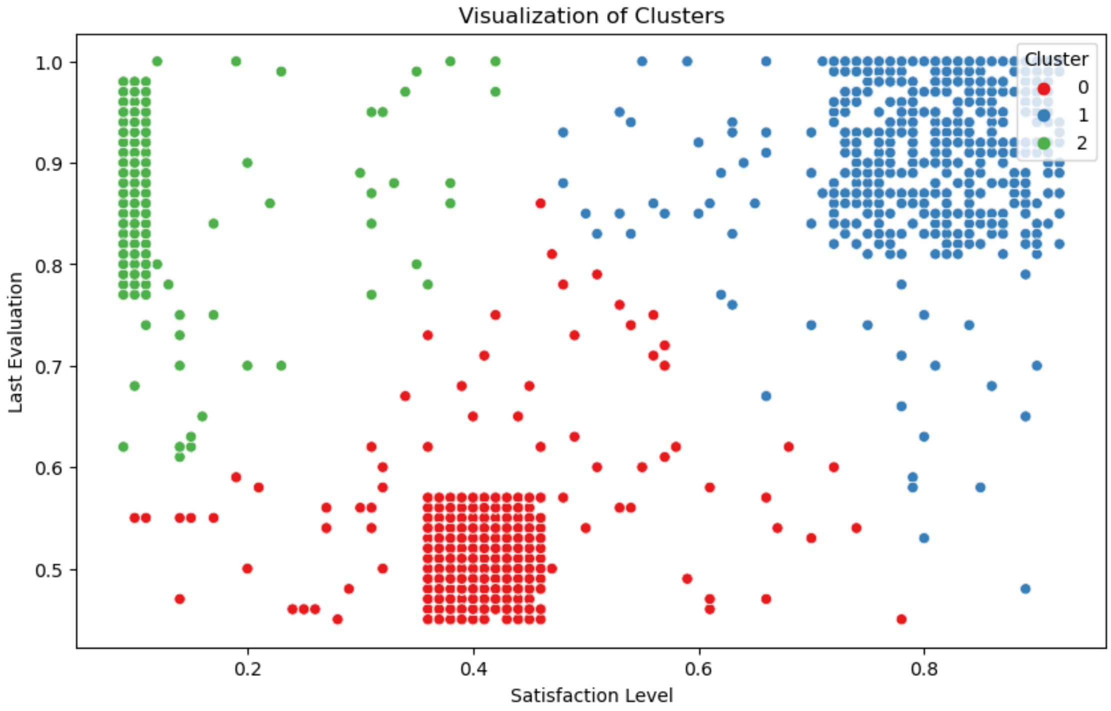
```
Length of cluster labels: 3571
Length of DataFrame: 14999
Length of cluster labels does not match length of DataFrame.
```

[56]:

```
   satisfaction_level  last_evaluation  number_project  average_montly_hours  \
0                0.38             0.53               2                   157
1                0.80             0.86               5                   262
2                0.11             0.88               7                   272
3                0.72             0.87               5                   223
4                0.37             0.52               2                   159

   time_spend_company  Work_accident  left  promotion_last_5years  sales  \
0                   3              0     1                      0  sales
1                   6              0     1                      0  sales
2                   4              0     1                      0  sales
3                   5              0     1                      0  sales
4                   3              0     1                      0  sales

   salary
0     low
1  medium
2  medium
3     low
4     low
```

[61]:

```
import pandas as pd
from sklearn.cluster import KMeans
import matplotlib.pyplot as plt
import seaborn as sns

# Load the dataset
data = pd.read_excel('1673873196_hr_comma_sep.xlsx')

# Filter employees who left the company
left_emp_data = data[data['left'] == 1]

# Select satisfaction_level and last_evaluation features
X = left_emp_data[['satisfaction_level', 'last_evaluation']]

# Perform KMeans clustering
kmeans = KMeans(n_clusters=3, random_state=42)
kmeans.fit(X)

# Add cluster labels to the DataFrame
left_emp_data['cluster'] = kmeans.labels_

# Visualize the clusters
plt.figure(figsize=(10,6))
sns.scatterplot(x='satisfaction_level', y='last_evaluation', hue='cluster',␣
 ↪palette='Set1', data=left_emp_data)
plt.title('Visualization of Clusters')
plt.xlabel('Satisfaction Level')
plt.ylabel('Last Evaluation')
plt.legend(title='Cluster', loc='upper right')
plt.show()

# Print the centroids of each cluster
print("Centroids of each cluster:")
print(kmeans.cluster_centers_)
```



```
Centroids of each cluster:
[[0.41014545 0.51698182]
 [0.80851586 0.91170931]
 [0.11115466 0.86930085]]
```

[62]:
```
left_emp_data['cluster'].value_counts()
```

[62]:
```
cluster
0    1650
1     977
2     944
Name: count, dtype: int64
```

[ ]:
```
Handle the left Class Imbalance using the SMOTE technique
4.1. Pre-process the data by converting categorical columns to numerical␣
  ↪columns by □ Separating categorical variables
and numeric variables.
□ Applying get_dummies() to the categorical variables.
□ Combining categorical variables and numeric variables.
4.2. Do the stratified split of the dataset to train and test in the ratio 80:
  ↪20 with random_state=123
4.3. Upsample the train dataset using the SMOTE technique from the imblearn␣
  ↪module
```

[8]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 14999 entries, 0 to 14998
Data columns (total 10 columns):
 #   Column                 Non-Null Count  Dtype  
---  ------                 --------------  -----  
 0   satisfaction_level     14999 non-null  float64
 1   last_evaluation        14999 non-null  float64
 2   number_project         14999 non-null  int64  
 3   average_montly_hours   14999 non-null  int64  
 4   time_spend_company     14999 non-null  int64  
 5   Work_accident          14999 non-null  int64  
 6   left                   14999 non-null  int64  
 7   promotion_last_5years  14999 non-null  int64  
 8   sales                  14999 non-null  object 
 9   salary                 14999 non-null  object 
dtypes: float64(2), int64(6), object(2)
memory usage: 1.1+ MB
```

[9]:
```
df_numerical=data.select_dtypes(include=['int64','float64'])
df_categorical=data.select_dtypes(include=['object'])
```

[10]:
```
df_categorical
```

[10]:
```
         sales  salary
0        sales     low
1        sales  medium
2        sales  medium
3        sales     low
4        sales     low
…          …      …
14994  support     low
14995  support     low
14996  support     low
14997  support     low
14998  support     low

[14999 rows x 2 columns]
```

[11]:
```
# apply dummy encoding
df_converted=pd.get_dummies(data=df_categorical).astype('int')
```

[12]:
```
df_converted
```

[12]:
```
       sales_IT  sales_RandD  sales_accounting  sales_hr  sales_management  \
0             0            0                 0         0                 0   
```

```
1             0            0                 0         0                 0
2             0            0                 0         0                 0
3             0            0                 0         0                 0
4             0            0                 0         0                 0
…         …          …               …       …               …
14994         0            0                 0         0                 0
14995         0            0                 0         0                 0
14996         0            0                 0         0                 0
14997         0            0                 0         0                 0
14998         0            0                 0         0                 0

       sales_marketing  sales_product_mng  sales_sales  sales_support  \
0                    0                  0            1              0
1                    0                  0            1              0
2                    0                  0            1              0
3                    0                  0            1              0
4                    0                  0            1              0
…                …                …          …            …
14994                0                  0            0              1
14995                0                  0            0              1
14996                0                  0            0              1
14997                0                  0            0              1
14998                0                  0            0              1

       sales_technical  salary_high  salary_low  salary_medium
0                    0            0           1              0
1                    0            0           0              1
2                    0            0           0              1
3                    0            0           1              0
4                    0            0           1              0
…                …          …         …            …
14994                0            0           1              0
14995                0            0           1              0
14996                0            0           1              0
14997                0            0           1              0
14998                0            0           1              0

[14999 rows x 13 columns]
```

[13]:

```
# concat the data
df_new=pd.concat([df_numerical,df_converted],axis=1)
```

[14]:

```
df_new.shape
```

[14]:

```
(14999, 21)
```

[15]:

```
df_new['left'].value_counts()
```

[15]:
```
left
0    11428
1     3571
Name: count, dtype: int64
```

[17]:
```python
import sklearn
print(sklearn.__version__)
```

```
1.5.0
```

[ ]:
```
Perform 5-fold cross-validation model training and evaluate performance
5.1. Train a Logistic Regression model, apply a 5-fold CV, and plot the␣
 ↪classification report
5.2. Train a Random Forest Classifier model, apply the 5-fold CV, and plot the␣
 ↪classification report
5.3. Train a Gradient Boosting Classifier model, apply the 5-fold CV, and plot␣
 ↪the classification report
```

[19]:
```
pip install pandas numpy matplotlib seaborn scikit-learn imbalanced-learn
```

```
Requirement already satisfied: pandas in
c:\users\priya\appdata\roaming\python\python311\site-packages (2.2.2)Note: you
may need to restart the kernel to use updated packages.

Requirement already satisfied: numpy in
c:\users\priya\appdata\roaming\python\python311\site-packages (1.26.4)
Requirement already satisfied: matplotlib in
c:\users\priya\appdata\roaming\python\python311\site-packages (3.9.0)
Requirement already satisfied: seaborn in
c:\users\priya\appdata\roaming\python\python311\site-packages (0.13.2)
Requirement already satisfied: scikit-learn in
c:\users\priya\appdata\roaming\python\python311\site-packages (1.5.0)
Requirement already satisfied: imbalanced-learn in
c:\users\priya\appdata\roaming\python\python311\site-packages (0.12.3)
Requirement already satisfied: python-dateutil>=2.8.2 in
c:\users\priya\appdata\roaming\python\python311\site-packages (from pandas)
(2.8.2)
Requirement already satisfied: pytz>=2020.1 in
c:\users\priya\appdata\roaming\python\python311\site-packages (from pandas)
(2024.1)
Requirement already satisfied: tzdata>=2022.7 in
c:\users\priya\appdata\roaming\python\python311\site-packages (from pandas)
(2024.1)
Requirement already satisfied: contourpy>=1.0.1 in
c:\users\priya\appdata\roaming\python\python311\site-packages (from matplotlib)
(1.2.1)
Requirement already satisfied: cycler>=0.10 in
```

```
c:\users\priya\appdata\roaming\python\python311\site-packages (from matplotlib)
(0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in
c:\users\priya\appdata\roaming\python\python311\site-packages (from matplotlib)
(4.53.0)
Requirement already satisfied: kiwisolver>=1.3.1 in
c:\users\priya\appdata\roaming\python\python311\site-packages (from matplotlib)
(1.4.5)
Requirement already satisfied: packaging>=20.0 in
c:\users\priya\appdata\roaming\python\python311\site-packages (from matplotlib)
(23.1)
Requirement already satisfied: pillow>=8 in
c:\users\priya\appdata\roaming\python\python311\site-packages (from matplotlib)
(10.3.0)
Requirement already satisfied: pyparsing>=2.3.1 in
c:\users\priya\appdata\roaming\python\python311\site-packages (from matplotlib)
(3.1.2)
Requirement already satisfied: scipy>=1.6.0 in
c:\users\priya\appdata\roaming\python\python311\site-packages (from scikit-
learn) (1.13.1)
Requirement already satisfied: joblib>=1.2.0 in
c:\users\priya\appdata\roaming\python\python311\site-packages (from scikit-
learn) (1.4.2)
Requirement already satisfied: threadpoolctl>=3.1.0 in
c:\users\priya\appdata\roaming\python\python311\site-packages (from scikit-
learn) (3.5.0)
Requirement already satisfied: six>=1.5 in
c:\users\priya\appdata\roaming\python\python311\site-packages (from python-
dateutil>=2.8.2->pandas) (1.16.0)
```

[23]:

```python
# Import necessary libraries
from sklearn.model_selection import cross_val_score
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score, roc_auc_score, classification_report

# Apply Logistic Regression
log_reg = LogisticRegression(max_iter=1000, random_state=123)
log_reg.fit(X_train_smote, y_train_smote)

# Predict on the test set
y_pred1 = log_reg.predict(X_test)

# Print the accuracy score
print('Accuracy score:', accuracy_score(y_test, y_pred1))

# Print ROC AUC score
roc_auc = roc_auc_score(y_test, y_pred1)
```

```
print('ROC AUC score:', roc_auc)

# Print classification report
print('Classification Report:\n', classification_report(y_test, y_pred1))
```

```
Accuracy score: 0.7823333333333333
ROC AUC score: 0.7603810553092628
Classification Report:
               precision    recall  f1-score   support

           0       0.90      0.80      0.85      2286
           1       0.53      0.72      0.61       714

    accuracy                           0.78      3000
   macro avg       0.72      0.76      0.73      3000
weighted avg       0.81      0.78      0.79      3000


C:\Users\priya\AppData\Roaming\Python\Python311\site-
packages\sklearn\linear_model\_logistic.py:469: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  n_iter_i = _check_optimize_result(
```

[25]:

```
print(roc_auc_score(y_test,y_pred1))
```

```
0.7603810553092628
```

[26]:

```
# Import necessary library
from sklearn import metrics

# Calculate predicted probabilities
y_pred_prob1 = log_reg.predict_proba(X_test)[:, 1]

# Calculate false positive rate, true positive rate, and thresholds
fpr, tpr, thresholds = metrics.roc_curve(y_test, y_pred_prob1)

# Print false positive rate, true positive rate, and thresholds
print("False Positive Rate (fpr):", fpr)
print("True Positive Rate (tpr):", tpr)
print("Thresholds:", thresholds)
```

```python
# Calculate ROC AUC score
roc_auc = metrics.auc(fpr, tpr)
print("ROC AUC Score:", roc_auc)
```

```
False Positive Rate (fpr): [0.00000000e+00 8.74890639e-04 4.81189851e-03
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 7.48981459e-03 4.16295770e-03 4.05602247e-03 7.33805728e-04
 4.91000909e-04 2.93637094e-04]
ROC AUC Score: 0.8206608977799343
```
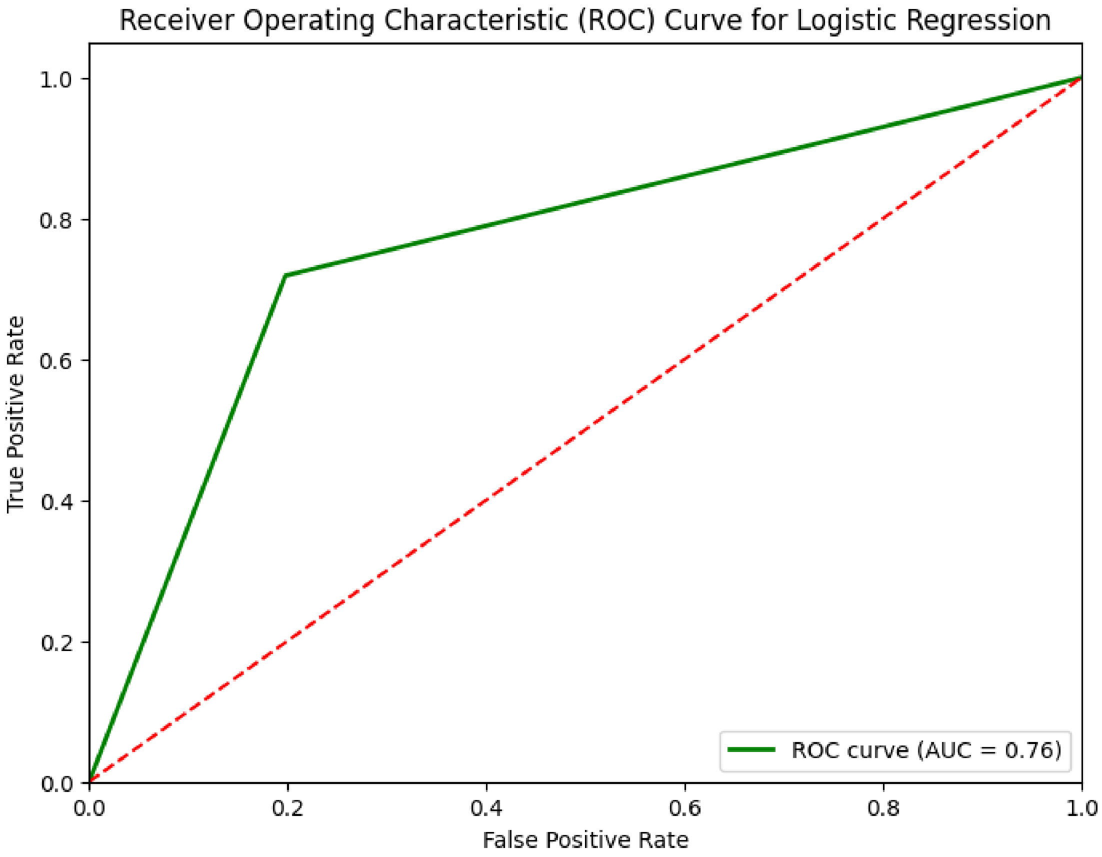

[27]:

```python
from sklearn import metrics

# Compute ROC curve
fpr, tpr, thresholds = metrics.roc_curve(y_test, y_pred1)

# Print FPR, TPR, and Thresholds
print("False Positive Rate (FPR):", fpr)
print("True Positive Rate (TPR):", tpr)
print("Thresholds:", thresholds)

# Calculate AUC
roc_auc = metrics.auc(fpr, tpr)

# Print AUC score
print("Area Under Curve (AUC):", roc_auc)
```

```
False Positive Rate (FPR): [0.         0.19772528 1.        ]
True Positive Rate (TPR): [0.         0.71848739 1.        ]
Thresholds: [inf  1.  0.]
Area Under Curve (AUC): 0.7603810553092628
```

[29]:

```python
import matplotlib.pyplot as plt

# Plot ROC curve
plt.figure(figsize=(8, 6))
plt.plot(fpr, tpr, color='green', lw=2, label='ROC curve (AUC = %0.2f)' %␣
↪roc_auc)
plt.plot([0, 1], [0, 1], color='red', linestyle='--')
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic (ROC) Curve for Logistic␣
↪Regression')
plt.legend(loc="lower right")
plt.show()
```



[36]:
```
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score

# Assuming X_train_resample and y_train_resample contain the resampled training␣
↪data using SMOTE

# Create and train Random Forest Classifier
```

```
random_forest = RandomForestClassifier(max_depth=5)
random_forest.fit(X_train_smote, y_train_smote)

# Predict on test data
y_pred = random_forest.predict(X_test)

# Print accuracy score
print('Accuracy score:', accuracy_score(y_test, y_pred))
```

```
Accuracy score: 0.9536666666666667
```

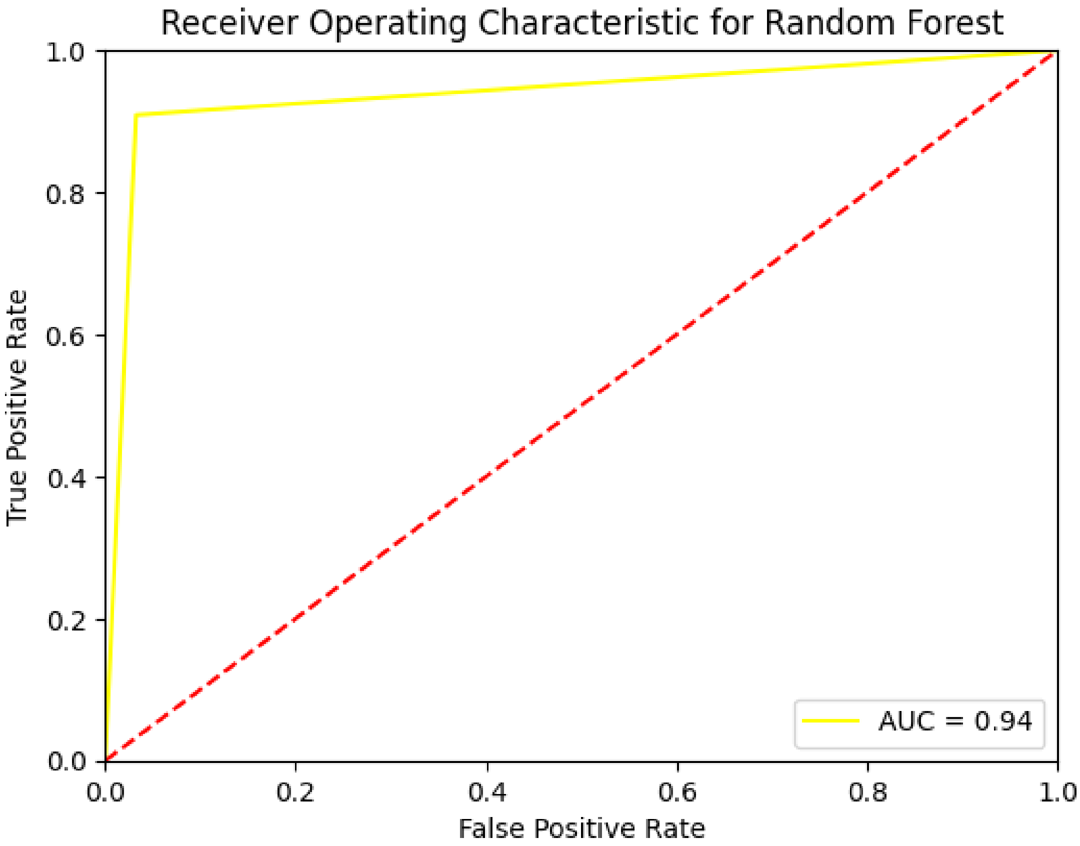
[37]:

```
from sklearn import metrics
fpr, tpr, threshold = metrics.roc_curve(y_test, y_pred)
print(fpr)
print(tpr)
print(threshold)
roc_auc = metrics.auc(fpr, tpr)
```

```
[0.         0.03237095 1.        ]
[0.         0.90896359 1.        ]
[inf  1.  0.]
```

[40]:

```
# method I: plt
plt.title('Receiver Operating Characteristic for Random Forest')
plt.plot(fpr, tpr, 'yellow', label = 'AUC = %0.2f' % roc_auc)  # Change 'b' to␣
 ↪'g' for green color
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1],'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()
```



```
[41]: # apply Gradient Boosting
      from sklearn.ensemble import GradientBoostingClassifier
      gradient_boost=GradientBoostingClassifier()
```

```
[42]: gradient_boost.fit(X_train_smote,y_train_smote)
      y_pred2=gradient_boost.predict(X_test)
```

```
[43]: print('Accuracy score',accuracy_score(y_test,y_pred2))
```

```
Accuracy score 0.9636666666666667
```

```
[44]: print(classification_report(y_test,y_pred2))
```

```
              precision    recall  f1-score   support

           0       0.98      0.97      0.98      2286
           1       0.92      0.93      0.92       714

    accuracy                           0.96      3000
   macro avg       0.95      0.95      0.95      3000
```

```
weighted avg       0.96      0.96      0.96      3000
```

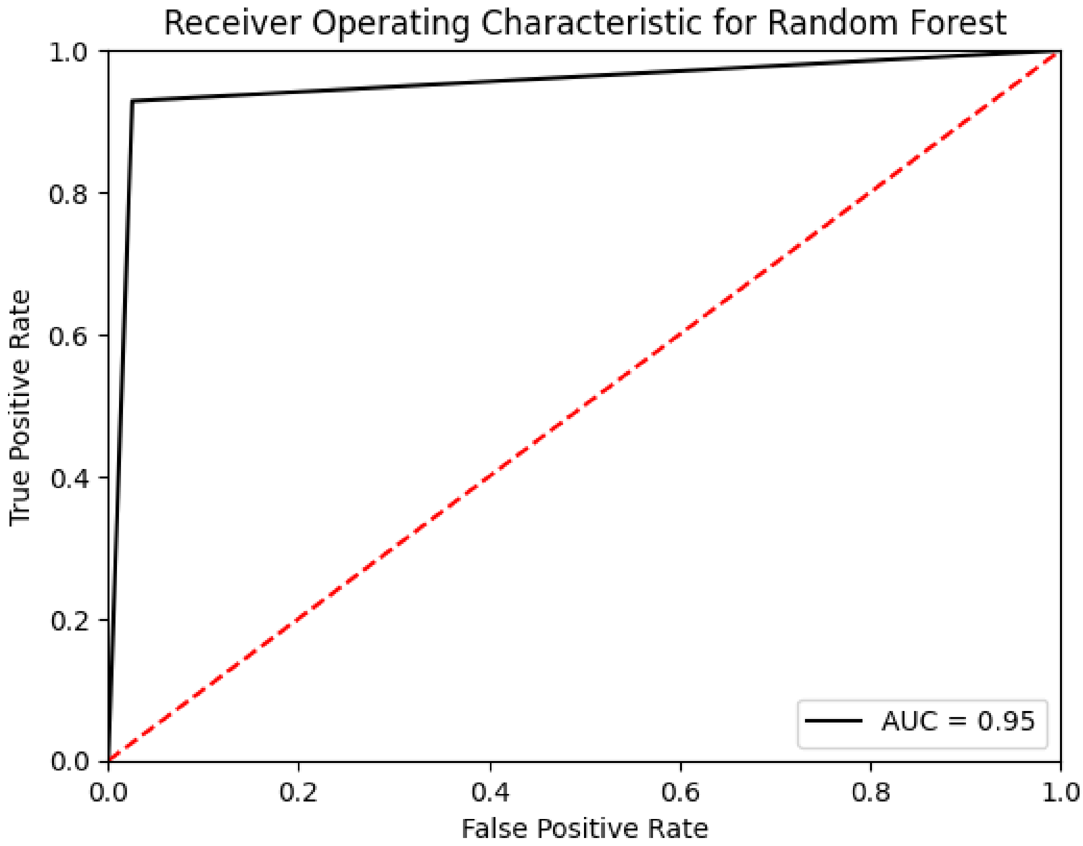
[45]:

```python
from sklearn import metrics
fpr, tpr, threshold = metrics.roc_curve(y_test, y_pred2)
print(fpr)
print(tpr)
print(threshold)
roc_auc = metrics.auc(fpr, tpr)
```

```
[0.         0.02537183 1.        ]
[0.         0.92857143 1.        ]
[inf  1.  0.]
```

[46]:

```python
# method I: plt
plt.title('Receiver Operating Characteristic for Random Forest')
plt.plot(fpr, tpr, 'black', label = 'AUC = %0.2f' % roc_auc)
plt.legend(loc = 'lower right')
plt.plot([0, 1], [0, 1],'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()
```



[47]:

```
!pip install xgboost
```

```
Collecting xgboost
  Downloading xgboost-2.0.3-py3-none-win_amd64.whl.metadata (2.0 kB)
Requirement already satisfied: numpy in
c:\users\priya\appdata\roaming\python\python311\site-packages (from xgboost)
(1.26.4)
Requirement already satisfied: scipy in
c:\users\priya\appdata\roaming\python\python311\site-packages (from xgboost)
(1.13.1)
Downloading xgboost-2.0.3-py3-none-win_amd64.whl (99.8 MB)
   ---------------------------------------- 0.0/99.8 MB ? eta -:--:--
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Installing collected packages: xgboost
Successfully installed xgboost-2.0.3
```

[48]:

```
# apply xgboost
import xgboost as xgb
model=xgb.XGBClassifier()
model.fit(X_train_smote,y_train_smote)
```

[48]:

```
XGBClassifier(base_score=None, booster=None, callbacks=None,
              colsample_bylevel=None, colsample_bynode=None,
              colsample_bytree=None, device=None, early_stopping_rounds=None,
              enable_categorical=False, eval_metric=None, feature_types=None,
              gamma=None, grow_policy=None, importance_type=None,
              interaction_constraints=None, learning_rate=None, max_bin=None,
              max_cat_threshold=None, max_cat_to_onehot=None,
              max_delta_step=None, max_depth=None, max_leaves=None,
              min_child_weight=None, missing=nan, monotone_constraints=None,
              multi_strategy=None, n_estimators=None, n_jobs=None,
              num_parallel_tree=None, random_state=None, …)
```

[49]:

```
y_pred3=model.predict(X_test)
```

[50]:

```
print('Accuracy score',accuracy_score(y_test,y_pred3))
```

```
Accuracy score 0.983
```

[ ]:

```
Suggest various retention strategies for targeted employees
7.1. Using the best model, predict the probability of employee turnover in the␣
 ↪test data
7.2. Based on the probability score range below, categorize the employees into␣
 ↪four zones and suggest your thoughts on
the retention strategies for each zone  Safe Zone (Green) (Score < 20%)
  Low Risk Zone (Yellow) (20% < Score < 60%)
  Medium Risk Zone (Orange) (60% < Score < 90%)
  High Risk Zone (Red) (Score > 90%).
```

[51]:

```
predicted_prob=model.predict_proba(X_test)
```

[52]:

```
predicted_prob[:,1]
```

[52]:

```
array([2.0239866e-04, 8.9765954e-01, 3.8354285e-02, …, 1.6143646e-02,
       1.4798146e-03, 9.8090887e-01], dtype=float32)
```

[53]:

```
zone=[]
prob=[]

for i in predicted_prob[:,1]:
  prob.append(i)
  if (i<=0.2):
    zone.append("Safe Zone")
  elif (i>0.2 and i<=0.6):
    zone.append("Low Risk Zone")
  elif (i>0.6 and i<=0.9):
    zone.append("Medium Risk Zone ")
  else:
    zone.append("High Risk Zone ")
```

[54]:

```
categories = ["Safe Zone","Low Risk Zone","Medium Risk Zone ","High Risk Zone "]
color = ["blue","green","yellow","Red"]
```

[56]:

```
colordict = dict(zip(categories, color))
clr = pd.DataFrame({"zone":zone,"probability":prob})
clr["Color"] = clr["zone"].apply(lambda x: colordict[x])
```

[57]:

```
clr['zone'] = clr['zone'].astype(str)
```

[59]:

```
color= clr["Color"].tolist()
c = ["blue","Red","Orange","Yellow"]
```

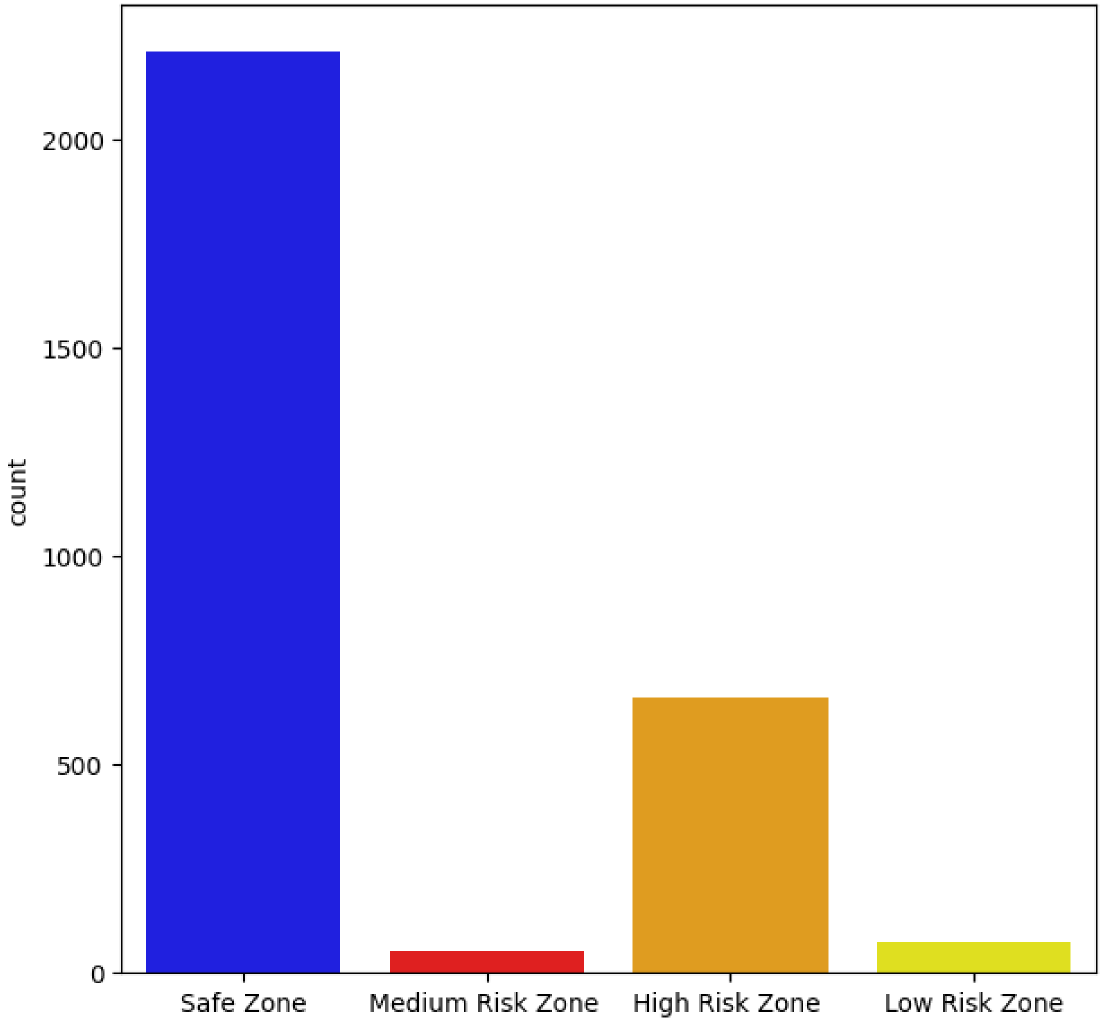
[60]:

```
plt.figure(figsize=(7,7))
sns.countplot(x=zone,palette=c)
```

```
C:\Users\priya\.jupyter\New folder\Lib\site-packages\seaborn\_oldcore.py:1765:
FutureWarning: unique with argument that is not not a Series, Index,
ExtensionArray, or np.ndarray is deprecated and will raise in a future version.
  order = pd.unique(vector)
```

[60]:

```
<Axes: ylabel='count'>
```



[61]:
```
data
```

[61]:
```
       satisfaction_level  last_evaluation  number_project  \
0                    0.38             0.53               2
1                    0.80             0.86               5
2                    0.11             0.88               7
3                    0.72             0.87               5
4                    0.37             0.52               2
…                     …                …              …
14994                0.40             0.57               2
14995                0.37             0.48               2
14996                0.37             0.53               2
14997                0.11             0.96               6
14998                0.37             0.52               2
```

```
       average_montly_hours  time_spend_company  Work_accident  left  \
0                       157                   3              0     1
1                       262                   6              0     1
2                       272                   4              0     1
3                       223                   5              0     1
4                       159                   3              0     1
…                     …                 …            …   …
14994                   151                   3              0     1
14995                   160                   3              0     1
14996                   143                   3              0     1
14997                   280                   4              0     1
14998                   158                   3              0     1

       promotion_last_5years    sales  salary
0                          0    sales     low
1                          0    sales  medium
2                          0    sales  medium
3                          0    sales     low
4                          0    sales     low
…                      …      …     …
14994                      0  support     low
14995                      0  support     low
14996                      0  support     low
14997                      0  support     low
14998                      0  support     low

[14999 rows x 10 columns]
```

```
[ ]:
```