Machine Learning

Lab Session 3

```
import pandas as pd
import numpy as np
import statistics
import seaborn as sns
import matplotlib.pyplot as plt
import random
from sklearn.model_selection import train_test_split
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score, confusion_matrix, classification_report
```

```
dataset = pd.read_csv("../project/combined_seismic_data.csv")
dataset = dataset.dropna()

def create_intensity_classes(df):
    # Define thresholds based on percentiles or domain knowledge
    low_threshold = df['max'].quantile(0.33)
    high_threshold = df['max'].quantile(0.66)

    # Create class labels
    conditions = [
        (df['max'] < low_threshold),
        (df['max'] >= low_threshold) & (df['max'] < high_threshold),
        (df['max'] >= high_threshold)
    ]
    class_labels = [0, 1, 2]  # or ['Low', 'Medium', 'High']

    return np.select(conditions, class_labels)
data = dataset.copy()
data = data[['max', 'distance_to_event']]
data["class"] = create_intensity_classes(data)
```

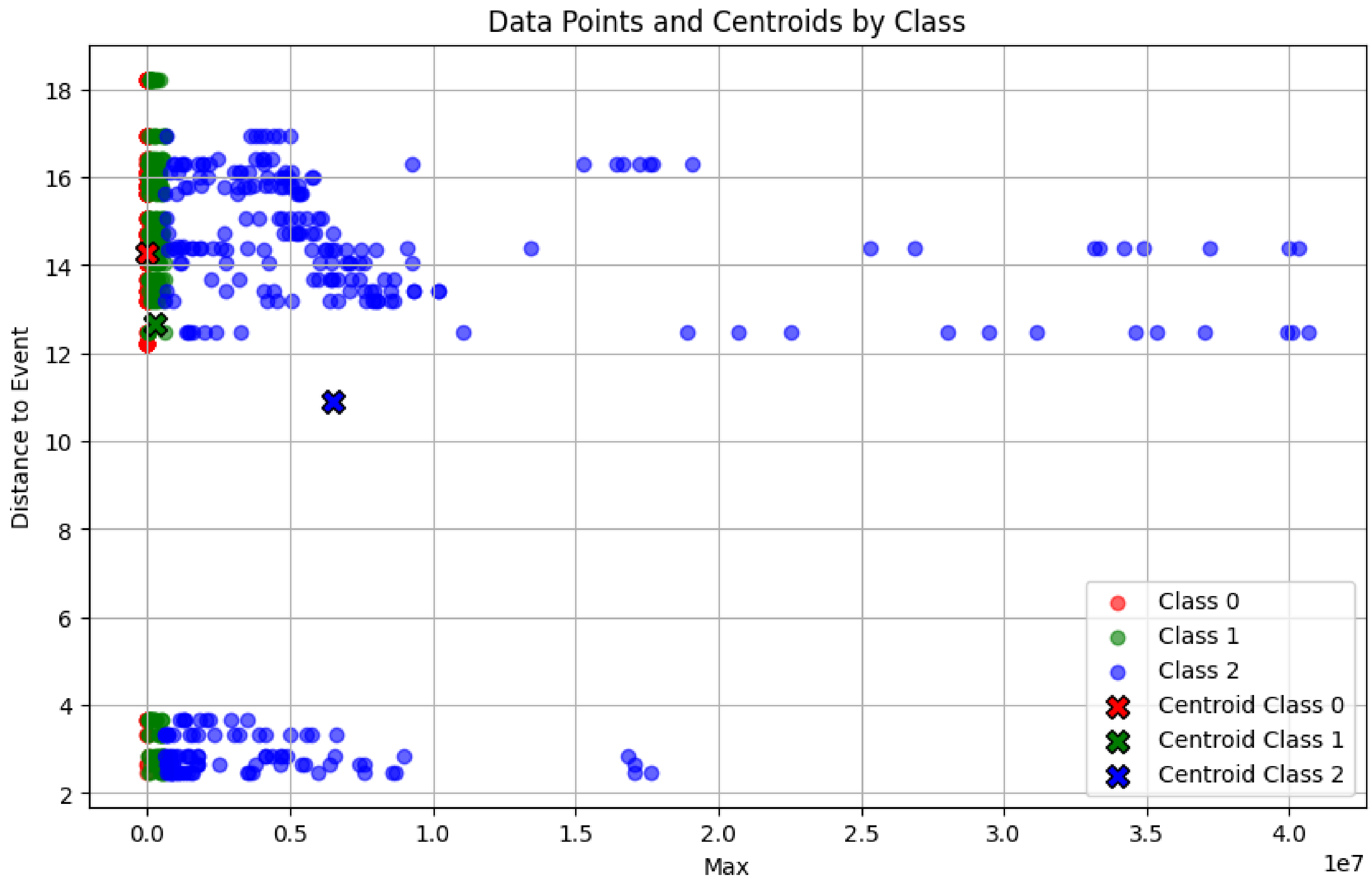
1.

```
X = data[['max', 'distance_to_event']].values
y = data['class'].values

class_0_data = X[y == 0]
class_1_data = X[y == 1]
class_2_data = X[y == 2]

# Calculate the mean (centroid) for each class
centroid_0 = np.mean(class_0_data, axis=0)
centroid_1 = np.mean(class_1_data, axis=0)
centroid_2 = np.mean(class_2_data, axis=0)

# Calculate the standard deviation (spread) for each class
spread_0 = np.std(class_0_data, axis=0)
spread_1 = np.std(class_1_data, axis=0)
spread_2 = np.std(class_2_data, axis=0)

# Calculate the Euclidean distance between the centroids
distance_between_centroids_0_1 = np.linalg.norm(centroid_0 - centroid_1)
distance_between_centroids_0_2 = np.linalg.norm(centroid_0 - centroid_1)
distance_between_centroids_1_2 = np.linalg.norm(centroid_1 - centroid_2)

# Print the results
print("Centroid for Class 0:", centroid_0)
print("Centroid for Class 1:", centroid_1)
print("Centroid for Class 2:", centroid_2)
print("Spread for Class 0:", spread_0)
print("Spread for Class 1:", spread_1)
print("Spread for Class 2:", spread_2)
print("Distance between Class 0 and Class 1 centroids:", distance_between_centroids_0_1)
print("Distance between Class 0 and Class 2 centroids:", distance_between_centroids_0_2)
print("Distance between Class 1 and Class 2 centroids:", distance_between_centroids_1_2)
```

```
Centroid for Class 0: [6666.17784702   14.29194371]
Centroid for Class 1: [2.69243960e+05 1.26714797e+01]
Centroid for Class 2: [6.49747856e+06 1.08977973e+01]
Spread for Class 0: [6.51849028e+03 2.97896721e+00]
Spread for Class 1: [1.77047229e+05 5.10299119e+00]
```

```
Spread for Class 2: [8.31579191e+06 5.59578540e+00]
Distance between Class 0 and Class 1 centroids: 262577.78250878665
Distance between Class 0 and Class 2 centroids: 262577.78250878665
Distance between Class 1 and Class 2 centroids: 6228234.598904195
```

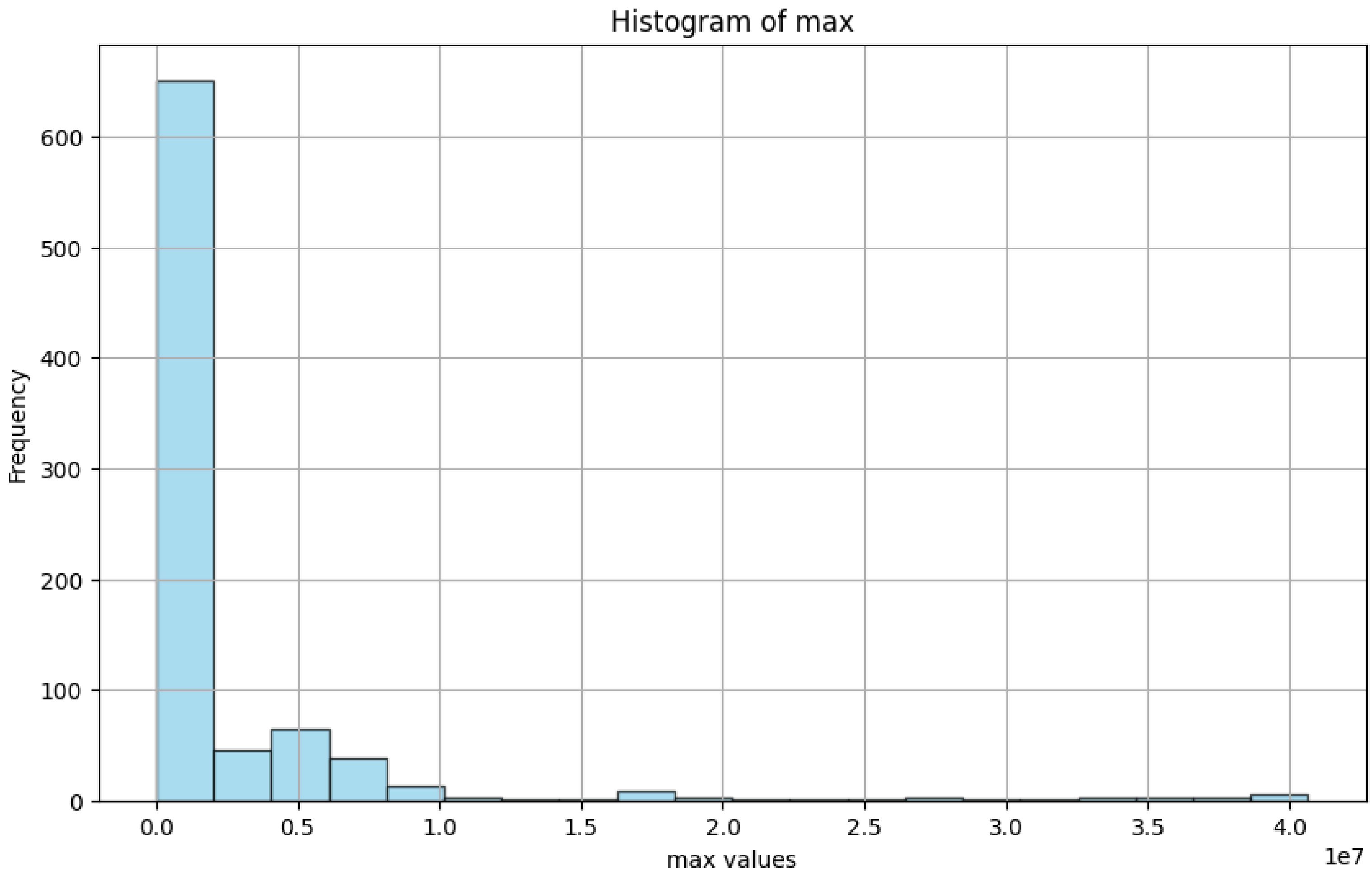
```
classes = np.unique(y)

# Define colors for each class
colors = ['r', 'g', 'b']

# Plot the data points
plt.figure(figsize=(10, 6))
for i, class_label in enumerate(classes):
    class_data = X[y == class_label]
    plt.scatter(class_data[:, 0], class_data[:, 1], color=colors[i], label=f'Class {class_label}', alpha=0.6) ###############

# Plot the centroids
for i, class_label in enumerate(classes):
    class_data = X[y == class_label]
    centroid = np.mean(class_data, axis=0)
    plt.scatter(centroid[0], centroid[1], color=colors[i], marker='X', s=100, edgecolor='black', label=f'Centroid Class {class_label}')

# Labels and title
plt.xlabel('Max')
plt.ylabel('Distance to Event')
plt.title('Data Points and Centroids by Class')
plt.legend()

# Show the plot
plt.grid(True)
plt.show()
```



2.

```
feature = 'max'
data = dataset[feature].values  # Extract the feature data

# Plot the histogram
plt.figure(figsize=(10, 6))
plt.hist(data, bins=20, color='skyblue', edgecolor='black', alpha=0.7)  # 20 bins for histogram
plt.title(f'Histogram of {feature}')
```

```
    plt.xlabel(f'{feature} values')
    plt.ylabel('Frequency')
    plt.grid(True)
    plt.show()

    # Calculate the mean and variance
    mean_value = np.mean(data)
    variance_value = np.var(data)

    print(f"Mean of {feature}: {mean_value}")
    print(f"Variance of {feature}: {variance_value}")
```

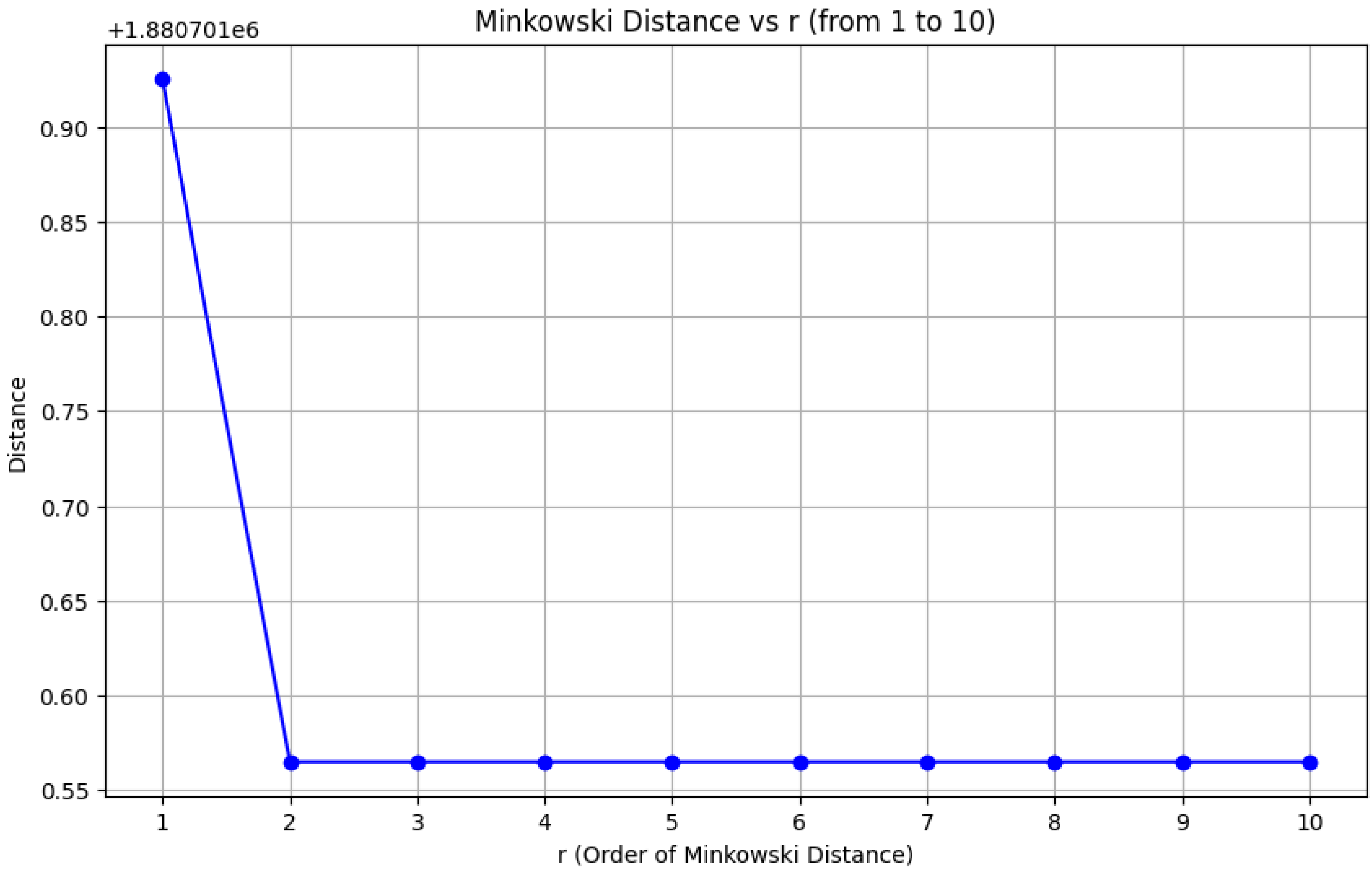



```
Mean of max: 2297793.2355669336
```

3.

```
# Choose two feature vectors
vec1 = dataset[['max', 'distance_to_event']].iloc[1].values
vec2 = dataset[['max', 'distance_to_event']].iloc[50].values

# Function to compute Minkowski distance
```

```
def minkowski_distance(vec1, vec2, r):
    return np.sum(np.abs(vec1 - vec2) ** r) ** (1/r)

# List to store the distances
distances = []

# Calculate Minkowski distance for r from 1 to 10
for r in range(1, 11):
    distance = minkowski_distance(vec1, vec2, r)
    distances.append(distance)

# Plotting the Minkowski distances
plt.figure(figsize=(10, 6))
plt.plot(range(1, 11), distances, marker='o', linestyle='-', color='b')
plt.title('Minkowski Distance vs r (from 1 to 10)')
plt.xlabel('r (Order of Minkowski Distance)')
plt.ylabel('Distance')
plt.grid(True)
plt.xticks(range(1, 11))
plt.show()

# Print distances for reference
for r, distance in zip(range(1, 11), distances):
    print(f"Minkowski distance (r={r}): {distance}")
```




```
Minkowski distance (r=1): 1880701.9259737087
Minkowski distance (r=2): 1880701.5648128015
Minkowski distance (r=3): 1880701.5648127652
Minkowski distance (r=4): 1880701.5648127669
Minkowski distance (r=5): 1880701.5648127685
Minkowski distance (r=6): 1880701.5648127652
Minkowski distance (r=7): 1880701.5648127652
Minkowski distance (r=8): 1880701.5648127669
Minkowski distance (r=9): 1880701.5648127652
```

4.

```
data = dataset.copy()
data["class"] = create_intensity_classes(data)

class_1_and_2 = data[data['class'].isin([1, 2])]

# Extract features and labels again after filtering
X = class_1_and_2[['max', 'distance_to_event']].values
y = class_1_and_2['class'].values

# Split the data into training and test sets (70% train, 30% test)
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=42)

# Check the shapes of the resulting datasets
print("Training features shape:", X_train.shape)
print("Test features shape:", X_test.shape)
print("Training labels shape:", y_train.shape)
print("Test labels shape:", y_test.shape)
```

```
Training features shape: (397, 2)
Test features shape: (171, 2)
Training labels shape: (397,)
Test labels shape: (171,)
```

5.

```
k=3
neigh = KNeighborsClassifier(n_neighbors=k)
neigh.fit(X_train,y_train)
```

```
KNeighborsClassifier
KNeighborsClassifier(n_neighbors=3)
```

6.

```
neigh.score(X_test,y_test)
```

```
0.9941520467836257
```

7.

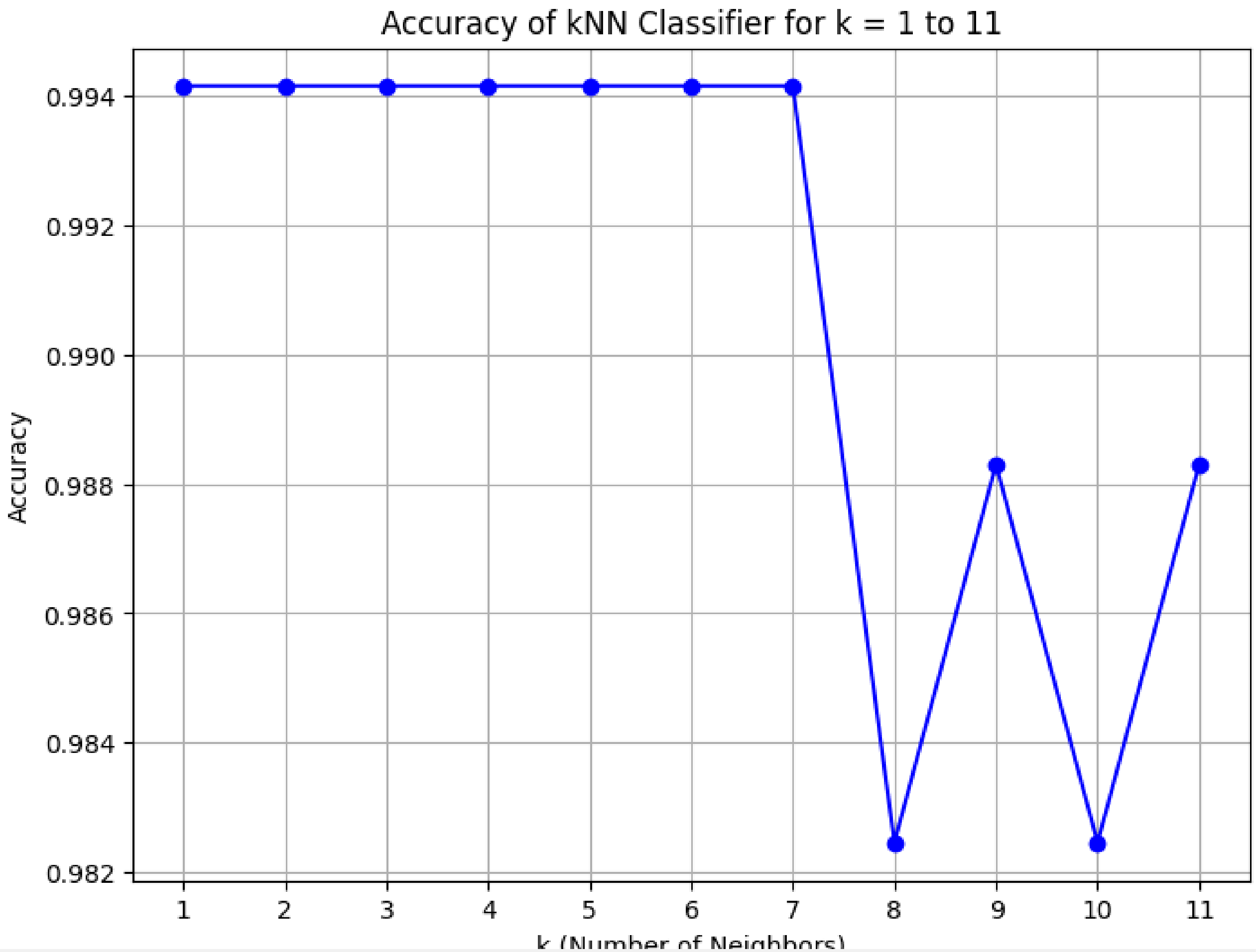
```
i = int(random.random()*X_test.shape[0])
test_vect = X_test[i]

predicted_class = neigh.predict([test_vect])

# Output the predicted class and the actual class
print(f"Test vector {i}: {test_vect}")
print(f"Predicted class: {predicted_class[0]}")
print(f"Actual class: {y_test[i]}")
```

```
Test vector 156: [7.61424396e+05 2.47816256e+00]
Predicted class: 2
Actual class: 2
```

8.

```
accuracies = []

# Train kNN classifiers for k = 1 to k = 11
for k in range(1, 12):
    knn = KNeighborsClassifier(n_neighbors=k)  # Initialize classifier with k
    knn.fit(X_train, y_train)  # Train the classifier
    y_pred = knn.predict(X_test)  # Predict on the test set
    accuracy = accuracy_score(y_test, y_pred)  # Calculate accuracy
    accuracies.append(accuracy)  # Store the accuracy

# Plot the accuracy for different values of k
plt.figure(figsize=(8, 6))
plt.plot(range(1, 12), accuracies, marker='o', linestyle='-', color='b')
plt.title('Accuracy of kNN Classifier for k = 1 to 11')
plt.xlabel('k (Number of Neighbors)')
```

```
plt.ylabel('Accuracy')
plt.xticks(range(1, 12))
plt.grid(True)
plt.show()
```



9.

```
# Make predictions on the training and test sets
y_train_pred = neigh.predict(X_train)
y_test_pred = neigh.predict(X_test)
```

```
# Confusion Matrix for both training and test sets
train_confusion_matrix = confusion_matrix(y_train, y_train_pred
test_confusion_matrix = confusion_matrix(y_test, y_test_pred)

# Print confusion matrices
print("Training Confusion Matrix:")
print(train_confusion_matrix)
print("\nTest Confusion Matrix:")
print(test_confusion_matrix)

print("\nTraining Classification Report:")
print(classification_report(y_train, y_train_pred))
print("\nTest Classification Report:")
```