Predictive Modeling for Credit Default Payments

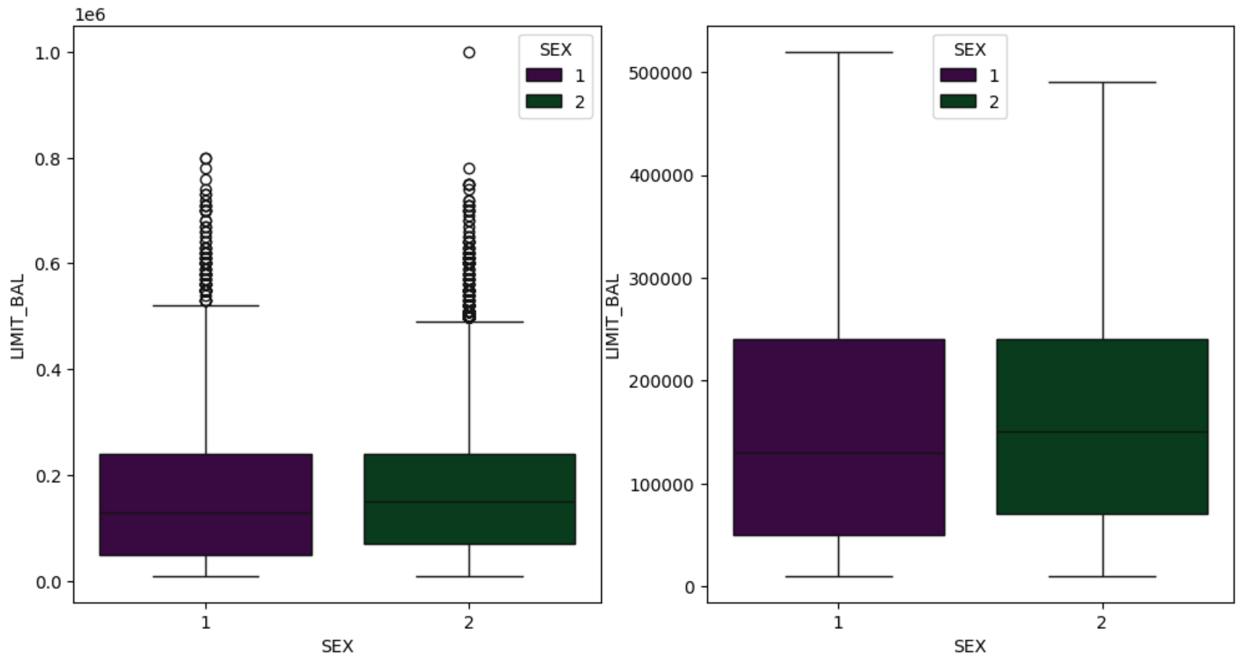
```python
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline

from sklearn.model_selection import train_test_split
from sklearn.metrics import roc_auc_score
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import AdaBoostClassifier
import lightgbm as lgb
import xgboost as xgb
from sklearn.preprocessing import StandardScaler
from sklearn.decomposition import PCA
from statsmodels.stats.outliers_influence import
variance_inflation_factor
```

```
/usr/local/lib/python3.10/dist-packages/dask/dataframe/__init__.py:42:
FutureWarning:
Dask dataframe query planning is disabled because dask-expr is not
installed.

You can install it with `pip install dask[dataframe]` or `conda
install dask`.
This will raise in a future version.

  warnings.warn(msg, FutureWarning)
```

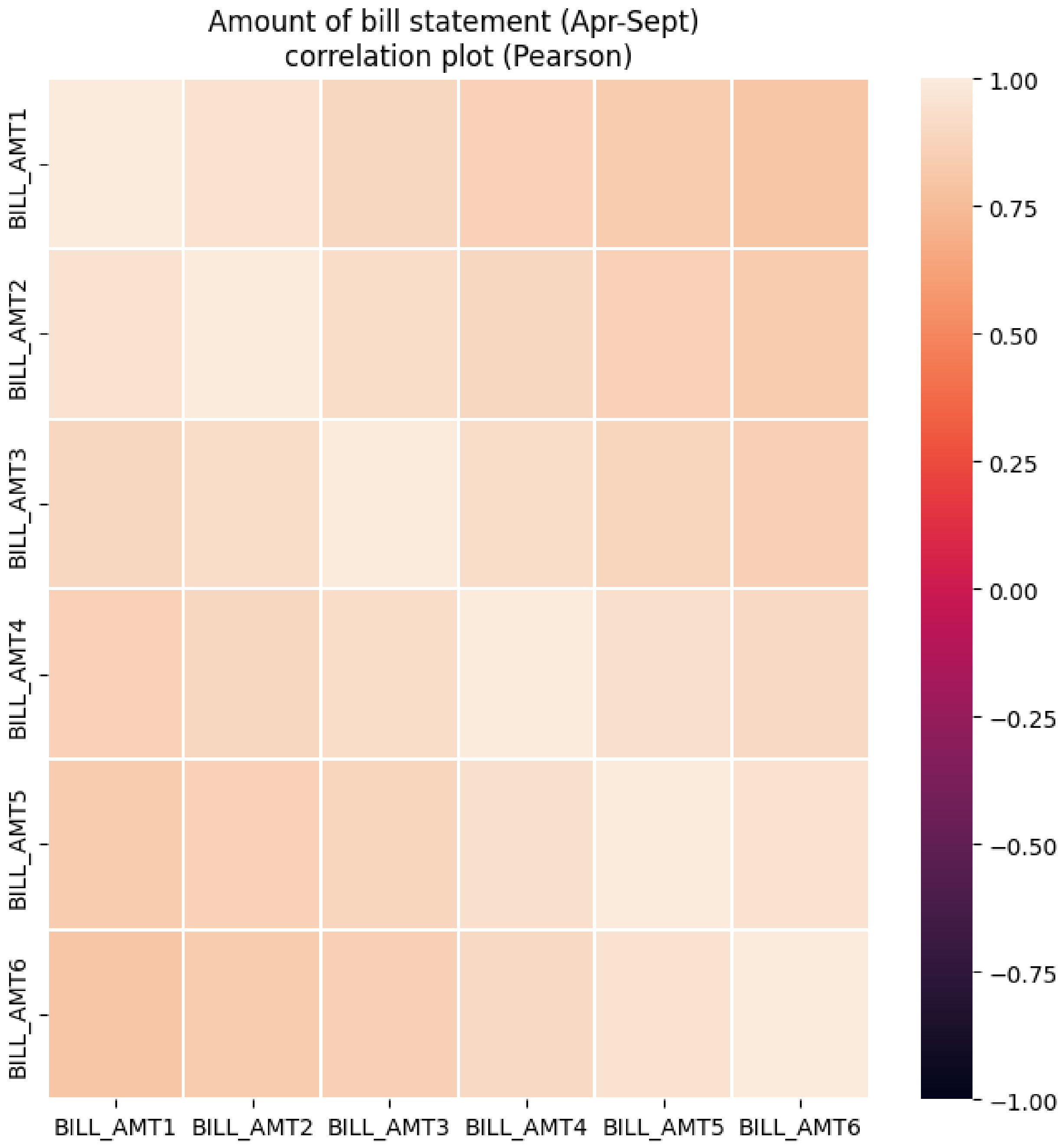
```
pip install dask[dataframe]
```

```
Requirement already satisfied: dask[dataframe] in
/usr/local/lib/python3.10/dist-packages (2024.10.0)
Requirement already satisfied: click>=8.1 in
/usr/local/lib/python3.10/dist-packages (from dask[dataframe]) (8.1.7)
Requirement already satisfied: cloudpickle>=3.0.0 in
/usr/local/lib/python3.10/dist-packages (from dask[dataframe]) (3.1.0)
Requirement already satisfied: fsspec>=2021.09.0 in
/usr/local/lib/python3.10/dist-packages (from dask[dataframe])
(2024.10.0)
Requirement already satisfied: packaging>=20.0 in
/usr/local/lib/python3.10/dist-packages (from dask[dataframe]) (24.2)
Requirement already satisfied: partd>=1.4.0 in
/usr/local/lib/python3.10/dist-packages (from dask[dataframe]) (1.4.2)
Requirement already satisfied: pyyaml>=5.3.1 in
/usr/local/lib/python3.10/dist-packages (from dask[dataframe]) (6.0.2)
Requirement already satisfied: toolz>=0.10.0 in
```

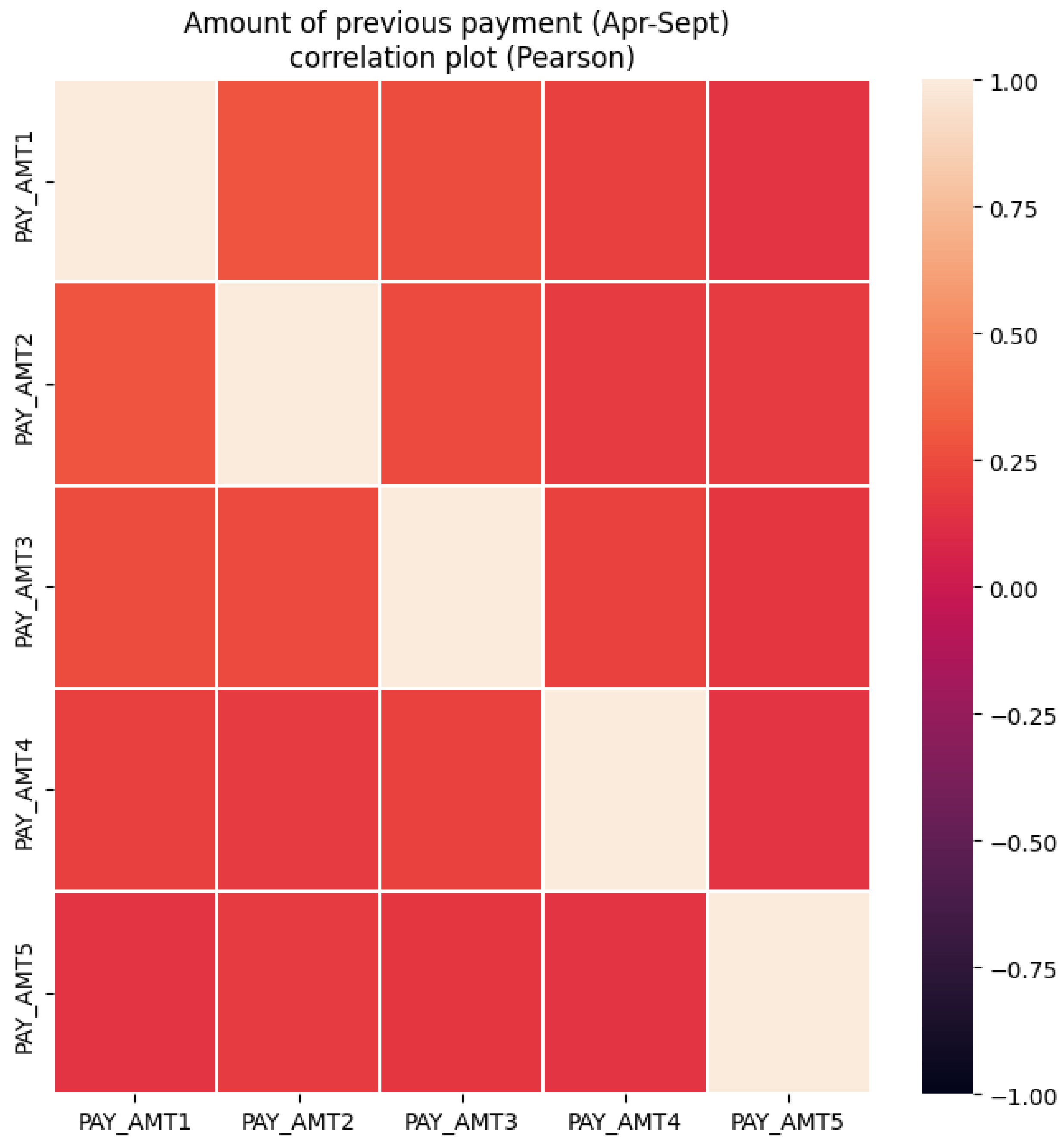
```
/usr/local/lib/python3.10/dist-packages (from dask[dataframe])
(0.12.1)
Requirement already satisfied: importlib-metadata>=4.13.0 in
/usr/local/lib/python3.10/dist-packages (from dask[dataframe]) (8.5.0)
Requirement already satisfied: pandas>=2.0 in
/usr/local/lib/python3.10/dist-packages (from dask[dataframe]) (2.2.2)
Collecting dask-expr<1.2,>=1.1 (from dask[dataframe])
  Downloading dask_expr-1.1.20-py3-none-any.whl.metadata (2.6 kB)
INFO: pip is looking at multiple versions of dask-expr to determine
which version is compatible with other requirements. This could take a
while.
  Downloading dask_expr-1.1.19-py3-none-any.whl.metadata (2.6 kB)
  Downloading dask_expr-1.1.18-py3-none-any.whl.metadata (2.6 kB)
  Downloading dask_expr-1.1.16-py3-none-any.whl.metadata (2.5 kB)
Requirement already satisfied: pyarrow>=14.0.1 in
/usr/local/lib/python3.10/dist-packages (from dask-expr<1.2,>=1.1-
>dask[dataframe]) (17.0.0)
Requirement already satisfied: zipp>=3.20 in
/usr/local/lib/python3.10/dist-packages (from importlib-
metadata>=4.13.0->dask[dataframe]) (3.21.0)
Requirement already satisfied: numpy>=1.22.4 in
/usr/local/lib/python3.10/dist-packages (from pandas>=2.0-
>dask[dataframe]) (1.26.4)
Requirement already satisfied: python-dateutil>=2.8.2 in
/usr/local/lib/python3.10/dist-packages (from pandas>=2.0-
>dask[dataframe]) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in
/usr/local/lib/python3.10/dist-packages (from pandas>=2.0-
>dask[dataframe]) (2024.2)
Requirement already satisfied: tzdata>=2022.7 in
/usr/local/lib/python3.10/dist-packages (from pandas>=2.0-
>dask[dataframe]) (2024.2)
Requirement already satisfied: locket in
/usr/local/lib/python3.10/dist-packages (from partd>=1.4.0-
>dask[dataframe]) (1.0.0)
Requirement already satisfied: six>=1.5 in
/usr/local/lib/python3.10/dist-packages (from python-dateutil>=2.8.2-
>pandas>=2.0->dask[dataframe]) (1.16.0)
Downloading dask_expr-1.1.16-py3-none-any.whl (243 kB)
━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 243.2/243.2 kB 4.3 MB/s eta
0:00:00

# Load data
data = pd.read_csv('UCI_Credit_Card.csv')

# Display initial data
print(data.head())

   ID  LIMIT_BAL  SEX  EDUCATION  MARRIAGE  AGE  PAY_0  PAY_2  PAY_3
PAY_4  \
0   1    20000.0    2          2         1   24       2       2      -1
-1
1   2   120000.0    2          2         2   26      -1       2       0
0
2   3    90000.0    2          2         2   34       0       0       0
0
3   4    50000.0    2          2         1   37       0       0       0
0
4   5    50000.0    1          2         1   57      -1       0      -1
0

   ...  BILL_AMT4  BILL_AMT5  BILL_AMT6  PAY_AMT1  PAY_AMT2  PAY_AMT3
\
0  ...        0.0        0.0        0.0       0.0     689.0       0.0

1  ...     3272.0     3455.0     3261.0       0.0    1000.0    1000.0

2  ...    14331.0    14948.0    15549.0    1518.0    1500.0    1000.0

3  ...    28314.0    28959.0    29547.0    2000.0    2019.0    1200.0

4  ...    20940.0    19146.0    19131.0    2000.0   36681.0   10000.0


   PAY_AMT4  PAY_AMT5  PAY_AMT6  default.payment.next.month
0       0.0       0.0       0.0                           1
1    1000.0       0.0    2000.0                           1
2    1000.0    1000.0    5000.0                           0
3    1100.0    1069.0    1000.0                           0
4    9000.0     689.0     679.0                           0

[5 rows x 25 columns]

# Boxplots
fig, (ax1, ax2) = plt.subplots(ncols=2, figsize=(12,6))
sns.boxplot(ax=ax1, x="SEX", y="LIMIT_BAL", hue="SEX", data=data,
palette="PRGn", showfliers=True)
sns.boxplot(ax=ax2, x="SEX", y="LIMIT_BAL", hue="SEX", data=data,
palette="PRGn", showfliers=False)
plt.show()
```



```python
# Correlation plots
var = ['BILL_AMT1', 'BILL_AMT2', 'BILL_AMT3', 'BILL_AMT4',
'BILL_AMT5', 'BILL_AMT6']
plt.figure(figsize=(8,8))
plt.title('Amount of bill statement (Apr-Sept) \ncorrelation plot
(Pearson)')
corr = data[var].corr()
sns.heatmap(corr, xticklabels=corr.columns, yticklabels=corr.columns,
linewidths=.1, vmin=-1, vmax=1)
plt.show()
```

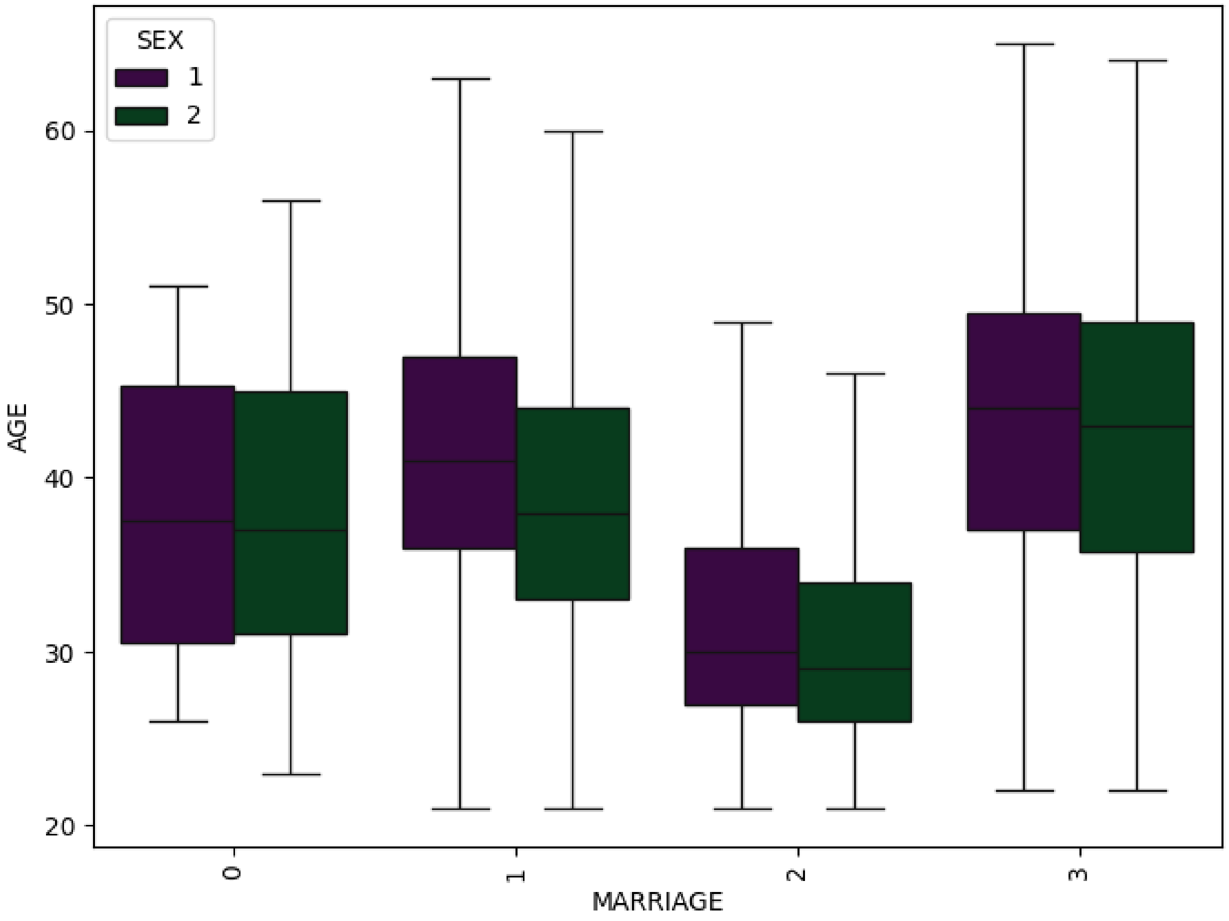


```
var = ['PAY_AMT1', 'PAY_AMT2', 'PAY_AMT3', 'PAY_AMT4', 'PAY_AMT5']
plt.figure(figsize=(8,8))
plt.title('Amount of previous payment (Apr-Sept) \ncorrelation plot
(Pearson)')
corr = data[var].corr()
sns.heatmap(corr, xticklabels=corr.columns, yticklabels=corr.columns,
linewidths=.1, vmin=-1, vmax=1)
plt.show()
```

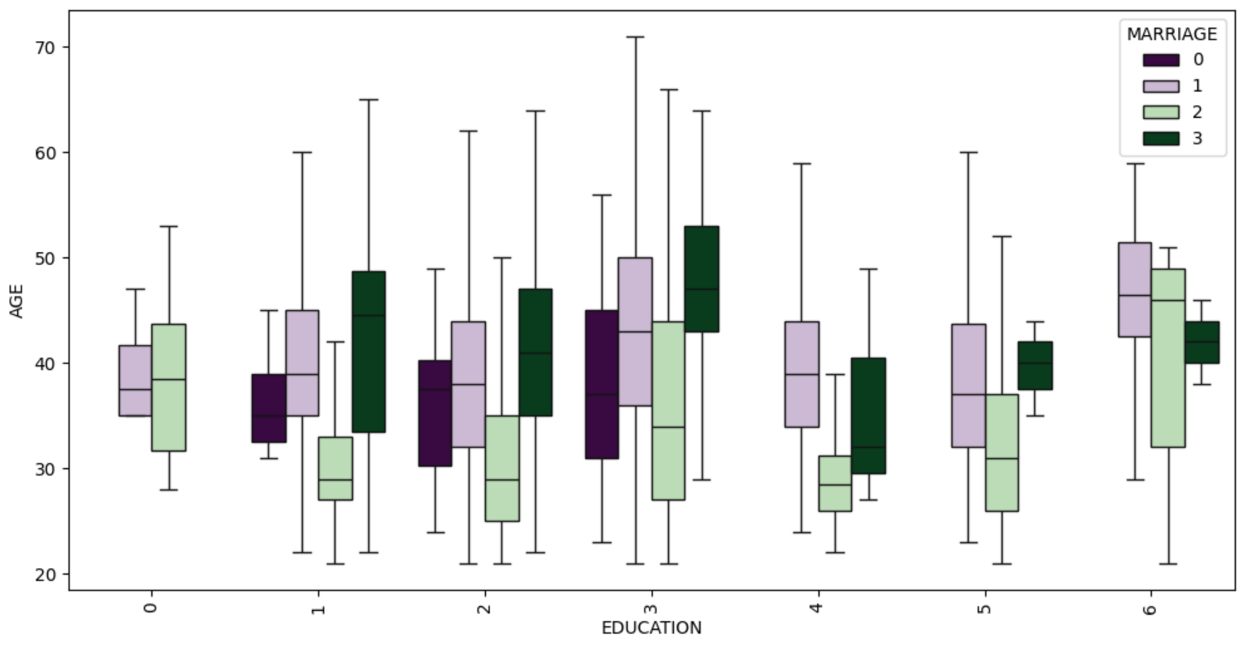


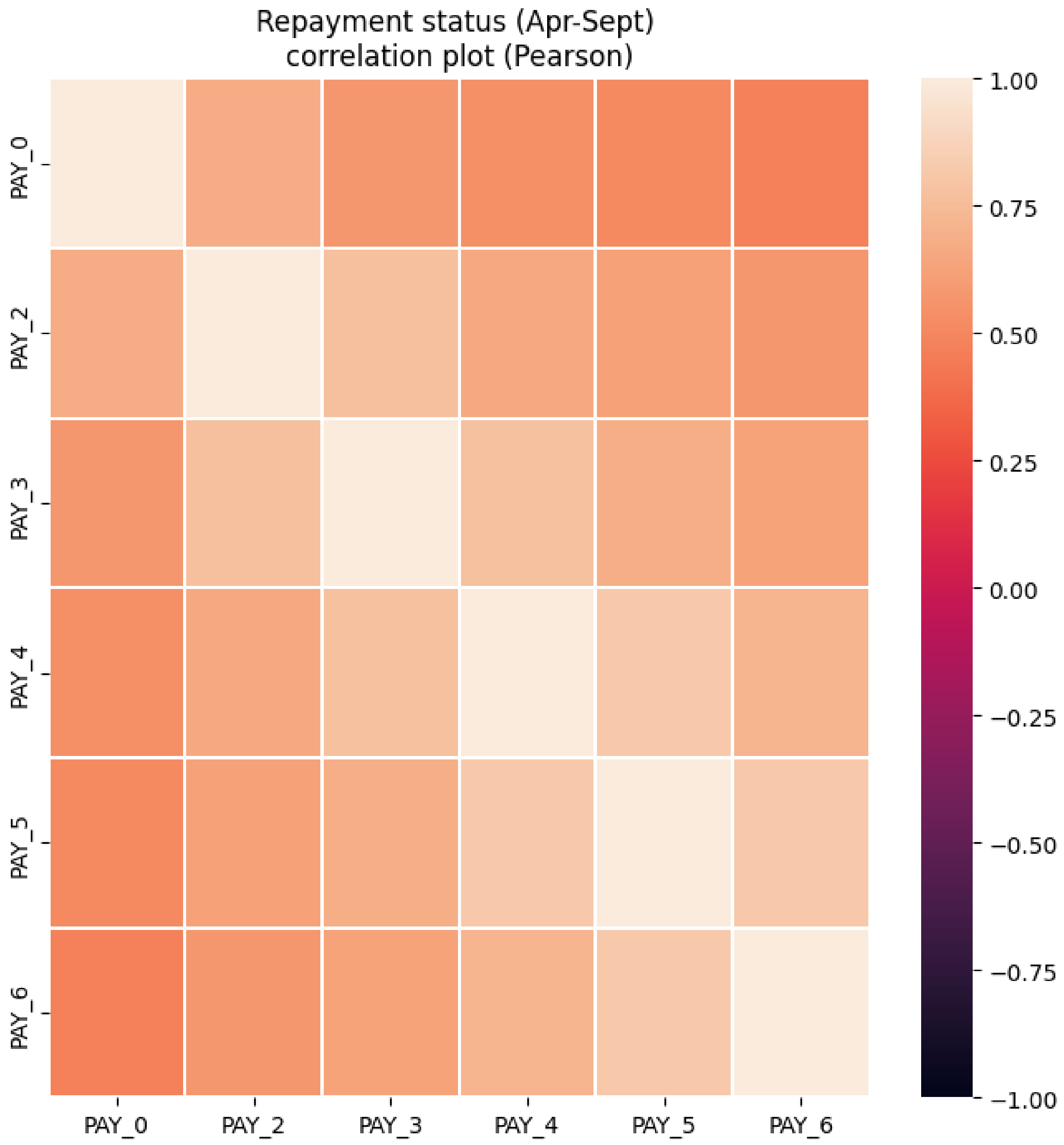
```python
def boxplot_variation(feature1, feature2, feature3, width=16):
    fig, ax1 = plt.subplots(ncols=1, figsize=(width,6))
    sns.boxplot(ax=ax1, x=feature1, y=feature2, hue=feature3,
data=data, palette="PRGn", showfliers=False)
    ax1.set_xticklabels(ax1.get_xticklabels(), rotation=90)
    plt.show()

boxplot_variation('MARRIAGE', 'AGE', 'SEX', 8)
boxplot_variation('EDUCATION', 'AGE', 'MARRIAGE', 12)
```

```
var = ['PAY_0', 'PAY_2', 'PAY_3', 'PAY_4', 'PAY_5', 'PAY_6']
plt.figure(figsize=(8,8))
plt.title('Repayment status (Apr-Sept) \ncorrelation plot (Pearson)')
corr = data[var].corr()
sns.heatmap(corr, xticklabels=corr.columns, yticklabels=corr.columns,
linewidths=.1, vmin=-1, vmax=1)
plt.show()

<ipython-input-10-4ac43c09ee06>:4: UserWarning: set_ticklabels()
should only be used with a fixed number of ticks, i.e. after
set_ticks() or using a FixedLocator.
  ax1.set_xticklabels(ax1.get_xticklabels(), rotation=90)
```



```
<ipython-input-10-4ac43c09ee06>:4: UserWarning: set_ticklabels()
should only be used with a fixed number of ticks, i.e. after
set_ticks() or using a FixedLocator.
  ax1.set_xticklabels(ax1.get_xticklabels(), rotation=90)
```


MARRIAGE
0
1
2
3
AGE
20
30
40
50
60
70
EDUCATION
0
1
2
3
4
5
6



```
# Handle missing values
total = data.isnull().sum().sort_values(ascending=False)
percent = (data.isnull().sum() / data.isnull().count() *
100).sort_values(ascending=False)
missing_data = pd.concat([total, percent], axis=1, keys=['Total',
'Percent'])
print(missing_data.transpose())
```

```
          ID  BILL_AMT2  PAY_AMT6  PAY_AMT5  PAY_AMT4  PAY_AMT3
PAY_AMT2  \
Total    0.0        0.0       0.0       0.0       0.0       0.0
0.0
Percent  0.0        0.0       0.0       0.0       0.0       0.0
0.0

         PAY_AMT1  BILL_AMT6  BILL_AMT5  ...  PAY_5  PAY_4  PAY_3
PAY_2  \
Total         0.0        0.0        0.0  ...    0.0    0.0    0.0
0.0
Percent       0.0        0.0        0.0  ...    0.0    0.0    0.0
0.0

         PAY_0  AGE  MARRIAGE  EDUCATION  SEX
default.payment.next.month
Total      0.0  0.0       0.0        0.0  0.0
0.0
Percent    0.0  0.0       0.0        0.0  0.0
0.0

[2 rows x 25 columns]

# Features and target
target = 'default.payment.next.month'
predictors = ['LIMIT_BAL', 'SEX', 'EDUCATION', 'AGE',
              'PAY_0', 'PAY_2', 'PAY_3', 'PAY_4', 'PAY_5', 'PAY_6',
              'BILL_AMT1', 'BILL_AMT2', 'BILL_AMT3', 'BILL_AMT4',
'BILL_AMT5', 'BILL_AMT6',
              'PAY_AMT1', 'PAY_AMT2', 'PAY_AMT3', 'PAY_AMT4',
'PAY_AMT5', 'PAY_AMT6']

# Standardize the data
data1 = data[predictors]
scaler = StandardScaler()
dataa = scaler.fit_transform(data1)
dot = pd.DataFrame(data=dataa, columns=data1.columns)

# PCA
p = PCA()
x_pca = p.fit_transform(dot)
explained_variance = p.explained_variance_ratio_
num_components = np.argmax(np.cumsum(explained_variance) >= 0.95) + 1
# Keep 95% variance
p = PCA(n_components=num_components)
new = pd.DataFrame(data=p.fit_transform(dot))

# VIF
vif = pd.DataFrame()
vif['features'] = new.columns
vif['VIF'] = [variance_inflation_factor(new.values, i) for i in
range(new.shape[1])]
print(vif)
```

```
    features  VIF
0          0  1.0
1          1  1.0
2          2  1.0
3          3  1.0
4          4  1.0
5          5  1.0
6          6  1.0
7          7  1.0
8          8  1.0
9          9  1.0
10        10  1.0
11        11  1.0
12        12  1.0
13        13  1.0
```

```
# Train-test split
x_train, x_test, y_train, y_test = train_test_split(new, data[target],
test_size=0.3, random_state=42)
# RandomForest
rf = RandomForestClassifier(n_estimators=100, random_state=42)
rf.fit(x_train, y_train)
print("RandomForest score:", rf.score(x_test, y_test))
```

```
RandomForest score: 0.8104444444444444
```

```
# AdaBoost
ada = AdaBoostClassifier(n_estimators=100, random_state=42)
ada.fit(x_train, y_train)
print("AdaBoost score:", ada.score(x_test, y_test))
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/ensemble/
_weight_boosting.py:527: FutureWarning: The SAMME.R algorithm (the
default) is deprecated and will be removed in 1.6. Use the SAMME
algorithm to circumvent this warning.
  warnings.warn(
```

```
AdaBoost score: 0.8068888888888889
```

```
# XGBoost
xgb_model = xgb.XGBClassifier(random_state=42)
xgb_model.fit(x_train, y_train)
print("XGBoost score:", xgb_model.score(x_test, y_test))
```

```
XGBoost score: 0.8063333333333333
```

```
# LightGBM
lgb_model = lgb.LGBMClassifier(random_state=42)
```

```python
lgb_model.fit(x_train, y_train)
print("LightGBM score:", lgb_model.score(x_test, y_test))
```

```
[LightGBM] [Info] Number of positive: 4676, number of negative: 16324
[LightGBM] [Info] Auto-choosing col-wise multi-threading, the overhead
of testing was 0.005643 seconds.
You can set `force_col_wise=true` to remove the overhead.
[LightGBM] [Info] Total Bins 3570
[LightGBM] [Info] Number of data points in the train set: 21000,
number of used features: 14
[LightGBM] [Info] [binary:BoostFromScore]: pavg=0.222667 ->
initscore=-1.250193
[LightGBM] [Info] Start training from score -1.250193
LightGBM score: 0.8127777777777778
```

```python
# User input for prediction
user_input = {
    'LIMIT_BAL': float(input("Enter value for LIMIT_BAL: ")),
    'SEX': int(input("Enter value for SEX (1=male, 2=female): ")),
    'EDUCATION': int(input("Enter value for EDUCATION (1=graduate
school, 2=university, 3=high school, 4=others): ")),
    'AGE': int(input("Enter value for AGE: ")),
    'PAY_0': int(input("Enter value for PAY_0: ")),
    'PAY_2': int(input("Enter value for PAY_2: ")),
    'PAY_3': int(input("Enter value for PAY_3: ")),
    'PAY_4': int(input("Enter value for PAY_4: ")),
    'PAY_5': int(input("Enter value for PAY_5: ")),
    'PAY_6': int(input("Enter value for PAY_6: ")),
    'BILL_AMT1': float(input("Enter value for BILL_AMT1: ")),
    'BILL_AMT2': float(input("Enter value for BILL_AMT2: ")),
    'BILL_AMT3': float(input("Enter value for BILL_AMT3: ")),
    'BILL_AMT4': float(input("Enter value for BILL_AMT4: ")),
    'BILL_AMT5': float(input("Enter value for BILL_AMT5: ")),
    'BILL_AMT6': float(input("Enter value for BILL_AMT6: ")),
    'PAY_AMT1': float(input("Enter value for PAY_AMT1: ")),
    'PAY_AMT2': float(input("Enter value for PAY_AMT2: ")),
    'PAY_AMT3': float(input("Enter value for PAY_AMT3: ")),
    'PAY_AMT4': float(input("Enter value for PAY_AMT4: ")),
    'PAY_AMT5': float(input("Enter value for PAY_AMT5: ")),
    'PAY_AMT6': float(input("Enter value for PAY_AMT6: "))
}
```

```
Enter value for LIMIT_BAL: 20000
Enter value for SEX (1=male, 2=female): 2
Enter value for EDUCATION (1=graduate school, 2=university, 3=high
school, 4=others): 2
Enter value for AGE: 24
Enter value for PAY_0: 2
Enter value for PAY_2: 3
Enter value for PAY_3: -1
Enter value for PAY_4: -1
Enter value for PAY_5: -2
Enter value for PAY_6: -2
Enter value for BILL_AMT1: 3913
Enter value for BILL_AMT2: 3102
Enter value for BILL_AMT3: 689
Enter value for BILL_AMT4: 0
Enter value for BILL_AMT5: 0
Enter value for BILL_AMT6: 0
Enter value for PAY_AMT1: 0
Enter value for PAY_AMT2: 689
Enter value for PAY_AMT3: 0
Enter value for PAY_AMT4: 0
Enter value for PAY_AMT5: 0
Enter value for PAY_AMT6: 0
```

```
# Standardize and transform user input
user_input_df = pd.DataFrame(user_input, index=[0])
user_input_scaled = scaler.transform(user_input_df[predictors])
user_input_pca = p.transform(user_input_scaled)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/base.py:493:
UserWarning: X does not have valid feature names, but PCA was fitted
with feature names
  warnings.warn(
```

```
# Predict
ypred = lgb_model.predict(user_input_pca)
if ypred[0] == 0:
    print("Not Eligible")
else:
    print("Eligible")
```

```
Eligible
```