Importing libraries

```
import os
from collections import defaultdict
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.datasets import load_iris
from sklearn.model_selection import train_test_split
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.naive_bayes import GaussianNB
from sklearn.neighbors import KNeighborsClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score, confusion_matrix, f1_score, precision_score, recall_score, classification_report
from sklearn.metrics import ConfusionMatrixDisplay
from sklearn.preprocessing import StandardScaler
import warnings
import seaborn as sns
from time import time

%matplotlib inline
warnings.filterwarnings('ignore')
```

```
import pandas as pd

import io

dataset = pd.read_csv('Processed_Combined_IoT_dataset.csv')
```

```
dataset.head()
```

	FC1_Read_Input_Register	FC2_Read_Discrete_Value	FC3_Read_Holding_Register	FC4_Read_Coil	current_
0	0.495216	0.499092	0.488897	0.499405	
1	0.495216	0.499092	0.488897	0.499405	
2	0.495216	0.499092	0.488897	0.499405	
3	0.495216	0.499092	0.488897	0.499405	
4	0.495216	0.499092	0.488897	0.499405	

```
print(dataset.shape)
```

```
(401119, 18)
```

```
print(list(dataset.columns))
```

```
['FC1_Read_Input_Register', 'FC2_Read_Discrete_Value', 'FC3_Read_Holding_Register', 'FC4_Read_Coil', 'current_temperature', 'door_s
```

```
target_cols=list(dataset.columns[-1:])
target_cols
```

```
['label']
```

```
feature_cols= list(dataset.columns[:-1])
feature_cols
```

```
['FC1_Read_Input_Register',
 'FC2_Read_Discrete_Value',
 'FC3_Read_Holding_Register',
 'FC4_Read_Coil',
 'current_temperature',
 'door_state',
 'fridge_temperature',
 'humidity',
 'latitude',
 'light_status',
 'longitude',
 'motion_status',
 'pressure',
 'sphone_signal',
```

```
'temp_condition',
'temperature',
'thermostat_status']
```

```
#split dataset in features and target variable
X = dataset.drop('label', axis=1) # Features
y = dataset['label'] # Target variable
```

```
X.head()
```

	FC1_Read_Input_Register	FC2_Read_Discrete_Value	FC3_Read_Holding_Register	FC4_Read_Coil	current_
0	0.495216	0.499092	0.488897	0.499405	
1	0.495216	0.499092	0.488897	0.499405	
2	0.495216	0.499092	0.488897	0.499405	
3	0.495216	0.499092	0.488897	0.499405	
4	0.495216	0.499092	0.488897	0.499405	

```
y.head()
```

```
0    0
1    0
2    0
3    0
4    0
Name: label, dtype: int64
```

```
# Split dataset into training set and test set
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=1) # 70% training and 30% test
```

```
# Check the shape of all of these
print("X_train shape is : ", X_train.shape)
print("X_test shape  is : ", X_test.shape)
print("y_train shape is : ", y_train.shape)
print("y_test shape is  : ", y_test.shape)
```

```
X_train shape is :  (280783, 17)
X_test shape  is :  (120336, 17)
y_train shape is :  (280783,)
y_test shape is  :  (120336,)
```

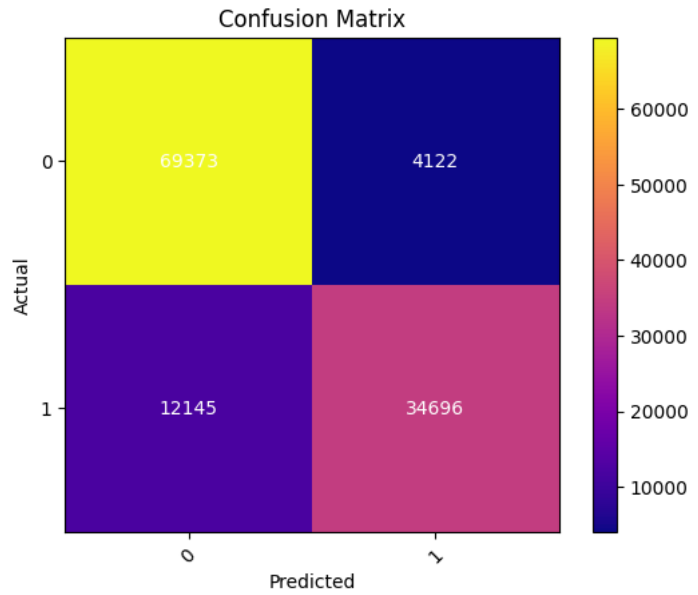
```
# Define a list of classifier classes
classifiers = [
    DecisionTreeClassifier,
    RandomForestClassifier,
    KNeighborsClassifier,
    LogisticRegression,
    GaussianNB,
]
```

```
def evaluate_classifier(class_type, train_x, train_Y, test_x, test_Y, label_names=None, **kwargs):
    start_time = time()  # Record the start time for training

    if class_type == 'DecisionTree':
        from sklearn.tree import DecisionTreeClassifier
        classifier = DecisionTreeClassifier(**kwargs)
    elif class_type == 'RandomForest':
        from sklearn.ensemble import RandomForestClassifier
        classifier = RandomForestClassifier(**kwargs)
    elif class_type == 'KNeighbors':
        from sklearn.neighbors import KNeighborsClassifier
        classifier = KNeighborsClassifier(**kwargs)
    elif class_type == 'LogisticRegression':
        from sklearn.linear_model import LogisticRegression
        classifier = LogisticRegression(**kwargs)
    elif class_type == 'NaiveBayes':
        from sklearn.naive_bayes import GaussianNB
        classifier = GaussianNB(**kwargs)
    else:
        raise ValueError(f"Unsupported classifier type: {class_type}")

    classifier.fit(train_x, train_Y)
    training_time = time() - start_time  # Calculate training time

    start_time = time()  # Record the start time for testing
```

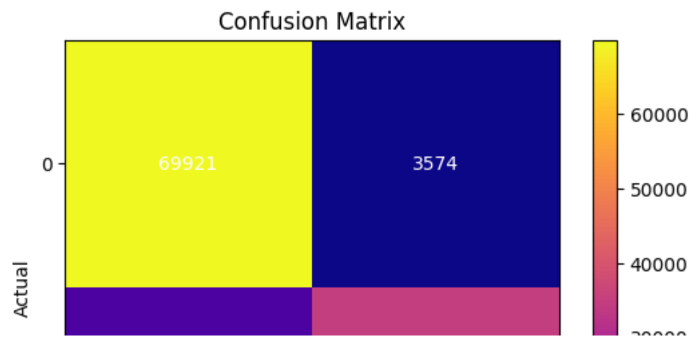
```
        y_pred = classifier.predict(test_x)
        testing_time = time() - start_time  # Calculate testing time

        class_name = class_type
        print(f"Classifier: {class_name}")
        print(f"Evaluation Report for {class_name}:")
        show_evaluation_results(test_Y, y_pred, label_names, training_time, testing_time)
        print("=" * 40)



    label_names = list(map(str, np.unique(y_test)))
    performance_metrics = []


    def show_evaluation_results(test_Y, y_pred, label_names, training_time, testing_time):
        accuracy = accuracy_score(test_Y, y_pred)
        conf_matx = confusion_matrix(test_Y, y_pred)
        f1score = f1_score(test_Y, y_pred, average="macro")
        precision = precision_score(test_Y, y_pred, average="macro")
        recall = recall_score(test_Y, y_pred, average="macro")

        print(f"F-Score: {f1score}")
        print(f"Precision: {precision}")
        print(f"Re-call: {recall}")
        print(f"Accuracy: {accuracy}")
        print(f"Confusion Matrix:\n{conf_matx}")

        clrp = classification_report(test_Y, y_pred, target_names=label_names)
        print(clrp)

        class_far = calculate_false_alarm_rate(conf_matx, label_names)
        for label_name, false_alarm in class_far.items():
            print(f"False Alarm of {label_name}: {false_alarm:.4f} ({false_alarm * 100:.2f}%)")

        overall_far = sum(class_far.values()) / len(class_far)
        print(f"Overall False Alarm Rate: {overall_far:.4f} ({overall_far * 100:.2f}%)")

        # Add training time, testing time, and error rate to the report
        print(f"Training Time: {training_time:.2f} seconds")
        print(f"Testing Time: {testing_time:.2f} seconds")
        error_rate = 1 - accuracy
        print(f"Error Rate: {error_rate:.4f} ({error_rate * 100:.2f}%)")

        # Create the heatmap using Matplotlib
        plt.imshow(conf_matx, interpolation='nearest', cmap='plasma')
        plt.title("Confusion Matrix")
        plt.colorbar()

        # Label the axes with numbers
        for i in range(len(label_names)):
            for j in range(len(label_names)):
                plt.text(j, i, str(conf_matx[i, j]), ha='center', va='center', color='white')

        # Label the axes
        plt.xlabel("Predicted")
        plt.ylabel("Actual")
        plt.xticks(np.arange(len(label_names)), label_names, rotation=45)
        plt.yticks(np.arange(len(label_names)), label_names)

        # Append performance metrics to the list
        performance_metrics.append({
            'F-Score': f1score,
            'Precision': precision,
            'Recall': recall,
            'Accuracy': accuracy,
            'Overall FAR': overall_far,
            'Training Time': training_time,
            'Testing Time': testing_time,
            'Error Rate': error_rate
        })

        plt.show()

    def calculate_false_alarm_rate(conf_matx, label_names):
        class_far = {}
        for i, label_name in enumerate(label_names):
            TP = conf_matx[i, i]
            FP = np.sum(conf_matx[:, i]) - TP
            FN = np.sum(conf_matx[i, :]) - TP
            TN = np.sum(conf_matx) - TP - FP - FN
            false_alarm = FP / (FP + TN)
            class_far[label_name] = false_alarm
```

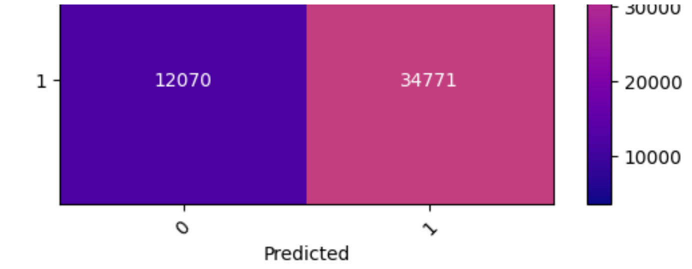
```
        return class_far


    classifiers = [
        ('DecisionTree', DecisionTreeClassifier(random_state=17)),
        ('RandomForest', RandomForestClassifier(random_state=17)),
        ('KNeighbors', KNeighborsClassifier()),
        ('LogisticRegression', LogisticRegression()),
        ('NaiveBayes', GaussianNB()),
    ]


    for classifier_name, _ in classifiers:
        evaluate_classifier(class_type=classifier_name, train_x=X_train, train_Y=y_train, test_x=X_test, test_Y=y_test, label_names=label_nam
```

```
Classifier: DecisionTree
Evaluation Report for DecisionTree:
F-Score: 0.8525781297206456
Precision: 0.8724133244340502
Re-call: 0.8423165766178815
Accuracy: 0.8648201701901342
Confusion Matrix:
[[69373  4122]
 [12145 34696]]
              precision    recall  f1-score   support

           0       0.85      0.94      0.90     73495
           1       0.89      0.74      0.81     46841

    accuracy                           0.86    120336
   macro avg       0.87      0.84      0.85    120336
weighted avg       0.87      0.86      0.86    120336

False Alarm of 0: 0.2593 (25.93%)
False Alarm of 1: 0.0561 (5.61%)
Overall False Alarm Rate: 0.1577 (15.77%)
Training Time: 3.53 seconds
Testing Time: 0.06 seconds
Error Rate: 0.1352 (13.52%)
```

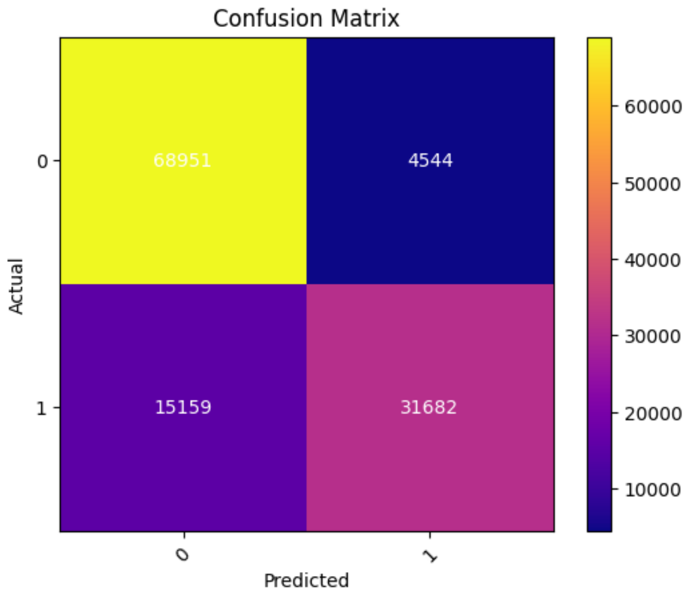



```
========================================
Classifier: RandomForest
Evaluation Report for RandomForest:
F-Score: 0.8578706200106176
Precision: 0.8797911526372347
Re-call: 0.8468453020774936
Accuracy: 0.8699973407791517
Confusion Matrix:
[[69921  3574]
 [12070 34771]]
              precision    recall  f1-score   support

           0       0.85      0.95      0.90     73495
           1       0.91      0.74      0.82     46841

    accuracy                           0.87    120336
   macro avg       0.88      0.85      0.86    120336
weighted avg       0.87      0.87      0.87    120336

False Alarm of 0: 0.2577 (25.77%)
False Alarm of 1: 0.0486 (4.86%)
Overall False Alarm Rate: 0.1532 (15.32%)
Training Time: 75.57 seconds
Testing Time: 3.82 seconds
Error Rate: 0.1300 (13.00%)
```

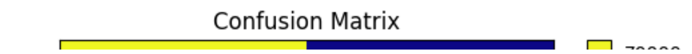




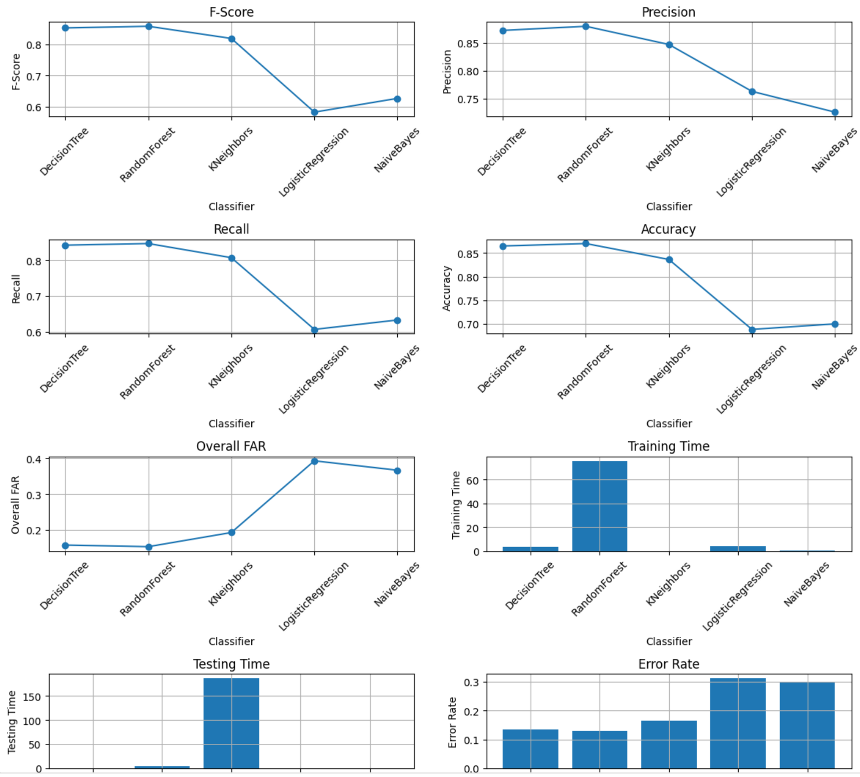

```
=======================================
Classifier: KNeighbors
Evaluation Report for KNeighbors:
F-Score: 0.8188954292131032
Precision: 0.8471684784464781
Re-call: 0.8072729637735185
Accuracy: 0.8362667863316049
Confusion Matrix:
[[68951  4544]
 [15159 31682]]
              precision    recall  f1-score   support

           0       0.82      0.94      0.87     73495
           1       0.87      0.68      0.76     46841

    accuracy                           0.84    120336
   macro avg       0.85      0.81      0.82    120336
weighted avg       0.84      0.84      0.83    120336

False Alarm of 0: 0.3236 (32.36%)
False Alarm of 1: 0.0618 (6.18%)
Overall False Alarm Rate: 0.1927 (19.27%)
Training Time: 0.05 seconds
Testing Time: 186.46 seconds
Error Rate: 0.1637 (16.37%)
```




```
=======================================
Classifier: LogisticRegression
Evaluation Report for LogisticRegression:
F-Score: 0.582669930370106
Precision: 0.7631321356723366
Re-call: 0.6065678430509 47
Accuracy: 0.6881814253423747
Confusion Matrix:
[[71660  1835]
 [35688 11153]]
              precision    recall  f1-score   support

           0       0.67      0.98      0.79     73495
           1       0.86      0.24      0.37     46841

    accuracy                           0.69    120336
   macro avg       0.76      0.61      0.58    120336
weighted avg       0.74      0.69      0.63    120336

False Alarm of 0: 0.7619 (76.19%)
False Alarm of 1: 0.0250 (2.50%)
Overall False Alarm Rate: 0.3934 (39.34%)
Training Time: 3.97 seconds
Testing Time: 0.02 seconds
Error Rate: 0.3118 (31.18%)
```




```
metrics_names = ['F-Score', 'Precision', 'Recall', 'Accuracy', 'Overall FAR', 'Training Time', 'Testing Time', 'Error Rate']
metrics_values = [list(metric.values()) for metric in performance_metrics]

plt.figure(figsize=(12, 12))  # Increase the figure size to accommodate additional charts

for i, metric_name in enumerate(metrics_names):
    plt.subplot(4, 2, i + 1)

    # Special handling for Time and Error Rate metrics
    if metric_name in ['Training Time', 'Testing Time', 'Error Rate']:
        plt.bar([classifier[0] for classifier in classifiers], [values[i] for values in metrics_values])
    else:
        plt.plot([classifier[0] for classifier in classifiers], [values[i] for values in metrics_values], marker='o')

    plt.title(metric_name)
    plt.xlabel('Classifier')
    plt.xticks(rotation=45)
    plt.ylabel(metric_name)
    plt.grid(True)

plt.tight_layout()
plt.show()
```


F-Score
Precision
Recall
Accuracy
Overall FAR
Training Time
Testing Time
Error Rate
DecisionTree
RandomForest
KNeighbors
LogisticRegression
NaiveBayes
Classifier