Loan_Prediction

1 Loan Prediction

[ ]:
```
# Import the libraries
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.preprocessing import LabelEncoder
import seaborn as sns
from sklearn.model_selection import train_test_split
import numpy as np
from sklearn.linear_model import LogisticRegression
from sklearn.neighbors import KNeighborsClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import RandomizedSearchCV, GridSearchCV
```

1:Data Aquisition

[ ]:
```
!pip show kaggle
```

```
Name: kaggle
Version: 1.5.16
Summary: Kaggle API
Home-page: https://github.com/Kaggle/kaggle-api
Author: Kaggle
Author-email: support@kaggle.com
License: Apache 2.0
Location: /usr/local/lib/python3.10/dist-packages
Requires: bleach, certifi, python-dateutil, python-slugify, requests, six, tqdm,
urllib3
Required-by:
```

[ ]:
```
from google.colab import files

uploaded = files.upload()
```

```
<IPython.core.display.HTML object>
```

```
Saving kaggle.json to kaggle.json
```

[ ]:
```
!mkdir -p ~/.kaggle
!mv kaggle.json ~/.kaggle/
!chmod 600 ~/.kaggle/kaggle.json
```

[ ]:
```
# Download the dataset
!kaggle datasets download -d subhamjain/
↪loan-prediction-based-on-customer-behavior
```

```
Downloading loan-prediction-based-on-customer-behavior.zip to /content
 78% 4.00M/5.15M [00:00<00:00, 6.02MB/s]
100% 5.15M/5.15M [00:00<00:00, 5.41MB/s]
```

[ ]:
```
# Unzip the dataset
!unzip loan-prediction-based-on-customer-behavior.zip -d /content/
```

```
Archive:  loan-prediction-based-on-customer-behavior.zip
  inflating: /content/Sample Prediction Dataset.csv
  inflating: /content/Test Data.csv
  inflating: /content/Training Data.csv
```

2. Data Exploration (EDA) and Preprocessing

[ ]:
```
training_df = pd.read_csv("Training Data.csv")
testing_df = pd.read_csv("Test Data.csv")
```

[ ]:
```
training_df = training_df.drop(columns=["Id"])
testing_df = testing_df.drop(columns=["ID"])
```

[ ]:
```
training_df.head()
```

[ ]:
```
    Income  Age  Experience Married/Single House_Ownership Car_Ownership  \
0  1303834   23           3         single          rented            no
1  7574516   40          10         single          rented            no
2  3991815   66           4        married          rented            no
3  6256451   41           2         single          rented           yes
4  5768871   47          11         single          rented            no

            Profession                 CITY           STATE  CURRENT_JOB_YRS  \
0  Mechanical_engineer                 Rewa  Madhya_Pradesh                3
1   Software_Developer             Parbhani     Maharashtra                9
2     Technical_writer            Alappuzha          Kerala                4
3   Software_Developer          Bhubaneswar          Odisha                2
4        Civil_servant  Tiruchirappalli[10]      Tamil_Nadu                3

   CURRENT_HOUSE_YRS  Risk_Flag
0                 13          0
1                 13          0
2                 10          0
```

```
3                  12           1
4                  14           1
```

[ ]:
```
testing_df.head()
```

[ ]:
```
    Income  Age  Experience Married/Single House_Ownership Car_Ownership  \
0  7393090   59          19         single          rented            no
1  1215004   25           5         single          rented            no
2  8901342   50          12         single          rented            no
3  1944421   49           9        married          rented           yes
4    13429   25          18         single          rented           yes

    Profession       CITY        STATE  CURRENT_JOB_YRS  CURRENT_HOUSE_YRS
0    Geologist      Malda  West Bengal                4                 13
1  Firefighter      Jalna  Maharashtra                5                 10
2       Lawyer      Thane  Maharashtra                9                 14
3      Analyst      Latur  Maharashtra                3                 12
4     Comedian Berhampore  West Bengal               13                 11
```

[ ]:
```
training_df.columns
```

[ ]:
```
Index(['Income', 'Age', 'Experience', 'Married/Single', 'House_Ownership',
       'Car_Ownership', 'Profession', 'CITY', 'STATE', 'CURRENT_JOB_YRS',
       'CURRENT_HOUSE_YRS', 'Risk_Flag'],
      dtype='object')
```

[ ]:
```
len(training_df.columns), len(testing_df.columns)
```

[ ]:
```
(12, 11)
```

[ ]:
```
len(training_df)
```

[ ]:
```
252000
```

[ ]:
```
len(testing_df)
```

[ ]:
```
28000
```

[ ]:
```
# Check for null values
training_df.isnull().sum()
```

[ ]:
```
Income               0
Age                  0
Experience           0
Married/Single       0
House_Ownership      0
Car_Ownership        0
Profession           0
```

```
CITY                 0
STATE                0
CURRENT_JOB_YRS      0
CURRENT_HOUSE_YRS    0
Risk_Flag            0
dtype: int64
```

[ ]:
```
# Check for null values
testing_df.isnull().sum()
```

[ ]:
```
Income               0
Age                  0
Experience           0
Married/Single       0
House_Ownership      0
Car_Ownership        0
Profession           0
CITY                 0
STATE                0
CURRENT_JOB_YRS      0
CURRENT_HOUSE_YRS    0
dtype: int64
```

[ ]:
```
# Check for unique values
training_df.index.is_unique
```

[ ]:
```
True
```

[ ]:
```
testing_df.index.is_unique
```

[ ]:
```
True
```

[ ]:
```
#Convert the categorical features to numerical features
# List of categorical column names
categorical_columns = ["Married/Single", "House_Ownership", "Car_Ownership",␣
 ↪"Profession", "CITY", "STATE"]

# Create a LabelEncoder instance
label_encoder = LabelEncoder()

# Apply Label Encoding to each categorical column
for column in categorical_columns:
    training_df[column] = label_encoder.fit_transform(training_df[column])
    testing_df[column] = label_encoder.fit_transform(testing_df[column])
```

[ ]:
```
training_df.head()
```

```
[ ]:     Income  Age  Experience  Married/Single  House_Ownership  Car_Ownership  \
     0  1303834   23           3               1                2              0
     1  7574516   40          10               1                2              0
     2  3991815   66           4               0                2              0
     3  6256451   41           2               1                2              1
     4  5768871   47          11               1                2              0

        Profession  CITY  STATE  CURRENT_JOB_YRS  CURRENT_HOUSE_YRS  Risk_Flag
     0          33   251     13                3                 13          0
     1          43   227     14                9                 13          0
     2          47     8     12                4                 10          0
     3          43    54     17                2                 12          1
     4          11   296     22                3                 14          1
```

```
[ ]: testing_df.head()
```

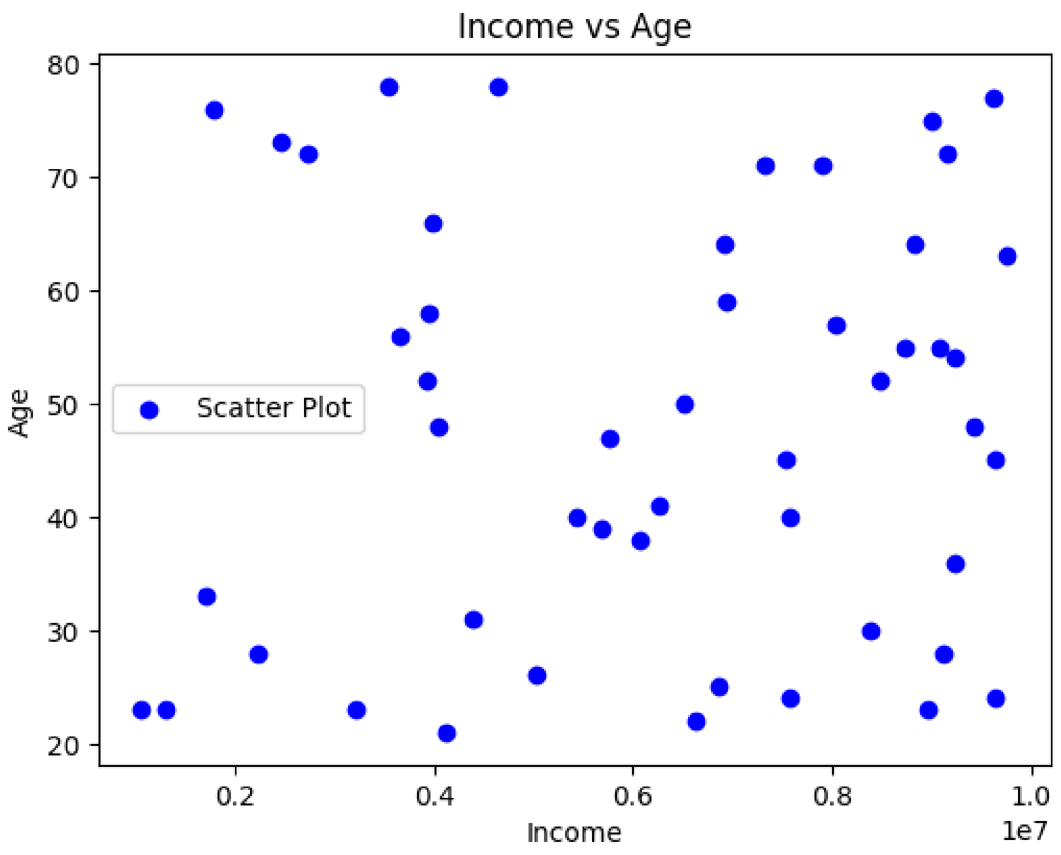
```
[ ]:     Income  Age  Experience  Married/Single  House_Ownership  Car_Ownership  \
     0  7393090   59          19               1                2              0
     1  1215004   25           5               1                2              0
     2  8901342   50          12               1                2              0
     3  1944421   49           9               0                2              1
     4    13429   25          18               1                2              1

        Profession  CITY  STATE  CURRENT_JOB_YRS  CURRENT_HOUSE_YRS
     0          26   181     28                4                 13
     1          24   131     14                5                 10
     2          30   290     14                9                 14
     3           1   171     14                3                 12
     4          12    39     28               13                 11
```

Data Visualization

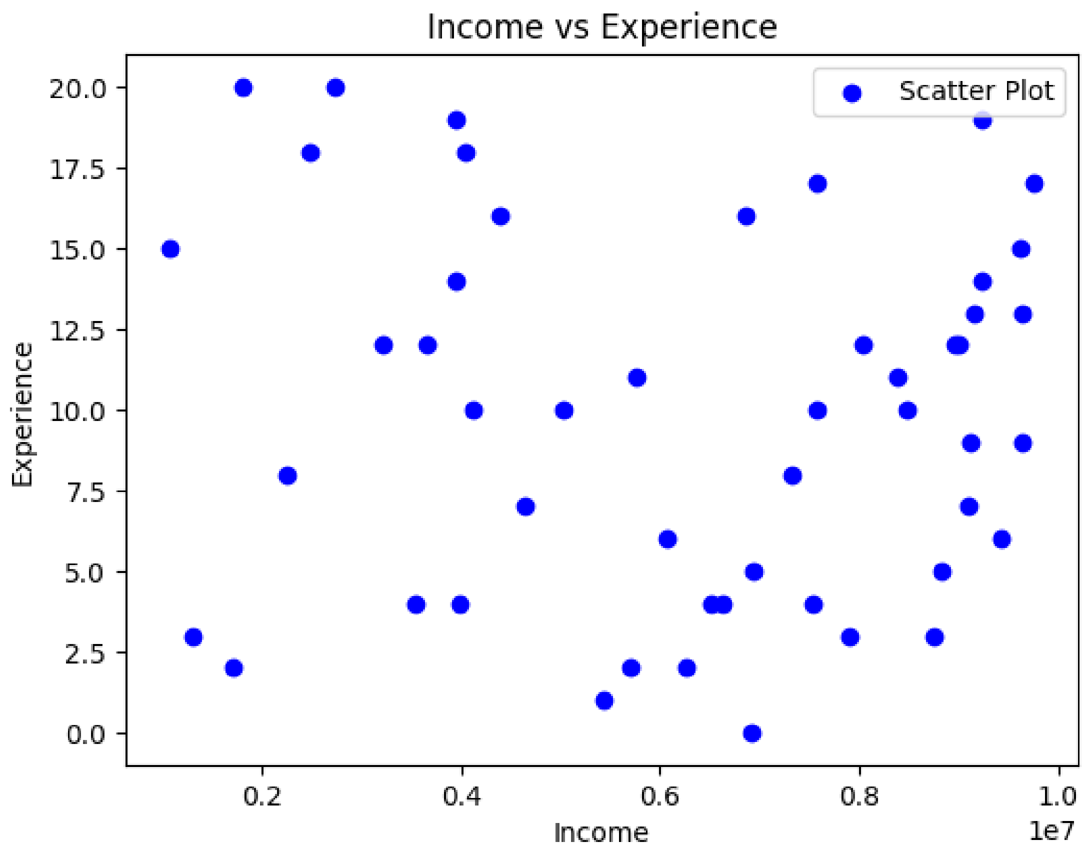
```
[ ]: # Create a function to plot scatter plot between two columns of the dataset
     def scatter_plot(x_data, y_data):
       """
       Plots a scatterplot between two columns of the dataset

       Args:
         x_data: column1 of the dataset.
         y_data: column2 of the dataset
       """

       # Create a scatter plot
       plt.scatter(x_data, y_data, color='blue', marker='o', label='Scatter Plot')

       # Add labels and title
       plt.xlabel(x_data.name)
```

```
    plt.ylabel(y_data.name)
    plt.title(f'{x_data.name} vs {y_data.name}')

    # Add a legend
    plt.legend()

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

[ ]:
```
# Plot a scatter plot for the first 50 samples of the training dataset
scatter_plot(training_df["Income"][:50], training_df["Age"][:50])
```

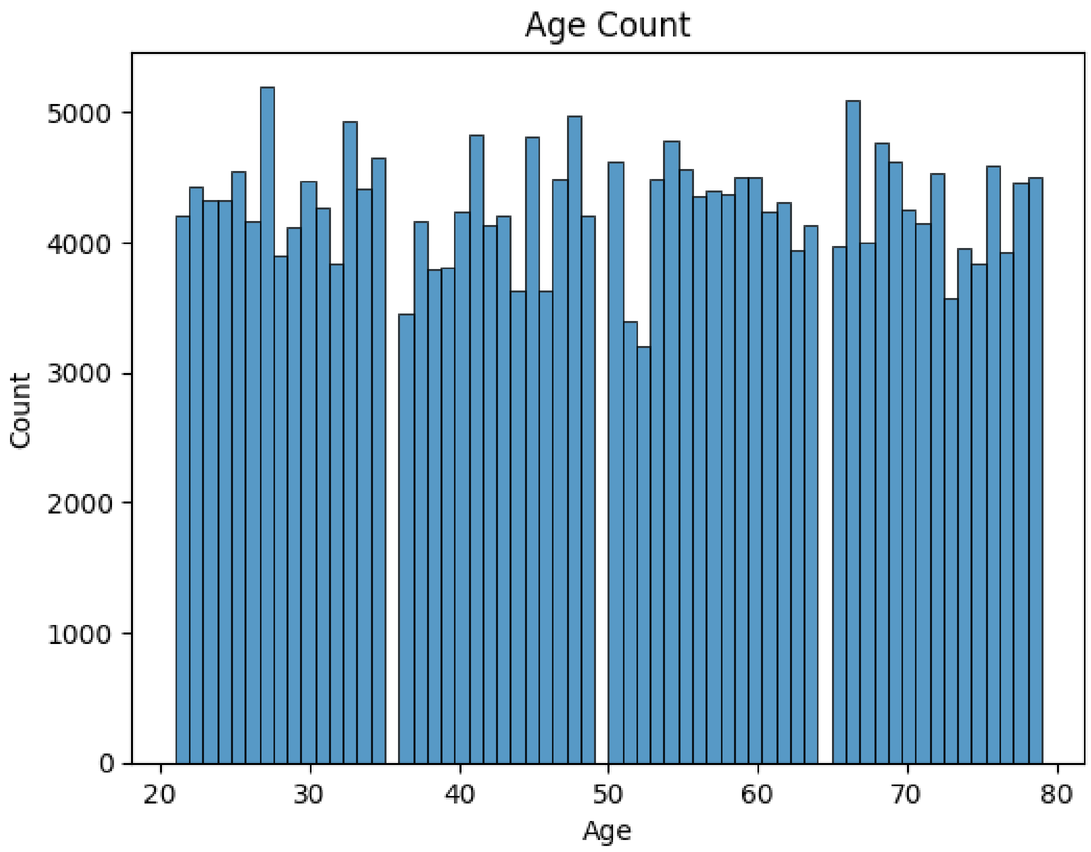


[ ]:
```
# Plot a scatter plot for the first 50 samples of the training dataset
scatter_plot(training_df["Income"][:50], training_df["Experience"][:50])
```



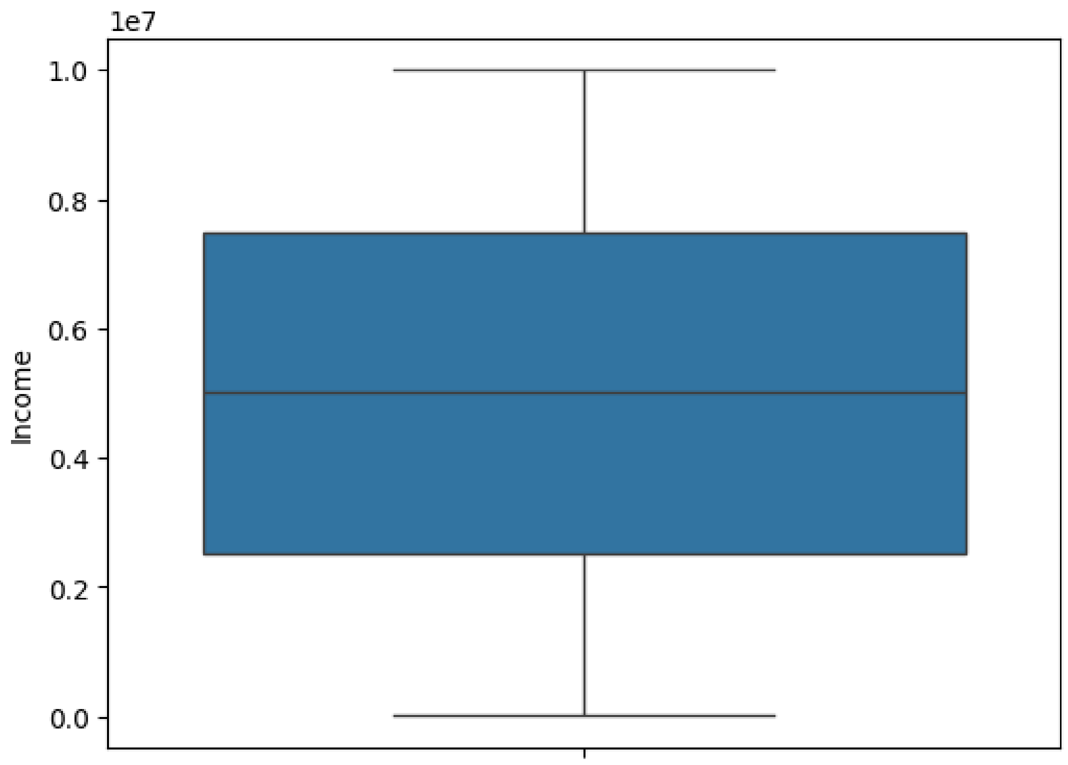
```
[ ]: # Plot Histogram for age column
     sns.histplot(training_df.Age)
     plt.xlabel("Age")
     plt.title("Age Count")
```

```
[ ]: Text(0.5, 1.0, 'Age Count')
```

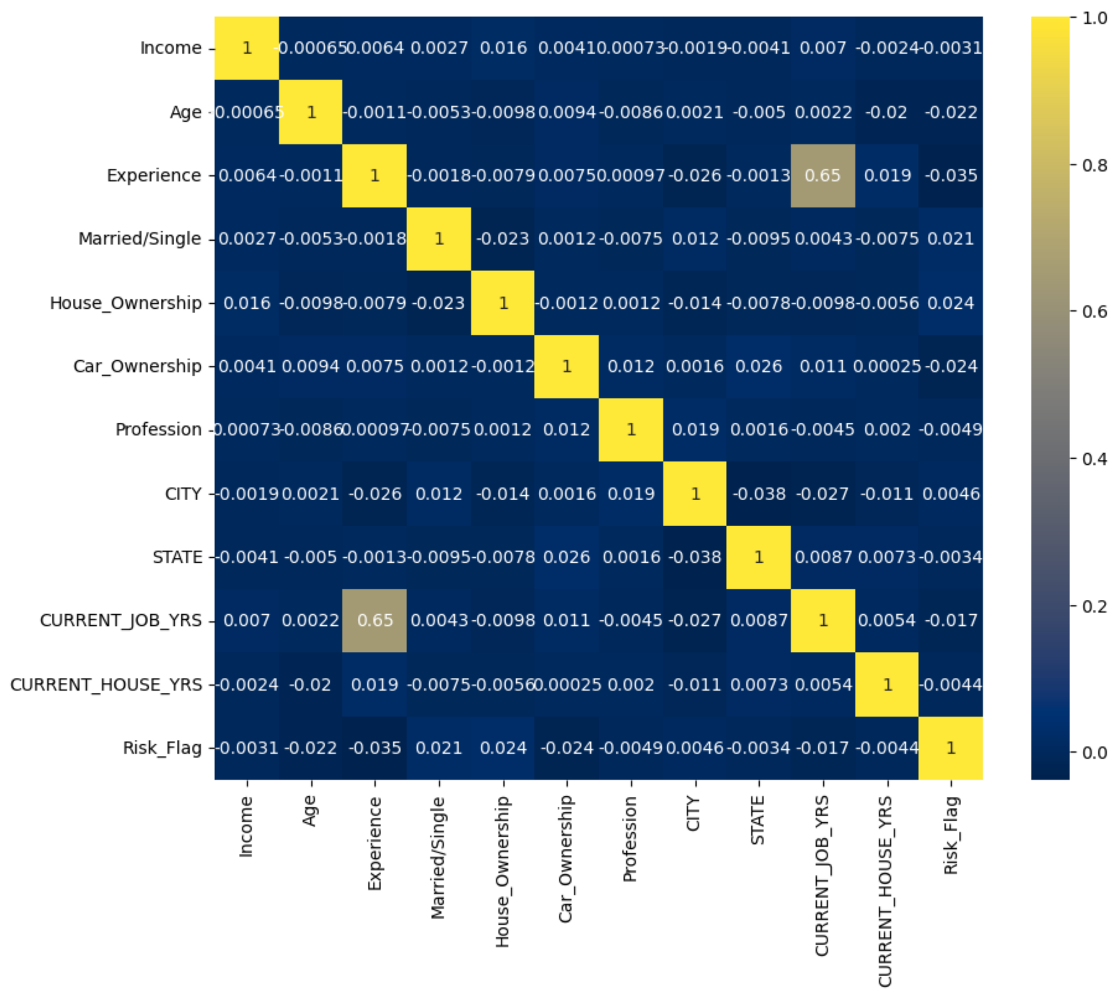


```
[ ]: # Plot Box plot on Income column
     sns.boxplot(training_df.Income)
```

```
[ ]: <Axes: ylabel='Income'>
```



```
[ ]: # Plot Heat map
plt.figure(figsize=(10,8))
sns.heatmap(training_df.corr(),annot=True,cmap='cividis')

plt.show()
```



3: Splitting into training and testing set

```
[ ]: x = training_df.drop("Risk_Flag", axis=1)
     y = training_df["Risk_Flag"]
```

```
[ ]: # Split into train & test set
     x_train, x_test, y_train, y_test = train_test_split(x, y, test_size=0.2)
```

4. Modelling

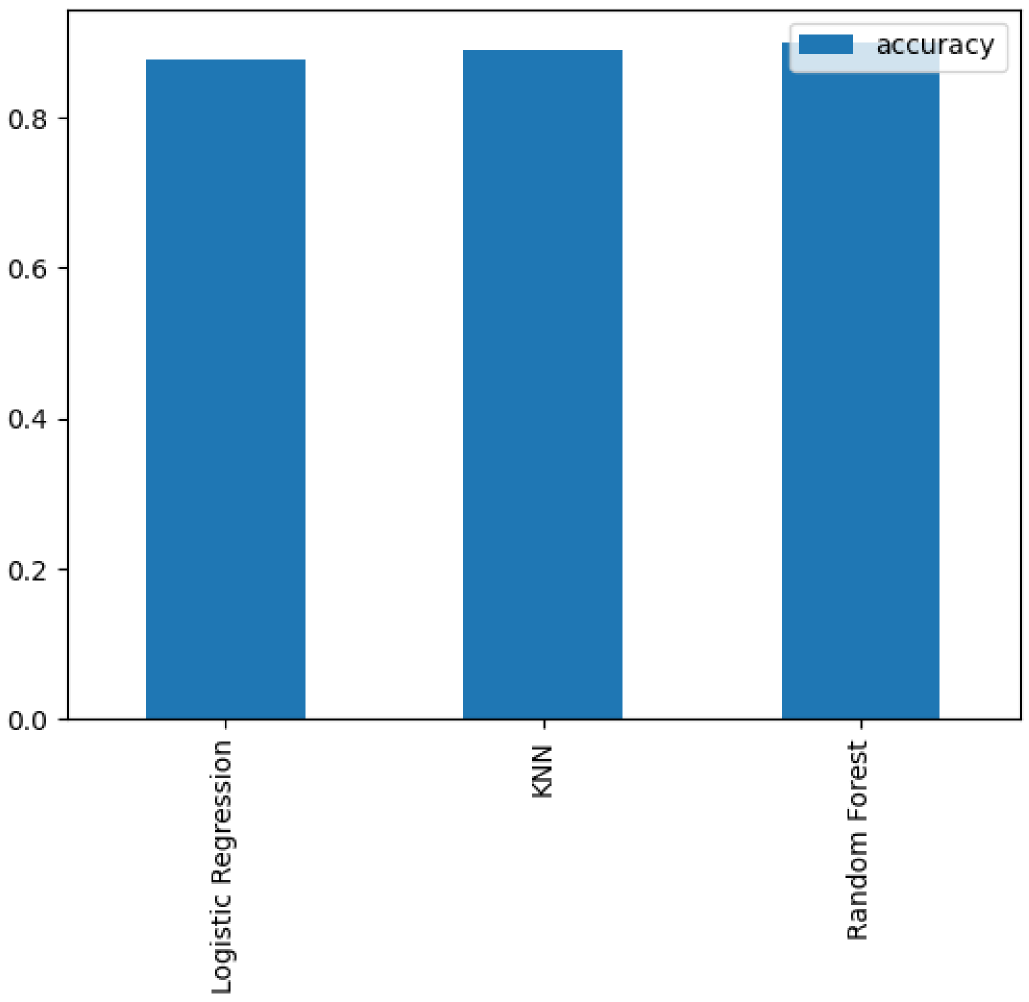
```
[ ]: # Put models in a dictionary
     models = {"Logistic Regression": LogisticRegression(),
               "KNN": KNeighborsClassifier(),
               "Random Forest": RandomForestClassifier()}

     # Create a function to fit and score models
```

```
def fit_and_score(models, X_train, X_test, y_train, y_test):
    """
    Fits and evaluates given machine learning models.
    models : a dict of differetn Scikit-Learn machine learning models
    X_train : training data (no labels)
    X_test : testing data (no labels)
    y_train : training labels
    y_test : test labels
    """
    # Set random seed
    np.random.seed(42)
    # Make a dictionary to keep model scores
    model_scores = {}
    # Loop through models
    for name, model in models.items():
        # Fit the model to the data
        model.fit(X_train, y_train)
        # Evaluate the model and append its score to model_scores
        model_scores[name] = model.score(X_test, y_test)
    return model_scores
```

[ ]:
```
model_scores = fit_and_score(models=models,
                             X_train=x_train,
                             X_test=x_test,
                             y_train=y_train,
                             y_test=y_test)

model_scores
```

[ ]:
```
{'Logistic Regression': 0.8767857142857143,
 'KNN': 0.888234126984127,
 'Random Forest': 0.8980952380952381}
```

[ ]:
```
# Comparing the models
model_compare = pd.DataFrame(model_scores, index=["accuracy"])
model_compare.T.plot.bar();
```



Hyperparameter Tuning

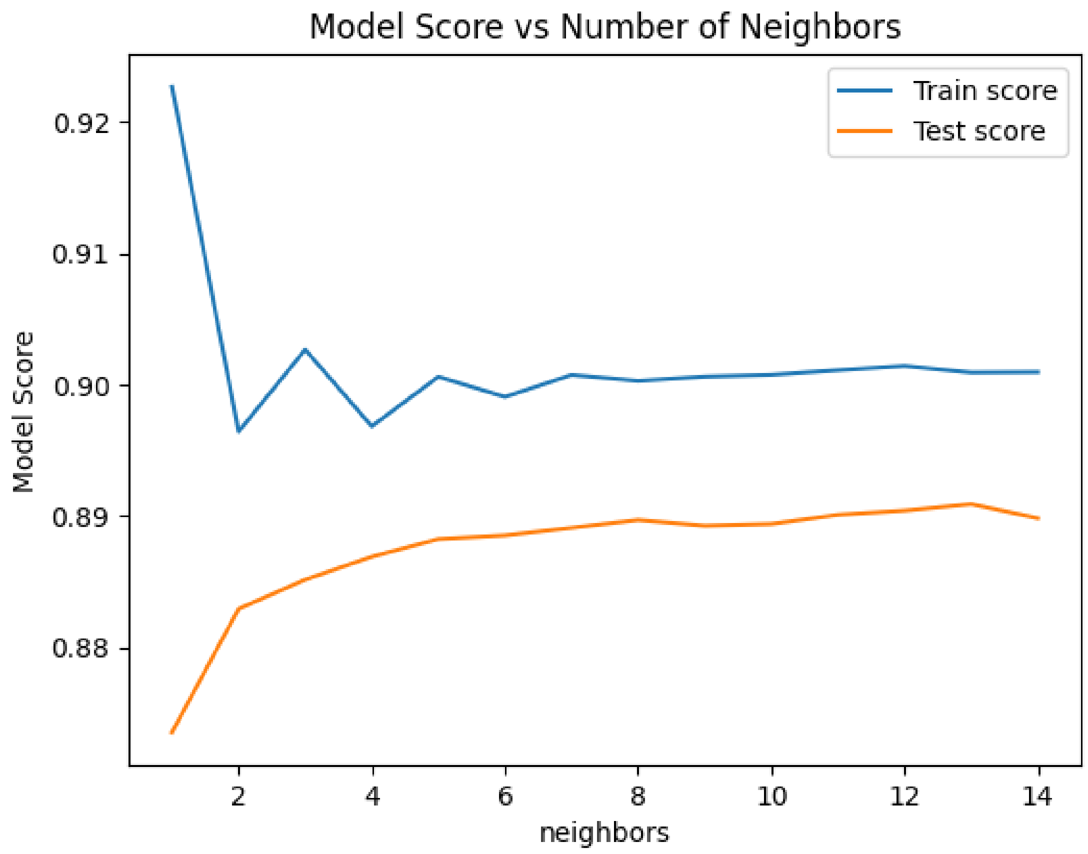
[ ]:
```python
train_scores = []
test_scores = []

# List of different values of n_neighbours
neighbors = range(1, 15)

# Initialize KNN
knn = KNeighborsClassifier()

for i in neighbors:
  knn.set_params(n_neighbors=i)
  knn.fit(x_train, y_train) # Fitting the algorith
  train_scores.append(knn.score(x_train, y_train)) # Updating train_scores
  test_scores.append(knn.score(x_test, y_test)) # updating test_scores
```

```
[ ]: train_scores, test_scores
```

```
[ ]: ([0.9227083333333334,
       0.8964136904761905,
       0.9026686507936508,
       0.8968253968253969,
       0.9005952380952381,
       0.8990674603174603,
       0.900734126984127,
       0.9002827380952381,
       0.9006051587301588,
       0.9007440476190476,
       0.9011011904761905,
       0.9014186507936508,
       0.900922619047619,
       0.900952380952381],
      [0.8735119047619048,
       0.8829166666666667,
       0.8851388888888889,
       0.8868849206349206,
       0.888234126984127,
       0.8885119047619048,
       0.8890873015873015,
       0.8896825396825396,
       0.8892460317460318,
       0.8893849206349206,
       0.890079365079365,
       0.8903968253968254,
       0.8908928571428572,
       0.8898214285714285])
```

```
[ ]: # Plot the model scores
     plt.plot(neighbors, train_scores, label="Train score")
     plt.plot(neighbors, test_scores, label="Test score")
     plt.xlabel("neighbors")
     plt.ylabel("Model Score")
     plt.title("Model Score vs Number of Neighbors")
     plt.legend()
     print(f"Maximum model score: {max(test_scores)*100:.2f}%")
```

```
Maximum model score: 89.09%
```



```
[ ]: # Tuning with RandomizedSearchCV

     # Define the hyperparameter search space for LogisticRegression
     log_param_dist = {
         'C': np.logspace(-5, 5, 20),  # Regularization strength
         'penalty': ['l1', 'l2'],  # Type of regularization
         'solver': ['saga']  # Solver algorithm
     }
```

```
[ ]: # Tune LogisticRegression model
     # Setup random seed
     np.random.seed(42)

     # Setup random hyperparameter search for logistic regression
     rs_log_reg = RandomizedSearchCV(LogisticRegression(),
                                     param_distributions=log_param_dist,
                                     cv=5,
                                     n_iter=20,
                                     verbose=True)
```

```python
# Fit random hyperparameter search model for LogisticRegression
rs_log_reg.fit(x_train, y_train)
```

```
Fitting 5 folds for each of 20 candidates, totalling 100 fits
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
```

```
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
```

```
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
```

```
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
```

```
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
```

```
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
```

```
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
```

```
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
```

```
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_sag.py:350:
ConvergenceWarning: The max_iter was reached which means the coef_ did not
converge
  warnings.warn(
```

[ ]:
```
RandomizedSearchCV(cv=5, estimator=LogisticRegression(), n_iter=20,
                   param_distributions={'C': array([1.00000000e-05,
3.35981829e-05, 1.12883789e-04, 3.79269019e-04,
       1.27427499e-03, 4.28133240e-03, 1.43844989e-02, 4.83293024e-02,
       1.62377674e-01, 5.45559478e-01, 1.83298071e+00, 6.15848211e+00,
       2.06913808e+01, 6.95192796e+01, 2.33572147e+02, 7.84759970e+02,
       2.63665090e+03, 8.85866790e+03, 2.97635144e+04, 1.00000000e+05]),
                                        'penalty': ['l1', 'l2'],
                                        'solver': ['saga']},
                   verbose=True)
```

[ ]:
```
rs_log_reg.best_params_
```

[ ]:
```
{'solver': 'saga', 'penalty': 'l2', 'C': 0.5455594781168515}
```

[ ]:
```
# Evaluate the model
rs_log_reg.score(x_test, y_test)
```

[ ]:
```
0.8767857142857143
```

[ ]:
```

```

5 Model Selection

```
[ ]: print(f"KNN Model (Tuned): {max(test_scores)*100:.2f}%")
     print(f"Logistic Regression (RandomizedSearchCV): {(rs_log_reg.score(x_test,␣
      ↪y_test))*100:.2f}%")
```

```
KNN Model (Tuned): 89.09%
Logistic Regression (RandomizedSearchCV): 87.68%
```

```
[ ]: model_scores
```

```
[ ]: {'Logistic Regression': 0.8767857142857143,
      'KNN': 0.888234126984127,
      'Random Forest': 0.8980952380952381}
```

```
[ ]: rf_model = RandomForestClassifier()
     rf_model.fit(x_train, y_train)
     rf_model.predict(x_test)
     rf_model.score(x_test, y_test)
```

```
[ ]: 0.8979166666666667
```

```
[ ]: # Since Random Forest has highest perfomarnce we will select Random Forest for␣
      ↪predictions

     sample_data = {"Income": 13023043,
                    "Age": 33,
                    "Experience": 10,
                    "Married/Single": 1,
                    "House_Ownership": 3,
                    "Car_Ownership": 5,
                    "Profession": 433,
                    "CITY": 220,
                    "STATE": 15,
                    "CURRENT_JOB_YRS": 11,
                    "CURRENT_HOUSE_YRS": 16}

     sample_df = pd.DataFrame(sample_data, index=[0])
     sample_df
     prediction = rf_model.predict(sample_df)
     if prediction[0] == 0:
       print(f"Prediction: {prediction[0]} \n No risk")
     else:
       print(f"Prediction: {prediction[0]} \n High Risk")
```

```
Prediction: 0
 No risk
```

```
[ ]:
```