

Origin: https://github.com/mridulrb/Predict-loan-eligibility-using-IBM-Watson-Studio/blob/master/Dataset/train_ctrUa4K.csv

```

from sklearn.pipeline import Pipeline
from sklearn.impute import SimpleImputer
from sklearn.preprocessing import StandardScaler, OneHotEncoder
from sklearn.compose import ColumnTransformer
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import GridSearchCV, train_test_split
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score, classification_report

import pandas as pd
import numpy as np

loan_data = pd.read_csv("loan_data.csv")

loan_data

{"summary": "{\n  \"name\": \"loan_data\", \n  \"rows\": 614, \n  \"fields\": [\n    {\n      \"column\": \"Loan_ID\", \n      \"properties\": {\n        \"dtype\": \"string\", \n        \"num_unique_values\": 614, \n        \"samples\": [\n          \"LP002139\", \n          \"LP002223\", \n          \"LP001570\" \n        ], \n        \"semantic_type\": \"\", \n        \"description\": \"\" \n      }, \n      \"column\": \"Gender\", \n      \"properties\": {\n        \"dtype\": \"category\", \n        \"num_unique_values\": 2, \n        \"samples\": [\n          \"Female\", \n          \"Male\" \n        ], \n        \"semantic_type\": \"\", \n        \"description\": \"\" \n      }, \n      \"column\": \"Married\", \n      \"properties\": {\n        \"dtype\": \"category\", \n        \"num_unique_values\": 2, \n        \"samples\": [\n          \"Yes\", \n          \"No\" \n        ], \n        \"semantic_type\": \"\", \n        \"description\": \"\" \n      }, \n      \"column\": \"Dependents\", \n      \"properties\": {\n        \"dtype\": \"category\", \n        \"num_unique_values\": 4, \n        \"samples\": [\n          \"3+\", \n          \"1\" \n        ], \n        \"semantic_type\": \"\", \n        \"description\": \"\" \n      }, \n      \"column\": \"Education\", \n      \"properties\": {\n        \"dtype\": \"category\", \n        \"num_unique_values\": 2, \n        \"samples\": [\n          \"Not Graduate\", \n          \"Graduate\" \n        ], \n        \"semantic_type\": \"\", \n        \"description\": \"\" \n      }, \n      \"column\": \"Self_Employed\", \n      \"properties\": {\n        \"dtype\": \"category\", \n        \"num_unique_values\": 2, \n        \"samples\": [\n          \"Yes\", \n          \"No\" \n        ], \n        \"semantic_type\": \"\", \n        \"description\": \"\" \n      }, \n      \"column\": \"\n    ] \n  } \n}

```

```

\\ApplicantIncome\\",\\n      \\\"properties\\\": {\\n      \\\"dtype\\\":
\\\"number\\\",\\n      \\\"std\\\": 6109,\\n      \\\"min\\\": 150,\\n
\\\"max\\\": 81000,\\n      \\\"num_unique_values\\\": 505,\\n
\\\"samples\\\": [\\n      8333,\\n      4342\\n      ],\\n
\\\"semantic_type\\\": \\\"\\\",\\n      \\\"description\\\": \\\"\\\"\\n      }\\
n      },\\n      {\\n      \\\"column\\\": \\\"CoapplicantIncome\\\",\\n
\\\"properties\\\": {\\n      \\\"dtype\\\": \\\"number\\\",\\n      \\\"std\\\":
2926.2483692241885,\\n      \\\"min\\\": 0.0,\\n      \\\"max\\\": 41667.0,\\
n      \\\"num_unique_values\\\": 287,\\n      \\\"samples\\\": [\\n
1840.0,\\n      2042.0\\n      ],\\n      \\\"semantic_type\\\":
\\\"\\\",\\n      \\\"description\\\": \\\"\\\"\\n      }\\n      },\\n      {\\n
\\\"column\\\": \\\"LoanAmount\\\",\\n      \\\"properties\\\": {\\n
\\\"dtype\\\": \\\"number\\\",\\n      \\\"std\\\": 85.58732523570545,\\n
\\\"min\\\": 9.0,\\n      \\\"max\\\": 700.0,\\n      \\\"num_unique_values\\\":
203,\\n      \\\"samples\\\": [\\n      100.0,\\n      70.0\\n
],\\n      \\\"semantic_type\\\": \\\"\\\",\\n      \\\"description\\\": \\\"\\\"\\n
}\\n      },\\n      {\\n      \\\"column\\\": \\\"Loan_Amount_Term\\\",\\n
\\\"properties\\\": {\\n      \\\"dtype\\\": \\\"number\\\",\\n      \\\"std\\\":
65.12040985461256,\\n      \\\"min\\\": 12.0,\\n      \\\"max\\\": 480.0,\\n
\\\"num_unique_values\\\": 10,\\n      \\\"samples\\\": [\\n      84.0,\\n
120.0\\n      ],\\n      \\\"semantic_type\\\": \\\"\\\",\\n
\\\"description\\\": \\\"\\\"\\n      }\\n      },\\n      {\\n      \\\"column\\\":
\\\"Credit_History\\\",\\n      \\\"properties\\\": {\\n      \\\"dtype\\\":
\\\"number\\\",\\n      \\\"std\\\": 0.3648783192364048,\\n      \\\"min\\\":
0.0,\\n      \\\"max\\\": 1.0,\\n      \\\"num_unique_values\\\": 2,\\n
\\\"samples\\\": [\\n      0.0,\\n      1.0\\n      ],\\n
\\\"semantic_type\\\": \\\"\\\",\\n      \\\"description\\\": \\\"\\\"\\n      }\\
n      },\\n      {\\n      \\\"column\\\": \\\"Property_Area\\\",\\n
\\\"properties\\\": {\\n      \\\"dtype\\\": \\\"category\\\",\\n
\\\"num_unique_values\\\": 3,\\n      \\\"samples\\\": [\\n
\\\"Urban\\\",\\n      \\\"Rural\\\"\\n      ],\\n
\\\"semantic_type\\\": \\\"\\\",\\n      \\\"description\\\": \\\"\\\"\\n      }\\
n      },\\n      {\\n      \\\"column\\\": \\\"Loan_Status\\\",\\n
\\\"properties\\\": {\\n      \\\"dtype\\\": \\\"category\\\",\\n
\\\"num_unique_values\\\": 2,\\n      \\\"samples\\\": [\\n      \\\"N\\\",\\n
\\\"Y\\\"\\n      ],\\n      \\\"semantic_type\\\": \\\"\\\",\\n
\\\"description\\\": \\\"\\\"\\n      }\\n      }\\n      ]\\
n}\\",\\\"type\\\":\\\"dataframe\\\",\\\"variable_name\\\":\\\"loan_data\\\"}

```

```
loan_data.describe()
```

```

{\\\"summary\\\":{\\n  \\\"name\\\": \\\"loan_data\\\",\\n  \\\"rows\\\": 8,\\n
\\\"fields\\\": [\\n    {\\n      \\\"column\\\": \\\"ApplicantIncome\\\",\\n
\\\"properties\\\": {\\n      \\\"dtype\\\": \\\"number\\\",\\n      \\\"std\\\":
27480.19432327756,\\n      \\\"min\\\": 150.0,\\n      \\\"max\\\":
81000.0,\\n      \\\"num_unique_values\\\": 8,\\n      \\\"samples\\\": [\\n
5403.459283387622,\\n      3812.5,\\n      614.0\\n      ],\\n
\\\"semantic_type\\\": \\\"\\\",\\n      \\\"description\\\": \\\"\\\"\\n      }\\
n    },\\n    {\\n      \\\"column\\\": \\\"CoapplicantIncome\\\",\\n
\\\"properties\\\": {\\n      \\\"dtype\\\": \\\"number\\\",\\n      \\\"std\\\":

```

```

14332.564053846478,\n          \"min\": 0.0,\n          \"max\": 41667.0,\n          \"num_unique_values\": 7,\n          \"samples\": [\n614.0,\n          1621.2457980271008,\n          2297.25\n          ],\n          \"semantic_type\": \"\", \n          \"description\": \"\"\n        },\n        {\n          \"column\": \"LoanAmount\", \n          \"properties\": {\n            \"dtype\": \"number\", \n            \"std\": 256.0091610169859,\n            \"min\": 9.0,\n            \"max\": 700.0,\n            \"num_unique_values\": 8,\n            \"samples\": [\n146.41216216216216,\n            128.0,\n            592.0\n            ],\n            \"semantic_type\": \"\", \n            \"description\": \"\"\n          },\n          {\n            \"column\": \"Loan_Amount_Term\", \n            \"properties\": {\n              \"dtype\": \"number\", \n              \"std\": 196.05608042946525,\n              \"min\": 12.0,\n              \"max\": 600.0,\n              \"num_unique_values\": 6,\n              \"samples\": [\n342.0,\n              480.0\n              ],\n              \"semantic_type\": \"\", \n              \"description\": \"\"\n            },\n            {\n              \"column\": \"Credit_History\", \n              \"properties\": {\n                \"dtype\": \"number\", \n                \"std\": 199.14146277938593,\n                \"min\": 0.0,\n                \"max\": 564.0,\n                \"num_unique_values\": 5,\n                \"samples\": [\n1.0,\n                0.3648783192364048\n                ],\n                \"semantic_type\": \"\", \n                \"description\": \"\"\n              }\n            }\n          ],\n          \"type\": \"dataframe\"}

```

```

loan_data['Gender'] = loan_data['Gender'].map({'Male': 1, 'Female': 0})
loan_data['Loan_Status'] = loan_data['Loan_Status'].map({'Y': 1, 'N': 0})
#loan_data['Married'] = loan_data['Married'].map({'Yes': 1, 'No': 0})
loan_data['Education'] = loan_data['Education'].map({'Graduate': 1, 'Not Graduate': 0})
loan_data['Property_Area'] = loan_data['Property_Area'].map({'Urban': 2, 'Semiurban': 1, 'Rural': 0})

```

```

# Calculate correlation between loan_status and other columns
correlation = loan_data.corr()
['Loan_Status'].sort_values(ascending=False)

```

```
print(correlation)
```

```

Loan_Status      1.000000
Credit_History   0.561678
Education         0.085884
Property_Area     0.032112
Gender            0.019857
ApplicantIncome  -0.004710
Loan_Amount_Term -0.021268
LoanAmount        -0.037318
CoapplicantIncome -0.059187
Name: Loan_Status, dtype: float64

```

```
<ipython-input-56-41a2481d504d>:2: FutureWarning: The default value of
numeric_only in DataFrame.corr is deprecated. In a future version, it
will default to False. Select only valid columns or specify the value
of numeric_only to silence this warning.
```

```
correlation = loan_data.corr()
['Loan_Status'].sort_values(ascending=False)
```

```
#looking for missing values
```

```
loan_data.apply(lambda x: sum(x.isnull()),axis=0)
```

```
Loan_ID          0
Gender           13
Married          3
Dependents       15
Education        0
Self_Employed   32
ApplicantIncome  0
CoapplicantIncome 0
LoanAmount      22
Loan_Amount_Term 14
Credit_History  50
Property_Area    0
Loan_Status      0
dtype: int64
```

```
import matplotlib.pyplot as plt
import seaborn as sns
```

```
# Histograms
```

```
plt.figure(figsize=(12, 6))
plt.subplot(2, 2, 1)
sns.histplot(data=loan_data, x='ApplicantIncome', bins=20, kde=True)
plt.title('Histogram of Applicant Income')
```

```
plt.subplot(2, 2, 2)
sns.histplot(data=loan_data, x='CoapplicantIncome', bins=20, kde=True)
plt.title('Histogram of Coapplicant Income')
```

```
plt.subplot(2, 2, 3)
sns.histplot(data=loan_data, x='LoanAmount', bins=20, kde=True)
plt.title('Histogram of Loan Amount')
```

```
# Bar Plots
```

```
plt.figure(figsize=(12, 6))
plt.subplot(1, 2, 1)
sns.countplot(data=loan_data, x='Loan_Status')
plt.title('Count of Loan Status')
```

```
plt.subplot(1, 2, 2)
sns.countplot(data=loan_data, x='Gender')
```

```

plt.title('Count of Gender')

# Box Plots
plt.figure(figsize=(12, 6))
plt.subplot(1, 2, 1)
sns.boxplot(data=loan_data, y='ApplicantIncome')
plt.title('Box Plot of Applicant Income')

plt.subplot(1, 2, 2)
sns.boxplot(data=loan_data, y='LoanAmount')
plt.title('Box Plot of Loan Amount')

# Scatter Plot
plt.figure(figsize=(8, 6))
sns.scatterplot(data=loan_data, x='ApplicantIncome', y='LoanAmount')
plt.title('Scatter Plot of Applicant Income vs Loan Amount')

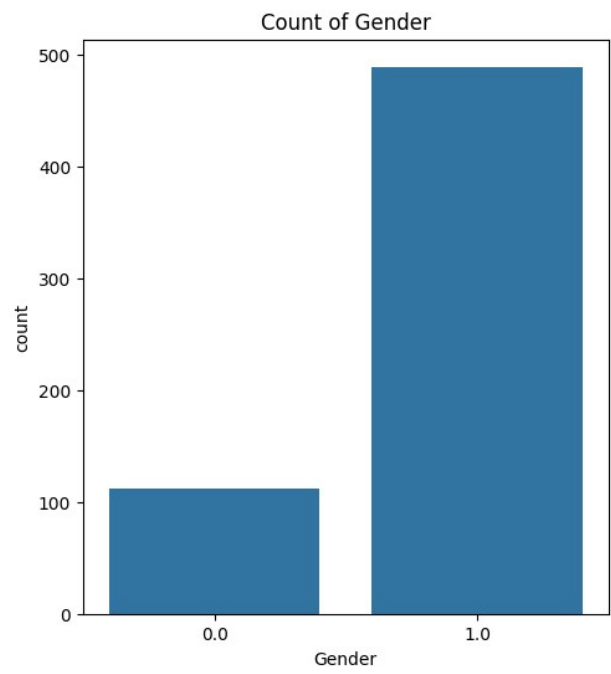
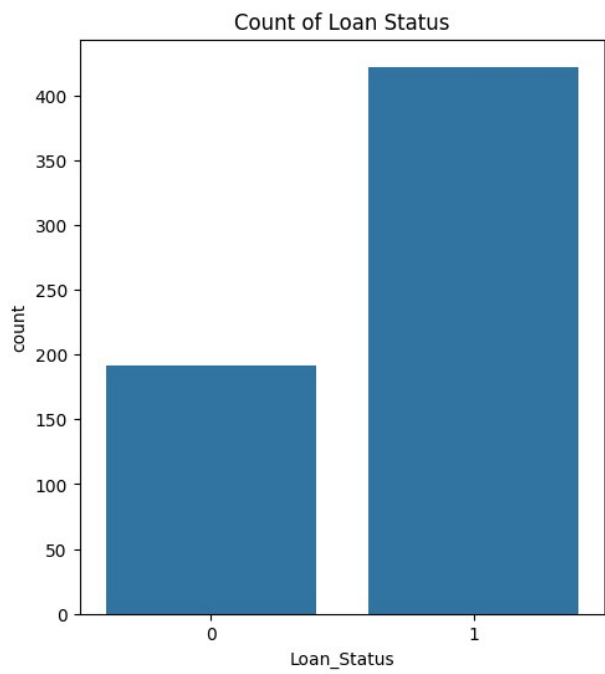
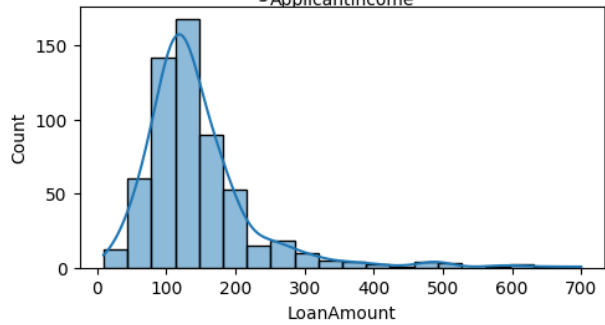
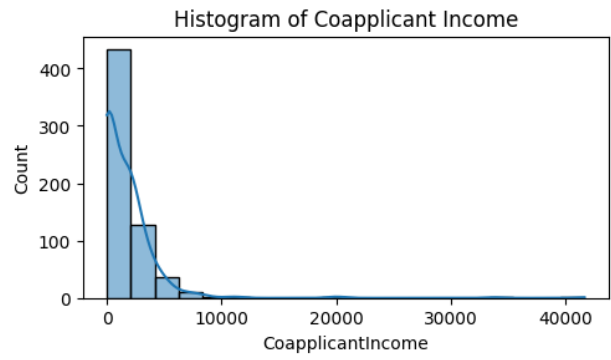
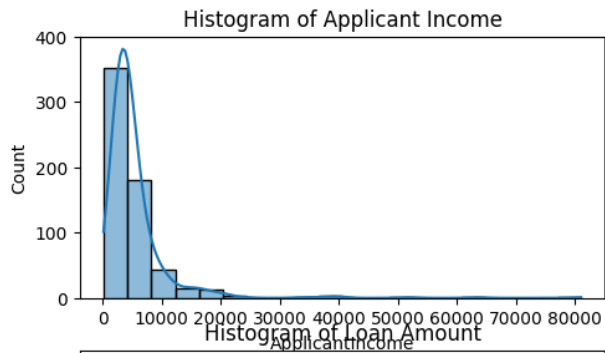
# Heatmap (Correlation Matrix)
plt.figure(figsize=(10, 8))
correlation_matrix = loan_data.corr()
sns.heatmap(correlation_matrix, annot=True, cmap='coolwarm',
fmt=".2f")
plt.title('Correlation Matrix Heatmap')

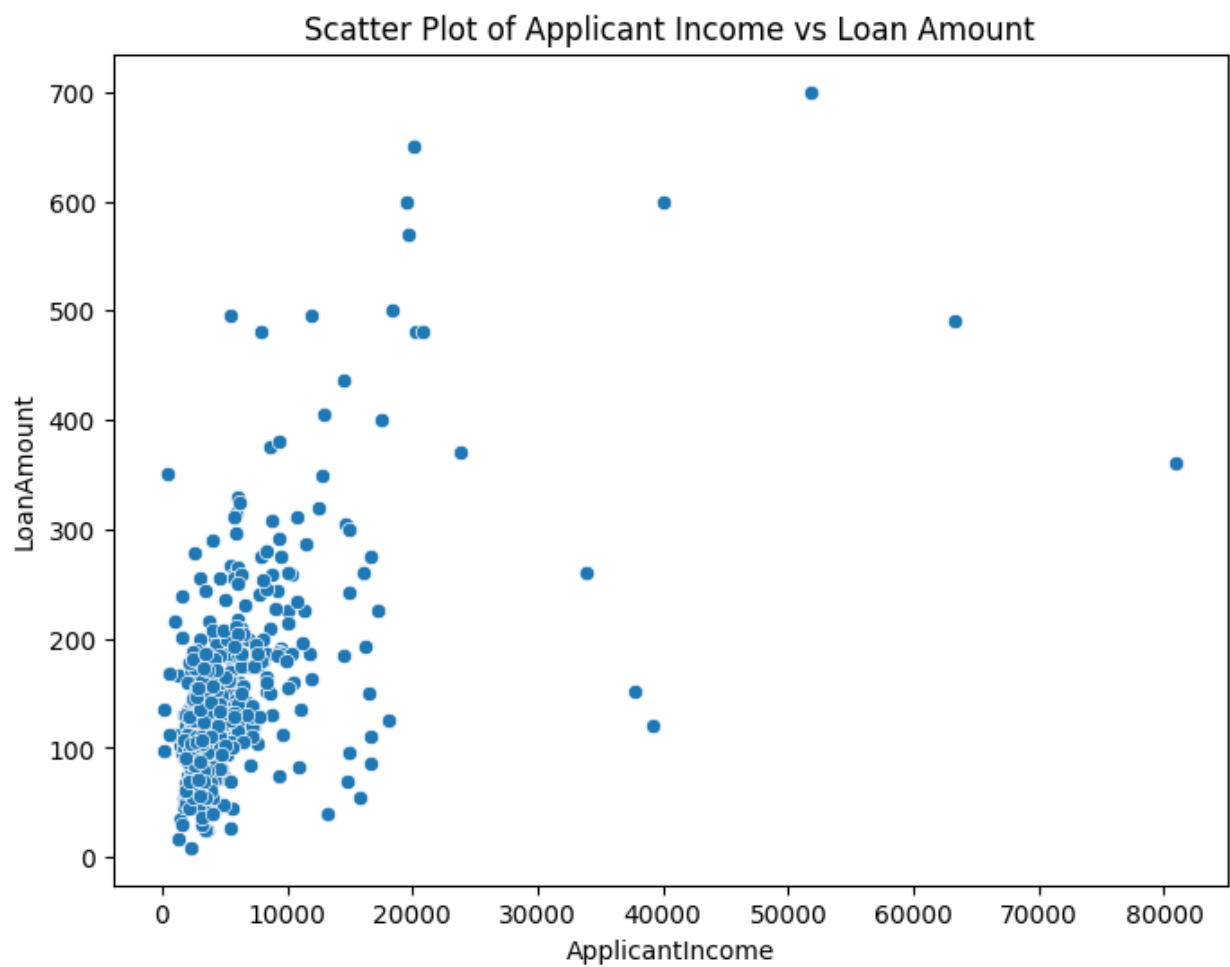
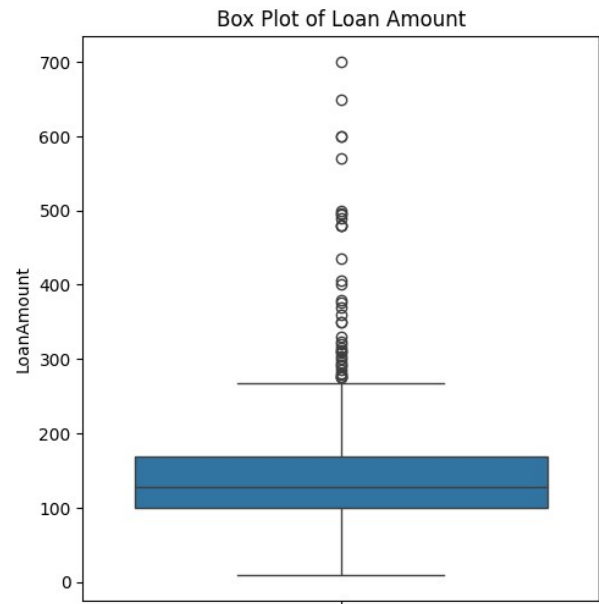
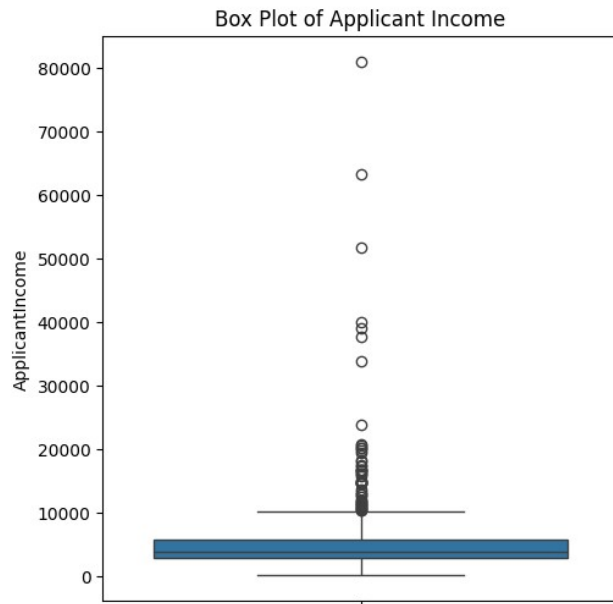
plt.tight_layout()
plt.show()

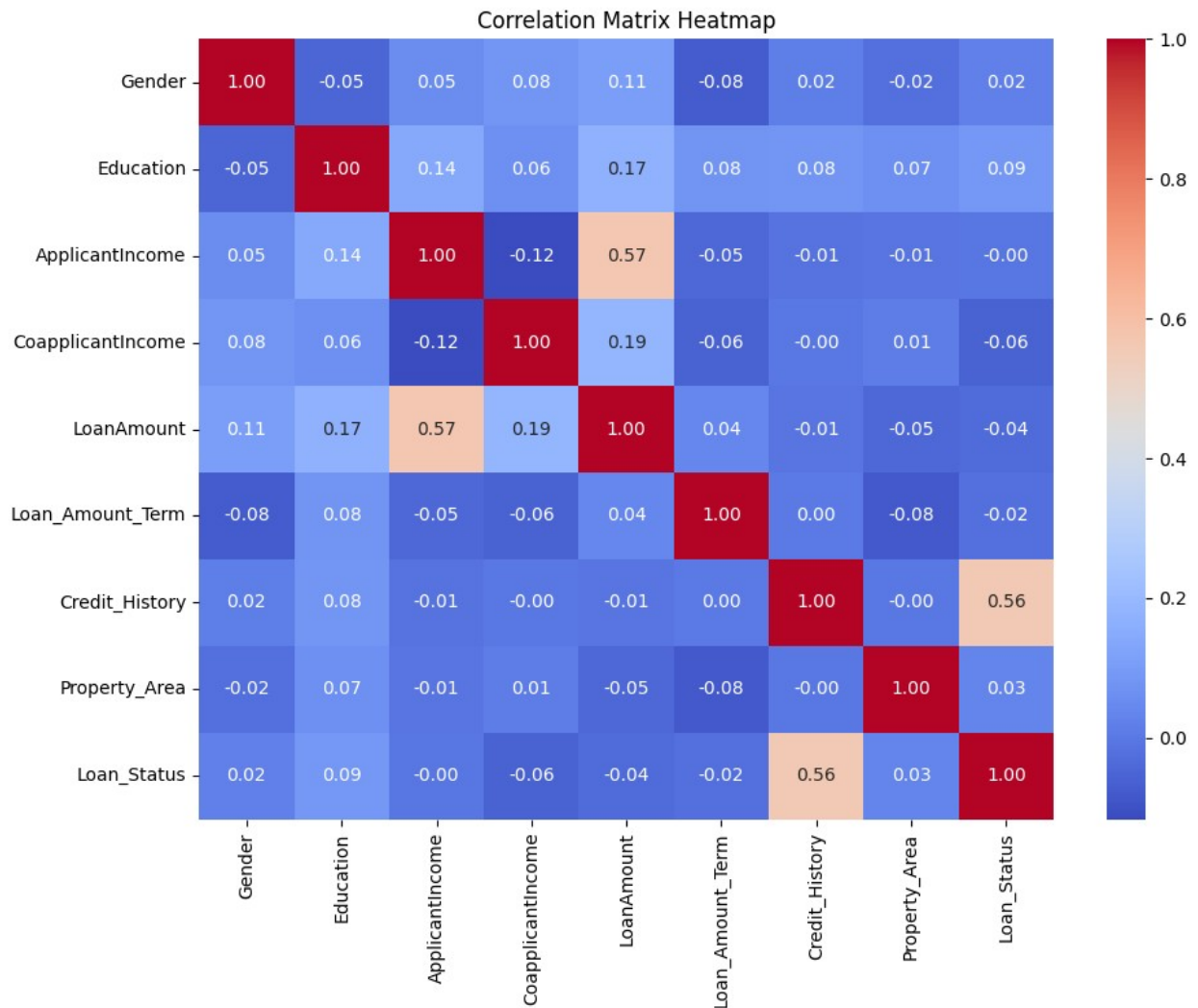
```

<ipython-input-59-4e74d1935192>:45: FutureWarning: The default value of numeric_only in DataFrame.corr is deprecated. In a future version, it will default to False. Select only valid columns or specify the value of numeric_only to silence this warning.

```
correlation_matrix = loan_data.corr()
```







```
#filling missing values
loan_data['Gender'].fillna(loan_data['Gender'].mode()[0],
inplace=True)
loan_data['Married'].fillna(loan_data['Married'].mode()[0],
inplace=True)
loan_data['Dependents'].fillna(loan_data['Dependents'].mode()[0],
inplace=True)
loan_data['Loan_Amount_Term'].fillna(loan_data['Loan_Amount_Term'].mode()[0], inplace=True)
loan_data['Credit_History'].fillna(loan_data['Credit_History'].mode()[0], inplace=True)
loan_data['Self_Employed'].fillna(loan_data['Self_Employed'].mode()[0], inplace=True)
loan_data['LoanAmount'].fillna(loan_data['LoanAmount'].mean(),
inplace=True)
[ ]
loan_data['LoanAmount_log']=np.log(loan_data['LoanAmount'])
```



```

loan_data['TotalIncome']= loan_data['ApplicantIncome'] +
loan_data['CoapplicantIncome']
loan_data['TotalIncome_log']=np.log(loan_data['TotalIncome'])

# Splitting data into features and target
X = loan_data.drop(columns=['Loan_Status', 'Loan_ID'])
y = loan_data['Loan_Status']

# Splitting data into train and test sets
X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=0.2, random_state=42)

# Preprocessing pipeline for numerical features
numeric_features = X.select_dtypes(include=['float64',
'int64']).columns
numeric_transformer = Pipeline(steps=[
    ('imputer', SimpleImputer(strategy='mean')),
    ('scaler', StandardScaler())
])

# Preprocessing pipeline for categorical features
categorical_features = X.select_dtypes(include=['object']).columns
categorical_transformer = Pipeline(steps=[
    ('imputer', SimpleImputer(strategy='most_frequent')),
    ('onehot', OneHotEncoder(handle_unknown='ignore'))
])

# Column Transformer to apply different preprocessing pipelines to
numerical and categorical features
preprocessor = ColumnTransformer(
    transformers=[
        ('num', numeric_transformer, numeric_features),
        ('cat', categorical_transformer, categorical_features)
    ])

# Logistic Regression Pipeline
lr_pipeline = Pipeline(steps=[('preprocessor', preprocessor),
    ('classifier', LogisticRegression())])

# Decision Tree Pipeline
dt_pipeline = Pipeline(steps=[('preprocessor', preprocessor),
    ('classifier',
DecisionTreeClassifier())])

# Random Forest Pipeline
rf_pipeline = Pipeline(steps=[('preprocessor', preprocessor),
    ('classifier',
RandomForestClassifier())])

# Parameter grids for hyperparameter tuning

```

```

lr_param_grid = {
    'classifier__C': [0.1, 1, 10, 100],
    'classifier__solver': ['liblinear', 'lbfgs']
}

dt_param_grid = {
    'classifier__max_depth': [None, 10, 20, 30],
    'classifier__min_samples_split': [2, 5, 10],
    'classifier__min_samples_leaf': [1, 2, 4]
}

rf_param_grid = {
    'classifier__n_estimators': [100, 200, 300],
    'classifier__max_features': ['auto', 'sqrt'],
    'classifier__min_samples_split': [2, 5, 10],
    'classifier__min_samples_leaf': [1, 2, 4],
    'classifier__bootstrap': [True, False]
}

# Grid search with cross-validation
lr_grid_search = GridSearchCV(lr_pipeline, lr_param_grid, cv=5)
dt_grid_search = GridSearchCV(dt_pipeline, dt_param_grid, cv=5)
rf_grid_search = GridSearchCV(rf_pipeline, rf_param_grid, cv=5)

# Fit the models
lr_grid_search.fit(X_train, y_train)
dt_grid_search.fit(X_train, y_train)
rf_grid_search.fit(X_train, y_train)

# Best hyperparameters for each model
best_lr_params = lr_grid_search.best_params_
best_dt_params = dt_grid_search.best_params_
best_rf_params = rf_grid_search.best_params_

# Best models
best_lr_model = lr_grid_search.best_estimator_
best_dt_model = dt_grid_search.best_estimator_
best_rf_model = rf_grid_search.best_estimator_

# Model evaluation
def evaluate_model(model, X_test, y_test):
    y_pred = model.predict(X_test)
    accuracy = accuracy_score(y_test, y_pred)
    report = classification_report(y_test, y_pred)
    return accuracy, report

lr_accuracy, lr_report = evaluate_model(best_lr_model, X_test, y_test)
dt_accuracy, dt_report = evaluate_model(best_dt_model, X_test, y_test)
rf_accuracy, rf_report = evaluate_model(best_rf_model, X_test, y_test)

```

```
# Print evaluation results
print("Logistic Regression:")
print("Best Parameters:", best_lr_params)
print("Accuracy:", lr_accuracy)
print("Classification Report:")
print(lr_report)
```

```
print("\nDecision Tree Classifier:")
print("Best Parameters:", best_dt_params)
print("Accuracy:", dt_accuracy)
print("Classification Report:")
print(dt_report)
```

```
print("\nRandom Forest Classifier:")
print("Best Parameters:", best_rf_params)
print("Accuracy:", rf_accuracy)
print("Classification Report:")
print(rf_report)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/ensemble/_forest.py:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be removed in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClassifiers.
```

```
    warn(
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/ensemble/_forest.py:424: FutureWarning: `max_features='auto'` has been deprecated in 1.1 and will be removed in 1.3. To keep the past behaviour, explicitly set `max_features='sqrt'` or remove this parameter as it is also the default value for RandomForestClassifiers and ExtraTreesClassifiers.
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Logistic Regression:

Best Parameters: {'classifier__C': 1, 'classifier__solver':
'liblinear'}

Accuracy: 0.7886178861788617

Classification Report:

	precision	recall	f1-score	support
0	0.90	0.44	0.59	43
1	0.76	0.97	0.86	80
accuracy			0.79	123
macro avg	0.83	0.71	0.73	123
weighted avg	0.81	0.79	0.77	123

Decision Tree Classifier:

Best Parameters: {'classifier__max_depth': 10,
'classifier__min_samples_leaf': 1, 'classifier__min_samples_split': 2}

Accuracy: 0.6910569105691057

Classification Report:

	precision	recall	f1-score	support
0	0.59	0.37	0.46	43
1	0.72	0.86	0.78	80
accuracy			0.69	123
macro avg	0.66	0.62	0.62	123
weighted avg	0.67	0.69	0.67	123

```

Random Forest Classifier:
Best Parameters: {'classifier__bootstrap': True,
'classifier__max_features': 'sqrt', 'classifier__min_samples_leaf': 4,
'classifier__min_samples_split': 10, 'classifier__n_estimators': 300}
Accuracy: 0.7804878048780488
Classification Report:

```

	precision	recall	f1-score	support
0	0.90	0.42	0.57	43
1	0.76	0.97	0.85	80
accuracy			0.78	123
macro avg	0.83	0.70	0.71	123
weighted avg	0.81	0.78	0.75	123

The evaluation metrics provided for each model (Logistic Regression, Decision Tree Classifier, and Random Forest Classifier) indicate their performance on a binary classification task. Here's a brief interpretation of the metrics:

Logistic Regression:

- Accuracy: 0.79
- Precision for class 0 (negative class): 0.90
- Recall for class 0: 0.44
- F1-score for class 0: 0.59
- Precision for class 1 (positive class): 0.76
- Recall for class 1: 0.97
- F1-score for class 1: 0.86

Overall, the logistic regression model achieves good accuracy and performs relatively well in terms of precision, recall, and F1-score for both classes.

Decision Tree Classifier:

- Accuracy: 0.69
- Precision for class 0: 0.59
- Recall for class 0: 0.37
- F1-score for class 0: 0.46
- Precision for class 1: 0.72
- Recall for class 1: 0.86
- F1-score for class 1: 0.78

The decision tree classifier has lower accuracy compared to logistic regression. It also has lower precision, recall, and F1-score for class 0, indicating it struggles more with correctly predicting negative instances.

Random Forest Classifier:

- Accuracy: 0.78

- Precision for class 0: 0.90
- Recall for class 0: 0.42
- F1-score for class 0: 0.57
- Precision for class 1: 0.76
- Recall for class 1: 0.97
- F1-score for class 1: 0.85

The random forest classifier achieves accuracy similar to logistic regression but has slightly lower precision, recall, and F1-score for class 0.

In summary, while the logistic regression and random forest classifiers perform relatively well overall, the decision tree classifier lags behind in terms of accuracy and its ability to correctly classify negative instances (class 0).