Notebook

November 23, 2024

1 Import libraries

```
import os
import sys
import cv2
import math
import json
import joblib
import nbformat
import numpy as np
import pandas as pd
import seaborn as sns
from tqdm import tqdm
from sklearn.svm import SVC
from datetime import datetime
import matplotlib.pyplot as plt
from nbconvert.exporters import PDFExporter
from skimage.feature import hog as skimage_hog
from sklearn.preprocessing import LabelEncoder
from IPython.display import display, Javascript
from sklearn.neighbors import KNeighborsClassifier
from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.metrics import classification_report, confusion_matrix
from scipy.spatial.distance import cityblock, cosine, correlation, sqeuclidean
```

2 Load data

```
project_dir = os.getcwd()
project_dir = os.path.dirname(project_dir)
```

```
width = 64
height = 64
```

```
data_dir = project_dir + "\\data"

train_path = os.path.join(data_dir, "train")
```

```
test_path = os.path.join(data_dir, "test")

train_images = []
test_images = []

train_labels = []
test_labels = []

for path in (train_path, test_path):
    if (path.split('\\')[-1] == "train"):
        for dir in os.listdir(path):
            label_path = os.path.join(path, dir)
            label = dir.split('\\')[-1]
            for image in os.listdir(label_path):
                image_path = os.path.join(label_path, image)
                image = cv2.imread(image_path)
                image = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
                image = cv2.resize(image, (width, height))
                train_images.append(image)
                train_labels.append(label)
    else:
        for dir in os.listdir(path):
            label_path = os.path.join(path, dir)
            label = dir.split('\\')[-1]
            for image in os.listdir(label_path):
                image_path = os.path.join(label_path, image)
                image = cv2.imread(image_path)
                image = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
                image = cv2.resize(image, (width, height))
                test_images.append(image)
                test_labels.append(label)
```

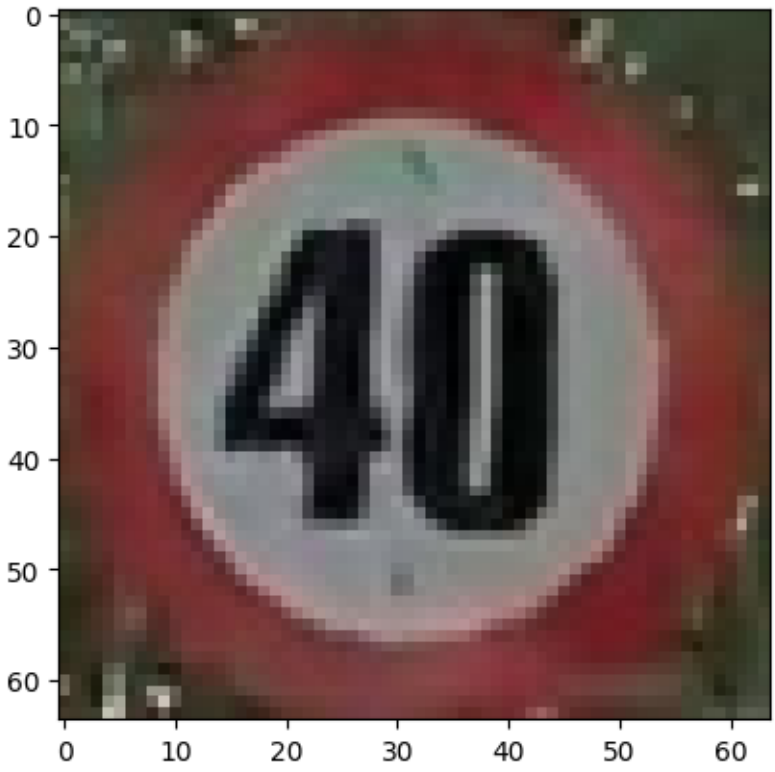
```
label_encoder = LabelEncoder()
train_labels_encoded = label_encoder.fit_transform(train_labels)
test_labels_encoded = label_encoder.transform(test_labels)
```

```
joblib.dump(train_images, project_dir + '\joblib\\train_images.joblib')
joblib.dump(test_images, project_dir + '\joblib\\test_images.joblib')
joblib.dump(train_labels_encoded, project_dir + '\joblib\\train_labels_encoded.
 ↪joblib')
joblib.dump(test_labels_encoded, project_dir + '\joblib\\test_labels_encoded.
 ↪joblib')
joblib.dump(label_encoder, project_dir + '\joblib\\label_encoder.joblib')
```

```
['d:\\ASUS\\Deploy-Traffic-Sign-Classification-through-
Images\\joblib\\label_encoder.joblib']
```

```
plt.imshow(test_images[0])
```

```
<matplotlib.image.AxesImage at 0x1f479a79a10>
```




```
plt.imshow(train_images[1])
```

```
<matplotlib.image.AxesImage at 0x1f479ae63d0>
```

3 Extract features

```
def blur_image(image):
    blurred_image = cv2.medianBlur(image, 5)
    return blurred_image
```

```
def color_histogram(image):
    # image = cv2.cvtColor(image, cv2.COLOR_RGB2LUV)
    row, column, channel = image.shape[:3]
    size = row * column
    feature = []
    for k in range(channel):
        histogram = np.squeeze(cv2.calcHist([image], [k], None, [32], [0, 256]))
        histogram = histogram / size
        feature.extend(histogram)
    return feature
```

```
def hog(image):
    # image = cv2.cvtColor(image, cv2.COLOR_RGB2LUV)
```

```
    hog_features = skimage_hog(image, orientations=9, pixels_per_cell=(8, 8),␣
 ↪cells_per_block=(2, 2), visualize=False, block_norm='L2-Hys',␣
 ↪transform_sqrt=True, channel_axis=2)
    return hog_features
```

```
def extract_features(images):
    blurred_images = [blur_image(image) for image in tqdm(images, desc="Blur␣
 ↪Images")]
    color_features = [color_histogram(image) for image in tqdm(blurred_images,␣
 ↪desc="Extracting Color Features")]
    hog_features = [hog(image) for image in tqdm(blurred_images,␣
 ↪desc="Extracting HOG Features")]
    combined_features = [np.concatenate((color_feature, hog_feature))
                         for color_feature, hog_feature in␣
 ↪tqdm(zip(color_features, hog_features), desc="Combining Features")]

    return combined_features
```

```
train_features = extract_features(train_images)
joblib.dump(train_features, project_dir + '\joblib\\train_features.joblib')
```

```
Blur Images: 100%|      | 1415/1415 [00:01<00:00, 1220.11it/s]
Extracting Color Features: 100%|      | 1415/1415 [00:00<00:00, 6458.08it/s]
Extracting HOG Features: 100%|      | 1415/1415 [00:08<00:00, 171.32it/s]
Combining Features: 1415it [00:00, 44723.14it/s]
```

```
['d:\\ASUS\\Deploy-Traffic-Sign-Classification-through-
Images\\joblib\\train_features.joblib']
```

```
test_features = extract_features(test_images)
joblib.dump(test_features, project_dir + '\joblib\\test_features.joblib')
```

```
Blur Images: 100%|      | 150/150 [00:00<00:00, 872.90it/s]
Extracting Color Features: 100%|      | 150/150 [00:00<00:00, 9602.05it/s]
Extracting HOG Features: 100%|      | 150/150 [00:00<00:00, 208.03it/s]
Combining Features: 150it [00:00, ?it/s]
```

```
['d:\\ASUS\\Deploy-Traffic-Sign-Classification-through-
Images\\joblib\\test_features.joblib']
```

4 Distance metrics KNN

```
def chi_square_distance(x, y):
    return cv2.compareHist(np.array(x, dtype=np.float32), np.array(y, dtype=np.
 ↪float32), cv2.HISTCMP_CHISQR)

def bhattacharyya_distance(x, y):
```

```
    return cv2.compareHist(np.array(x, dtype=np.float32), np.array(y, dtype=np.
 ↪float32), cv2.HISTCMP_BHATTACHARYYA)

def intersection_distance(x, y):
    return 1 - cv2.compareHist(np.array(x, dtype=np.float32), np.array(y,␣
 ↪dtype=np.float32), cv2.HISTCMP_INTERSECT)
```

5 Load Best Model

```
# knn_model = joblib.load(project_dir + '\\joblib\\best_knn_model.joblib')
# svm_model = joblib.load(project_dir + '\\joblib\\best_svm_model.joblib')

# y_pred_knn = knn_model.predict(test_features)
# y_pred_svm = svm_model.predict(test_features)
```

6 Gridsearch KNN

```
knn_model = KNeighborsClassifier()
knn_model.fit(train_features, train_labels_encoded)
y_pred_knn = knn_model.predict(test_features)
```

```
param_grid = {
    'n_neighbors': [1, 2, 3],
    'weights': ['uniform', 'distance'],
    'leaf_size': [1, 2, 3, 4, 5],
    'metric': [
        cityblock,
        cosine,
        # correlation,
        sqeuclidean,
        chi_square_distance,
        bhattacharyya_distance,
        intersection_distance
    ]
}

knn_model = KNeighborsClassifier()
grid_search_knn = GridSearchCV(
    knn_model,
    param_grid,
    cv=3,
    scoring='f1_macro',
    verbose=3
)
```

```
grid_search_knn.fit(train_features, train_labels_encoded)
```

```
Fitting 3 folds for each of 180 candidates, totalling 540 fits
[CV 1/3] END leaf_size=1, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=uniform;, score=0.875 total time=   5.6s
[CV 2/3] END leaf_size=1, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=uniform;, score=0.840 total time=   5.7s
[CV 3/3] END leaf_size=1, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=uniform;, score=0.846 total time=   5.3s
[CV 1/3] END leaf_size=1, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=distance;, score=0.875 total time=   5.4s
[CV 2/3] END leaf_size=1, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=distance;, score=0.840 total time=   5.2s
[CV 3/3] END leaf_size=1, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=distance;, score=0.846 total time=   5.1s
[CV 1/3] END leaf_size=1, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=uniform;, score=0.828 total time=   5.0s
[CV 2/3] END leaf_size=1, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=uniform;, score=0.812 total time=   5.4s
[CV 3/3] END leaf_size=1, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=uniform;, score=0.801 total time=   5.4s
[CV 1/3] END leaf_size=1, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=distance;, score=0.875 total time=   5.2s
[CV 2/3] END leaf_size=1, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=distance;, score=0.840 total time=   5.6s
[CV 3/3] END leaf_size=1, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=distance;, score=0.846 total time=   5.9s
[CV 1/3] END leaf_size=1, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=uniform;, score=0.857 total time=   5.7s
[CV 2/3] END leaf_size=1, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=uniform;, score=0.814 total time=   5.3s
[CV 3/3] END leaf_size=1, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=uniform;, score=0.830 total time=   5.3s
[CV 1/3] END leaf_size=1, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=distance;, score=0.858 total time=   6.4s
[CV 2/3] END leaf_size=1, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=distance;, score=0.816 total time=   5.4s
[CV 3/3] END leaf_size=1, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=distance;, score=0.850 total time=   5.5s
[CV 1/3] END leaf_size=1, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=uniform;, score=0.873 total time=  14.0s
[CV 2/3] END leaf_size=1, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=uniform;, score=0.831 total time=  14.7s
[CV 3/3] END leaf_size=1, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=uniform;, score=0.818 total time=  13.9s
[CV 1/3] END leaf_size=1, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=distance;, score=0.873 total time=  13.9s
[CV 2/3] END leaf_size=1, metric=<function cosine at 0x000001F477193380>,
```

```
n_neighbors=1, weights=distance;, score=0.831 total time=  14.0s
[CV 3/3] END leaf_size=1, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=distance;, score=0.818 total time=  14.3s
[CV 1/3] END leaf_size=1, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=uniform;, score=0.826 total time=  14.8s
[CV 2/3] END leaf_size=1, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=uniform;, score=0.755 total time=  13.9s
[CV 3/3] END leaf_size=1, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=uniform;, score=0.768 total time=  14.1s
[CV 1/3] END leaf_size=1, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=distance;, score=0.873 total time=  13.8s
[CV 2/3] END leaf_size=1, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=distance;, score=0.831 total time=  13.9s
[CV 3/3] END leaf_size=1, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=distance;, score=0.818 total time=  14.4s
[CV 1/3] END leaf_size=1, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=uniform;, score=0.853 total time=  14.0s
[CV 2/3] END leaf_size=1, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=uniform;, score=0.785 total time=  14.0s
[CV 3/3] END leaf_size=1, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=uniform;, score=0.779 total time=  14.2s
[CV 1/3] END leaf_size=1, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=distance;, score=0.864 total time=  15.2s
[CV 2/3] END leaf_size=1, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=distance;, score=0.807 total time=  14.3s
[CV 3/3] END leaf_size=1, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=distance;, score=0.797 total time=  13.2s
[CV 1/3] END leaf_size=1, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=uniform;, score=0.871 total time=   5.3s
[CV 2/3] END leaf_size=1, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=uniform;, score=0.831 total time=   5.2s
[CV 3/3] END leaf_size=1, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=uniform;, score=0.816 total time=   5.2s
[CV 1/3] END leaf_size=1, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=distance;, score=0.871 total time=   5.3s
[CV 2/3] END leaf_size=1, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=distance;, score=0.831 total time=   5.6s
[CV 3/3] END leaf_size=1, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=distance;, score=0.816 total time=   5.8s
[CV 1/3] END leaf_size=1, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=uniform;, score=0.831 total time=   5.7s
[CV 2/3] END leaf_size=1, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=uniform;, score=0.757 total time=   5.4s
[CV 3/3] END leaf_size=1, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=uniform;, score=0.772 total time=   5.6s
[CV 1/3] END leaf_size=1, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=distance;, score=0.871 total time=   5.5s
[CV 2/3] END leaf_size=1, metric=<function sqeuclidean at 0x000001F477193240>,
```

```
n_neighbors=2, weights=distance;, score=0.831 total time=   5.5s
[CV 3/3] END leaf_size=1, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=distance;, score=0.816 total time=   5.4s
[CV 1/3] END leaf_size=1, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=uniform;, score=0.848 total time=   5.5s
[CV 2/3] END leaf_size=1, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=uniform;, score=0.782 total time=   5.5s
[CV 3/3] END leaf_size=1, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=uniform;, score=0.774 total time=   5.6s
[CV 1/3] END leaf_size=1, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=distance;, score=0.858 total time=   5.9s
[CV 2/3] END leaf_size=1, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=distance;, score=0.802 total time=   6.8s
[CV 3/3] END leaf_size=1, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=distance;, score=0.793 total time=   6.3s
[CV 1/3] END leaf_size=1, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=uniform;, score=0.743 total time=
6.6s
[CV 2/3] END leaf_size=1, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=uniform;, score=0.706 total time=
6.7s
[CV 3/3] END leaf_size=1, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=uniform;, score=0.646 total time=
6.8s
[CV 1/3] END leaf_size=1, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=distance;, score=0.743 total time=
6.7s
[CV 2/3] END leaf_size=1, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=distance;, score=0.706 total time=
6.8s
[CV 3/3] END leaf_size=1, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=distance;, score=0.646 total time=
6.5s
[CV 1/3] END leaf_size=1, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=uniform;, score=0.688 total time=
6.7s
[CV 2/3] END leaf_size=1, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=uniform;, score=0.684 total time=
6.7s
[CV 3/3] END leaf_size=1, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=uniform;, score=0.641 total time=
6.9s
[CV 1/3] END leaf_size=1, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=distance;, score=0.743 total time=
7.2s
[CV 2/3] END leaf_size=1, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=distance;, score=0.706 total time=
6.5s
```

```
[CV 3/3] END leaf_size=1, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=distance;, score=0.646 total time=
6.9s
[CV 1/3] END leaf_size=1, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=uniform;, score=0.716 total time=
6.7s
[CV 2/3] END leaf_size=1, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=uniform;, score=0.713 total time=
6.6s
[CV 3/3] END leaf_size=1, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=uniform;, score=0.678 total time=
6.9s
[CV 1/3] END leaf_size=1, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=distance;, score=0.728 total time=
6.7s
[CV 2/3] END leaf_size=1, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=distance;, score=0.720 total time=
6.8s
[CV 3/3] END leaf_size=1, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=distance;, score=0.692 total time=
8.5s
[CV 1/3] END leaf_size=1, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=uniform;, score=0.867 total time=
9.6s
[CV 2/3] END leaf_size=1, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=uniform;, score=0.794 total time=
12.2s
[CV 3/3] END leaf_size=1, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=uniform;, score=0.761 total time=
8.5s
[CV 1/3] END leaf_size=1, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=distance;, score=0.867 total time=
10.1s
[CV 2/3] END leaf_size=1, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=distance;, score=0.794 total time=
6.8s
[CV 3/3] END leaf_size=1, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=distance;, score=0.761 total time=
6.3s
[CV 1/3] END leaf_size=1, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=uniform;, score=0.773 total time=
5.9s
[CV 2/3] END leaf_size=1, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=uniform;, score=0.741 total time=
5.9s
[CV 3/3] END leaf_size=1, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=uniform;, score=0.719 total time=
6.7s
```

```
[CV 1/3] END leaf_size=1, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=distance;, score=0.867 total time=
5.9s
[CV 2/3] END leaf_size=1, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=distance;, score=0.794 total time=
5.6s
[CV 3/3] END leaf_size=1, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=distance;, score=0.761 total time=
8.7s
[CV 1/3] END leaf_size=1, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=uniform;, score=0.827 total time=
7.6s
[CV 2/3] END leaf_size=1, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=uniform;, score=0.741 total time=
6.8s
[CV 3/3] END leaf_size=1, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=uniform;, score=0.731 total time=
6.0s
[CV 1/3] END leaf_size=1, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=distance;, score=0.846 total time=
6.0s
[CV 2/3] END leaf_size=1, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=distance;, score=0.749 total time=
5.9s
[CV 3/3] END leaf_size=1, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=distance;, score=0.750 total time=
6.7s
[CV 1/3] END leaf_size=1, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=uniform;, score=0.802 total time=
6.4s
[CV 2/3] END leaf_size=1, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=uniform;, score=0.722 total time=
5.7s
[CV 3/3] END leaf_size=1, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=uniform;, score=0.682 total time=
5.7s
[CV 1/3] END leaf_size=1, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=distance;, score=0.076 total time=
5.9s
[CV 2/3] END leaf_size=1, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=distance;, score=0.076 total time=
6.4s
[CV 3/3] END leaf_size=1, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=distance;, score=0.076 total time=
7.7s
[CV 1/3] END leaf_size=1, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=uniform;, score=0.703 total time=
5.5s
```

```
[CV 2/3] END leaf_size=1, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=uniform;, score=0.668 total time=
5.3s
[CV 3/3] END leaf_size=1, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=uniform;, score=0.645 total time=
5.9s
[CV 1/3] END leaf_size=1, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=distance;, score=0.076 total time=
5.6s
[CV 2/3] END leaf_size=1, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=distance;, score=0.076 total time=
7.1s
[CV 3/3] END leaf_size=1, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=distance;, score=0.076 total time=
6.5s
[CV 1/3] END leaf_size=1, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=uniform;, score=0.779 total time=
5.4s
[CV 2/3] END leaf_size=1, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=uniform;, score=0.664 total time=
5.9s
[CV 3/3] END leaf_size=1, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=uniform;, score=0.678 total time=
5.7s
[CV 1/3] END leaf_size=1, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=distance;, score=0.076 total time=
6.0s
[CV 2/3] END leaf_size=1, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=distance;, score=0.076 total time=
5.7s
[CV 3/3] END leaf_size=1, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=distance;, score=0.076 total time=
6.4s
[CV 1/3] END leaf_size=2, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=uniform;, score=0.875 total time=   5.8s
[CV 2/3] END leaf_size=2, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=uniform;, score=0.840 total time=   6.2s
[CV 3/3] END leaf_size=2, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=uniform;, score=0.846 total time=   6.0s
[CV 1/3] END leaf_size=2, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=distance;, score=0.875 total time=   7.1s
[CV 2/3] END leaf_size=2, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=distance;, score=0.840 total time=   6.3s
[CV 3/3] END leaf_size=2, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=distance;, score=0.846 total time=   6.1s
[CV 1/3] END leaf_size=2, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=uniform;, score=0.828 total time=   6.5s
[CV 2/3] END leaf_size=2, metric=<function cityblock at 0x000001F4771936A0>,
```

```
n_neighbors=2, weights=uniform;, score=0.812 total time=   6.6s
[CV 3/3] END leaf_size=2, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=uniform;, score=0.801 total time=   6.5s
[CV 1/3] END leaf_size=2, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=distance;, score=0.875 total time=   5.9s
[CV 2/3] END leaf_size=2, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=distance;, score=0.840 total time=   5.4s
[CV 3/3] END leaf_size=2, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=distance;, score=0.846 total time=   6.3s
[CV 1/3] END leaf_size=2, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=uniform;, score=0.857 total time=   6.0s
[CV 2/3] END leaf_size=2, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=uniform;, score=0.814 total time=   6.4s
[CV 3/3] END leaf_size=2, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=uniform;, score=0.830 total time=   6.3s
[CV 1/3] END leaf_size=2, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=distance;, score=0.858 total time=   6.0s
[CV 2/3] END leaf_size=2, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=distance;, score=0.816 total time=   5.9s
[CV 3/3] END leaf_size=2, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=distance;, score=0.850 total time=   8.2s
[CV 1/3] END leaf_size=2, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=uniform;, score=0.873 total time=  17.3s
[CV 2/3] END leaf_size=2, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=uniform;, score=0.831 total time=  17.3s
[CV 3/3] END leaf_size=2, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=uniform;, score=0.818 total time=  16.6s
[CV 1/3] END leaf_size=2, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=distance;, score=0.873 total time=  19.3s
[CV 2/3] END leaf_size=2, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=distance;, score=0.831 total time=  16.8s
[CV 3/3] END leaf_size=2, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=distance;, score=0.818 total time=  14.3s
[CV 1/3] END leaf_size=2, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=uniform;, score=0.826 total time=  14.1s
[CV 2/3] END leaf_size=2, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=uniform;, score=0.755 total time=  13.1s
[CV 3/3] END leaf_size=2, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=uniform;, score=0.768 total time=  14.4s
[CV 1/3] END leaf_size=2, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=distance;, score=0.873 total time=  14.1s
[CV 2/3] END leaf_size=2, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=distance;, score=0.831 total time=  14.9s
[CV 3/3] END leaf_size=2, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=distance;, score=0.818 total time=  13.8s
[CV 1/3] END leaf_size=2, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=uniform;, score=0.853 total time=  14.0s
[CV 2/3] END leaf_size=2, metric=<function cosine at 0x000001F477193380>,
```

```
n_neighbors=3, weights=uniform;, score=0.785 total time=  13.2s
[CV 3/3] END leaf_size=2, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=uniform;, score=0.779 total time=  13.1s
[CV 1/3] END leaf_size=2, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=distance;, score=0.864 total time=  13.9s
[CV 2/3] END leaf_size=2, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=distance;, score=0.807 total time=  13.3s
[CV 3/3] END leaf_size=2, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=distance;, score=0.797 total time=  13.5s
[CV 1/3] END leaf_size=2, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=uniform;, score=0.871 total time=   5.6s
[CV 2/3] END leaf_size=2, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=uniform;, score=0.831 total time=   5.5s
[CV 3/3] END leaf_size=2, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=uniform;, score=0.816 total time=   5.5s
[CV 1/3] END leaf_size=2, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=distance;, score=0.871 total time=   5.5s
[CV 2/3] END leaf_size=2, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=distance;, score=0.831 total time=   5.6s
[CV 3/3] END leaf_size=2, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=distance;, score=0.816 total time=   6.1s
[CV 1/3] END leaf_size=2, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=uniform;, score=0.831 total time=   5.7s
[CV 2/3] END leaf_size=2, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=uniform;, score=0.757 total time=   5.5s
[CV 3/3] END leaf_size=2, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=uniform;, score=0.772 total time=   5.5s
[CV 1/3] END leaf_size=2, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=distance;, score=0.871 total time=   5.5s
[CV 2/3] END leaf_size=2, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=distance;, score=0.831 total time=   5.8s
[CV 3/3] END leaf_size=2, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=distance;, score=0.816 total time=   5.5s
[CV 1/3] END leaf_size=2, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=uniform;, score=0.848 total time=   5.5s
[CV 2/3] END leaf_size=2, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=uniform;, score=0.782 total time=   5.5s
[CV 3/3] END leaf_size=2, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=uniform;, score=0.774 total time=   5.1s
[CV 1/3] END leaf_size=2, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=distance;, score=0.858 total time=   5.2s
[CV 2/3] END leaf_size=2, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=distance;, score=0.802 total time=   6.5s
[CV 3/3] END leaf_size=2, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=distance;, score=0.793 total time=   6.0s
[CV 1/3] END leaf_size=2, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=uniform;, score=0.743 total time=
6.8s
```

```
[CV 2/3] END leaf_size=2, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=uniform;, score=0.706 total time=
6.6s
[CV 3/3] END leaf_size=2, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=uniform;, score=0.646 total time=
6.5s
[CV 1/3] END leaf_size=2, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=distance;, score=0.743 total time=
6.9s
[CV 2/3] END leaf_size=2, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=distance;, score=0.706 total time=
6.8s
[CV 3/3] END leaf_size=2, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=distance;, score=0.646 total time=
6.7s
[CV 1/3] END leaf_size=2, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=uniform;, score=0.688 total time=
6.6s
[CV 2/3] END leaf_size=2, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=uniform;, score=0.684 total time=
6.6s
[CV 3/3] END leaf_size=2, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=uniform;, score=0.641 total time=
7.4s
[CV 1/3] END leaf_size=2, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=distance;, score=0.743 total time=
8.5s
[CV 2/3] END leaf_size=2, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=distance;, score=0.706 total time=
8.4s
[CV 3/3] END leaf_size=2, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=distance;, score=0.646 total time=
7.4s
[CV 1/3] END leaf_size=2, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=uniform;, score=0.716 total time=
6.8s
[CV 2/3] END leaf_size=2, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=uniform;, score=0.713 total time=
6.8s
[CV 3/3] END leaf_size=2, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=uniform;, score=0.678 total time=
9.0s
[CV 1/3] END leaf_size=2, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=distance;, score=0.728 total time=
8.1s
[CV 2/3] END leaf_size=2, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=distance;, score=0.720 total time=
7.5s
```

```
[CV 3/3] END leaf_size=2, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=distance;, score=0.692 total time=
7.7s
[CV 1/3] END leaf_size=2, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=uniform;, score=0.867 total time=
6.2s
[CV 2/3] END leaf_size=2, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=uniform;, score=0.794 total time=
6.3s
[CV 3/3] END leaf_size=2, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=uniform;, score=0.761 total time=
6.7s
[CV 1/3] END leaf_size=2, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=distance;, score=0.867 total time=
6.7s
[CV 2/3] END leaf_size=2, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=distance;, score=0.794 total time=
6.4s
[CV 3/3] END leaf_size=2, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=distance;, score=0.761 total time=
6.3s
[CV 1/3] END leaf_size=2, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=uniform;, score=0.773 total time=
6.5s
[CV 2/3] END leaf_size=2, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=uniform;, score=0.741 total time=
6.8s
[CV 3/3] END leaf_size=2, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=uniform;, score=0.719 total time=
8.0s
[CV 1/3] END leaf_size=2, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=distance;, score=0.867 total time=
7.2s
[CV 2/3] END leaf_size=2, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=distance;, score=0.794 total time=
7.2s
[CV 3/3] END leaf_size=2, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=distance;, score=0.761 total time=
8.5s
[CV 1/3] END leaf_size=2, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=uniform;, score=0.827 total time=
7.4s
[CV 2/3] END leaf_size=2, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=uniform;, score=0.741 total time=
6.6s
[CV 3/3] END leaf_size=2, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=uniform;, score=0.731 total time=
6.7s
```

```
[CV 1/3] END leaf_size=2, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=distance;, score=0.846 total time=
6.3s
[CV 2/3] END leaf_size=2, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=distance;, score=0.749 total time=
6.1s
[CV 3/3] END leaf_size=2, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=distance;, score=0.750 total time=
6.4s
[CV 1/3] END leaf_size=2, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=uniform;, score=0.802 total time=
5.8s
[CV 2/3] END leaf_size=2, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=uniform;, score=0.722 total time=
5.6s
[CV 3/3] END leaf_size=2, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=uniform;, score=0.682 total time=
5.7s
[CV 1/3] END leaf_size=2, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=distance;, score=0.076 total time=
5.4s
[CV 2/3] END leaf_size=2, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=distance;, score=0.076 total time=
6.9s
[CV 3/3] END leaf_size=2, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=distance;, score=0.076 total time=
7.2s
[CV 1/3] END leaf_size=2, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=uniform;, score=0.703 total time=
6.5s
[CV 2/3] END leaf_size=2, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=uniform;, score=0.668 total time=
6.5s
[CV 3/3] END leaf_size=2, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=uniform;, score=0.645 total time=
7.6s
[CV 1/3] END leaf_size=2, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=distance;, score=0.076 total time=
6.2s
[CV 2/3] END leaf_size=2, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=distance;, score=0.076 total time=
5.7s
[CV 3/3] END leaf_size=2, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=distance;, score=0.076 total time=
5.4s
[CV 1/3] END leaf_size=2, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=uniform;, score=0.779 total time=
6.7s
```

```
[CV 2/3] END leaf_size=2, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=uniform;, score=0.664 total time=
6.1s
[CV 3/3] END leaf_size=2, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=uniform;, score=0.678 total time=
6.4s
[CV 1/3] END leaf_size=2, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=distance;, score=0.076 total time=
5.4s
[CV 2/3] END leaf_size=2, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=distance;, score=0.076 total time=
5.8s
[CV 3/3] END leaf_size=2, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=distance;, score=0.076 total time=
5.6s
[CV 1/3] END leaf_size=3, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=uniform;, score=0.875 total time=   5.7s
[CV 2/3] END leaf_size=3, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=uniform;, score=0.840 total time=   5.6s
[CV 3/3] END leaf_size=3, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=uniform;, score=0.846 total time=   9.1s
[CV 1/3] END leaf_size=3, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=distance;, score=0.875 total time=   5.8s
[CV 2/3] END leaf_size=3, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=distance;, score=0.840 total time=   5.8s
[CV 3/3] END leaf_size=3, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=distance;, score=0.846 total time=   5.7s
[CV 1/3] END leaf_size=3, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=uniform;, score=0.828 total time=   8.3s
[CV 2/3] END leaf_size=3, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=uniform;, score=0.812 total time=   8.3s
[CV 3/3] END leaf_size=3, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=uniform;, score=0.801 total time=   6.0s
[CV 1/3] END leaf_size=3, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=distance;, score=0.875 total time=   6.2s
[CV 2/3] END leaf_size=3, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=distance;, score=0.840 total time=   5.6s
[CV 3/3] END leaf_size=3, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=distance;, score=0.846 total time=   5.4s
[CV 1/3] END leaf_size=3, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=uniform;, score=0.857 total time=   5.8s
[CV 2/3] END leaf_size=3, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=uniform;, score=0.814 total time=   5.7s
[CV 3/3] END leaf_size=3, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=uniform;, score=0.830 total time=   6.0s
[CV 1/3] END leaf_size=3, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=distance;, score=0.858 total time=   5.5s
[CV 2/3] END leaf_size=3, metric=<function cityblock at 0x000001F4771936A0>,
```

```
n_neighbors=3, weights=distance;, score=0.816 total time=   5.9s
[CV 3/3] END leaf_size=3, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=distance;, score=0.850 total time=   5.8s
[CV 1/3] END leaf_size=3, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=uniform;, score=0.873 total time=  15.6s
[CV 2/3] END leaf_size=3, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=uniform;, score=0.831 total time=  15.7s
[CV 3/3] END leaf_size=3, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=uniform;, score=0.818 total time=  15.5s
[CV 1/3] END leaf_size=3, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=distance;, score=0.873 total time=  14.7s
[CV 2/3] END leaf_size=3, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=distance;, score=0.831 total time=  14.6s
[CV 3/3] END leaf_size=3, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=distance;, score=0.818 total time=  14.0s
[CV 1/3] END leaf_size=3, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=uniform;, score=0.826 total time=  14.9s
[CV 2/3] END leaf_size=3, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=uniform;, score=0.755 total time=  14.5s
[CV 3/3] END leaf_size=3, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=uniform;, score=0.768 total time=  15.9s
[CV 1/3] END leaf_size=3, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=distance;, score=0.873 total time=  14.1s
[CV 2/3] END leaf_size=3, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=distance;, score=0.831 total time=  13.4s
[CV 3/3] END leaf_size=3, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=distance;, score=0.818 total time=  14.6s
[CV 1/3] END leaf_size=3, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=uniform;, score=0.853 total time=  15.4s
[CV 2/3] END leaf_size=3, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=uniform;, score=0.785 total time=  16.1s
[CV 3/3] END leaf_size=3, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=uniform;, score=0.779 total time=  15.4s
[CV 1/3] END leaf_size=3, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=distance;, score=0.864 total time=  15.0s
[CV 2/3] END leaf_size=3, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=distance;, score=0.807 total time=  14.4s
[CV 3/3] END leaf_size=3, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=distance;, score=0.797 total time=  14.7s
[CV 1/3] END leaf_size=3, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=uniform;, score=0.871 total time=   6.0s
[CV 2/3] END leaf_size=3, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=uniform;, score=0.831 total time=   6.0s
[CV 3/3] END leaf_size=3, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=uniform;, score=0.816 total time=   6.1s
[CV 1/3] END leaf_size=3, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=distance;, score=0.871 total time=   6.1s
[CV 2/3] END leaf_size=3, metric=<function sqeuclidean at 0x000001F477193240>,
```

```
n_neighbors=1, weights=distance;, score=0.831 total time=   6.4s
[CV 3/3] END leaf_size=3, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=distance;, score=0.816 total time=   6.1s
[CV 1/3] END leaf_size=3, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=uniform;, score=0.831 total time=   8.0s
[CV 2/3] END leaf_size=3, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=uniform;, score=0.757 total time=   6.6s
[CV 3/3] END leaf_size=3, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=uniform;, score=0.772 total time=   5.6s
[CV 1/3] END leaf_size=3, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=distance;, score=0.871 total time=   5.6s
[CV 2/3] END leaf_size=3, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=distance;, score=0.831 total time=   6.1s
[CV 3/3] END leaf_size=3, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=distance;, score=0.816 total time=   7.0s
[CV 1/3] END leaf_size=3, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=uniform;, score=0.848 total time=   5.6s
[CV 2/3] END leaf_size=3, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=uniform;, score=0.782 total time=   5.5s
[CV 3/3] END leaf_size=3, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=uniform;, score=0.774 total time=   5.7s
[CV 1/3] END leaf_size=3, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=distance;, score=0.858 total time=   6.0s
[CV 2/3] END leaf_size=3, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=distance;, score=0.802 total time=   5.5s
[CV 3/3] END leaf_size=3, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=distance;, score=0.793 total time=   5.5s
[CV 1/3] END leaf_size=3, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=uniform;, score=0.743 total time=
7.0s
[CV 2/3] END leaf_size=3, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=uniform;, score=0.706 total time=
6.5s
[CV 3/3] END leaf_size=3, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=uniform;, score=0.646 total time=
7.2s
[CV 1/3] END leaf_size=3, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=distance;, score=0.743 total time=
8.2s
[CV 2/3] END leaf_size=3, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=distance;, score=0.706 total time=
7.3s
[CV 3/3] END leaf_size=3, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=distance;, score=0.646 total time=
6.6s
[CV 1/3] END leaf_size=3, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=uniform;, score=0.688 total time=
6.7s
```

```
[CV 2/3] END leaf_size=3, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=uniform;, score=0.684 total time=
7.0s
[CV 3/3] END leaf_size=3, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=uniform;, score=0.641 total time=
9.4s
[CV 1/3] END leaf_size=3, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=distance;, score=0.743 total time=
8.0s
[CV 2/3] END leaf_size=3, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=distance;, score=0.706 total time=
8.6s
[CV 3/3] END leaf_size=3, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=distance;, score=0.646 total time=
6.9s
[CV 1/3] END leaf_size=3, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=uniform;, score=0.716 total time=
7.3s
[CV 2/3] END leaf_size=3, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=uniform;, score=0.713 total time=
7.7s
[CV 3/3] END leaf_size=3, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=uniform;, score=0.678 total time=
8.8s
[CV 1/3] END leaf_size=3, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=distance;, score=0.728 total time=
10.6s
[CV 2/3] END leaf_size=3, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=distance;, score=0.720 total time=
9.4s
[CV 3/3] END leaf_size=3, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=distance;, score=0.692 total time=
9.2s
[CV 1/3] END leaf_size=3, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=uniform;, score=0.867 total time=
9.0s
[CV 2/3] END leaf_size=3, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=uniform;, score=0.794 total time=
9.0s
[CV 3/3] END leaf_size=3, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=uniform;, score=0.761 total time=
8.0s
[CV 1/3] END leaf_size=3, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=distance;, score=0.867 total time=
6.9s
[CV 2/3] END leaf_size=3, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=distance;, score=0.794 total time=
7.9s
```

```
[CV 3/3] END leaf_size=3, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=distance;, score=0.761 total time=
6.6s
[CV 1/3] END leaf_size=3, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=uniform;, score=0.773 total time=
6.4s
[CV 2/3] END leaf_size=3, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=uniform;, score=0.741 total time=
6.6s
[CV 3/3] END leaf_size=3, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=uniform;, score=0.719 total time=
6.6s
[CV 1/3] END leaf_size=3, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=distance;, score=0.867 total time=
7.1s
[CV 2/3] END leaf_size=3, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=distance;, score=0.794 total time=
6.6s
[CV 3/3] END leaf_size=3, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=distance;, score=0.761 total time=
6.5s
[CV 1/3] END leaf_size=3, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=uniform;, score=0.827 total time=
6.6s
[CV 2/3] END leaf_size=3, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=uniform;, score=0.741 total time=
6.2s
[CV 3/3] END leaf_size=3, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=uniform;, score=0.731 total time=
6.9s
[CV 1/3] END leaf_size=3, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=distance;, score=0.846 total time=
7.5s
[CV 2/3] END leaf_size=3, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=distance;, score=0.749 total time=
8.2s
[CV 3/3] END leaf_size=3, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=distance;, score=0.750 total time=
7.7s
[CV 1/3] END leaf_size=3, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=uniform;, score=0.802 total time=
6.1s
[CV 2/3] END leaf_size=3, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=uniform;, score=0.722 total time=
5.9s
[CV 3/3] END leaf_size=3, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=uniform;, score=0.682 total time=
6.0s
```

```
[CV 1/3] END leaf_size=3, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=distance;, score=0.076 total time=
6.5s
[CV 2/3] END leaf_size=3, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=distance;, score=0.076 total time=
7.8s
[CV 3/3] END leaf_size=3, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=distance;, score=0.076 total time=
5.7s
[CV 1/3] END leaf_size=3, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=uniform;, score=0.703 total time=
5.3s
[CV 2/3] END leaf_size=3, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=uniform;, score=0.668 total time=
5.2s
[CV 3/3] END leaf_size=3, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=uniform;, score=0.645 total time=
5.2s
[CV 1/3] END leaf_size=3, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=distance;, score=0.076 total time=
5.0s
[CV 2/3] END leaf_size=3, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=distance;, score=0.076 total time=
5.1s
[CV 3/3] END leaf_size=3, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=distance;, score=0.076 total time=
5.6s
[CV 1/3] END leaf_size=3, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=uniform;, score=0.779 total time=
5.4s
[CV 2/3] END leaf_size=3, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=uniform;, score=0.664 total time=
5.5s
[CV 3/3] END leaf_size=3, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=uniform;, score=0.678 total time=
5.4s
[CV 1/3] END leaf_size=3, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=distance;, score=0.076 total time=
5.5s
[CV 2/3] END leaf_size=3, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=distance;, score=0.076 total time=
5.6s
[CV 3/3] END leaf_size=3, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=distance;, score=0.076 total time=
5.8s
[CV 1/3] END leaf_size=4, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=uniform;, score=0.875 total time=   5.6s
[CV 2/3] END leaf_size=4, metric=<function cityblock at 0x000001F4771936A0>,
```

```
n_neighbors=1, weights=uniform;, score=0.840 total time=   6.1s
[CV 3/3] END leaf_size=4, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=uniform;, score=0.846 total time=   5.9s
[CV 1/3] END leaf_size=4, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=distance;, score=0.875 total time=   7.2s
[CV 2/3] END leaf_size=4, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=distance;, score=0.840 total time=   5.9s
[CV 3/3] END leaf_size=4, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=distance;, score=0.846 total time=   6.8s
[CV 1/3] END leaf_size=4, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=uniform;, score=0.828 total time=   7.1s
[CV 2/3] END leaf_size=4, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=uniform;, score=0.812 total time=   7.1s
[CV 3/3] END leaf_size=4, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=uniform;, score=0.801 total time=   6.7s
[CV 1/3] END leaf_size=4, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=distance;, score=0.875 total time=  29.3s
[CV 2/3] END leaf_size=4, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=distance;, score=0.840 total time=  49.5s
[CV 3/3] END leaf_size=4, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=distance;, score=0.846 total time=  38.0s
[CV 1/3] END leaf_size=4, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=uniform;, score=0.857 total time=199.7min
[CV 2/3] END leaf_size=4, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=uniform;, score=0.814 total time=   4.8s
[CV 3/3] END leaf_size=4, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=uniform;, score=0.830 total time=   4.4s
[CV 1/3] END leaf_size=4, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=distance;, score=0.858 total time=   8.9s
[CV 2/3] END leaf_size=4, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=distance;, score=0.816 total time=   5.0s
[CV 3/3] END leaf_size=4, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=distance;, score=0.850 total time=   5.9s
[CV 1/3] END leaf_size=4, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=uniform;, score=0.873 total time=   9.6s
[CV 2/3] END leaf_size=4, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=uniform;, score=0.831 total time=   9.6s
[CV 3/3] END leaf_size=4, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=uniform;, score=0.818 total time=   9.1s
[CV 1/3] END leaf_size=4, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=distance;, score=0.873 total time=  10.1s
[CV 2/3] END leaf_size=4, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=distance;, score=0.831 total time=  10.2s
[CV 3/3] END leaf_size=4, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=distance;, score=0.818 total time=   9.2s
[CV 1/3] END leaf_size=4, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=uniform;, score=0.826 total time=  13.1s
[CV 2/3] END leaf_size=4, metric=<function cosine at 0x000001F477193380>,
```

```
n_neighbors=2, weights=uniform;, score=0.755 total time=  14.4s
[CV 3/3] END leaf_size=4, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=uniform;, score=0.768 total time=  20.1s
[CV 1/3] END leaf_size=4, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=distance;, score=0.873 total time=  18.1s
[CV 2/3] END leaf_size=4, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=distance;, score=0.831 total time=  22.1s
[CV 3/3] END leaf_size=4, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=distance;, score=0.818 total time=  18.7s
[CV 1/3] END leaf_size=4, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=uniform;, score=0.853 total time=  18.9s
[CV 2/3] END leaf_size=4, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=uniform;, score=0.785 total time=  17.5s
[CV 3/3] END leaf_size=4, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=uniform;, score=0.779 total time=  18.8s
[CV 1/3] END leaf_size=4, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=distance;, score=0.864 total time=  27.1s
[CV 2/3] END leaf_size=4, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=distance;, score=0.807 total time=  19.3s
[CV 3/3] END leaf_size=4, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=distance;, score=0.797 total time=  16.9s
[CV 1/3] END leaf_size=4, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=uniform;, score=0.871 total time=   6.3s
[CV 2/3] END leaf_size=4, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=uniform;, score=0.831 total time=   6.5s
[CV 3/3] END leaf_size=4, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=uniform;, score=0.816 total time=   7.2s
[CV 1/3] END leaf_size=4, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=distance;, score=0.871 total time=   6.2s
[CV 2/3] END leaf_size=4, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=distance;, score=0.831 total time=   6.3s
[CV 3/3] END leaf_size=4, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=distance;, score=0.816 total time=   6.1s
[CV 1/3] END leaf_size=4, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=uniform;, score=0.831 total time=   6.9s
[CV 2/3] END leaf_size=4, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=uniform;, score=0.757 total time=   6.6s
[CV 3/3] END leaf_size=4, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=uniform;, score=0.772 total time=   6.7s
[CV 1/3] END leaf_size=4, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=distance;, score=0.871 total time=   6.0s
[CV 2/3] END leaf_size=4, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=distance;, score=0.831 total time=   6.0s
[CV 3/3] END leaf_size=4, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=distance;, score=0.816 total time=   5.7s
[CV 1/3] END leaf_size=4, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=uniform;, score=0.848 total time=   6.8s
[CV 2/3] END leaf_size=4, metric=<function sqeuclidean at 0x000001F477193240>,
```

```
n_neighbors=3, weights=uniform;, score=0.782 total time=   5.9s
[CV 3/3] END leaf_size=4, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=uniform;, score=0.774 total time=   5.9s
[CV 1/3] END leaf_size=4, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=distance;, score=0.858 total time=   5.9s
[CV 2/3] END leaf_size=4, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=distance;, score=0.802 total time=   6.2s
[CV 3/3] END leaf_size=4, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=distance;, score=0.793 total time=   5.9s
[CV 1/3] END leaf_size=4, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=uniform;, score=0.743 total time=
7.1s
[CV 2/3] END leaf_size=4, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=uniform;, score=0.706 total time=
7.0s
[CV 3/3] END leaf_size=4, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=uniform;, score=0.646 total time=
8.3s
[CV 1/3] END leaf_size=4, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=distance;, score=0.743 total time=
9.6s
[CV 2/3] END leaf_size=4, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=distance;, score=0.706 total time=
10.8s
[CV 3/3] END leaf_size=4, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=distance;, score=0.646 total time=
9.1s
[CV 1/3] END leaf_size=4, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=uniform;, score=0.688 total time=
8.5s
[CV 2/3] END leaf_size=4, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=uniform;, score=0.684 total time=
8.4s
[CV 3/3] END leaf_size=4, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=uniform;, score=0.641 total time=
7.6s
[CV 1/3] END leaf_size=4, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=distance;, score=0.743 total time=
7.9s
[CV 2/3] END leaf_size=4, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=distance;, score=0.706 total time=
7.5s
[CV 3/3] END leaf_size=4, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=distance;, score=0.646 total time=
11.5s
[CV 1/3] END leaf_size=4, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=uniform;, score=0.716 total time=
13.6s
```

```
[CV 2/3] END leaf_size=4, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=uniform;, score=0.713 total time=
14.0s
[CV 3/3] END leaf_size=4, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=uniform;, score=0.678 total time=
16.1s
[CV 1/3] END leaf_size=4, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=distance;, score=0.728 total time=
15.4s
[CV 2/3] END leaf_size=4, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=distance;, score=0.720 total time=
15.6s
[CV 3/3] END leaf_size=4, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=distance;, score=0.692 total time=
14.0s
[CV 1/3] END leaf_size=4, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=uniform;, score=0.867 total time=
13.1s
[CV 2/3] END leaf_size=4, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=uniform;, score=0.794 total time=
13.1s
[CV 3/3] END leaf_size=4, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=uniform;, score=0.761 total time=
13.2s
[CV 1/3] END leaf_size=4, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=distance;, score=0.867 total time=
12.6s
[CV 2/3] END leaf_size=4, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=distance;, score=0.794 total time=
12.7s
[CV 3/3] END leaf_size=4, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=distance;, score=0.761 total time=
13.8s
[CV 1/3] END leaf_size=4, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=uniform;, score=0.773 total time=
12.6s
[CV 2/3] END leaf_size=4, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=uniform;, score=0.741 total time=
13.9s
[CV 3/3] END leaf_size=4, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=uniform;, score=0.719 total time=
14.0s
[CV 1/3] END leaf_size=4, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=distance;, score=0.867 total time=
13.0s
[CV 2/3] END leaf_size=4, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=distance;, score=0.794 total time=
8.7s
```

```
[CV 3/3] END leaf_size=4, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=distance;, score=0.761 total time=
7.6s
[CV 1/3] END leaf_size=4, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=uniform;, score=0.827 total time=
7.7s
[CV 2/3] END leaf_size=4, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=uniform;, score=0.741 total time=
7.5s
[CV 3/3] END leaf_size=4, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=uniform;, score=0.731 total time=
8.3s
[CV 1/3] END leaf_size=4, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=distance;, score=0.846 total time=
7.5s
[CV 2/3] END leaf_size=4, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=distance;, score=0.749 total time=
7.5s
[CV 3/3] END leaf_size=4, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=distance;, score=0.750 total time=
7.3s
[CV 1/3] END leaf_size=4, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=uniform;, score=0.802 total time=
6.6s
[CV 2/3] END leaf_size=4, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=uniform;, score=0.722 total time=
6.7s
[CV 3/3] END leaf_size=4, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=uniform;, score=0.682 total time=
6.7s
[CV 1/3] END leaf_size=4, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=distance;, score=0.076 total time=
6.9s
[CV 2/3] END leaf_size=4, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=distance;, score=0.076 total time=
6.6s
[CV 3/3] END leaf_size=4, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=distance;, score=0.076 total time=
7.3s
[CV 1/3] END leaf_size=4, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=uniform;, score=0.703 total time=
6.6s
[CV 2/3] END leaf_size=4, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=uniform;, score=0.668 total time=
6.2s
[CV 3/3] END leaf_size=4, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=uniform;, score=0.645 total time=
6.3s
```

```
[CV 1/3] END leaf_size=4, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=distance;, score=0.076 total time=
6.7s
[CV 2/3] END leaf_size=4, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=distance;, score=0.076 total time=
6.7s
[CV 3/3] END leaf_size=4, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=distance;, score=0.076 total time=
6.6s
[CV 1/3] END leaf_size=4, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=uniform;, score=0.779 total time=
7.0s
[CV 2/3] END leaf_size=4, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=uniform;, score=0.664 total time=
7.9s
[CV 3/3] END leaf_size=4, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=uniform;, score=0.678 total time=
8.5s
[CV 1/3] END leaf_size=4, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=distance;, score=0.076 total time=
7.3s
[CV 2/3] END leaf_size=4, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=distance;, score=0.076 total time=
7.0s
[CV 3/3] END leaf_size=4, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=distance;, score=0.076 total time=
7.2s
[CV 1/3] END leaf_size=5, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=uniform;, score=0.875 total time=   7.1s
[CV 2/3] END leaf_size=5, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=uniform;, score=0.840 total time=   7.1s
[CV 3/3] END leaf_size=5, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=uniform;, score=0.846 total time=   7.1s
[CV 1/3] END leaf_size=5, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=distance;, score=0.875 total time=   7.0s
[CV 2/3] END leaf_size=5, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=distance;, score=0.840 total time=   7.0s
[CV 3/3] END leaf_size=5, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=1, weights=distance;, score=0.846 total time=   7.6s
[CV 1/3] END leaf_size=5, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=uniform;, score=0.828 total time=   6.9s
[CV 2/3] END leaf_size=5, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=uniform;, score=0.812 total time=   6.9s
[CV 3/3] END leaf_size=5, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=uniform;, score=0.801 total time=   6.9s
[CV 1/3] END leaf_size=5, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=distance;, score=0.875 total time=   7.1s
[CV 2/3] END leaf_size=5, metric=<function cityblock at 0x000001F4771936A0>,
```

```
n_neighbors=2, weights=distance;, score=0.840 total time=   8.5s
[CV 3/3] END leaf_size=5, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=2, weights=distance;, score=0.846 total time=   7.4s
[CV 1/3] END leaf_size=5, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=uniform;, score=0.857 total time=   7.7s
[CV 2/3] END leaf_size=5, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=uniform;, score=0.814 total time=   7.9s
[CV 3/3] END leaf_size=5, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=uniform;, score=0.830 total time=   8.3s
[CV 1/3] END leaf_size=5, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=distance;, score=0.858 total time=   7.5s
[CV 2/3] END leaf_size=5, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=distance;, score=0.816 total time=   8.1s
[CV 3/3] END leaf_size=5, metric=<function cityblock at 0x000001F4771936A0>,
n_neighbors=3, weights=distance;, score=0.850 total time=   9.9s
[CV 1/3] END leaf_size=5, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=uniform;, score=0.873 total time=  23.7s
[CV 2/3] END leaf_size=5, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=uniform;, score=0.831 total time=  20.5s
[CV 3/3] END leaf_size=5, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=uniform;, score=0.818 total time=  19.3s
[CV 1/3] END leaf_size=5, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=distance;, score=0.873 total time=  18.6s
[CV 2/3] END leaf_size=5, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=distance;, score=0.831 total time=  18.4s
[CV 3/3] END leaf_size=5, metric=<function cosine at 0x000001F477193380>,
n_neighbors=1, weights=distance;, score=0.818 total time=  18.6s
[CV 1/3] END leaf_size=5, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=uniform;, score=0.826 total time=  18.0s
[CV 2/3] END leaf_size=5, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=uniform;, score=0.755 total time=  18.4s
[CV 3/3] END leaf_size=5, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=uniform;, score=0.768 total time=  19.2s
[CV 1/3] END leaf_size=5, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=distance;, score=0.873 total time=  18.4s
[CV 2/3] END leaf_size=5, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=distance;, score=0.831 total time=  18.6s
[CV 3/3] END leaf_size=5, metric=<function cosine at 0x000001F477193380>,
n_neighbors=2, weights=distance;, score=0.818 total time=  18.8s
[CV 1/3] END leaf_size=5, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=uniform;, score=0.853 total time=  19.1s
[CV 2/3] END leaf_size=5, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=uniform;, score=0.785 total time=  17.6s
[CV 3/3] END leaf_size=5, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=uniform;, score=0.779 total time=  17.6s
[CV 1/3] END leaf_size=5, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=distance;, score=0.864 total time=  19.0s
[CV 2/3] END leaf_size=5, metric=<function cosine at 0x000001F477193380>,
```

```
n_neighbors=3, weights=distance;, score=0.807 total time=  18.1s
[CV 3/3] END leaf_size=5, metric=<function cosine at 0x000001F477193380>,
n_neighbors=3, weights=distance;, score=0.797 total time=  18.6s
[CV 1/3] END leaf_size=5, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=uniform;, score=0.871 total time=   7.4s
[CV 2/3] END leaf_size=5, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=uniform;, score=0.831 total time=   7.3s
[CV 3/3] END leaf_size=5, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=uniform;, score=0.816 total time=   8.1s
[CV 1/3] END leaf_size=5, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=distance;, score=0.871 total time=   7.4s
[CV 2/3] END leaf_size=5, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=distance;, score=0.831 total time=   7.1s
[CV 3/3] END leaf_size=5, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=1, weights=distance;, score=0.816 total time=   7.0s
[CV 1/3] END leaf_size=5, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=uniform;, score=0.831 total time=   7.1s
[CV 2/3] END leaf_size=5, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=uniform;, score=0.757 total time=   6.9s
[CV 3/3] END leaf_size=5, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=uniform;, score=0.772 total time=   7.3s
[CV 1/3] END leaf_size=5, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=distance;, score=0.871 total time=   7.3s
[CV 2/3] END leaf_size=5, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=distance;, score=0.831 total time=   7.6s
[CV 3/3] END leaf_size=5, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=2, weights=distance;, score=0.816 total time=   8.2s
[CV 1/3] END leaf_size=5, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=uniform;, score=0.848 total time=   7.3s
[CV 2/3] END leaf_size=5, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=uniform;, score=0.782 total time=   7.4s
[CV 3/3] END leaf_size=5, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=uniform;, score=0.774 total time=   7.1s
[CV 1/3] END leaf_size=5, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=distance;, score=0.858 total time=   7.0s
[CV 2/3] END leaf_size=5, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=distance;, score=0.802 total time=   7.2s
[CV 3/3] END leaf_size=5, metric=<function sqeuclidean at 0x000001F477193240>,
n_neighbors=3, weights=distance;, score=0.793 total time=   7.2s
[CV 1/3] END leaf_size=5, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=uniform;, score=0.743 total time=
8.6s
[CV 2/3] END leaf_size=5, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=uniform;, score=0.706 total time=
8.6s
[CV 3/3] END leaf_size=5, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=uniform;, score=0.646 total time=
8.8s
```

```
[CV 1/3] END leaf_size=5, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=distance;, score=0.743 total time=
8.4s
[CV 2/3] END leaf_size=5, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=distance;, score=0.706 total time=
8.8s
[CV 3/3] END leaf_size=5, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=1, weights=distance;, score=0.646 total time=
8.9s
[CV 1/3] END leaf_size=5, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=uniform;, score=0.688 total time=
8.5s
[CV 2/3] END leaf_size=5, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=uniform;, score=0.684 total time=
8.7s
[CV 3/3] END leaf_size=5, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=uniform;, score=0.641 total time=
8.7s
[CV 1/3] END leaf_size=5, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=distance;, score=0.743 total time=
9.0s
[CV 2/3] END leaf_size=5, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=distance;, score=0.706 total time=
8.6s
[CV 3/3] END leaf_size=5, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=2, weights=distance;, score=0.646 total time=
8.6s
[CV 1/3] END leaf_size=5, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=uniform;, score=0.716 total time=
8.3s
[CV 2/3] END leaf_size=5, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=uniform;, score=0.713 total time=
8.2s
[CV 3/3] END leaf_size=5, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=uniform;, score=0.678 total time=
8.4s
[CV 1/3] END leaf_size=5, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=distance;, score=0.728 total time=
8.6s
[CV 2/3] END leaf_size=5, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=distance;, score=0.720 total time=
8.8s
[CV 3/3] END leaf_size=5, metric=<function chi_square_distance at
0x000001F479B48400>, n_neighbors=3, weights=distance;, score=0.692 total time=
9.6s
[CV 1/3] END leaf_size=5, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=uniform;, score=0.867 total time=
7.6s
```

```
[CV 2/3] END leaf_size=5, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=uniform;, score=0.794 total time=
7.8s
[CV 3/3] END leaf_size=5, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=uniform;, score=0.761 total time=
7.5s
[CV 1/3] END leaf_size=5, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=distance;, score=0.867 total time=
7.5s
[CV 2/3] END leaf_size=5, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=distance;, score=0.794 total time=
8.3s
[CV 3/3] END leaf_size=5, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=1, weights=distance;, score=0.761 total time=
7.4s
[CV 1/3] END leaf_size=5, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=uniform;, score=0.773 total time=
7.7s
[CV 2/3] END leaf_size=5, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=uniform;, score=0.741 total time=
8.5s
[CV 3/3] END leaf_size=5, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=uniform;, score=0.719 total time=
7.6s
[CV 1/3] END leaf_size=5, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=distance;, score=0.867 total time=
7.9s
[CV 2/3] END leaf_size=5, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=distance;, score=0.794 total time=
7.8s
[CV 3/3] END leaf_size=5, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=2, weights=distance;, score=0.761 total time=
7.6s
[CV 1/3] END leaf_size=5, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=uniform;, score=0.827 total time=
7.5s
[CV 2/3] END leaf_size=5, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=uniform;, score=0.741 total time=
7.2s
[CV 3/3] END leaf_size=5, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=uniform;, score=0.731 total time=
7.3s
[CV 1/3] END leaf_size=5, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=distance;, score=0.846 total time=
7.8s
[CV 2/3] END leaf_size=5, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=distance;, score=0.749 total time=
7.9s
```

```
[CV 3/3] END leaf_size=5, metric=<function bhattacharyya_distance at
0x000001F479B482C0>, n_neighbors=3, weights=distance;, score=0.750 total time=
7.5s
[CV 1/3] END leaf_size=5, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=uniform;, score=0.802 total time=
6.9s
[CV 2/3] END leaf_size=5, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=uniform;, score=0.722 total time=
6.9s
[CV 3/3] END leaf_size=5, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=uniform;, score=0.682 total time=
6.9s
[CV 1/3] END leaf_size=5, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=distance;, score=0.076 total time=
6.8s
[CV 2/3] END leaf_size=5, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=distance;, score=0.076 total time=
6.9s
[CV 3/3] END leaf_size=5, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=1, weights=distance;, score=0.076 total time=
6.8s
[CV 1/3] END leaf_size=5, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=uniform;, score=0.703 total time=
7.2s
[CV 2/3] END leaf_size=5, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=uniform;, score=0.668 total time=
6.9s
[CV 3/3] END leaf_size=5, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=uniform;, score=0.645 total time=
6.8s
[CV 1/3] END leaf_size=5, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=distance;, score=0.076 total time=
6.7s
[CV 2/3] END leaf_size=5, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=distance;, score=0.076 total time=
6.6s
[CV 3/3] END leaf_size=5, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=2, weights=distance;, score=0.076 total time=
6.7s
[CV 1/3] END leaf_size=5, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=uniform;, score=0.779 total time=
6.8s
[CV 2/3] END leaf_size=5, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=uniform;, score=0.664 total time=
6.7s
[CV 3/3] END leaf_size=5, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=uniform;, score=0.678 total time=
6.9s
```

```
[CV 1/3] END leaf_size=5, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=distance;, score=0.076 total time=
6.7s
[CV 2/3] END leaf_size=5, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=distance;, score=0.076 total time=
7.5s
[CV 3/3] END leaf_size=5, metric=<function intersection_distance at
0x000001F479B48180>, n_neighbors=3, weights=distance;, score=0.076 total time=
6.8s
```

```
GridSearchCV(cv=3, estimator=KNeighborsClassifier(),
             param_grid={'leaf_size': [1, 2, 3, 4, 5],
                         'metric': [<function cityblock at 0x000001F4771936A0>,
                                    <function cosine at 0x000001F477193380>,
                                    <function sqeuclidean at
0x000001F477193240>,
                                    <function chi_square_distance at
0x000001F479B48400>,
                                    <function bhattacharyya_distance at
0x000001F479B482C0>,
                                    <function intersection_distance at
0x000001F479B48180>],
                         'n_neighbors': [1, 2, 3],
                         'weights': ['uniform', 'distance']},
             scoring='f1_macro', verbose=3)
```

```
best_knn = grid_search_knn.best_estimator_
print(f"Best Params: {grid_search_knn.best_params_}")


y_pred_knn = best_knn.predict(test_features)

joblib.dump(best_knn, project_dir + '\joblib\\best_knn_model.joblib')
```

```
Best Params: {'leaf_size': 1, 'metric': <function cityblock at
0x000001F4771936A0>, 'n_neighbors': 1, 'weights': 'uniform'}
```

```
['d:\\ASUS\\Deploy-Traffic-Sign-Classification-through-
Images\\joblib\\best_knn_model.joblib']
```

7 Gridsearch SVM

```
svm_model = SVC()
svm_model.fit(train_features, train_labels_encoded)
y_pred_svm = svm_model.predict(test_features)
```

```
param_grid = {
    'C': [0.05, 0.001, 0.1, 1.0 , 10],
    'kernel': ['rbf', 'linear', 'poly', 'sigmoid'],
    'gamma': ['scale', 'auto', 0.2, 0.1, 0.15],
    # 'degree': [2, 3, 4],
}

svm_model = SVC()

grid_search_svm = GridSearchCV(
    estimator=svm_model,
    param_grid=param_grid,
    cv=3,
    scoring='f1_macro',
    verbose=3,
)

grid_search_svm.fit(train_features, train_labels_encoded)
```

```
Fitting 3 folds for each of 100 candidates, totalling 300 fits
[CV 1/3] END …C=0.05, gamma=scale, kernel=rbf;, score=0.447 total time=   3.1s
[CV 2/3] END …C=0.05, gamma=scale, kernel=rbf;, score=0.469 total time=   3.2s
[CV 3/3] END …C=0.05, gamma=scale, kernel=rbf;, score=0.426 total time=   3.3s
[CV 1/3] END C=0.05, gamma=scale, kernel=linear;, score=0.847 total time=   1.4s
[CV 2/3] END C=0.05, gamma=scale, kernel=linear;, score=0.789 total time=   1.5s
[CV 3/3] END C=0.05, gamma=scale, kernel=linear;, score=0.787 total time=   1.4s
[CV 1/3] END ..C=0.05, gamma=scale, kernel=poly;, score=0.666 total time=   2.3s
[CV 2/3] END ..C=0.05, gamma=scale, kernel=poly;, score=0.654 total time=   2.3s
[CV 3/3] END ..C=0.05, gamma=scale, kernel=poly;, score=0.590 total time=   2.3s
[CV 1/3] END C=0.05, gamma=scale, kernel=sigmoid;, score=0.442 total time=
2.8s
[CV 2/3] END C=0.05, gamma=scale, kernel=sigmoid;, score=0.465 total time=
2.9s
[CV 3/3] END C=0.05, gamma=scale, kernel=sigmoid;, score=0.450 total time=
2.7s
[CV 1/3] END …C=0.05, gamma=auto, kernel=rbf;, score=0.076 total time=   3.4s
[CV 2/3] END …C=0.05, gamma=auto, kernel=rbf;, score=0.076 total time=   3.4s
[CV 3/3] END …C=0.05, gamma=auto, kernel=rbf;, score=0.076 total time=   3.5s
[CV 1/3] END .C=0.05, gamma=auto, kernel=linear;, score=0.847 total time=   1.4s
[CV 2/3] END .C=0.05, gamma=auto, kernel=linear;, score=0.789 total time=   1.4s
[CV 3/3] END .C=0.05, gamma=auto, kernel=linear;, score=0.787 total time=   1.4s
[CV 1/3] END …C=0.05, gamma=auto, kernel=poly;, score=0.076 total time=   3.1s
[CV 2/3] END …C=0.05, gamma=auto, kernel=poly;, score=0.076 total time=   3.1s
[CV 3/3] END …C=0.05, gamma=auto, kernel=poly;, score=0.076 total time=   3.0s
[CV 1/3] END C=0.05, gamma=auto, kernel=sigmoid;, score=0.076 total time=   3.1s
[CV 2/3] END C=0.05, gamma=auto, kernel=sigmoid;, score=0.076 total time=   3.1s
[CV 3/3] END C=0.05, gamma=auto, kernel=sigmoid;, score=0.076 total time=   3.0s
[CV 1/3] END …C=0.05, gamma=0.2, kernel=rbf;, score=0.076 total time=   3.7s
```

```
[CV 2/3] END …C=0.05, gamma=0.2, kernel=rbf;, score=0.076 total time=   3.7s
[CV 3/3] END …C=0.05, gamma=0.2, kernel=rbf;, score=0.076 total time=   3.6s
[CV 1/3] END ..C=0.05, gamma=0.2, kernel=linear;, score=0.847 total time=   1.5s
[CV 2/3] END ..C=0.05, gamma=0.2, kernel=linear;, score=0.789 total time=   1.4s
[CV 3/3] END ..C=0.05, gamma=0.2, kernel=linear;, score=0.787 total time=   1.4s
[CV 1/3] END …C=0.05, gamma=0.2, kernel=poly;, score=0.883 total time=   2.1s
[CV 2/3] END …C=0.05, gamma=0.2, kernel=poly;, score=0.865 total time=   2.1s
[CV 3/3] END …C=0.05, gamma=0.2, kernel=poly;, score=0.823 total time=   2.1s
[CV 1/3] END .C=0.05, gamma=0.2, kernel=sigmoid;, score=0.076 total time=   3.0s
[CV 2/3] END .C=0.05, gamma=0.2, kernel=sigmoid;, score=0.076 total time=   2.9s
[CV 3/3] END .C=0.05, gamma=0.2, kernel=sigmoid;, score=0.076 total time=   2.9s
[CV 1/3] END …C=0.05, gamma=0.1, kernel=rbf;, score=0.093 total time=   3.3s
[CV 2/3] END …C=0.05, gamma=0.1, kernel=rbf;, score=0.085 total time=   3.5s
[CV 3/3] END …C=0.05, gamma=0.1, kernel=rbf;, score=0.128 total time=   3.6s
[CV 1/3] END ..C=0.05, gamma=0.1, kernel=linear;, score=0.847 total time=   1.4s
[CV 2/3] END ..C=0.05, gamma=0.1, kernel=linear;, score=0.789 total time=   1.4s
[CV 3/3] END ..C=0.05, gamma=0.1, kernel=linear;, score=0.787 total time=   1.3s
[CV 1/3] END …C=0.05, gamma=0.1, kernel=poly;, score=0.883 total time=   2.2s
[CV 2/3] END …C=0.05, gamma=0.1, kernel=poly;, score=0.865 total time=   2.1s
[CV 3/3] END …C=0.05, gamma=0.1, kernel=poly;, score=0.823 total time=   2.0s
[CV 1/3] END .C=0.05, gamma=0.1, kernel=sigmoid;, score=0.101 total time=   3.3s
[CV 2/3] END .C=0.05, gamma=0.1, kernel=sigmoid;, score=0.083 total time=   3.2s
[CV 3/3] END .C=0.05, gamma=0.1, kernel=sigmoid;, score=0.084 total time=   3.1s
[CV 1/3] END …C=0.05, gamma=0.15, kernel=rbf;, score=0.076 total time=   3.6s
[CV 2/3] END …C=0.05, gamma=0.15, kernel=rbf;, score=0.076 total time=   3.7s
[CV 3/3] END …C=0.05, gamma=0.15, kernel=rbf;, score=0.076 total time=   3.6s
[CV 1/3] END .C=0.05, gamma=0.15, kernel=linear;, score=0.847 total time=   1.4s
[CV 2/3] END .C=0.05, gamma=0.15, kernel=linear;, score=0.789 total time=   1.4s
[CV 3/3] END .C=0.05, gamma=0.15, kernel=linear;, score=0.787 total time=   1.4s
[CV 1/3] END …C=0.05, gamma=0.15, kernel=poly;, score=0.883 total time=   2.2s
[CV 2/3] END …C=0.05, gamma=0.15, kernel=poly;, score=0.865 total time=   2.0s
[CV 3/3] END …C=0.05, gamma=0.15, kernel=poly;, score=0.823 total time=   2.1s
[CV 1/3] END C=0.05, gamma=0.15, kernel=sigmoid;, score=0.076 total time=   3.1s
[CV 2/3] END C=0.05, gamma=0.15, kernel=sigmoid;, score=0.076 total time=   3.2s
[CV 3/3] END C=0.05, gamma=0.15, kernel=sigmoid;, score=0.076 total time=   3.1s
[CV 1/3] END ..C=0.001, gamma=scale, kernel=rbf;, score=0.076 total time=   3.4s
[CV 2/3] END ..C=0.001, gamma=scale, kernel=rbf;, score=0.076 total time=   3.2s
[CV 3/3] END ..C=0.001, gamma=scale, kernel=rbf;, score=0.076 total time=   3.3s
[CV 1/3] END C=0.001, gamma=scale, kernel=linear;, score=0.447 total time=
2.6s
[CV 2/3] END C=0.001, gamma=scale, kernel=linear;, score=0.470 total time=
2.6s
[CV 3/3] END C=0.001, gamma=scale, kernel=linear;, score=0.462 total time=
2.6s
[CV 1/3] END .C=0.001, gamma=scale, kernel=poly;, score=0.076 total time=   3.1s
[CV 2/3] END .C=0.001, gamma=scale, kernel=poly;, score=0.076 total time=   3.1s
[CV 3/3] END .C=0.001, gamma=scale, kernel=poly;, score=0.076 total time=   3.0s
[CV 1/3] END C=0.001, gamma=scale, kernel=sigmoid;, score=0.076 total time=
```

```
3.2s
[CV 2/3] END C=0.001, gamma=scale, kernel=sigmoid;, score=0.076 total time=
3.1s
[CV 3/3] END C=0.001, gamma=scale, kernel=sigmoid;, score=0.076 total time=
3.2s
[CV 1/3] END …C=0.001, gamma=auto, kernel=rbf;, score=0.076 total time=   3.4s
[CV 2/3] END …C=0.001, gamma=auto, kernel=rbf;, score=0.076 total time=   3.6s
[CV 3/3] END …C=0.001, gamma=auto, kernel=rbf;, score=0.076 total time=   3.5s
[CV 1/3] END C=0.001, gamma=auto, kernel=linear;, score=0.447 total time=   2.6s
[CV 2/3] END C=0.001, gamma=auto, kernel=linear;, score=0.470 total time=   2.7s
[CV 3/3] END C=0.001, gamma=auto, kernel=linear;, score=0.462 total time=   2.7s
[CV 1/3] END ..C=0.001, gamma=auto, kernel=poly;, score=0.076 total time=   3.1s
[CV 2/3] END ..C=0.001, gamma=auto, kernel=poly;, score=0.076 total time=   3.0s
[CV 3/3] END ..C=0.001, gamma=auto, kernel=poly;, score=0.076 total time=   3.1s
[CV 1/3] END C=0.001, gamma=auto, kernel=sigmoid;, score=0.076 total time=
3.0s
[CV 2/3] END C=0.001, gamma=auto, kernel=sigmoid;, score=0.076 total time=
3.0s
[CV 3/3] END C=0.001, gamma=auto, kernel=sigmoid;, score=0.076 total time=
3.0s
[CV 1/3] END …C=0.001, gamma=0.2, kernel=rbf;, score=0.076 total time=   3.5s
[CV 2/3] END …C=0.001, gamma=0.2, kernel=rbf;, score=0.076 total time=   3.4s
[CV 3/3] END …C=0.001, gamma=0.2, kernel=rbf;, score=0.076 total time=   3.4s
[CV 1/3] END .C=0.001, gamma=0.2, kernel=linear;, score=0.447 total time=   2.6s
[CV 2/3] END .C=0.001, gamma=0.2, kernel=linear;, score=0.470 total time=   2.5s
[CV 3/3] END .C=0.001, gamma=0.2, kernel=linear;, score=0.462 total time=   2.4s
[CV 1/3] END …C=0.001, gamma=0.2, kernel=poly;, score=0.855 total time=   1.9s
[CV 2/3] END …C=0.001, gamma=0.2, kernel=poly;, score=0.843 total time=   2.0s
[CV 3/3] END …C=0.001, gamma=0.2, kernel=poly;, score=0.802 total time=   2.0s
[CV 1/3] END C=0.001, gamma=0.2, kernel=sigmoid;, score=0.076 total time=   3.0s
[CV 2/3] END C=0.001, gamma=0.2, kernel=sigmoid;, score=0.076 total time=   3.1s
[CV 3/3] END C=0.001, gamma=0.2, kernel=sigmoid;, score=0.076 total time=   3.0s
[CV 1/3] END …C=0.001, gamma=0.1, kernel=rbf;, score=0.076 total time=   3.5s
[CV 2/3] END …C=0.001, gamma=0.1, kernel=rbf;, score=0.076 total time=   3.3s
[CV 3/3] END …C=0.001, gamma=0.1, kernel=rbf;, score=0.076 total time=   3.3s
[CV 1/3] END .C=0.001, gamma=0.1, kernel=linear;, score=0.447 total time=   2.5s
[CV 2/3] END .C=0.001, gamma=0.1, kernel=linear;, score=0.470 total time=   2.4s
[CV 3/3] END .C=0.001, gamma=0.1, kernel=linear;, score=0.462 total time=   2.6s
[CV 1/3] END …C=0.001, gamma=0.1, kernel=poly;, score=0.594 total time=   2.2s
[CV 2/3] END …C=0.001, gamma=0.1, kernel=poly;, score=0.577 total time=   2.5s
[CV 3/3] END …C=0.001, gamma=0.1, kernel=poly;, score=0.542 total time=   2.4s
[CV 1/3] END C=0.001, gamma=0.1, kernel=sigmoid;, score=0.076 total time=   3.1s
[CV 2/3] END C=0.001, gamma=0.1, kernel=sigmoid;, score=0.076 total time=   3.1s
[CV 3/3] END C=0.001, gamma=0.1, kernel=sigmoid;, score=0.076 total time=   3.1s
[CV 1/3] END …C=0.001, gamma=0.15, kernel=rbf;, score=0.076 total time=   3.4s
[CV 2/3] END …C=0.001, gamma=0.15, kernel=rbf;, score=0.076 total time=   3.4s
[CV 3/3] END …C=0.001, gamma=0.15, kernel=rbf;, score=0.076 total time=   3.4s
[CV 1/3] END C=0.001, gamma=0.15, kernel=linear;, score=0.447 total time=   2.8s
```

```
[CV 2/3] END C=0.001, gamma=0.15, kernel=linear;, score=0.470 total time=   2.7s
[CV 3/3] END C=0.001, gamma=0.15, kernel=linear;, score=0.462 total time=   2.6s
[CV 1/3] END ..C=0.001, gamma=0.15, kernel=poly;, score=0.802 total time=   2.0s
[CV 2/3] END ..C=0.001, gamma=0.15, kernel=poly;, score=0.778 total time=   2.1s
[CV 3/3] END ..C=0.001, gamma=0.15, kernel=poly;, score=0.719 total time=   2.1s
[CV 1/3] END C=0.001, gamma=0.15, kernel=sigmoid;, score=0.076 total time=
3.1s
[CV 2/3] END C=0.001, gamma=0.15, kernel=sigmoid;, score=0.076 total time=
3.1s
[CV 3/3] END C=0.001, gamma=0.15, kernel=sigmoid;, score=0.076 total time=
3.2s
[CV 1/3] END …C=0.1, gamma=scale, kernel=rbf;, score=0.521 total time=   2.9s
[CV 2/3] END …C=0.1, gamma=scale, kernel=rbf;, score=0.538 total time=   3.0s
[CV 3/3] END …C=0.1, gamma=scale, kernel=rbf;, score=0.517 total time=   2.9s
[CV 1/3] END .C=0.1, gamma=scale, kernel=linear;, score=0.840 total time=   1.4s
[CV 2/3] END .C=0.1, gamma=scale, kernel=linear;, score=0.805 total time=   1.4s
[CV 3/3] END .C=0.1, gamma=scale, kernel=linear;, score=0.798 total time=   1.4s
[CV 1/3] END …C=0.1, gamma=scale, kernel=poly;, score=0.804 total time=   1.9s
[CV 2/3] END …C=0.1, gamma=scale, kernel=poly;, score=0.778 total time=   2.0s
[CV 3/3] END …C=0.1, gamma=scale, kernel=poly;, score=0.709 total time=   1.9s
[CV 1/3] END C=0.1, gamma=scale, kernel=sigmoid;, score=0.512 total time=   2.3s
[CV 2/3] END C=0.1, gamma=scale, kernel=sigmoid;, score=0.503 total time=   2.4s
[CV 3/3] END C=0.1, gamma=scale, kernel=sigmoid;, score=0.497 total time=   2.5s
[CV 1/3] END …C=0.1, gamma=auto, kernel=rbf;, score=0.076 total time=   3.6s
[CV 2/3] END …C=0.1, gamma=auto, kernel=rbf;, score=0.076 total time=   3.5s
[CV 3/3] END …C=0.1, gamma=auto, kernel=rbf;, score=0.076 total time=   3.8s
[CV 1/3] END ..C=0.1, gamma=auto, kernel=linear;, score=0.840 total time=   1.5s
[CV 2/3] END ..C=0.1, gamma=auto, kernel=linear;, score=0.805 total time=   1.4s
[CV 3/3] END ..C=0.1, gamma=auto, kernel=linear;, score=0.798 total time=   1.5s
[CV 1/3] END …C=0.1, gamma=auto, kernel=poly;, score=0.076 total time=   3.7s
[CV 2/3] END …C=0.1, gamma=auto, kernel=poly;, score=0.076 total time=   2.8s
[CV 3/3] END …C=0.1, gamma=auto, kernel=poly;, score=0.076 total time=   2.2s
[CV 1/3] END .C=0.1, gamma=auto, kernel=sigmoid;, score=0.076 total time=   2.6s
[CV 2/3] END .C=0.1, gamma=auto, kernel=sigmoid;, score=0.076 total time=   2.3s
[CV 3/3] END .C=0.1, gamma=auto, kernel=sigmoid;, score=0.076 total time=   1.9s
[CV 1/3] END …C=0.1, gamma=0.2, kernel=rbf;, score=0.076 total time=   2.5s
[CV 2/3] END …C=0.1, gamma=0.2, kernel=rbf;, score=0.076 total time=   2.5s
[CV 3/3] END …C=0.1, gamma=0.2, kernel=rbf;, score=0.076 total time=   3.3s
[CV 1/3] END …C=0.1, gamma=0.2, kernel=linear;, score=0.840 total time=   1.0s
[CV 2/3] END …C=0.1, gamma=0.2, kernel=linear;, score=0.805 total time=   0.9s
[CV 3/3] END …C=0.1, gamma=0.2, kernel=linear;, score=0.798 total time=   1.0s
[CV 1/3] END …C=0.1, gamma=0.2, kernel=poly;, score=0.883 total time=   1.9s
[CV 2/3] END …C=0.1, gamma=0.2, kernel=poly;, score=0.865 total time=   1.9s
[CV 3/3] END …C=0.1, gamma=0.2, kernel=poly;, score=0.823 total time=   1.3s
[CV 1/3] END ..C=0.1, gamma=0.2, kernel=sigmoid;, score=0.076 total time=   2.1s
[CV 2/3] END ..C=0.1, gamma=0.2, kernel=sigmoid;, score=0.076 total time=   2.6s
[CV 3/3] END ..C=0.1, gamma=0.2, kernel=sigmoid;, score=0.076 total time=   2.7s
[CV 1/3] END …C=0.1, gamma=0.1, kernel=rbf;, score=0.392 total time=   2.5s
```

```
[CV 2/3] END …C=0.1, gamma=0.1, kernel=rbf;, score=0.420 total time=   3.4s
[CV 3/3] END …C=0.1, gamma=0.1, kernel=rbf;, score=0.372 total time=   2.6s
[CV 1/3] END …C=0.1, gamma=0.1, kernel=linear;, score=0.840 total time=   1.0s
[CV 2/3] END …C=0.1, gamma=0.1, kernel=linear;, score=0.805 total time=   1.0s
[CV 3/3] END …C=0.1, gamma=0.1, kernel=linear;, score=0.798 total time=   1.1s
[CV 1/3] END …C=0.1, gamma=0.1, kernel=poly;, score=0.883 total time=   1.7s
[CV 2/3] END …C=0.1, gamma=0.1, kernel=poly;, score=0.865 total time=   1.8s
[CV 3/3] END …C=0.1, gamma=0.1, kernel=poly;, score=0.823 total time=   1.7s
[CV 1/3] END ..C=0.1, gamma=0.1, kernel=sigmoid;, score=0.325 total time=   2.7s
[CV 2/3] END ..C=0.1, gamma=0.1, kernel=sigmoid;, score=0.313 total time=   2.3s
[CV 3/3] END ..C=0.1, gamma=0.1, kernel=sigmoid;, score=0.308 total time=   2.2s
[CV 1/3] END …C=0.1, gamma=0.15, kernel=rbf;, score=0.080 total time=   2.7s
[CV 2/3] END …C=0.1, gamma=0.15, kernel=rbf;, score=0.085 total time=   2.7s
[CV 3/3] END …C=0.1, gamma=0.15, kernel=rbf;, score=0.110 total time=   2.7s
[CV 1/3] END ..C=0.1, gamma=0.15, kernel=linear;, score=0.840 total time=   0.9s
[CV 2/3] END ..C=0.1, gamma=0.15, kernel=linear;, score=0.805 total time=   1.0s
[CV 3/3] END ..C=0.1, gamma=0.15, kernel=linear;, score=0.798 total time=   1.1s
[CV 1/3] END …C=0.1, gamma=0.15, kernel=poly;, score=0.883 total time=   1.6s
[CV 2/3] END …C=0.1, gamma=0.15, kernel=poly;, score=0.865 total time=   1.8s
[CV 3/3] END …C=0.1, gamma=0.15, kernel=poly;, score=0.823 total time=   4.1s
[CV 1/3] END .C=0.1, gamma=0.15, kernel=sigmoid;, score=0.076 total time=   4.6s
[CV 2/3] END .C=0.1, gamma=0.15, kernel=sigmoid;, score=0.079 total time=   3.0s
[CV 3/3] END .C=0.1, gamma=0.15, kernel=sigmoid;, score=0.080 total time=   2.7s
[CV 1/3] END …C=1.0, gamma=scale, kernel=rbf;, score=0.843 total time=   2.1s
[CV 2/3] END …C=1.0, gamma=scale, kernel=rbf;, score=0.832 total time=   2.4s
[CV 3/3] END …C=1.0, gamma=scale, kernel=rbf;, score=0.781 total time=   2.2s
[CV 1/3] END .C=1.0, gamma=scale, kernel=linear;, score=0.842 total time=   1.3s
[CV 2/3] END .C=1.0, gamma=scale, kernel=linear;, score=0.796 total time=   1.4s
[CV 3/3] END .C=1.0, gamma=scale, kernel=linear;, score=0.792 total time=   1.3s
[CV 1/3] END …C=1.0, gamma=scale, kernel=poly;, score=0.883 total time=   1.8s
[CV 2/3] END …C=1.0, gamma=scale, kernel=poly;, score=0.865 total time=   2.0s
[CV 3/3] END …C=1.0, gamma=scale, kernel=poly;, score=0.820 total time=   1.9s
[CV 1/3] END C=1.0, gamma=scale, kernel=sigmoid;, score=0.763 total time=   1.8s
[CV 2/3] END C=1.0, gamma=scale, kernel=sigmoid;, score=0.752 total time=   1.8s
[CV 3/3] END C=1.0, gamma=scale, kernel=sigmoid;, score=0.702 total time=   1.6s
[CV 1/3] END …C=1.0, gamma=auto, kernel=rbf;, score=0.457 total time=   3.1s
[CV 2/3] END …C=1.0, gamma=auto, kernel=rbf;, score=0.475 total time=   3.4s
[CV 3/3] END …C=1.0, gamma=auto, kernel=rbf;, score=0.460 total time=   3.3s
[CV 1/3] END ..C=1.0, gamma=auto, kernel=linear;, score=0.842 total time=   1.6s
[CV 2/3] END ..C=1.0, gamma=auto, kernel=linear;, score=0.796 total time=   1.5s
[CV 3/3] END ..C=1.0, gamma=auto, kernel=linear;, score=0.792 total time=   1.5s
[CV 1/3] END …C=1.0, gamma=auto, kernel=poly;, score=0.076 total time=   3.0s
[CV 2/3] END …C=1.0, gamma=auto, kernel=poly;, score=0.076 total time=   3.4s
[CV 3/3] END …C=1.0, gamma=auto, kernel=poly;, score=0.076 total time=   3.1s
[CV 1/3] END .C=1.0, gamma=auto, kernel=sigmoid;, score=0.442 total time=   3.1s
[CV 2/3] END .C=1.0, gamma=auto, kernel=sigmoid;, score=0.458 total time=   3.4s
[CV 3/3] END .C=1.0, gamma=auto, kernel=sigmoid;, score=0.440 total time=   2.9s
[CV 1/3] END …C=1.0, gamma=0.2, kernel=rbf;, score=0.397 total time=   3.6s
```

```
[CV 2/3] END …C=1.0, gamma=0.2, kernel=rbf;, score=0.459 total time=   3.5s
[CV 3/3] END …C=1.0, gamma=0.2, kernel=rbf;, score=0.392 total time=   3.6s
[CV 1/3] END …C=1.0, gamma=0.2, kernel=linear;, score=0.842 total time=   1.5s
[CV 2/3] END …C=1.0, gamma=0.2, kernel=linear;, score=0.796 total time=   1.5s
[CV 3/3] END …C=1.0, gamma=0.2, kernel=linear;, score=0.792 total time=   1.4s
[CV 1/3] END …C=1.0, gamma=0.2, kernel=poly;, score=0.883 total time=   2.1s
[CV 2/3] END …C=1.0, gamma=0.2, kernel=poly;, score=0.865 total time=   2.1s
[CV 3/3] END …C=1.0, gamma=0.2, kernel=poly;, score=0.823 total time=   2.2s
[CV 1/3] END ..C=1.0, gamma=0.2, kernel=sigmoid;, score=0.110 total time=   3.2s
[CV 2/3] END ..C=1.0, gamma=0.2, kernel=sigmoid;, score=0.087 total time=   3.6s
[CV 3/3] END ..C=1.0, gamma=0.2, kernel=sigmoid;, score=0.091 total time=   3.1s
[CV 1/3] END …C=1.0, gamma=0.1, kernel=rbf;, score=0.802 total time=   4.0s
[CV 2/3] END …C=1.0, gamma=0.1, kernel=rbf;, score=0.785 total time=   3.6s
[CV 3/3] END …C=1.0, gamma=0.1, kernel=rbf;, score=0.735 total time=   3.5s
[CV 1/3] END …C=1.0, gamma=0.1, kernel=linear;, score=0.842 total time=   1.5s
[CV 2/3] END …C=1.0, gamma=0.1, kernel=linear;, score=0.796 total time=   1.5s
[CV 3/3] END …C=1.0, gamma=0.1, kernel=linear;, score=0.792 total time=   1.5s
[CV 1/3] END …C=1.0, gamma=0.1, kernel=poly;, score=0.883 total time=   2.2s
[CV 2/3] END …C=1.0, gamma=0.1, kernel=poly;, score=0.865 total time=   2.3s
[CV 3/3] END …C=1.0, gamma=0.1, kernel=poly;, score=0.823 total time=   2.2s
[CV 1/3] END ..C=1.0, gamma=0.1, kernel=sigmoid;, score=0.468 total time=   2.6s
[CV 2/3] END ..C=1.0, gamma=0.1, kernel=sigmoid;, score=0.502 total time=   2.6s
[CV 3/3] END ..C=1.0, gamma=0.1, kernel=sigmoid;, score=0.490 total time=   2.6s
[CV 1/3] END …C=1.0, gamma=0.15, kernel=rbf;, score=0.623 total time=   3.7s
[CV 2/3] END …C=1.0, gamma=0.15, kernel=rbf;, score=0.635 total time=   3.8s
[CV 3/3] END …C=1.0, gamma=0.15, kernel=rbf;, score=0.588 total time=   3.8s
[CV 1/3] END ..C=1.0, gamma=0.15, kernel=linear;, score=0.842 total time=   1.5s
[CV 2/3] END ..C=1.0, gamma=0.15, kernel=linear;, score=0.796 total time=   1.5s
[CV 3/3] END ..C=1.0, gamma=0.15, kernel=linear;, score=0.792 total time=   1.6s
[CV 1/3] END …C=1.0, gamma=0.15, kernel=poly;, score=0.883 total time=   2.2s
[CV 2/3] END …C=1.0, gamma=0.15, kernel=poly;, score=0.865 total time=   2.4s
[CV 3/3] END …C=1.0, gamma=0.15, kernel=poly;, score=0.823 total time=   2.2s
[CV 1/3] END .C=1.0, gamma=0.15, kernel=sigmoid;, score=0.389 total time=   3.1s
[CV 2/3] END .C=1.0, gamma=0.15, kernel=sigmoid;, score=0.383 total time=   3.1s
[CV 3/3] END .C=1.0, gamma=0.15, kernel=sigmoid;, score=0.337 total time=   3.2s
[CV 1/3] END …C=10, gamma=scale, kernel=rbf;, score=0.875 total time=   2.6s
[CV 2/3] END …C=10, gamma=scale, kernel=rbf;, score=0.861 total time=   2.7s
[CV 3/3] END …C=10, gamma=scale, kernel=rbf;, score=0.822 total time=   3.0s
[CV 1/3] END ..C=10, gamma=scale, kernel=linear;, score=0.842 total time=   1.8s
[CV 2/3] END ..C=10, gamma=scale, kernel=linear;, score=0.796 total time=   1.6s
[CV 3/3] END ..C=10, gamma=scale, kernel=linear;, score=0.792 total time=   1.5s
[CV 1/3] END …C=10, gamma=scale, kernel=poly;, score=0.883 total time=   2.1s
[CV 2/3] END …C=10, gamma=scale, kernel=poly;, score=0.865 total time=   2.0s
[CV 3/3] END …C=10, gamma=scale, kernel=poly;, score=0.823 total time=   2.1s
[CV 1/3] END .C=10, gamma=scale, kernel=sigmoid;, score=0.735 total time=   1.1s
[CV 2/3] END .C=10, gamma=scale, kernel=sigmoid;, score=0.701 total time=   1.2s
[CV 3/3] END .C=10, gamma=scale, kernel=sigmoid;, score=0.690 total time=   1.5s
[CV 1/3] END …C=10, gamma=auto, kernel=rbf;, score=0.778 total time=   3.4s
```

```
[CV 2/3] END …C=10, gamma=auto, kernel=rbf;, score=0.752 total time=   2.9s
[CV 3/3] END …C=10, gamma=auto, kernel=rbf;, score=0.698 total time=   2.5s
[CV 1/3] END …C=10, gamma=auto, kernel=linear;, score=0.842 total time=   1.7s
[CV 2/3] END …C=10, gamma=auto, kernel=linear;, score=0.796 total time=   1.8s
[CV 3/3] END …C=10, gamma=auto, kernel=linear;, score=0.792 total time=   2.0s
[CV 1/3] END …C=10, gamma=auto, kernel=poly;, score=0.076 total time=   3.4s
[CV 2/3] END …C=10, gamma=auto, kernel=poly;, score=0.076 total time=   3.0s
[CV 3/3] END …C=10, gamma=auto, kernel=poly;, score=0.076 total time=   3.0s
[CV 1/3] END ..C=10, gamma=auto, kernel=sigmoid;, score=0.677 total time=   2.0s
[CV 2/3] END ..C=10, gamma=auto, kernel=sigmoid;, score=0.685 total time=   2.1s
[CV 3/3] END ..C=10, gamma=auto, kernel=sigmoid;, score=0.637 total time=   2.0s
[CV 1/3] END …C=10, gamma=0.2, kernel=rbf;, score=0.426 total time=   4.2s
[CV 2/3] END …C=10, gamma=0.2, kernel=rbf;, score=0.477 total time=   4.9s
[CV 3/3] END …C=10, gamma=0.2, kernel=rbf;, score=0.410 total time=   4.6s
[CV 1/3] END …C=10, gamma=0.2, kernel=linear;, score=0.842 total time=   1.9s
[CV 2/3] END …C=10, gamma=0.2, kernel=linear;, score=0.796 total time=   1.8s
[CV 3/3] END …C=10, gamma=0.2, kernel=linear;, score=0.792 total time=   1.7s
[CV 1/3] END …C=10, gamma=0.2, kernel=poly;, score=0.883 total time=   2.7s
[CV 2/3] END …C=10, gamma=0.2, kernel=poly;, score=0.865 total time=   2.5s
[CV 3/3] END …C=10, gamma=0.2, kernel=poly;, score=0.823 total time=   2.4s
[CV 1/3] END …C=10, gamma=0.2, kernel=sigmoid;, score=0.263 total time=   3.3s
[CV 2/3] END …C=10, gamma=0.2, kernel=sigmoid;, score=0.321 total time=   2.9s
[CV 3/3] END …C=10, gamma=0.2, kernel=sigmoid;, score=0.312 total time=   3.2s
[CV 1/3] END …C=10, gamma=0.1, kernel=rbf;, score=0.826 total time=   3.5s
[CV 2/3] END …C=10, gamma=0.1, kernel=rbf;, score=0.793 total time=   3.5s
[CV 3/3] END …C=10, gamma=0.1, kernel=rbf;, score=0.752 total time=   3.4s
[CV 1/3] END …C=10, gamma=0.1, kernel=linear;, score=0.842 total time=   1.5s
[CV 2/3] END …C=10, gamma=0.1, kernel=linear;, score=0.796 total time=   1.4s
[CV 3/3] END …C=10, gamma=0.1, kernel=linear;, score=0.792 total time=   1.4s
[CV 1/3] END …C=10, gamma=0.1, kernel=poly;, score=0.883 total time=   2.1s
[CV 2/3] END …C=10, gamma=0.1, kernel=poly;, score=0.865 total time=   2.1s
[CV 3/3] END …C=10, gamma=0.1, kernel=poly;, score=0.823 total time=   2.0s
[CV 1/3] END …C=10, gamma=0.1, kernel=sigmoid;, score=0.464 total time=   1.4s
[CV 2/3] END …C=10, gamma=0.1, kernel=sigmoid;, score=0.508 total time=   1.6s
[CV 3/3] END …C=10, gamma=0.1, kernel=sigmoid;, score=0.440 total time=   1.5s
[CV 1/3] END …C=10, gamma=0.15, kernel=rbf;, score=0.686 total time=   3.4s
[CV 2/3] END …C=10, gamma=0.15, kernel=rbf;, score=0.668 total time=   3.6s
[CV 3/3] END …C=10, gamma=0.15, kernel=rbf;, score=0.619 total time=   3.6s
[CV 1/3] END …C=10, gamma=0.15, kernel=linear;, score=0.842 total time=   1.5s
[CV 2/3] END …C=10, gamma=0.15, kernel=linear;, score=0.796 total time=   1.4s
[CV 3/3] END …C=10, gamma=0.15, kernel=linear;, score=0.792 total time=   1.3s
[CV 1/3] END …C=10, gamma=0.15, kernel=poly;, score=0.883 total time=   2.0s
[CV 2/3] END …C=10, gamma=0.15, kernel=poly;, score=0.865 total time=   2.1s
[CV 3/3] END …C=10, gamma=0.15, kernel=poly;, score=0.823 total time=   2.0s
[CV 1/3] END ..C=10, gamma=0.15, kernel=sigmoid;, score=0.337 total time=   2.1s
[CV 2/3] END ..C=10, gamma=0.15, kernel=sigmoid;, score=0.375 total time=   2.3s
[CV 3/3] END ..C=10, gamma=0.15, kernel=sigmoid;, score=0.388 total time=   2.3s
```

```
GridSearchCV(cv=3, estimator=SVC(),
             param_grid={'C': [0.05, 0.001, 0.1, 1.0, 10],
                         'gamma': ['scale', 'auto', 0.2, 0.1, 0.15],
                         'kernel': ['rbf', 'linear', 'poly', 'sigmoid']},
             scoring='f1_macro', verbose=3)
```

```
best_svm = grid_search_svm.best_estimator_
# Get the best parameters and score
print("Best parameters:", grid_search_svm.best_params_)

y_pred_svm = best_svm.predict(test_features)

joblib.dump(best_svm, project_dir + '\joblib\\best_svm_model.joblib')
```

```
Best parameters: {'C': 0.05, 'gamma': 0.2, 'kernel': 'poly'}
```

```
['d:\\ASUS\\Deploy-Traffic-Sign-Classification-through-
Images\\joblib\\best_svm_model.joblib']
```

8 Predict on test images for KNN

```
report_knn = classification_report(test_labels_encoded, y_pred_knn,␣
  ↪target_names=label_encoder.classes_)
print(report_knn)
```

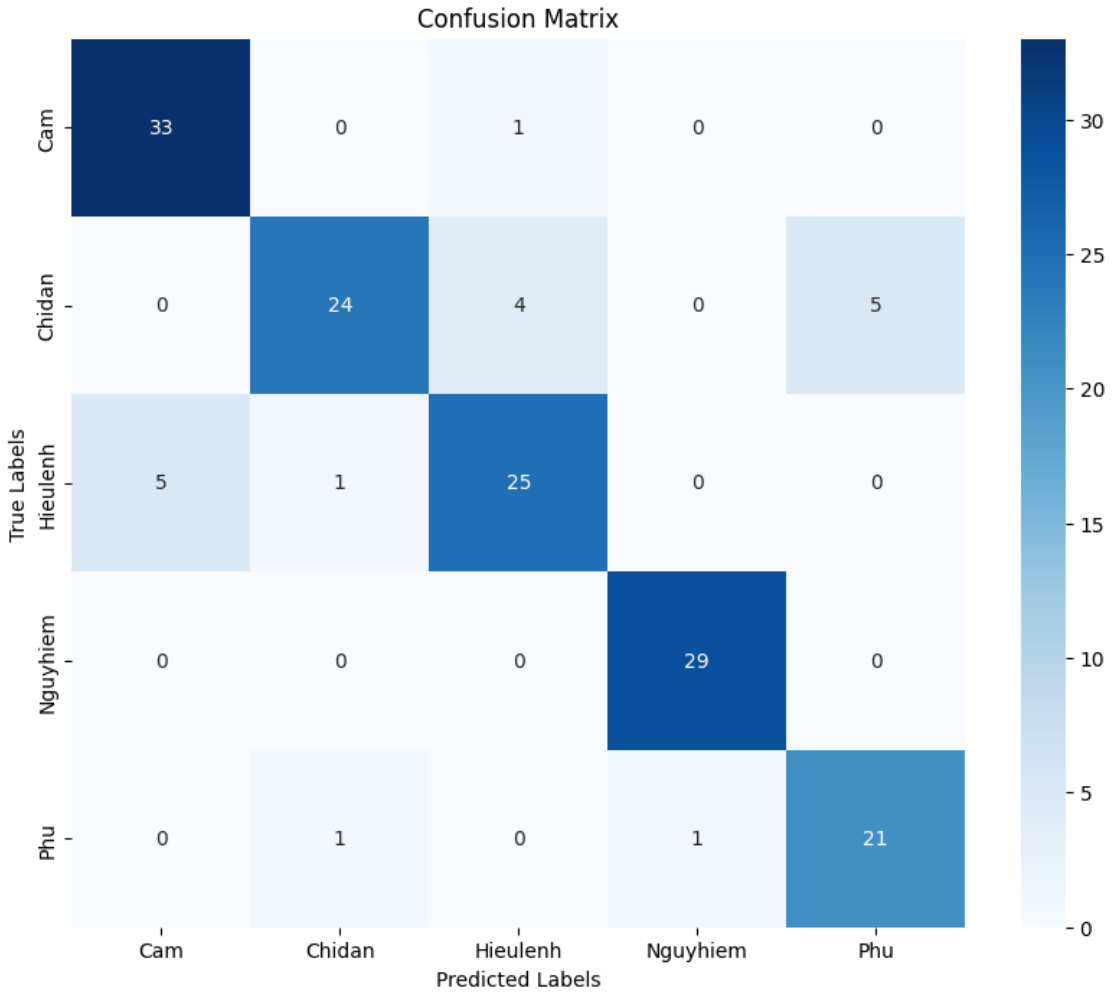
```
              precision    recall  f1-score   support

         Cam       0.87      0.97      0.92        34
      Chidan       0.92      0.73      0.81        33
    Hieulenh       0.83      0.81      0.82        31
    Nguyhiem       0.97      1.00      0.98        29
         Phu       0.81      0.91      0.86        23

    accuracy                           0.88       150
   macro avg       0.88      0.88      0.88       150
weighted avg       0.88      0.88      0.88       150
```

```
heatmap_label_knn = confusion_matrix(test_labels_encoded, y_pred_knn)

plt.figure(figsize=(10, 8))
sns.heatmap(heatmap_label_knn, annot=True, fmt='d', cmap='Blues',␣
  ↪xticklabels=label_encoder.classes_, yticklabels=label_encoder.classes_)
plt.title('Confusion Matrix')
plt.xlabel('Predicted Labels')
plt.ylabel('True Labels')
plt.show()
```




```
n_columns = 10
n_rows = math.ceil(len(test_images) / n_columns)

fig, axes = plt.subplots(n_rows, n_columns, figsize=(30, n_rows * 3))

for idx, (image, true_label, pred_label) in enumerate(zip(test_images,␣
 ↪test_labels_encoded, y_pred_knn)):
    row = idx // n_columns
    col = idx % n_columns

    axes[row, col].imshow(image)
    axes[row, col].set_title(f'True: {label_encoder.classes_[true_label]}\nPred:
 ↪ {label_encoder.classes_[pred_label]}')
    axes[row, col].axis('off')
```

```
for ax in axes.flat:
    if not ax.has_data():
        ax.axis('off')

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

9 Predict on test images for SVM

```
report_svm = classification_report(test_labels_encoded, y_pred_svm,␣
  ↪target_names=label_encoder.classes_)
print(report_svm)
```

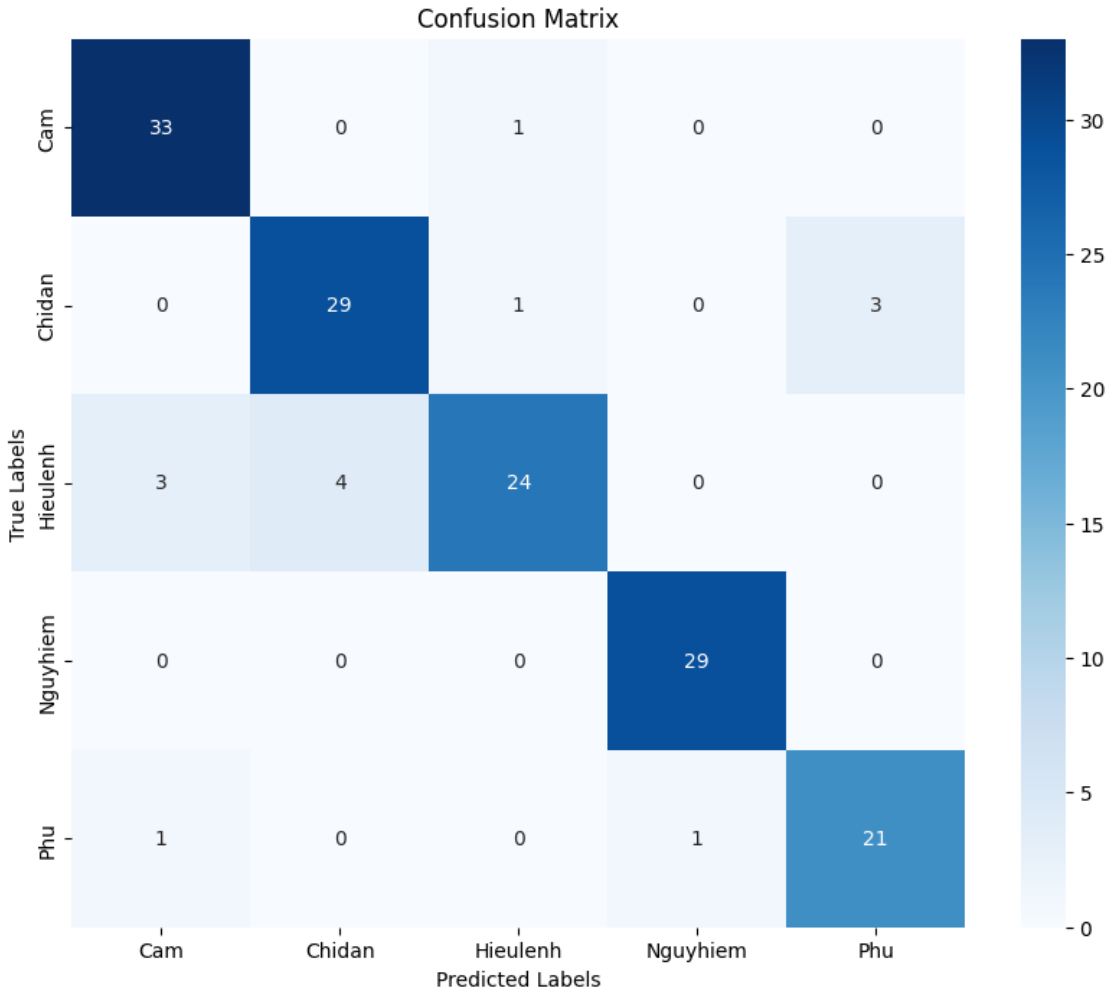
```
              precision    recall  f1-score   support

         Cam       0.89      0.97      0.93        34
      Chidan       0.88      0.88      0.88        33
    Hieulenh       0.92      0.77      0.84        31
    Nguyhiem       0.97      1.00      0.98        29
         Phu       0.88      0.91      0.89        23

    accuracy                           0.91       150
   macro avg       0.91      0.91      0.91       150
weighted avg       0.91      0.91      0.91       150
```

```
heatmap_label_svm = confusion_matrix(test_labels_encoded, y_pred_svm)

plt.figure(figsize=(10, 8))
sns.heatmap(heatmap_label_svm, annot=True, fmt='d', cmap='Blues',␣
  ↪xticklabels=label_encoder.classes_, yticklabels=label_encoder.classes_)
plt.title('Confusion Matrix')
plt.xlabel('Predicted Labels')
plt.ylabel('True Labels')
plt.show()
```




```
n_columns = 10
n_rows = math.ceil(len(test_images) / n_columns)

fig, axes = plt.subplots(n_rows, n_columns, figsize=(30, n_rows * 3))

for idx, (image, true_label, pred_label) in enumerate(zip(test_images,␣
 ↪test_labels_encoded, y_pred_svm)):
    row = idx // n_columns
    col = idx % n_columns

    axes[row, col].imshow(image)
    axes[row, col].set_title(f'True: {label_encoder.classes_[true_label]}\nPred:
 ↪ {label_encoder.classes_[pred_label]}')
    axes[row, col].axis('off')
```

```
for ax in axes.flat:
    if not ax.has_data():
        ax.axis('off')

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

10 Save grid search results

```
def export_notebook_to_pdf(notebook_path, project_dir):
    results_dir = os.path.join(project_dir)
    os.makedirs(results_dir, exist_ok=True)

    # Đọc notebook
    with open(notebook_path, 'r', encoding='utf-8') as f:
        nb = nbformat.read(f, as_version=4)

    # Cấu hình PDF exporter
    pdf_exporter = PDFExporter()
    pdf_exporter.exclude_input_prompt = True
    pdf_exporter.exclude_output_prompt = True

    # Thêm template và style cơ bản
    pdf_exporter.template_name = 'classic'

    # Chuyển đổi sang PDF
    pdf_data, resources = pdf_exporter.from_notebook_node(nb)

    # Tạo tên file với timestamp
    current_time = datetime.now().strftime('%Y-%m-%d_%H_%M_%S')
    pdf_file = os.path.join(results_dir, f"notebook_export_{current_time}.pdf")

    # Lưu file PDF
    with open(pdf_file, 'wb') as f:
        f.write(pdf_data)

    print(f"Đã xuất file PDF thành công: {pdf_file}")
    return pdf_file
```

```
# project_dir = os.path.dirname(project_dir)
notebook_path = project_dir + "\\model\\main.ipynb"
proj_dir = project_dir + "\\grid_search_results"

export_notebook_to_pdf(notebook_path, proj_dir)
```

```
Đã xuất file PDF thành công: d:\ASUS\Deploy-Traffic-Sign-Classification-through-Images\grid_search_results\notebook_export_2024-11-22_12_09_16.pdf
```

```
'd:\\ASUS\\Deploy-Traffic-Sign-Classification-through-
Images\\grid_search_results\\notebook_export_2024-11-22_12_09_16.pdf'
```