Notebook

December 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 GridSearchCV
from sklearn.metrics import classification_report, confusion_matrix
from scipy.spatial.distance import cityblock, cosine, sqeuclidean, euclidean
```

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)
```

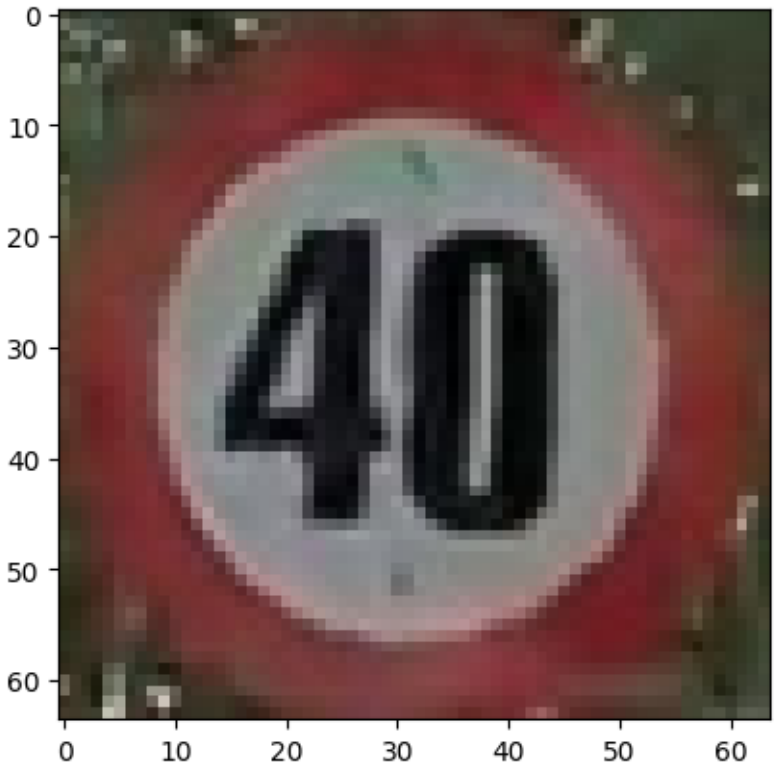
```
label_encoder = LabelEncoder()
train_labels_encoded = label_encoder.fit_transform(train_labels)
test_labels_encoded = label_encoder.transform(test_labels)
```

```
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')
```

```
['e:\\Documents\\CS231\\project_temp\\Traffic-Sign-Classification-through-
Images\\joblib\\label_encoder.joblib']
```

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

```
<matplotlib.image.AxesImage at 0x240499a08b0>
```




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

```
<matplotlib.image.AxesImage at 0x2405d4c27d0>
```

3 Extract features

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

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

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

```
def blur_image(image):
    blurred_image = cv2.GaussianBlur(image, (5,5), 0)
    return blurred_image
```

```
# plt.imshow(blur_image1(test_images[0]))
```

```
# plt.imshow(blur_image1(train_images[1]))
```

```
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 plot_color_histogram(image):

#     fig, axs = plt.subplots(2, 2, figsize=(12, 10))

#     num_pixels = image.shape[0] * image.shape[1]

#     color = ("r", "g", "b")
#     for k, clr in enumerate(color):
#         histogram = np.squeeze(cv2.calcHist([image], [k], None, [256], [0,␣
 ↪256]))
#         histogram = histogram / num_pixels
#         axs[0, 0].plot(histogram, color=clr)
#         axs[0, 0].set_xlim(0, 256)
#     axs[0, 0].set_title('Histogram tổng quát RGB')

#     titles = ['Red Channel', 'Green Channel', 'Blue Channel']
#     positions = [(0, 1), (1, 0), (1, 1)]

#     for idx, (clr, title, pos) in enumerate(zip(color, titles, positions)):
#         histogram = np.squeeze(cv2.calcHist([image], [idx], None, [256], [0,␣
 ↪256]))
#         histogram = histogram / num_pixels
#         axs[pos].plot(histogram, color=clr)
#         axs[pos].set_xlim(0, 256)
#         axs[pos].set_title(f"{title}")

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

```
# plot_color_histogram(train_images[0])
```

```
def hog(image):
    # image = cv2.cvtColor(image, cv2.COLOR_RGB2LUV)
    hog_features = skimage_hog(image, orientations=18, pixels_per_cell=(8, 8),␣
 ↪cells_per_block=(4, 4), visualize=False, block_norm='L2-Hys',␣
 ↪transform_sqrt=True, channel_axis=2)
    return hog_features
```

```
# _, image1 = hog(blur_image(train_images[1]))
# plt.imshow(image1, cmap=plt.cm.gray)
```

```
# _, image2 = hog(blur_image1(train_images[1]))
# plt.imshow(image2, cmap=plt.cm.gray)
```

```
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%|      | 1416/1416 [00:00<00:00, 61355.96it/s]
Extracting Color Features: 100%|      | 1416/1416 [00:00<00:00,
32033.13it/s]
Extracting HOG Features: 100%|      | 1416/1416 [00:01<00:00, 779.80it/s]
Combining Features: 1416it [00:00, 30891.96it/s]

['e:\\Documents\\CS231\\project_temp\\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%|      | 149/149 [00:00<00:00, 49705.82it/s]
Extracting Color Features: 100%|      | 149/149 [00:00<00:00, 36126.44it/s]
Extracting HOG Features: 100%|      | 149/149 [00:00<00:00, 805.43it/s]
Combining Features: 149it [00:00, 24833.16it/s]

['e:\\Documents\\CS231\\project_temp\\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)
```

```
# print("Tham số của KNN Model:")
# print(knn_model.get_params())

# print("\nTham số của SVM Model:")
# print(svm_model.get_params())
```

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': [3, 4, 5, 6, 7, 10],
    'weights': ['uniform', 'distance'],
    'metric': [
        cityblock,
        euclidean,
        cosine,
        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 84 candidates, totalling 252 fits
[CV 1/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=3,
weights=uniform;, score=0.859 total time=   6.0s
[CV 2/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=3,
weights=uniform;, score=0.839 total time=   5.4s
[CV 3/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=3,
weights=uniform;, score=0.853 total time=   5.5s
[CV 1/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=3,
weights=distance;, score=0.859 total time=   5.6s
[CV 2/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=3,
weights=distance;, score=0.841 total time=   5.4s
[CV 3/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=3,
weights=distance;, score=0.864 total time=   5.4s
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weights=uniform;, score=0.821 total time=   5.5s
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weights=uniform;, score=0.826 total time=   5.4s
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weights=uniform;, score=0.833 total time=   5.4s
[CV 1/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=4,
weights=distance;, score=0.873 total time=   5.8s
[CV 2/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=4,
weights=distance;, score=0.861 total time=   5.5s
[CV 3/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=4,
weights=distance;, score=0.871 total time=   5.5s
[CV 1/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=5,
weights=uniform;, score=0.827 total time=   5.5s
[CV 2/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=5,
weights=uniform;, score=0.843 total time=   5.3s
[CV 3/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=5,
weights=uniform;, score=0.837 total time=   5.4s
[CV 1/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=5,
weights=distance;, score=0.842 total time=   5.3s
[CV 2/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=5,
```

```
weights=distance;, score=0.862 total time=   5.2s
[CV 3/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=5,
weights=distance;, score=0.855 total time=   5.3s
[CV 1/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=6,
weights=uniform;, score=0.807 total time=   5.2s
[CV 2/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=6,
weights=uniform;, score=0.830 total time=   5.3s
[CV 3/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=6,
weights=uniform;, score=0.817 total time=   5.3s
[CV 1/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=6,
weights=distance;, score=0.842 total time=   5.4s
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weights=distance;, score=0.856 total time=   5.4s
[CV 3/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=6,
weights=distance;, score=0.863 total time=   5.4s
[CV 1/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=7,
weights=uniform;, score=0.814 total time=   5.4s
[CV 2/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=7,
weights=uniform;, score=0.826 total time=   5.5s
[CV 3/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=7,
weights=uniform;, score=0.816 total time=   5.4s
[CV 1/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=7,
weights=distance;, score=0.838 total time=   5.3s
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weights=distance;, score=0.846 total time=   5.4s
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weights=distance;, score=0.843 total time=   5.5s
[CV 1/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=10,
weights=uniform;, score=0.805 total time=   5.3s
[CV 2/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=10,
weights=uniform;, score=0.790 total time=   5.4s
[CV 3/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=10,
weights=uniform;, score=0.774 total time=   5.3s
[CV 1/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=10,
weights=distance;, score=0.832 total time=   5.3s
[CV 2/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=10,
weights=distance;, score=0.821 total time=   5.4s
[CV 3/3] END metric=<function cityblock at 0x0000024038C1D750>, n_neighbors=10,
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weights=uniform;, score=0.855 total time=   6.7s
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weights=uniform;, score=0.829 total time=   6.7s
[CV 3/3] END metric=<function euclidean at 0x0000024038C1D2D0>, n_neighbors=3,
weights=uniform;, score=0.807 total time=   6.8s
[CV 1/3] END metric=<function euclidean at 0x0000024038C1D2D0>, n_neighbors=3,
weights=distance;, score=0.867 total time=   6.8s
[CV 2/3] END metric=<function euclidean at 0x0000024038C1D2D0>, n_neighbors=3,
```

```
weights=distance;, score=0.839 total time=   6.8s
[CV 3/3] END metric=<function euclidean at 0x0000024038C1D2D0>, n_neighbors=3,
weights=distance;, score=0.813 total time=   6.7s
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weights=uniform;, score=0.831 total time=   6.8s
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weights=uniform;, score=0.841 total time=   6.7s
[CV 3/3] END metric=<function euclidean at 0x0000024038C1D2D0>, n_neighbors=4,
weights=uniform;, score=0.788 total time=   6.7s
[CV 1/3] END metric=<function euclidean at 0x0000024038C1D2D0>, n_neighbors=4,
weights=distance;, score=0.863 total time=   6.7s
[CV 2/3] END metric=<function euclidean at 0x0000024038C1D2D0>, n_neighbors=4,
weights=distance;, score=0.851 total time=   6.7s
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weights=uniform;, score=0.837 total time=   6.7s
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weights=uniform;, score=0.810 total time=   6.7s
[CV 3/3] END metric=<function euclidean at 0x0000024038C1D2D0>, n_neighbors=5,
weights=uniform;, score=0.788 total time=   6.8s
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weights=uniform;, score=0.808 total time=   6.8s
[CV 2/3] END metric=<function euclidean at 0x0000024038C1D2D0>, n_neighbors=6,
weights=uniform;, score=0.790 total time=   6.9s
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[CV 1/3] END metric=<function euclidean at 0x0000024038C1D2D0>, n_neighbors=7,
weights=uniform;, score=0.814 total time=   6.8s
[CV 2/3] END metric=<function euclidean at 0x0000024038C1D2D0>, n_neighbors=7,
weights=uniform;, score=0.789 total time=   6.8s
[CV 3/3] END metric=<function euclidean at 0x0000024038C1D2D0>, n_neighbors=7,
weights=uniform;, score=0.774 total time=   6.7s
[CV 1/3] END metric=<function euclidean at 0x0000024038C1D2D0>, n_neighbors=7,
weights=distance;, score=0.826 total time=   6.7s
[CV 2/3] END metric=<function euclidean at 0x0000024038C1D2D0>, n_neighbors=7,
```

```
weights=distance;, score=0.801 total time=   6.7s
[CV 3/3] END metric=<function euclidean at 0x0000024038C1D2D0>, n_neighbors=7,
weights=distance;, score=0.791 total time=   6.7s
[CV 1/3] END metric=<function euclidean at 0x0000024038C1D2D0>, n_neighbors=10,
weights=uniform;, score=0.799 total time=   6.7s
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weights=uniform;, score=0.768 total time=   6.7s
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weights=distance;, score=0.821 total time=   6.7s
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weights=distance;, score=0.796 total time=   6.7s
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weights=distance;, score=0.760 total time=   6.7s
[CV 1/3] END metric=<function cosine at 0x0000024038C1D480>, n_neighbors=3,
weights=uniform;, score=0.859 total time=   8.0s
[CV 2/3] END metric=<function cosine at 0x0000024038C1D480>, n_neighbors=3,
weights=uniform;, score=0.834 total time=   8.0s
[CV 3/3] END metric=<function cosine at 0x0000024038C1D480>, n_neighbors=3,
weights=uniform;, score=0.809 total time=   8.0s
[CV 1/3] END metric=<function cosine at 0x0000024038C1D480>, n_neighbors=3,
weights=distance;, score=0.875 total time=   8.0s
[CV 2/3] END metric=<function cosine at 0x0000024038C1D480>, n_neighbors=3,
weights=distance;, score=0.841 total time=   8.0s
[CV 3/3] END metric=<function cosine at 0x0000024038C1D480>, n_neighbors=3,
weights=distance;, score=0.820 total time=   8.0s
[CV 1/3] END metric=<function cosine at 0x0000024038C1D480>, n_neighbors=4,
weights=uniform;, score=0.834 total time=   8.0s
[CV 2/3] END metric=<function cosine at 0x0000024038C1D480>, n_neighbors=4,
weights=uniform;, score=0.838 total time=   8.1s
[CV 3/3] END metric=<function cosine at 0x0000024038C1D480>, n_neighbors=4,
weights=uniform;, score=0.801 total time=   8.0s
[CV 1/3] END metric=<function cosine at 0x0000024038C1D480>, n_neighbors=4,
weights=distance;, score=0.867 total time=   8.0s
[CV 2/3] END metric=<function cosine at 0x0000024038C1D480>, n_neighbors=4,
weights=distance;, score=0.855 total time=   8.1s
[CV 3/3] END metric=<function cosine at 0x0000024038C1D480>, n_neighbors=4,
weights=distance;, score=0.824 total time=   8.2s
[CV 1/3] END metric=<function cosine at 0x0000024038C1D480>, n_neighbors=5,
weights=uniform;, score=0.843 total time=   7.9s
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weights=distance;, score=0.827 total time=   8.1s
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weights=uniform;, score=0.792 total time=   7.9s
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[CV 3/3] END metric=<function cosine at 0x0000024038C1D480>, n_neighbors=6,
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[CV 2/3] END metric=<function sqeuclidean at 0x0000024038C1D360>, n_neighbors=6,
weights=uniform;, score=0.790 total time=   5.2s
[CV 3/3] END metric=<function sqeuclidean at 0x0000024038C1D360>, n_neighbors=6,
weights=uniform;, score=0.776 total time=   5.4s
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[CV 3/3] END metric=<function sqeuclidean at 0x0000024038C1D360>, n_neighbors=7,
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weights=distance;, score=0.806 total time=   4.9s
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[CV 2/3] END metric=<function sqeuclidean at 0x0000024038C1D360>,
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[CV 3/3] END metric=<function sqeuclidean at 0x0000024038C1D360>,
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n_neighbors=3, weights=distance;, score=0.749 total time=   9.3s
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n_neighbors=4, weights=uniform;, score=0.697 total time=   9.2s
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n_neighbors=4, weights=distance;, score=0.765 total time=   9.3s
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n_neighbors=5, weights=uniform;, score=0.729 total time=   9.1s
[CV 2/3] END metric=<function chi_square_distance at 0x0000024076195E10>,
n_neighbors=5, weights=uniform;, score=0.712 total time=   9.1s
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n_neighbors=5, weights=distance;, score=0.763 total time=   9.1s
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n_neighbors=5, weights=distance;, score=0.726 total time=   9.6s
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n_neighbors=4, weights=uniform;, score=0.801 total time=   9.7s
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[CV 3/3] END metric=<function bhattacharyya_distance at 0x000002405D4A9FC0>,
n_neighbors=4, weights=distance;, score=0.790 total time=   9.5s
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n_neighbors=7, weights=distance;, score=0.773 total time=   9.3s
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[CV 2/3] END metric=<function bhattacharyya_distance at 0x000002405D4A9FC0>,
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n_neighbors=10, weights=distance;, score=0.800 total time=   9.4s
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[CV 2/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
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[CV 1/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=5, weights=uniform;, score=0.760 total time=   6.3s
[CV 2/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=5, weights=uniform;, score=0.756 total time=   6.2s
[CV 3/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=5, weights=uniform;, score=0.693 total time=   6.2s
[CV 1/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=5, weights=distance;, score=0.075 total time=   6.3s
[CV 2/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
```

```
n_neighbors=5, weights=distance;, score=0.075 total time=   6.4s
[CV 3/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=5, weights=distance;, score=0.075 total time=   6.3s
[CV 1/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=6, weights=uniform;, score=0.737 total time=   6.9s
[CV 2/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=6, weights=uniform;, score=0.745 total time=   6.9s
[CV 3/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=6, weights=uniform;, score=0.670 total time=   7.8s
[CV 1/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=6, weights=distance;, score=0.075 total time=   8.5s
[CV 2/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=6, weights=distance;, score=0.075 total time=   7.9s
[CV 3/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=6, weights=distance;, score=0.075 total time=   6.5s
[CV 1/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=7, weights=uniform;, score=0.736 total time=   6.5s
[CV 2/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=7, weights=uniform;, score=0.741 total time=   6.5s
[CV 3/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=7, weights=uniform;, score=0.676 total time=   6.4s
[CV 1/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=7, weights=distance;, score=0.075 total time=   6.3s
[CV 2/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=7, weights=distance;, score=0.075 total time=   6.3s
[CV 3/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=7, weights=distance;, score=0.075 total time=   6.2s
[CV 1/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=10, weights=uniform;, score=0.706 total time=   6.4s
[CV 2/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=10, weights=uniform;, score=0.700 total time=   7.2s
[CV 3/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=10, weights=uniform;, score=0.629 total time=   6.3s
[CV 1/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=10, weights=distance;, score=0.075 total time=   6.7s
[CV 2/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=10, weights=distance;, score=0.075 total time=   6.6s
[CV 3/3] END metric=<function intersection_distance at 0x000002405D4AA200>,
n_neighbors=10, weights=distance;, score=0.075 total time=   6.2s

GridSearchCV(cv=3, estimator=KNeighborsClassifier(),
             param_grid={'metric': [<function cityblock at 0x0000024038C1D750>,
                                    <function euclidean at 0x0000024038C1D2D0>,
                                    <function cosine at 0x0000024038C1D480>,
                                    <function sqeuclidean at
0x0000024038C1D360>,
                                    <function chi_square_distance at
```

```
0x0000024076195E10>,
                                    <function bhattacharyya_distance at
0x000002405D4A9FC0>,
                                    <function intersection_distance at
0x000002405D4AA200>],
                          'n_neighbors': [3, 4, 5, 6, 7, 10],
                          'weights': ['uniform', 'distance']},
             scoring='f1_macro', verbose=3)
```

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

print(f"Thuật toán sử dụng: {best_knn.algorithm}")

y_pred_knn = best_knn.predict(test_features)

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

```
Best Params: {'metric': <function cityblock at 0x0000024038C1D750>,
'n_neighbors': 4, 'weights': 'distance'}
Thuật toán sử dụng: auto
```

```
['e:\\Documents\\CS231\\project_temp\\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': [0.1, 0.2, 0.3, 0.4],
    'kernel': ['rbf', 'linear', 'poly', 'sigmoid'],
    'gamma': ['scale', 'auto', 0.1, 0.01, 0.001],
    '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 240 candidates, totalling 720 fits
[CV 1/3] END C=0.1, degree=2, gamma=scale, kernel=rbf;, score=0.514 total time=
4.2s
[CV 2/3] END C=0.1, degree=2, gamma=scale, kernel=rbf;, score=0.522 total time=
4.6s
[CV 3/3] END C=0.1, degree=2, gamma=scale, kernel=rbf;, score=0.539 total time=
4.2s
[CV 1/3] END C=0.1, degree=2, gamma=scale, kernel=linear;, score=0.860 total
time=   1.8s
[CV 2/3] END C=0.1, degree=2, gamma=scale, kernel=linear;, score=0.868 total
time=   2.0s
[CV 3/3] END C=0.1, degree=2, gamma=scale, kernel=linear;, score=0.841 total
time=   1.9s
[CV 1/3] END C=0.1, degree=2, gamma=scale, kernel=poly;, score=0.641 total time=
2.9s
[CV 2/3] END C=0.1, degree=2, gamma=scale, kernel=poly;, score=0.592 total time=
2.8s
[CV 3/3] END C=0.1, degree=2, gamma=scale, kernel=poly;, score=0.659 total time=
2.7s
[CV 1/3] END C=0.1, degree=2, gamma=scale, kernel=sigmoid;, score=0.551 total
time=   2.8s
[CV 2/3] END C=0.1, degree=2, gamma=scale, kernel=sigmoid;, score=0.535 total
time=   2.9s
[CV 3/3] END C=0.1, degree=2, gamma=scale, kernel=sigmoid;, score=0.538 total
time=   3.0s
[CV 1/3] END C=0.1, degree=2, gamma=auto, kernel=rbf;, score=0.075 total time=
5.1s
[CV 2/3] END C=0.1, degree=2, gamma=auto, kernel=rbf;, score=0.075 total time=
4.9s
[CV 3/3] END C=0.1, degree=2, gamma=auto, kernel=rbf;, score=0.075 total time=
5.0s
[CV 1/3] END C=0.1, degree=2, gamma=auto, kernel=linear;, score=0.860 total
time=   1.8s
[CV 2/3] END C=0.1, degree=2, gamma=auto, kernel=linear;, score=0.868 total
time=   1.8s
[CV 3/3] END C=0.1, degree=2, gamma=auto, kernel=linear;, score=0.841 total
time=   1.9s
[CV 1/3] END C=0.1, degree=2, gamma=auto, kernel=poly;, score=0.075 total time=
4.0s
[CV 2/3] END C=0.1, degree=2, gamma=auto, kernel=poly;, score=0.075 total time=
3.9s
[CV 3/3] END C=0.1, degree=2, gamma=auto, kernel=poly;, score=0.075 total time=
4.5s
[CV 1/3] END C=0.1, degree=2, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   3.9s
```

```
[CV 2/3] END C=0.1, degree=2, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.1s
[CV 3/3] END C=0.1, degree=2, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.1s
[CV 1/3] END C=0.1, degree=2, gamma=0.1, kernel=rbf;, score=0.451 total time=
4.5s
[CV 2/3] END C=0.1, degree=2, gamma=0.1, kernel=rbf;, score=0.466 total time=
4.6s
[CV 3/3] END C=0.1, degree=2, gamma=0.1, kernel=rbf;, score=0.448 total time=
4.5s
[CV 1/3] END C=0.1, degree=2, gamma=0.1, kernel=linear;, score=0.860 total time=
1.8s
[CV 2/3] END C=0.1, degree=2, gamma=0.1, kernel=linear;, score=0.868 total time=
2.1s
[CV 3/3] END C=0.1, degree=2, gamma=0.1, kernel=linear;, score=0.841 total time=
1.8s
[CV 1/3] END C=0.1, degree=2, gamma=0.1, kernel=poly;, score=0.850 total time=
2.5s
[CV 2/3] END C=0.1, degree=2, gamma=0.1, kernel=poly;, score=0.850 total time=
2.4s
[CV 3/3] END C=0.1, degree=2, gamma=0.1, kernel=poly;, score=0.787 total time=
2.4s
[CV 1/3] END C=0.1, degree=2, gamma=0.1, kernel=sigmoid;, score=0.508 total
time=   2.9s
[CV 2/3] END C=0.1, degree=2, gamma=0.1, kernel=sigmoid;, score=0.507 total
time=   2.9s
[CV 3/3] END C=0.1, degree=2, gamma=0.1, kernel=sigmoid;, score=0.517 total
time=   2.6s
[CV 1/3] END C=0.1, degree=2, gamma=0.01, kernel=rbf;, score=0.455 total time=
4.4s
[CV 2/3] END C=0.1, degree=2, gamma=0.01, kernel=rbf;, score=0.468 total time=
4.3s
[CV 3/3] END C=0.1, degree=2, gamma=0.01, kernel=rbf;, score=0.468 total time=
4.2s
[CV 1/3] END C=0.1, degree=2, gamma=0.01, kernel=linear;, score=0.860 total
time=   1.7s
[CV 2/3] END C=0.1, degree=2, gamma=0.01, kernel=linear;, score=0.868 total
time=   1.8s
[CV 3/3] END C=0.1, degree=2, gamma=0.01, kernel=linear;, score=0.841 total
time=   1.7s
[CV 1/3] END C=0.1, degree=2, gamma=0.01, kernel=poly;, score=0.075 total time=
4.0s
[CV 2/3] END C=0.1, degree=2, gamma=0.01, kernel=poly;, score=0.075 total time=
4.0s
[CV 3/3] END C=0.1, degree=2, gamma=0.01, kernel=poly;, score=0.075 total time=
3.9s
[CV 1/3] END C=0.1, degree=2, gamma=0.01, kernel=sigmoid;, score=0.455 total
time=   3.7s
```

```
[CV 2/3] END C=0.1, degree=2, gamma=0.01, kernel=sigmoid;, score=0.462 total
time=   3.9s
[CV 3/3] END C=0.1, degree=2, gamma=0.01, kernel=sigmoid;, score=0.461 total
time=   3.9s
[CV 1/3] END C=0.1, degree=2, gamma=0.001, kernel=rbf;, score=0.075 total time=
5.3s
[CV 2/3] END C=0.1, degree=2, gamma=0.001, kernel=rbf;, score=0.075 total time=
4.9s
[CV 3/3] END C=0.1, degree=2, gamma=0.001, kernel=rbf;, score=0.075 total time=
4.9s
[CV 1/3] END C=0.1, degree=2, gamma=0.001, kernel=linear;, score=0.860 total
time=   1.8s
[CV 2/3] END C=0.1, degree=2, gamma=0.001, kernel=linear;, score=0.868 total
time=   1.8s
[CV 3/3] END C=0.1, degree=2, gamma=0.001, kernel=linear;, score=0.841 total
time=   1.8s
[CV 1/3] END C=0.1, degree=2, gamma=0.001, kernel=poly;, score=0.075 total time=
3.9s
[CV 2/3] END C=0.1, degree=2, gamma=0.001, kernel=poly;, score=0.075 total time=
3.9s
[CV 3/3] END C=0.1, degree=2, gamma=0.001, kernel=poly;, score=0.075 total time=
3.9s
[CV 1/3] END C=0.1, degree=2, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   4.0s
[CV 2/3] END C=0.1, degree=2, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   4.2s
[CV 3/3] END C=0.1, degree=2, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   4.2s
[CV 1/3] END C=0.1, degree=3, gamma=scale, kernel=rbf;, score=0.514 total time=
4.1s
[CV 2/3] END C=0.1, degree=3, gamma=scale, kernel=rbf;, score=0.522 total time=
4.1s
[CV 3/3] END C=0.1, degree=3, gamma=scale, kernel=rbf;, score=0.539 total time=
4.1s
[CV 1/3] END C=0.1, degree=3, gamma=scale, kernel=linear;, score=0.860 total
time=   1.8s
[CV 2/3] END C=0.1, degree=3, gamma=scale, kernel=linear;, score=0.868 total
time=   1.9s
[CV 3/3] END C=0.1, degree=3, gamma=scale, kernel=linear;, score=0.841 total
time=   1.8s
[CV 1/3] END C=0.1, degree=3, gamma=scale, kernel=poly;, score=0.648 total time=
3.1s
[CV 2/3] END C=0.1, degree=3, gamma=scale, kernel=poly;, score=0.611 total time=
3.1s
[CV 3/3] END C=0.1, degree=3, gamma=scale, kernel=poly;, score=0.672 total time=
3.2s
[CV 1/3] END C=0.1, degree=3, gamma=scale, kernel=sigmoid;, score=0.551 total
time=   2.9s
```

```
[CV 2/3] END C=0.1, degree=3, gamma=scale, kernel=sigmoid;, score=0.535 total
time=   2.8s
[CV 3/3] END C=0.1, degree=3, gamma=scale, kernel=sigmoid;, score=0.538 total
time=   2.8s
[CV 1/3] END C=0.1, degree=3, gamma=auto, kernel=rbf;, score=0.075 total time=
5.1s
[CV 2/3] END C=0.1, degree=3, gamma=auto, kernel=rbf;, score=0.075 total time=
4.9s
[CV 3/3] END C=0.1, degree=3, gamma=auto, kernel=rbf;, score=0.075 total time=
5.0s
[CV 1/3] END C=0.1, degree=3, gamma=auto, kernel=linear;, score=0.860 total
time=   1.7s
[CV 2/3] END C=0.1, degree=3, gamma=auto, kernel=linear;, score=0.868 total
time=   1.8s
[CV 3/3] END C=0.1, degree=3, gamma=auto, kernel=linear;, score=0.841 total
time=   1.8s
[CV 1/3] END C=0.1, degree=3, gamma=auto, kernel=poly;, score=0.075 total time=
4.1s
[CV 2/3] END C=0.1, degree=3, gamma=auto, kernel=poly;, score=0.075 total time=
4.1s
[CV 3/3] END C=0.1, degree=3, gamma=auto, kernel=poly;, score=0.075 total time=
4.2s
[CV 1/3] END C=0.1, degree=3, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.9s
[CV 2/3] END C=0.1, degree=3, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.6s
[CV 3/3] END C=0.1, degree=3, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.1s
[CV 1/3] END C=0.1, degree=3, gamma=0.1, kernel=rbf;, score=0.451 total time=
4.8s
[CV 2/3] END C=0.1, degree=3, gamma=0.1, kernel=rbf;, score=0.466 total time=
5.1s
[CV 3/3] END C=0.1, degree=3, gamma=0.1, kernel=rbf;, score=0.448 total time=
4.8s
[CV 1/3] END C=0.1, degree=3, gamma=0.1, kernel=linear;, score=0.860 total time=
1.9s
[CV 2/3] END C=0.1, degree=3, gamma=0.1, kernel=linear;, score=0.868 total time=
1.9s
[CV 3/3] END C=0.1, degree=3, gamma=0.1, kernel=linear;, score=0.841 total time=
1.9s
[CV 1/3] END C=0.1, degree=3, gamma=0.1, kernel=poly;, score=0.895 total time=
3.1s
[CV 2/3] END C=0.1, degree=3, gamma=0.1, kernel=poly;, score=0.890 total time=
3.4s
[CV 3/3] END C=0.1, degree=3, gamma=0.1, kernel=poly;, score=0.862 total time=
3.2s
[CV 1/3] END C=0.1, degree=3, gamma=0.1, kernel=sigmoid;, score=0.508 total
time=   3.0s
```

```
[CV 2/3] END C=0.1, degree=3, gamma=0.1, kernel=sigmoid;, score=0.507 total
time=   3.0s
[CV 3/3] END C=0.1, degree=3, gamma=0.1, kernel=sigmoid;, score=0.517 total
time=   3.0s
[CV 1/3] END C=0.1, degree=3, gamma=0.01, kernel=rbf;, score=0.455 total time=
4.5s
[CV 2/3] END C=0.1, degree=3, gamma=0.01, kernel=rbf;, score=0.468 total time=
4.9s
[CV 3/3] END C=0.1, degree=3, gamma=0.01, kernel=rbf;, score=0.468 total time=
5.7s
[CV 1/3] END C=0.1, degree=3, gamma=0.01, kernel=linear;, score=0.860 total
time=   2.1s
[CV 2/3] END C=0.1, degree=3, gamma=0.01, kernel=linear;, score=0.868 total
time=   2.4s
[CV 3/3] END C=0.1, degree=3, gamma=0.01, kernel=linear;, score=0.841 total
time=   2.0s
[CV 1/3] END C=0.1, degree=3, gamma=0.01, kernel=poly;, score=0.075 total time=
4.2s
[CV 2/3] END C=0.1, degree=3, gamma=0.01, kernel=poly;, score=0.075 total time=
4.1s
[CV 3/3] END C=0.1, degree=3, gamma=0.01, kernel=poly;, score=0.075 total time=
4.0s
[CV 1/3] END C=0.1, degree=3, gamma=0.01, kernel=sigmoid;, score=0.455 total
time=   4.0s
[CV 2/3] END C=0.1, degree=3, gamma=0.01, kernel=sigmoid;, score=0.462 total
time=   4.9s
[CV 3/3] END C=0.1, degree=3, gamma=0.01, kernel=sigmoid;, score=0.461 total
time=   5.4s
[CV 1/3] END C=0.1, degree=3, gamma=0.001, kernel=rbf;, score=0.075 total time=
7.3s
[CV 2/3] END C=0.1, degree=3, gamma=0.001, kernel=rbf;, score=0.075 total time=
7.3s
[CV 3/3] END C=0.1, degree=3, gamma=0.001, kernel=rbf;, score=0.075 total time=
6.6s
[CV 1/3] END C=0.1, degree=3, gamma=0.001, kernel=linear;, score=0.860 total
time=   2.2s
[CV 2/3] END C=0.1, degree=3, gamma=0.001, kernel=linear;, score=0.868 total
time=   2.2s
[CV 3/3] END C=0.1, degree=3, gamma=0.001, kernel=linear;, score=0.841 total
time=   2.1s
[CV 1/3] END C=0.1, degree=3, gamma=0.001, kernel=poly;, score=0.075 total time=
4.0s
[CV 2/3] END C=0.1, degree=3, gamma=0.001, kernel=poly;, score=0.075 total time=
3.8s
[CV 3/3] END C=0.1, degree=3, gamma=0.001, kernel=poly;, score=0.075 total time=
3.8s
[CV 1/3] END C=0.1, degree=3, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   3.8s
```

```
[CV 2/3] END C=0.1, degree=3, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   3.9s
[CV 3/3] END C=0.1, degree=3, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   3.8s
[CV 1/3] END C=0.1, degree=4, gamma=scale, kernel=rbf;, score=0.514 total time=
4.6s
[CV 2/3] END C=0.1, degree=4, gamma=scale, kernel=rbf;, score=0.522 total time=
4.7s
[CV 3/3] END C=0.1, degree=4, gamma=scale, kernel=rbf;, score=0.539 total time=
4.8s
[CV 1/3] END C=0.1, degree=4, gamma=scale, kernel=linear;, score=0.860 total
time=   2.0s
[CV 2/3] END C=0.1, degree=4, gamma=scale, kernel=linear;, score=0.868 total
time=   2.2s
[CV 3/3] END C=0.1, degree=4, gamma=scale, kernel=linear;, score=0.841 total
time=   2.0s
[CV 1/3] END C=0.1, degree=4, gamma=scale, kernel=poly;, score=0.652 total time=
3.6s
[CV 2/3] END C=0.1, degree=4, gamma=scale, kernel=poly;, score=0.607 total time=
3.7s
[CV 3/3] END C=0.1, degree=4, gamma=scale, kernel=poly;, score=0.619 total time=
3.8s
[CV 1/3] END C=0.1, degree=4, gamma=scale, kernel=sigmoid;, score=0.551 total
time=   3.2s
[CV 2/3] END C=0.1, degree=4, gamma=scale, kernel=sigmoid;, score=0.535 total
time=   3.3s
[CV 3/3] END C=0.1, degree=4, gamma=scale, kernel=sigmoid;, score=0.538 total
time=   3.2s
[CV 1/3] END C=0.1, degree=4, gamma=auto, kernel=rbf;, score=0.075 total time=
5.6s
[CV 2/3] END C=0.1, degree=4, gamma=auto, kernel=rbf;, score=0.075 total time=
5.8s
[CV 3/3] END C=0.1, degree=4, gamma=auto, kernel=rbf;, score=0.075 total time=
5.7s
[CV 1/3] END C=0.1, degree=4, gamma=auto, kernel=linear;, score=0.860 total
time=   2.1s
[CV 2/3] END C=0.1, degree=4, gamma=auto, kernel=linear;, score=0.868 total
time=   2.1s
[CV 3/3] END C=0.1, degree=4, gamma=auto, kernel=linear;, score=0.841 total
time=   2.1s
[CV 1/3] END C=0.1, degree=4, gamma=auto, kernel=poly;, score=0.075 total time=
4.5s
[CV 2/3] END C=0.1, degree=4, gamma=auto, kernel=poly;, score=0.075 total time=
4.4s
[CV 3/3] END C=0.1, degree=4, gamma=auto, kernel=poly;, score=0.075 total time=
4.4s
[CV 1/3] END C=0.1, degree=4, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.5s
```

```
[CV 2/3] END C=0.1, degree=4, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.6s
[CV 3/3] END C=0.1, degree=4, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.3s
[CV 1/3] END C=0.1, degree=4, gamma=0.1, kernel=rbf;, score=0.451 total time=
4.7s
[CV 2/3] END C=0.1, degree=4, gamma=0.1, kernel=rbf;, score=0.466 total time=
4.7s
[CV 3/3] END C=0.1, degree=4, gamma=0.1, kernel=rbf;, score=0.448 total time=
5.2s
[CV 1/3] END C=0.1, degree=4, gamma=0.1, kernel=linear;, score=0.860 total time=
2.1s
[CV 2/3] END C=0.1, degree=4, gamma=0.1, kernel=linear;, score=0.868 total time=
2.1s
[CV 3/3] END C=0.1, degree=4, gamma=0.1, kernel=linear;, score=0.841 total time=
2.0s
[CV 1/3] END C=0.1, degree=4, gamma=0.1, kernel=poly;, score=0.886 total time=
3.9s
[CV 2/3] END C=0.1, degree=4, gamma=0.1, kernel=poly;, score=0.875 total time=
3.9s
[CV 3/3] END C=0.1, degree=4, gamma=0.1, kernel=poly;, score=0.856 total time=
3.7s
[CV 1/3] END C=0.1, degree=4, gamma=0.1, kernel=sigmoid;, score=0.508 total
time=   2.8s
[CV 2/3] END C=0.1, degree=4, gamma=0.1, kernel=sigmoid;, score=0.507 total
time=   3.2s
[CV 3/3] END C=0.1, degree=4, gamma=0.1, kernel=sigmoid;, score=0.517 total
time=   3.1s
[CV 1/3] END C=0.1, degree=4, gamma=0.01, kernel=rbf;, score=0.455 total time=
4.8s
[CV 2/3] END C=0.1, degree=4, gamma=0.01, kernel=rbf;, score=0.468 total time=
4.8s
[CV 3/3] END C=0.1, degree=4, gamma=0.01, kernel=rbf;, score=0.468 total time=
4.7s
[CV 1/3] END C=0.1, degree=4, gamma=0.01, kernel=linear;, score=0.860 total
time=   2.0s
[CV 2/3] END C=0.1, degree=4, gamma=0.01, kernel=linear;, score=0.868 total
time=   2.1s
[CV 3/3] END C=0.1, degree=4, gamma=0.01, kernel=linear;, score=0.841 total
time=   2.0s
[CV 1/3] END C=0.1, degree=4, gamma=0.01, kernel=poly;, score=0.075 total time=
4.5s
[CV 2/3] END C=0.1, degree=4, gamma=0.01, kernel=poly;, score=0.075 total time=
4.5s
[CV 3/3] END C=0.1, degree=4, gamma=0.01, kernel=poly;, score=0.075 total time=
4.4s
[CV 1/3] END C=0.1, degree=4, gamma=0.01, kernel=sigmoid;, score=0.455 total
time=   4.1s
```

```
[CV 2/3] END C=0.1, degree=4, gamma=0.01, kernel=sigmoid;, score=0.462 total
time=   4.1s
[CV 3/3] END C=0.1, degree=4, gamma=0.01, kernel=sigmoid;, score=0.461 total
time=   4.0s
[CV 1/3] END C=0.1, degree=4, gamma=0.001, kernel=rbf;, score=0.075 total time=
5.5s
[CV 2/3] END C=0.1, degree=4, gamma=0.001, kernel=rbf;, score=0.075 total time=
5.6s
[CV 3/3] END C=0.1, degree=4, gamma=0.001, kernel=rbf;, score=0.075 total time=
5.6s
[CV 1/3] END C=0.1, degree=4, gamma=0.001, kernel=linear;, score=0.860 total
time=   2.1s
[CV 2/3] END C=0.1, degree=4, gamma=0.001, kernel=linear;, score=0.868 total
time=   2.1s
[CV 3/3] END C=0.1, degree=4, gamma=0.001, kernel=linear;, score=0.841 total
time=   2.1s
[CV 1/3] END C=0.1, degree=4, gamma=0.001, kernel=poly;, score=0.075 total time=
4.5s
[CV 2/3] END C=0.1, degree=4, gamma=0.001, kernel=poly;, score=0.075 total time=
4.5s
[CV 3/3] END C=0.1, degree=4, gamma=0.001, kernel=poly;, score=0.075 total time=
4.5s
[CV 1/3] END C=0.1, degree=4, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   4.4s
[CV 2/3] END C=0.1, degree=4, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   4.5s
[CV 3/3] END C=0.1, degree=4, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   4.5s
[CV 1/3] END C=0.2, degree=2, gamma=scale, kernel=rbf;, score=0.632 total time=
4.2s
[CV 2/3] END C=0.2, degree=2, gamma=scale, kernel=rbf;, score=0.590 total time=
4.3s
[CV 3/3] END C=0.2, degree=2, gamma=scale, kernel=rbf;, score=0.659 total time=
4.2s
[CV 1/3] END C=0.2, degree=2, gamma=scale, kernel=linear;, score=0.865 total
time=   2.1s
[CV 2/3] END C=0.2, degree=2, gamma=scale, kernel=linear;, score=0.852 total
time=   2.1s
[CV 3/3] END C=0.2, degree=2, gamma=scale, kernel=linear;, score=0.843 total
time=   2.0s
[CV 1/3] END C=0.2, degree=2, gamma=scale, kernel=poly;, score=0.780 total time=
2.9s
[CV 2/3] END C=0.2, degree=2, gamma=scale, kernel=poly;, score=0.783 total time=
3.0s
[CV 3/3] END C=0.2, degree=2, gamma=scale, kernel=poly;, score=0.736 total time=
2.9s
[CV 1/3] END C=0.2, degree=2, gamma=scale, kernel=sigmoid;, score=0.649 total
time=   2.8s
```

```
[CV 2/3] END C=0.2, degree=2, gamma=scale, kernel=sigmoid;, score=0.616 total
time=   3.1s
[CV 3/3] END C=0.2, degree=2, gamma=scale, kernel=sigmoid;, score=0.664 total
time=   3.5s
[CV 1/3] END C=0.2, degree=2, gamma=auto, kernel=rbf;, score=0.075 total time=
6.1s
[CV 2/3] END C=0.2, degree=2, gamma=auto, kernel=rbf;, score=0.075 total time=
5.6s
[CV 3/3] END C=0.2, degree=2, gamma=auto, kernel=rbf;, score=0.075 total time=
5.5s
[CV 1/3] END C=0.2, degree=2, gamma=auto, kernel=linear;, score=0.865 total
time=   2.0s
[CV 2/3] END C=0.2, degree=2, gamma=auto, kernel=linear;, score=0.852 total
time=   2.1s
[CV 3/3] END C=0.2, degree=2, gamma=auto, kernel=linear;, score=0.843 total
time=   2.2s
[CV 1/3] END C=0.2, degree=2, gamma=auto, kernel=poly;, score=0.075 total time=
5.5s
[CV 2/3] END C=0.2, degree=2, gamma=auto, kernel=poly;, score=0.075 total time=
5.7s
[CV 3/3] END C=0.2, degree=2, gamma=auto, kernel=poly;, score=0.075 total time=
4.5s
[CV 1/3] END C=0.2, degree=2, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.4s
[CV 2/3] END C=0.2, degree=2, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.4s
[CV 3/3] END C=0.2, degree=2, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.4s
[CV 1/3] END C=0.2, degree=2, gamma=0.1, kernel=rbf;, score=0.520 total time=
4.8s
[CV 2/3] END C=0.2, degree=2, gamma=0.1, kernel=rbf;, score=0.524 total time=
5.2s
[CV 3/3] END C=0.2, degree=2, gamma=0.1, kernel=rbf;, score=0.559 total time=
5.2s
[CV 1/3] END C=0.2, degree=2, gamma=0.1, kernel=linear;, score=0.865 total time=
2.1s
[CV 2/3] END C=0.2, degree=2, gamma=0.1, kernel=linear;, score=0.852 total time=
2.1s
[CV 3/3] END C=0.2, degree=2, gamma=0.1, kernel=linear;, score=0.843 total time=
2.0s
[CV 1/3] END C=0.2, degree=2, gamma=0.1, kernel=poly;, score=0.899 total time=
2.8s
[CV 2/3] END C=0.2, degree=2, gamma=0.1, kernel=poly;, score=0.882 total time=
2.9s
[CV 3/3] END C=0.2, degree=2, gamma=0.1, kernel=poly;, score=0.850 total time=
2.9s
[CV 1/3] END C=0.2, degree=2, gamma=0.1, kernel=sigmoid;, score=0.598 total
time=   2.3s
```

```
[CV 2/3] END C=0.2, degree=2, gamma=0.1, kernel=sigmoid;, score=0.608 total
time=   2.7s
[CV 3/3] END C=0.2, degree=2, gamma=0.1, kernel=sigmoid;, score=0.609 total
time=   2.7s
[CV 1/3] END C=0.2, degree=2, gamma=0.01, kernel=rbf;, score=0.561 total time=
4.3s
[CV 2/3] END C=0.2, degree=2, gamma=0.01, kernel=rbf;, score=0.545 total time=
4.3s
[CV 3/3] END C=0.2, degree=2, gamma=0.01, kernel=rbf;, score=0.545 total time=
4.3s
[CV 1/3] END C=0.2, degree=2, gamma=0.01, kernel=linear;, score=0.865 total
time=   2.0s
[CV 2/3] END C=0.2, degree=2, gamma=0.01, kernel=linear;, score=0.852 total
time=   2.0s
[CV 3/3] END C=0.2, degree=2, gamma=0.01, kernel=linear;, score=0.843 total
time=   2.0s
[CV 1/3] END C=0.2, degree=2, gamma=0.01, kernel=poly;, score=0.360 total time=
4.5s
[CV 2/3] END C=0.2, degree=2, gamma=0.01, kernel=poly;, score=0.248 total time=
4.7s
[CV 3/3] END C=0.2, degree=2, gamma=0.01, kernel=poly;, score=0.280 total time=
4.5s
[CV 1/3] END C=0.2, degree=2, gamma=0.01, kernel=sigmoid;, score=0.482 total
time=   3.7s
[CV 2/3] END C=0.2, degree=2, gamma=0.01, kernel=sigmoid;, score=0.486 total
time=   3.6s
[CV 3/3] END C=0.2, degree=2, gamma=0.01, kernel=sigmoid;, score=0.514 total
time=   3.8s
[CV 1/3] END C=0.2, degree=2, gamma=0.001, kernel=rbf;, score=0.332 total time=
7.2s
[CV 2/3] END C=0.2, degree=2, gamma=0.001, kernel=rbf;, score=0.243 total time=
6.6s
[CV 3/3] END C=0.2, degree=2, gamma=0.001, kernel=rbf;, score=0.238 total time=
7.2s
[CV 1/3] END C=0.2, degree=2, gamma=0.001, kernel=linear;, score=0.865 total
time=   2.0s
[CV 2/3] END C=0.2, degree=2, gamma=0.001, kernel=linear;, score=0.852 total
time=   1.9s
[CV 3/3] END C=0.2, degree=2, gamma=0.001, kernel=linear;, score=0.843 total
time=   2.1s
[CV 1/3] END C=0.2, degree=2, gamma=0.001, kernel=poly;, score=0.075 total time=
3.9s
[CV 2/3] END C=0.2, degree=2, gamma=0.001, kernel=poly;, score=0.075 total time=
3.8s
[CV 3/3] END C=0.2, degree=2, gamma=0.001, kernel=poly;, score=0.075 total time=
3.8s
[CV 1/3] END C=0.2, degree=2, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   3.9s
```

```
[CV 2/3] END C=0.2, degree=2, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   3.9s
[CV 3/3] END C=0.2, degree=2, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   3.9s
[CV 1/3] END C=0.2, degree=3, gamma=scale, kernel=rbf;, score=0.632 total time=
3.7s
[CV 2/3] END C=0.2, degree=3, gamma=scale, kernel=rbf;, score=0.590 total time=
3.8s
[CV 3/3] END C=0.2, degree=3, gamma=scale, kernel=rbf;, score=0.659 total time=
3.6s
[CV 1/3] END C=0.2, degree=3, gamma=scale, kernel=linear;, score=0.865 total
time=   1.7s
[CV 2/3] END C=0.2, degree=3, gamma=scale, kernel=linear;, score=0.852 total
time=   1.8s
[CV 3/3] END C=0.2, degree=3, gamma=scale, kernel=linear;, score=0.843 total
time=   1.9s
[CV 1/3] END C=0.2, degree=3, gamma=scale, kernel=poly;, score=0.793 total time=
2.8s
[CV 2/3] END C=0.2, degree=3, gamma=scale, kernel=poly;, score=0.795 total time=
2.8s
[CV 3/3] END C=0.2, degree=3, gamma=scale, kernel=poly;, score=0.762 total time=
2.7s
[CV 1/3] END C=0.2, degree=3, gamma=scale, kernel=sigmoid;, score=0.649 total
time=   2.4s
[CV 2/3] END C=0.2, degree=3, gamma=scale, kernel=sigmoid;, score=0.616 total
time=   2.4s
[CV 3/3] END C=0.2, degree=3, gamma=scale, kernel=sigmoid;, score=0.664 total
time=   2.4s
[CV 1/3] END C=0.2, degree=3, gamma=auto, kernel=rbf;, score=0.075 total time=
4.8s
[CV 2/3] END C=0.2, degree=3, gamma=auto, kernel=rbf;, score=0.075 total time=
4.9s
[CV 3/3] END C=0.2, degree=3, gamma=auto, kernel=rbf;, score=0.075 total time=
5.3s
[CV 1/3] END C=0.2, degree=3, gamma=auto, kernel=linear;, score=0.865 total
time=   2.0s
[CV 2/3] END C=0.2, degree=3, gamma=auto, kernel=linear;, score=0.852 total
time=   2.1s
[CV 3/3] END C=0.2, degree=3, gamma=auto, kernel=linear;, score=0.843 total
time=   2.0s
[CV 1/3] END C=0.2, degree=3, gamma=auto, kernel=poly;, score=0.075 total time=
4.5s
[CV 2/3] END C=0.2, degree=3, gamma=auto, kernel=poly;, score=0.075 total time=
4.8s
[CV 3/3] END C=0.2, degree=3, gamma=auto, kernel=poly;, score=0.075 total time=
4.3s
[CV 1/3] END C=0.2, degree=3, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.6s
```

```
[CV 2/3] END C=0.2, degree=3, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.5s
[CV 3/3] END C=0.2, degree=3, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.5s
[CV 1/3] END C=0.2, degree=3, gamma=0.1, kernel=rbf;, score=0.520 total time=
5.2s
[CV 2/3] END C=0.2, degree=3, gamma=0.1, kernel=rbf;, score=0.524 total time=
6.0s
[CV 3/3] END C=0.2, degree=3, gamma=0.1, kernel=rbf;, score=0.559 total time=
5.1s
[CV 1/3] END C=0.2, degree=3, gamma=0.1, kernel=linear;, score=0.865 total time=
2.3s
[CV 2/3] END C=0.2, degree=3, gamma=0.1, kernel=linear;, score=0.852 total time=
2.1s
[CV 3/3] END C=0.2, degree=3, gamma=0.1, kernel=linear;, score=0.843 total time=
2.0s
[CV 1/3] END C=0.2, degree=3, gamma=0.1, kernel=poly;, score=0.901 total time=
3.4s
[CV 2/3] END C=0.2, degree=3, gamma=0.1, kernel=poly;, score=0.893 total time=
3.6s
[CV 3/3] END C=0.2, degree=3, gamma=0.1, kernel=poly;, score=0.862 total time=
3.5s
[CV 1/3] END C=0.2, degree=3, gamma=0.1, kernel=sigmoid;, score=0.598 total
time=   2.7s
[CV 2/3] END C=0.2, degree=3, gamma=0.1, kernel=sigmoid;, score=0.608 total
time=   2.9s
[CV 3/3] END C=0.2, degree=3, gamma=0.1, kernel=sigmoid;, score=0.609 total
time=   2.8s
[CV 1/3] END C=0.2, degree=3, gamma=0.01, kernel=rbf;, score=0.561 total time=
4.3s
[CV 2/3] END C=0.2, degree=3, gamma=0.01, kernel=rbf;, score=0.545 total time=
4.5s
[CV 3/3] END C=0.2, degree=3, gamma=0.01, kernel=rbf;, score=0.545 total time=
4.3s
[CV 1/3] END C=0.2, degree=3, gamma=0.01, kernel=linear;, score=0.865 total
time=   2.0s
[CV 2/3] END C=0.2, degree=3, gamma=0.01, kernel=linear;, score=0.852 total
time=   2.2s
[CV 3/3] END C=0.2, degree=3, gamma=0.01, kernel=linear;, score=0.843 total
time=   2.0s
[CV 1/3] END C=0.2, degree=3, gamma=0.01, kernel=poly;, score=0.075 total time=
4.5s
[CV 2/3] END C=0.2, degree=3, gamma=0.01, kernel=poly;, score=0.075 total time=
4.6s
[CV 3/3] END C=0.2, degree=3, gamma=0.01, kernel=poly;, score=0.075 total time=
4.5s
[CV 1/3] END C=0.2, degree=3, gamma=0.01, kernel=sigmoid;, score=0.482 total
time=   3.6s
```

```
[CV 2/3] END C=0.2, degree=3, gamma=0.01, kernel=sigmoid;, score=0.486 total
time=   3.8s
[CV 3/3] END C=0.2, degree=3, gamma=0.01, kernel=sigmoid;, score=0.514 total
time=   3.5s
[CV 1/3] END C=0.2, degree=3, gamma=0.001, kernel=rbf;, score=0.332 total time=
5.7s
[CV 2/3] END C=0.2, degree=3, gamma=0.001, kernel=rbf;, score=0.243 total time=
5.5s
[CV 3/3] END C=0.2, degree=3, gamma=0.001, kernel=rbf;, score=0.238 total time=
5.6s
[CV 1/3] END C=0.2, degree=3, gamma=0.001, kernel=linear;, score=0.865 total
time=   2.0s
[CV 2/3] END C=0.2, degree=3, gamma=0.001, kernel=linear;, score=0.852 total
time=   2.2s
[CV 3/3] END C=0.2, degree=3, gamma=0.001, kernel=linear;, score=0.843 total
time=   2.0s
[CV 1/3] END C=0.2, degree=3, gamma=0.001, kernel=poly;, score=0.075 total time=
4.4s
[CV 2/3] END C=0.2, degree=3, gamma=0.001, kernel=poly;, score=0.075 total time=
4.5s
[CV 3/3] END C=0.2, degree=3, gamma=0.001, kernel=poly;, score=0.075 total time=
4.5s
[CV 1/3] END C=0.2, degree=3, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   4.4s
[CV 2/3] END C=0.2, degree=3, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   4.5s
[CV 3/3] END C=0.2, degree=3, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   4.6s
[CV 1/3] END C=0.2, degree=4, gamma=scale, kernel=rbf;, score=0.632 total time=
4.3s
[CV 2/3] END C=0.2, degree=4, gamma=scale, kernel=rbf;, score=0.590 total time=
4.3s
[CV 3/3] END C=0.2, degree=4, gamma=scale, kernel=rbf;, score=0.659 total time=
4.2s
[CV 1/3] END C=0.2, degree=4, gamma=scale, kernel=linear;, score=0.865 total
time=   2.1s
[CV 2/3] END C=0.2, degree=4, gamma=scale, kernel=linear;, score=0.852 total
time=   2.1s
[CV 3/3] END C=0.2, degree=4, gamma=scale, kernel=linear;, score=0.843 total
time=   2.0s
[CV 1/3] END C=0.2, degree=4, gamma=scale, kernel=poly;, score=0.810 total time=
3.8s
[CV 2/3] END C=0.2, degree=4, gamma=scale, kernel=poly;, score=0.795 total time=
3.7s
[CV 3/3] END C=0.2, degree=4, gamma=scale, kernel=poly;, score=0.774 total time=
3.8s
[CV 1/3] END C=0.2, degree=4, gamma=scale, kernel=sigmoid;, score=0.649 total
time=   2.8s
```

```
[CV 2/3] END C=0.2, degree=4, gamma=scale, kernel=sigmoid;, score=0.616 total
time=   2.8s
[CV 3/3] END C=0.2, degree=4, gamma=scale, kernel=sigmoid;, score=0.664 total
time=   2.8s
[CV 1/3] END C=0.2, degree=4, gamma=auto, kernel=rbf;, score=0.075 total time=
5.9s
[CV 2/3] END C=0.2, degree=4, gamma=auto, kernel=rbf;, score=0.075 total time=
6.1s
[CV 3/3] END C=0.2, degree=4, gamma=auto, kernel=rbf;, score=0.075 total time=
6.1s
[CV 1/3] END C=0.2, degree=4, gamma=auto, kernel=linear;, score=0.865 total
time=   1.8s
[CV 2/3] END C=0.2, degree=4, gamma=auto, kernel=linear;, score=0.852 total
time=   2.1s
[CV 3/3] END C=0.2, degree=4, gamma=auto, kernel=linear;, score=0.843 total
time=   2.1s
[CV 1/3] END C=0.2, degree=4, gamma=auto, kernel=poly;, score=0.075 total time=
4.2s
[CV 2/3] END C=0.2, degree=4, gamma=auto, kernel=poly;, score=0.075 total time=
4.4s
[CV 3/3] END C=0.2, degree=4, gamma=auto, kernel=poly;, score=0.075 total time=
4.3s
[CV 1/3] END C=0.2, degree=4, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.3s
[CV 2/3] END C=0.2, degree=4, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.4s
[CV 3/3] END C=0.2, degree=4, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.5s
[CV 1/3] END C=0.2, degree=4, gamma=0.1, kernel=rbf;, score=0.520 total time=
4.8s
[CV 2/3] END C=0.2, degree=4, gamma=0.1, kernel=rbf;, score=0.524 total time=
4.9s
[CV 3/3] END C=0.2, degree=4, gamma=0.1, kernel=rbf;, score=0.559 total time=
5.0s
[CV 1/3] END C=0.2, degree=4, gamma=0.1, kernel=linear;, score=0.865 total time=
2.1s
[CV 2/3] END C=0.2, degree=4, gamma=0.1, kernel=linear;, score=0.852 total time=
2.3s
[CV 3/3] END C=0.2, degree=4, gamma=0.1, kernel=linear;, score=0.843 total time=
2.5s
[CV 1/3] END C=0.2, degree=4, gamma=0.1, kernel=poly;, score=0.886 total time=
5.0s
[CV 2/3] END C=0.2, degree=4, gamma=0.1, kernel=poly;, score=0.875 total time=
4.4s
[CV 3/3] END C=0.2, degree=4, gamma=0.1, kernel=poly;, score=0.856 total time=
3.7s
[CV 1/3] END C=0.2, degree=4, gamma=0.1, kernel=sigmoid;, score=0.598 total
time=   2.6s
```

```
[CV 2/3] END C=0.2, degree=4, gamma=0.1, kernel=sigmoid;, score=0.608 total
time=   2.8s
[CV 3/3] END C=0.2, degree=4, gamma=0.1, kernel=sigmoid;, score=0.609 total
time=   2.7s
[CV 1/3] END C=0.2, degree=4, gamma=0.01, kernel=rbf;, score=0.561 total time=
4.3s
[CV 2/3] END C=0.2, degree=4, gamma=0.01, kernel=rbf;, score=0.545 total time=
4.3s
[CV 3/3] END C=0.2, degree=4, gamma=0.01, kernel=rbf;, score=0.545 total time=
4.2s
[CV 1/3] END C=0.2, degree=4, gamma=0.01, kernel=linear;, score=0.865 total
time=   1.9s
[CV 2/3] END C=0.2, degree=4, gamma=0.01, kernel=linear;, score=0.852 total
time=   2.0s
[CV 3/3] END C=0.2, degree=4, gamma=0.01, kernel=linear;, score=0.843 total
time=   1.7s
[CV 1/3] END C=0.2, degree=4, gamma=0.01, kernel=poly;, score=0.075 total time=
4.3s
[CV 2/3] END C=0.2, degree=4, gamma=0.01, kernel=poly;, score=0.075 total time=
4.4s
[CV 3/3] END C=0.2, degree=4, gamma=0.01, kernel=poly;, score=0.075 total time=
4.4s
[CV 1/3] END C=0.2, degree=4, gamma=0.01, kernel=sigmoid;, score=0.482 total
time=   3.5s
[CV 2/3] END C=0.2, degree=4, gamma=0.01, kernel=sigmoid;, score=0.486 total
time=   3.6s
[CV 3/3] END C=0.2, degree=4, gamma=0.01, kernel=sigmoid;, score=0.514 total
time=   3.4s
[CV 1/3] END C=0.2, degree=4, gamma=0.001, kernel=rbf;, score=0.332 total time=
5.5s
[CV 2/3] END C=0.2, degree=4, gamma=0.001, kernel=rbf;, score=0.243 total time=
5.5s
[CV 3/3] END C=0.2, degree=4, gamma=0.001, kernel=rbf;, score=0.238 total time=
5.5s
[CV 1/3] END C=0.2, degree=4, gamma=0.001, kernel=linear;, score=0.865 total
time=   1.9s
[CV 2/3] END C=0.2, degree=4, gamma=0.001, kernel=linear;, score=0.852 total
time=   2.0s
[CV 3/3] END C=0.2, degree=4, gamma=0.001, kernel=linear;, score=0.843 total
time=   1.8s
[CV 1/3] END C=0.2, degree=4, gamma=0.001, kernel=poly;, score=0.075 total time=
4.3s
[CV 2/3] END C=0.2, degree=4, gamma=0.001, kernel=poly;, score=0.075 total time=
4.2s
[CV 3/3] END C=0.2, degree=4, gamma=0.001, kernel=poly;, score=0.075 total time=
4.5s
[CV 1/3] END C=0.2, degree=4, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   4.3s
```

```
[CV 2/3] END C=0.2, degree=4, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   4.3s
[CV 3/3] END C=0.2, degree=4, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   4.3s
[CV 1/3] END C=0.3, degree=2, gamma=scale, kernel=rbf;, score=0.739 total time=
3.9s
[CV 2/3] END C=0.3, degree=2, gamma=scale, kernel=rbf;, score=0.744 total time=
4.2s
[CV 3/3] END C=0.3, degree=2, gamma=scale, kernel=rbf;, score=0.719 total time=
3.8s
[CV 1/3] END C=0.3, degree=2, gamma=scale, kernel=linear;, score=0.864 total
time=   2.1s
[CV 2/3] END C=0.3, degree=2, gamma=scale, kernel=linear;, score=0.844 total
time=   1.9s
[CV 3/3] END C=0.3, degree=2, gamma=scale, kernel=linear;, score=0.845 total
time=   2.1s
[CV 1/3] END C=0.3, degree=2, gamma=scale, kernel=poly;, score=0.803 total time=
2.9s
[CV 2/3] END C=0.3, degree=2, gamma=scale, kernel=poly;, score=0.822 total time=
2.8s
[CV 3/3] END C=0.3, degree=2, gamma=scale, kernel=poly;, score=0.759 total time=
2.7s
[CV 1/3] END C=0.3, degree=2, gamma=scale, kernel=sigmoid;, score=0.716 total
time=   2.5s
[CV 2/3] END C=0.3, degree=2, gamma=scale, kernel=sigmoid;, score=0.706 total
time=   2.7s
[CV 3/3] END C=0.3, degree=2, gamma=scale, kernel=sigmoid;, score=0.686 total
time=   2.5s
[CV 1/3] END C=0.3, degree=2, gamma=auto, kernel=rbf;, score=0.075 total time=
5.4s
[CV 2/3] END C=0.3, degree=2, gamma=auto, kernel=rbf;, score=0.075 total time=
5.4s
[CV 3/3] END C=0.3, degree=2, gamma=auto, kernel=rbf;, score=0.075 total time=
5.4s
[CV 1/3] END C=0.3, degree=2, gamma=auto, kernel=linear;, score=0.864 total
time=   2.0s
[CV 2/3] END C=0.3, degree=2, gamma=auto, kernel=linear;, score=0.844 total
time=   2.2s
[CV 3/3] END C=0.3, degree=2, gamma=auto, kernel=linear;, score=0.845 total
time=   2.1s
[CV 1/3] END C=0.3, degree=2, gamma=auto, kernel=poly;, score=0.075 total time=
4.5s
[CV 2/3] END C=0.3, degree=2, gamma=auto, kernel=poly;, score=0.075 total time=
4.3s
[CV 3/3] END C=0.3, degree=2, gamma=auto, kernel=poly;, score=0.075 total time=
4.3s
[CV 1/3] END C=0.3, degree=2, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.4s
```

```
[CV 2/3] END C=0.3, degree=2, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.3s
[CV 3/3] END C=0.3, degree=2, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.3s
[CV 1/3] END C=0.3, degree=2, gamma=0.1, kernel=rbf;, score=0.652 total time=
4.7s
[CV 2/3] END C=0.3, degree=2, gamma=0.1, kernel=rbf;, score=0.605 total time=
4.8s
[CV 3/3] END C=0.3, degree=2, gamma=0.1, kernel=rbf;, score=0.647 total time=
4.6s
[CV 1/3] END C=0.3, degree=2, gamma=0.1, kernel=linear;, score=0.864 total time=
1.9s
[CV 2/3] END C=0.3, degree=2, gamma=0.1, kernel=linear;, score=0.844 total time=
2.2s
[CV 3/3] END C=0.3, degree=2, gamma=0.1, kernel=linear;, score=0.845 total time=
2.2s
[CV 1/3] END C=0.3, degree=2, gamma=0.1, kernel=poly;, score=0.894 total time=
2.9s
[CV 2/3] END C=0.3, degree=2, gamma=0.1, kernel=poly;, score=0.891 total time=
3.0s
[CV 3/3] END C=0.3, degree=2, gamma=0.1, kernel=poly;, score=0.865 total time=
2.8s
[CV 1/3] END C=0.3, degree=2, gamma=0.1, kernel=sigmoid;, score=0.654 total
time=   2.5s
[CV 2/3] END C=0.3, degree=2, gamma=0.1, kernel=sigmoid;, score=0.641 total
time=   2.7s
[CV 3/3] END C=0.3, degree=2, gamma=0.1, kernel=sigmoid;, score=0.639 total
time=   2.4s
[CV 1/3] END C=0.3, degree=2, gamma=0.01, kernel=rbf;, score=0.569 total time=
3.9s
[CV 2/3] END C=0.3, degree=2, gamma=0.01, kernel=rbf;, score=0.551 total time=
4.0s
[CV 3/3] END C=0.3, degree=2, gamma=0.01, kernel=rbf;, score=0.583 total time=
3.9s
[CV 1/3] END C=0.3, degree=2, gamma=0.01, kernel=linear;, score=0.864 total
time=   2.0s
[CV 2/3] END C=0.3, degree=2, gamma=0.01, kernel=linear;, score=0.844 total
time=   2.0s
[CV 3/3] END C=0.3, degree=2, gamma=0.01, kernel=linear;, score=0.845 total
time=   2.1s
[CV 1/3] END C=0.3, degree=2, gamma=0.01, kernel=poly;, score=0.439 total time=
4.4s
[CV 2/3] END C=0.3, degree=2, gamma=0.01, kernel=poly;, score=0.454 total time=
4.3s
[CV 3/3] END C=0.3, degree=2, gamma=0.01, kernel=poly;, score=0.442 total time=
4.2s
[CV 1/3] END C=0.3, degree=2, gamma=0.01, kernel=sigmoid;, score=0.552 total
time=   3.2s
```

```
[CV 2/3] END C=0.3, degree=2, gamma=0.01, kernel=sigmoid;, score=0.539 total
time=   3.3s
[CV 3/3] END C=0.3, degree=2, gamma=0.01, kernel=sigmoid;, score=0.538 total
time=   3.2s
[CV 1/3] END C=0.3, degree=2, gamma=0.001, kernel=rbf;, score=0.442 total time=
5.6s
[CV 2/3] END C=0.3, degree=2, gamma=0.001, kernel=rbf;, score=0.457 total time=
5.4s
[CV 3/3] END C=0.3, degree=2, gamma=0.001, kernel=rbf;, score=0.457 total time=
5.4s
[CV 1/3] END C=0.3, degree=2, gamma=0.001, kernel=linear;, score=0.864 total
time=   2.0s
[CV 2/3] END C=0.3, degree=2, gamma=0.001, kernel=linear;, score=0.844 total
time=   2.0s
[CV 3/3] END C=0.3, degree=2, gamma=0.001, kernel=linear;, score=0.845 total
time=   2.0s
[CV 1/3] END C=0.3, degree=2, gamma=0.001, kernel=poly;, score=0.075 total time=
4.4s
[CV 2/3] END C=0.3, degree=2, gamma=0.001, kernel=poly;, score=0.075 total time=
4.3s
[CV 3/3] END C=0.3, degree=2, gamma=0.001, kernel=poly;, score=0.075 total time=
4.3s
[CV 1/3] END C=0.3, degree=2, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   4.3s
[CV 2/3] END C=0.3, degree=2, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   4.3s
[CV 3/3] END C=0.3, degree=2, gamma=0.001, kernel=sigmoid;, score=0.080 total
time=   4.4s
[CV 1/3] END C=0.3, degree=3, gamma=scale, kernel=rbf;, score=0.739 total time=
4.0s
[CV 2/3] END C=0.3, degree=3, gamma=scale, kernel=rbf;, score=0.744 total time=
4.0s
[CV 3/3] END C=0.3, degree=3, gamma=scale, kernel=rbf;, score=0.719 total time=
3.9s
[CV 1/3] END C=0.3, degree=3, gamma=scale, kernel=linear;, score=0.864 total
time=   2.1s
[CV 2/3] END C=0.3, degree=3, gamma=scale, kernel=linear;, score=0.844 total
time=   1.8s
[CV 3/3] END C=0.3, degree=3, gamma=scale, kernel=linear;, score=0.845 total
time=   2.1s
[CV 1/3] END C=0.3, degree=3, gamma=scale, kernel=poly;, score=0.835 total time=
3.4s
[CV 2/3] END C=0.3, degree=3, gamma=scale, kernel=poly;, score=0.838 total time=
3.2s
[CV 3/3] END C=0.3, degree=3, gamma=scale, kernel=poly;, score=0.803 total time=
3.1s
[CV 1/3] END C=0.3, degree=3, gamma=scale, kernel=sigmoid;, score=0.716 total
time=   2.5s
```

```
[CV 2/3] END C=0.3, degree=3, gamma=scale, kernel=sigmoid;, score=0.706 total
time=   2.6s
[CV 3/3] END C=0.3, degree=3, gamma=scale, kernel=sigmoid;, score=0.686 total
time=   2.5s
[CV 1/3] END C=0.3, degree=3, gamma=auto, kernel=rbf;, score=0.075 total time=
5.4s
[CV 2/3] END C=0.3, degree=3, gamma=auto, kernel=rbf;, score=0.075 total time=
5.6s
[CV 3/3] END C=0.3, degree=3, gamma=auto, kernel=rbf;, score=0.075 total time=
5.4s
[CV 1/3] END C=0.3, degree=3, gamma=auto, kernel=linear;, score=0.864 total
time=   2.0s
[CV 2/3] END C=0.3, degree=3, gamma=auto, kernel=linear;, score=0.844 total
time=   2.0s
[CV 3/3] END C=0.3, degree=3, gamma=auto, kernel=linear;, score=0.845 total
time=   1.8s
[CV 1/3] END C=0.3, degree=3, gamma=auto, kernel=poly;, score=0.075 total time=
4.3s
[CV 2/3] END C=0.3, degree=3, gamma=auto, kernel=poly;, score=0.075 total time=
4.4s
[CV 3/3] END C=0.3, degree=3, gamma=auto, kernel=poly;, score=0.075 total time=
4.3s
[CV 1/3] END C=0.3, degree=3, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.3s
[CV 2/3] END C=0.3, degree=3, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.3s
[CV 3/3] END C=0.3, degree=3, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.3s
[CV 1/3] END C=0.3, degree=3, gamma=0.1, kernel=rbf;, score=0.652 total time=
4.7s
[CV 2/3] END C=0.3, degree=3, gamma=0.1, kernel=rbf;, score=0.605 total time=
4.7s
[CV 3/3] END C=0.3, degree=3, gamma=0.1, kernel=rbf;, score=0.647 total time=
4.6s
[CV 1/3] END C=0.3, degree=3, gamma=0.1, kernel=linear;, score=0.864 total time=
2.0s
[CV 2/3] END C=0.3, degree=3, gamma=0.1, kernel=linear;, score=0.844 total time=
2.0s
[CV 3/3] END C=0.3, degree=3, gamma=0.1, kernel=linear;, score=0.845 total time=
1.8s
[CV 1/3] END C=0.3, degree=3, gamma=0.1, kernel=poly;, score=0.901 total time=
4.0s
[CV 2/3] END C=0.3, degree=3, gamma=0.1, kernel=poly;, score=0.893 total time=
4.3s
[CV 3/3] END C=0.3, degree=3, gamma=0.1, kernel=poly;, score=0.862 total time=
3.5s
[CV 1/3] END C=0.3, degree=3, gamma=0.1, kernel=sigmoid;, score=0.654 total
time=   2.4s
```

```
[CV 2/3] END C=0.3, degree=3, gamma=0.1, kernel=sigmoid;, score=0.641 total
time=   2.6s
[CV 3/3] END C=0.3, degree=3, gamma=0.1, kernel=sigmoid;, score=0.639 total
time=   2.5s
[CV 1/3] END C=0.3, degree=3, gamma=0.01, kernel=rbf;, score=0.569 total time=
3.9s
[CV 2/3] END C=0.3, degree=3, gamma=0.01, kernel=rbf;, score=0.551 total time=
4.1s
[CV 3/3] END C=0.3, degree=3, gamma=0.01, kernel=rbf;, score=0.583 total time=
3.8s
[CV 1/3] END C=0.3, degree=3, gamma=0.01, kernel=linear;, score=0.864 total
time=   1.8s
[CV 2/3] END C=0.3, degree=3, gamma=0.01, kernel=linear;, score=0.844 total
time=   2.0s
[CV 3/3] END C=0.3, degree=3, gamma=0.01, kernel=linear;, score=0.845 total
time=   2.1s
[CV 1/3] END C=0.3, degree=3, gamma=0.01, kernel=poly;, score=0.075 total time=
4.5s
[CV 2/3] END C=0.3, degree=3, gamma=0.01, kernel=poly;, score=0.075 total time=
4.3s
[CV 3/3] END C=0.3, degree=3, gamma=0.01, kernel=poly;, score=0.075 total time=
4.7s
[CV 1/3] END C=0.3, degree=3, gamma=0.01, kernel=sigmoid;, score=0.552 total
time=   3.3s
[CV 2/3] END C=0.3, degree=3, gamma=0.01, kernel=sigmoid;, score=0.539 total
time=   3.3s
[CV 3/3] END C=0.3, degree=3, gamma=0.01, kernel=sigmoid;, score=0.538 total
time=   3.1s
[CV 1/3] END C=0.3, degree=3, gamma=0.001, kernel=rbf;, score=0.442 total time=
5.4s
[CV 2/3] END C=0.3, degree=3, gamma=0.001, kernel=rbf;, score=0.457 total time=
5.6s
[CV 3/3] END C=0.3, degree=3, gamma=0.001, kernel=rbf;, score=0.457 total time=
5.4s
[CV 1/3] END C=0.3, degree=3, gamma=0.001, kernel=linear;, score=0.864 total
time=   1.8s
[CV 2/3] END C=0.3, degree=3, gamma=0.001, kernel=linear;, score=0.844 total
time=   2.0s
[CV 3/3] END C=0.3, degree=3, gamma=0.001, kernel=linear;, score=0.845 total
time=   1.8s
[CV 1/3] END C=0.3, degree=3, gamma=0.001, kernel=poly;, score=0.075 total time=
4.3s
[CV 2/3] END C=0.3, degree=3, gamma=0.001, kernel=poly;, score=0.075 total time=
4.6s
[CV 3/3] END C=0.3, degree=3, gamma=0.001, kernel=poly;, score=0.075 total time=
4.5s
[CV 1/3] END C=0.3, degree=3, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   4.3s
```

```
[CV 2/3] END C=0.3, degree=3, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   4.3s
[CV 3/3] END C=0.3, degree=3, gamma=0.001, kernel=sigmoid;, score=0.080 total
time=   4.3s
[CV 1/3] END C=0.3, degree=4, gamma=scale, kernel=rbf;, score=0.739 total time=
3.9s
[CV 2/3] END C=0.3, degree=4, gamma=scale, kernel=rbf;, score=0.744 total time=
4.0s
[CV 3/3] END C=0.3, degree=4, gamma=scale, kernel=rbf;, score=0.719 total time=
4.0s
[CV 1/3] END C=0.3, degree=4, gamma=scale, kernel=linear;, score=0.864 total
time=   1.8s
[CV 2/3] END C=0.3, degree=4, gamma=scale, kernel=linear;, score=0.844 total
time=   2.1s
[CV 3/3] END C=0.3, degree=4, gamma=scale, kernel=linear;, score=0.845 total
time=   2.1s
[CV 1/3] END C=0.3, degree=4, gamma=scale, kernel=poly;, score=0.863 total time=
3.8s
[CV 2/3] END C=0.3, degree=4, gamma=scale, kernel=poly;, score=0.847 total time=
3.8s
[CV 3/3] END C=0.3, degree=4, gamma=scale, kernel=poly;, score=0.821 total time=
3.7s
[CV 1/3] END C=0.3, degree=4, gamma=scale, kernel=sigmoid;, score=0.716 total
time=   2.6s
[CV 2/3] END C=0.3, degree=4, gamma=scale, kernel=sigmoid;, score=0.706 total
time=   2.6s
[CV 3/3] END C=0.3, degree=4, gamma=scale, kernel=sigmoid;, score=0.686 total
time=   2.5s
[CV 1/3] END C=0.3, degree=4, gamma=auto, kernel=rbf;, score=0.075 total time=
5.5s
[CV 2/3] END C=0.3, degree=4, gamma=auto, kernel=rbf;, score=0.075 total time=
5.5s
[CV 3/3] END C=0.3, degree=4, gamma=auto, kernel=rbf;, score=0.075 total time=
5.5s
[CV 1/3] END C=0.3, degree=4, gamma=auto, kernel=linear;, score=0.864 total
time=   2.0s
[CV 2/3] END C=0.3, degree=4, gamma=auto, kernel=linear;, score=0.844 total
time=   2.0s
[CV 3/3] END C=0.3, degree=4, gamma=auto, kernel=linear;, score=0.845 total
time=   1.8s
[CV 1/3] END C=0.3, degree=4, gamma=auto, kernel=poly;, score=0.075 total time=
4.3s
[CV 2/3] END C=0.3, degree=4, gamma=auto, kernel=poly;, score=0.075 total time=
4.3s
[CV 3/3] END C=0.3, degree=4, gamma=auto, kernel=poly;, score=0.075 total time=
4.4s
[CV 1/3] END C=0.3, degree=4, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.3s
```

```
[CV 2/3] END C=0.3, degree=4, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.3s
[CV 3/3] END C=0.3, degree=4, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.3s
[CV 1/3] END C=0.3, degree=4, gamma=0.1, kernel=rbf;, score=0.652 total time=
4.6s
[CV 2/3] END C=0.3, degree=4, gamma=0.1, kernel=rbf;, score=0.605 total time=
4.7s
[CV 3/3] END C=0.3, degree=4, gamma=0.1, kernel=rbf;, score=0.647 total time=
4.7s
[CV 1/3] END C=0.3, degree=4, gamma=0.1, kernel=linear;, score=0.864 total time=
2.0s
[CV 2/3] END C=0.3, degree=4, gamma=0.1, kernel=linear;, score=0.844 total time=
2.1s
[CV 3/3] END C=0.3, degree=4, gamma=0.1, kernel=linear;, score=0.845 total time=
2.0s
[CV 1/3] END C=0.3, degree=4, gamma=0.1, kernel=poly;, score=0.886 total time=
3.8s
[CV 2/3] END C=0.3, degree=4, gamma=0.1, kernel=poly;, score=0.875 total time=
3.8s
[CV 3/3] END C=0.3, degree=4, gamma=0.1, kernel=poly;, score=0.856 total time=
3.8s
[CV 1/3] END C=0.3, degree=4, gamma=0.1, kernel=sigmoid;, score=0.654 total
time=   2.4s
[CV 2/3] END C=0.3, degree=4, gamma=0.1, kernel=sigmoid;, score=0.641 total
time=   2.5s
[CV 3/3] END C=0.3, degree=4, gamma=0.1, kernel=sigmoid;, score=0.639 total
time=   2.4s
[CV 1/3] END C=0.3, degree=4, gamma=0.01, kernel=rbf;, score=0.569 total time=
3.9s
[CV 2/3] END C=0.3, degree=4, gamma=0.01, kernel=rbf;, score=0.551 total time=
4.0s
[CV 3/3] END C=0.3, degree=4, gamma=0.01, kernel=rbf;, score=0.583 total time=
3.9s
[CV 1/3] END C=0.3, degree=4, gamma=0.01, kernel=linear;, score=0.864 total
time=   2.0s
[CV 2/3] END C=0.3, degree=4, gamma=0.01, kernel=linear;, score=0.844 total
time=   2.1s
[CV 3/3] END C=0.3, degree=4, gamma=0.01, kernel=linear;, score=0.845 total
time=   2.0s
[CV 1/3] END C=0.3, degree=4, gamma=0.01, kernel=poly;, score=0.075 total time=
4.3s
[CV 2/3] END C=0.3, degree=4, gamma=0.01, kernel=poly;, score=0.075 total time=
4.3s
[CV 3/3] END C=0.3, degree=4, gamma=0.01, kernel=poly;, score=0.075 total time=
4.4s
[CV 1/3] END C=0.3, degree=4, gamma=0.01, kernel=sigmoid;, score=0.552 total
time=   3.2s
```

```
[CV 2/3] END C=0.3, degree=4, gamma=0.01, kernel=sigmoid;, score=0.539 total
time=   3.4s
[CV 3/3] END C=0.3, degree=4, gamma=0.01, kernel=sigmoid;, score=0.538 total
time=   3.2s
[CV 1/3] END C=0.3, degree=4, gamma=0.001, kernel=rbf;, score=0.442 total time=
5.4s
[CV 2/3] END C=0.3, degree=4, gamma=0.001, kernel=rbf;, score=0.457 total time=
5.5s
[CV 3/3] END C=0.3, degree=4, gamma=0.001, kernel=rbf;, score=0.457 total time=
5.5s
[CV 1/3] END C=0.3, degree=4, gamma=0.001, kernel=linear;, score=0.864 total
time=   1.8s
[CV 2/3] END C=0.3, degree=4, gamma=0.001, kernel=linear;, score=0.844 total
time=   2.0s
[CV 3/3] END C=0.3, degree=4, gamma=0.001, kernel=linear;, score=0.845 total
time=   2.0s
[CV 1/3] END C=0.3, degree=4, gamma=0.001, kernel=poly;, score=0.075 total time=
4.5s
[CV 2/3] END C=0.3, degree=4, gamma=0.001, kernel=poly;, score=0.075 total time=
4.3s
[CV 3/3] END C=0.3, degree=4, gamma=0.001, kernel=poly;, score=0.075 total time=
4.3s
[CV 1/3] END C=0.3, degree=4, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   4.5s
[CV 2/3] END C=0.3, degree=4, gamma=0.001, kernel=sigmoid;, score=0.075 total
time=   4.3s
[CV 3/3] END C=0.3, degree=4, gamma=0.001, kernel=sigmoid;, score=0.080 total
time=   4.3s
[CV 1/3] END C=0.4, degree=2, gamma=scale, kernel=rbf;, score=0.776 total time=
3.9s
[CV 2/3] END C=0.4, degree=2, gamma=scale, kernel=rbf;, score=0.774 total time=
4.0s
[CV 3/3] END C=0.4, degree=2, gamma=scale, kernel=rbf;, score=0.745 total time=
3.9s
[CV 1/3] END C=0.4, degree=2, gamma=scale, kernel=linear;, score=0.862 total
time=   2.1s
[CV 2/3] END C=0.4, degree=2, gamma=scale, kernel=linear;, score=0.844 total
time=   1.8s
[CV 3/3] END C=0.4, degree=2, gamma=scale, kernel=linear;, score=0.845 total
time=   2.0s
[CV 1/3] END C=0.4, degree=2, gamma=scale, kernel=poly;, score=0.851 total time=
2.8s
[CV 2/3] END C=0.4, degree=2, gamma=scale, kernel=poly;, score=0.848 total time=
2.7s
[CV 3/3] END C=0.4, degree=2, gamma=scale, kernel=poly;, score=0.774 total time=
2.6s
[CV 1/3] END C=0.4, degree=2, gamma=scale, kernel=sigmoid;, score=0.726 total
time=   2.4s
```

```
[CV 2/3] END C=0.4, degree=2, gamma=scale, kernel=sigmoid;, score=0.731 total
time=   2.5s
[CV 3/3] END C=0.4, degree=2, gamma=scale, kernel=sigmoid;, score=0.707 total
time=   2.4s
[CV 1/3] END C=0.4, degree=2, gamma=auto, kernel=rbf;, score=0.075 total time=
5.6s
[CV 2/3] END C=0.4, degree=2, gamma=auto, kernel=rbf;, score=0.075 total time=
5.4s
[CV 3/3] END C=0.4, degree=2, gamma=auto, kernel=rbf;, score=0.075 total time=
5.4s
[CV 1/3] END C=0.4, degree=2, gamma=auto, kernel=linear;, score=0.862 total
time=   2.0s
[CV 2/3] END C=0.4, degree=2, gamma=auto, kernel=linear;, score=0.844 total
time=   1.8s
[CV 3/3] END C=0.4, degree=2, gamma=auto, kernel=linear;, score=0.845 total
time=   2.0s
[CV 1/3] END C=0.4, degree=2, gamma=auto, kernel=poly;, score=0.075 total time=
4.5s
[CV 2/3] END C=0.4, degree=2, gamma=auto, kernel=poly;, score=0.075 total time=
4.3s
[CV 3/3] END C=0.4, degree=2, gamma=auto, kernel=poly;, score=0.075 total time=
4.3s
[CV 1/3] END C=0.4, degree=2, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.3s
[CV 2/3] END C=0.4, degree=2, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.3s
[CV 3/3] END C=0.4, degree=2, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.3s
[CV 1/3] END C=0.4, degree=2, gamma=0.1, kernel=rbf;, score=0.719 total time=
4.0s
[CV 2/3] END C=0.4, degree=2, gamma=0.1, kernel=rbf;, score=0.728 total time=
4.2s
[CV 3/3] END C=0.4, degree=2, gamma=0.1, kernel=rbf;, score=0.727 total time=
4.0s
[CV 1/3] END C=0.4, degree=2, gamma=0.1, kernel=linear;, score=0.862 total time=
1.6s
[CV 2/3] END C=0.4, degree=2, gamma=0.1, kernel=linear;, score=0.844 total time=
1.6s
[CV 3/3] END C=0.4, degree=2, gamma=0.1, kernel=linear;, score=0.845 total time=
1.6s
[CV 1/3] END C=0.4, degree=2, gamma=0.1, kernel=poly;, score=0.896 total time=
2.5s
[CV 2/3] END C=0.4, degree=2, gamma=0.1, kernel=poly;, score=0.888 total time=
2.4s
[CV 3/3] END C=0.4, degree=2, gamma=0.1, kernel=poly;, score=0.872 total time=
2.3s
[CV 1/3] END C=0.4, degree=2, gamma=0.1, kernel=sigmoid;, score=0.672 total
time=   2.1s
```

```
[CV 2/3] END C=0.4, degree=2, gamma=0.1, kernel=sigmoid;, score=0.684 total
time=   2.0s
[CV 3/3] END C=0.4, degree=2, gamma=0.1, kernel=sigmoid;, score=0.659 total
time=   2.0s
[CV 1/3] END C=0.4, degree=2, gamma=0.01, kernel=rbf;, score=0.633 total time=
3.4s
[CV 2/3] END C=0.4, degree=2, gamma=0.01, kernel=rbf;, score=0.590 total time=
3.3s
[CV 3/3] END C=0.4, degree=2, gamma=0.01, kernel=rbf;, score=0.659 total time=
3.2s
[CV 1/3] END C=0.4, degree=2, gamma=0.01, kernel=linear;, score=0.862 total
time=   1.6s
[CV 2/3] END C=0.4, degree=2, gamma=0.01, kernel=linear;, score=0.844 total
time=   1.7s
[CV 3/3] END C=0.4, degree=2, gamma=0.01, kernel=linear;, score=0.845 total
time=   1.6s
[CV 1/3] END C=0.4, degree=2, gamma=0.01, kernel=poly;, score=0.446 total time=
3.6s
[CV 2/3] END C=0.4, degree=2, gamma=0.01, kernel=poly;, score=0.463 total time=
3.6s
[CV 3/3] END C=0.4, degree=2, gamma=0.01, kernel=poly;, score=0.451 total time=
3.5s
[CV 1/3] END C=0.4, degree=2, gamma=0.01, kernel=sigmoid;, score=0.563 total
time=   2.6s
[CV 2/3] END C=0.4, degree=2, gamma=0.01, kernel=sigmoid;, score=0.550 total
time=   2.6s
[CV 3/3] END C=0.4, degree=2, gamma=0.01, kernel=sigmoid;, score=0.555 total
time=   2.6s
[CV 1/3] END C=0.4, degree=2, gamma=0.001, kernel=rbf;, score=0.452 total time=
4.6s
[CV 2/3] END C=0.4, degree=2, gamma=0.001, kernel=rbf;, score=0.462 total time=
4.7s
[CV 3/3] END C=0.4, degree=2, gamma=0.001, kernel=rbf;, score=0.461 total time=
4.6s
[CV 1/3] END C=0.4, degree=2, gamma=0.001, kernel=linear;, score=0.862 total
time=   1.6s
[CV 2/3] END C=0.4, degree=2, gamma=0.001, kernel=linear;, score=0.844 total
time=   1.6s
[CV 3/3] END C=0.4, degree=2, gamma=0.001, kernel=linear;, score=0.845 total
time=   1.7s
[CV 1/3] END C=0.4, degree=2, gamma=0.001, kernel=poly;, score=0.075 total time=
3.7s
[CV 2/3] END C=0.4, degree=2, gamma=0.001, kernel=poly;, score=0.075 total time=
3.7s
[CV 3/3] END C=0.4, degree=2, gamma=0.001, kernel=poly;, score=0.075 total time=
3.7s
[CV 1/3] END C=0.4, degree=2, gamma=0.001, kernel=sigmoid;, score=0.350 total
time=   3.7s
```

```
[CV 2/3] END C=0.4, degree=2, gamma=0.001, kernel=sigmoid;, score=0.255 total
time=   3.7s
[CV 3/3] END C=0.4, degree=2, gamma=0.001, kernel=sigmoid;, score=0.289 total
time=   3.7s
[CV 1/3] END C=0.4, degree=3, gamma=scale, kernel=rbf;, score=0.776 total time=
3.4s
[CV 2/3] END C=0.4, degree=3, gamma=scale, kernel=rbf;, score=0.774 total time=
3.4s
[CV 3/3] END C=0.4, degree=3, gamma=scale, kernel=rbf;, score=0.745 total time=
3.3s
[CV 1/3] END C=0.4, degree=3, gamma=scale, kernel=linear;, score=0.862 total
time=   1.7s
[CV 2/3] END C=0.4, degree=3, gamma=scale, kernel=linear;, score=0.844 total
time=   1.6s
[CV 3/3] END C=0.4, degree=3, gamma=scale, kernel=linear;, score=0.845 total
time=   1.7s
[CV 1/3] END C=0.4, degree=3, gamma=scale, kernel=poly;, score=0.868 total time=
2.9s
[CV 2/3] END C=0.4, degree=3, gamma=scale, kernel=poly;, score=0.876 total time=
2.8s
[CV 3/3] END C=0.4, degree=3, gamma=scale, kernel=poly;, score=0.833 total time=
2.7s
[CV 1/3] END C=0.4, degree=3, gamma=scale, kernel=sigmoid;, score=0.726 total
time=   2.0s
[CV 2/3] END C=0.4, degree=3, gamma=scale, kernel=sigmoid;, score=0.731 total
time=   1.9s
[CV 3/3] END C=0.4, degree=3, gamma=scale, kernel=sigmoid;, score=0.707 total
time=   2.0s
[CV 1/3] END C=0.4, degree=3, gamma=auto, kernel=rbf;, score=0.075 total time=
5.2s
[CV 2/3] END C=0.4, degree=3, gamma=auto, kernel=rbf;, score=0.075 total time=
5.6s
[CV 3/3] END C=0.4, degree=3, gamma=auto, kernel=rbf;, score=0.075 total time=
5.5s
[CV 1/3] END C=0.4, degree=3, gamma=auto, kernel=linear;, score=0.862 total
time=   2.1s
[CV 2/3] END C=0.4, degree=3, gamma=auto, kernel=linear;, score=0.844 total
time=   2.0s
[CV 3/3] END C=0.4, degree=3, gamma=auto, kernel=linear;, score=0.845 total
time=   2.0s
[CV 1/3] END C=0.4, degree=3, gamma=auto, kernel=poly;, score=0.075 total time=
4.4s
[CV 2/3] END C=0.4, degree=3, gamma=auto, kernel=poly;, score=0.075 total time=
4.3s
[CV 3/3] END C=0.4, degree=3, gamma=auto, kernel=poly;, score=0.075 total time=
4.3s
[CV 1/3] END C=0.4, degree=3, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.3s
```

```
[CV 2/3] END C=0.4, degree=3, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.3s
[CV 3/3] END C=0.4, degree=3, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.5s
[CV 1/3] END C=0.4, degree=3, gamma=0.1, kernel=rbf;, score=0.719 total time=
4.5s
[CV 2/3] END C=0.4, degree=3, gamma=0.1, kernel=rbf;, score=0.728 total time=
4.7s
[CV 3/3] END C=0.4, degree=3, gamma=0.1, kernel=rbf;, score=0.727 total time=
4.6s
[CV 1/3] END C=0.4, degree=3, gamma=0.1, kernel=linear;, score=0.862 total time=
2.0s
[CV 2/3] END C=0.4, degree=3, gamma=0.1, kernel=linear;, score=0.844 total time=
2.0s
[CV 3/3] END C=0.4, degree=3, gamma=0.1, kernel=linear;, score=0.845 total time=
1.8s
[CV 1/3] END C=0.4, degree=3, gamma=0.1, kernel=poly;, score=0.901 total time=
3.2s
[CV 2/3] END C=0.4, degree=3, gamma=0.1, kernel=poly;, score=0.893 total time=
3.6s
[CV 3/3] END C=0.4, degree=3, gamma=0.1, kernel=poly;, score=0.862 total time=
3.3s
[CV 1/3] END C=0.4, degree=3, gamma=0.1, kernel=sigmoid;, score=0.672 total
time=   2.4s
[CV 2/3] END C=0.4, degree=3, gamma=0.1, kernel=sigmoid;, score=0.684 total
time=   2.5s
[CV 3/3] END C=0.4, degree=3, gamma=0.1, kernel=sigmoid;, score=0.659 total
time=   2.4s
[CV 1/3] END C=0.4, degree=3, gamma=0.01, kernel=rbf;, score=0.633 total time=
3.8s
[CV 2/3] END C=0.4, degree=3, gamma=0.01, kernel=rbf;, score=0.590 total time=
3.8s
[CV 3/3] END C=0.4, degree=3, gamma=0.01, kernel=rbf;, score=0.659 total time=
3.7s
[CV 1/3] END C=0.4, degree=3, gamma=0.01, kernel=linear;, score=0.862 total
time=   2.1s
[CV 2/3] END C=0.4, degree=3, gamma=0.01, kernel=linear;, score=0.844 total
time=   1.9s
[CV 3/3] END C=0.4, degree=3, gamma=0.01, kernel=linear;, score=0.845 total
time=   2.0s
[CV 1/3] END C=0.4, degree=3, gamma=0.01, kernel=poly;, score=0.075 total time=
4.4s
[CV 2/3] END C=0.4, degree=3, gamma=0.01, kernel=poly;, score=0.075 total time=
4.3s
[CV 3/3] END C=0.4, degree=3, gamma=0.01, kernel=poly;, score=0.075 total time=
4.3s
[CV 1/3] END C=0.4, degree=3, gamma=0.01, kernel=sigmoid;, score=0.563 total
time=   3.1s
```

```
[CV 2/3] END C=0.4, degree=3, gamma=0.01, kernel=sigmoid;, score=0.550 total
time=   3.1s
[CV 3/3] END C=0.4, degree=3, gamma=0.01, kernel=sigmoid;, score=0.555 total
time=   3.0s
[CV 1/3] END C=0.4, degree=3, gamma=0.001, kernel=rbf;, score=0.452 total time=
5.3s
[CV 2/3] END C=0.4, degree=3, gamma=0.001, kernel=rbf;, score=0.462 total time=
5.3s
[CV 3/3] END C=0.4, degree=3, gamma=0.001, kernel=rbf;, score=0.461 total time=
5.4s
[CV 1/3] END C=0.4, degree=3, gamma=0.001, kernel=linear;, score=0.862 total
time=   1.8s
[CV 2/3] END C=0.4, degree=3, gamma=0.001, kernel=linear;, score=0.844 total
time=   2.0s
[CV 3/3] END C=0.4, degree=3, gamma=0.001, kernel=linear;, score=0.845 total
time=   1.8s
[CV 1/3] END C=0.4, degree=3, gamma=0.001, kernel=poly;, score=0.075 total time=
4.3s
[CV 2/3] END C=0.4, degree=3, gamma=0.001, kernel=poly;, score=0.075 total time=
4.3s
[CV 3/3] END C=0.4, degree=3, gamma=0.001, kernel=poly;, score=0.075 total time=
4.3s
[CV 1/3] END C=0.4, degree=3, gamma=0.001, kernel=sigmoid;, score=0.350 total
time=   4.5s
[CV 2/3] END C=0.4, degree=3, gamma=0.001, kernel=sigmoid;, score=0.255 total
time=   4.4s
[CV 3/3] END C=0.4, degree=3, gamma=0.001, kernel=sigmoid;, score=0.289 total
time=   4.3s
[CV 1/3] END C=0.4, degree=4, gamma=scale, kernel=rbf;, score=0.776 total time=
3.9s
[CV 2/3] END C=0.4, degree=4, gamma=scale, kernel=rbf;, score=0.774 total time=
3.9s
[CV 3/3] END C=0.4, degree=4, gamma=scale, kernel=rbf;, score=0.745 total time=
3.8s
[CV 1/3] END C=0.4, degree=4, gamma=scale, kernel=linear;, score=0.862 total
time=   2.0s
[CV 2/3] END C=0.4, degree=4, gamma=scale, kernel=linear;, score=0.844 total
time=   2.0s
[CV 3/3] END C=0.4, degree=4, gamma=scale, kernel=linear;, score=0.845 total
time=   2.1s
[CV 1/3] END C=0.4, degree=4, gamma=scale, kernel=poly;, score=0.874 total time=
3.8s
[CV 2/3] END C=0.4, degree=4, gamma=scale, kernel=poly;, score=0.866 total time=
3.8s
[CV 3/3] END C=0.4, degree=4, gamma=scale, kernel=poly;, score=0.841 total time=
3.8s
[CV 1/3] END C=0.4, degree=4, gamma=scale, kernel=sigmoid;, score=0.726 total
time=   2.4s
```

```
[CV 2/3] END C=0.4, degree=4, gamma=scale, kernel=sigmoid;, score=0.731 total
time=   2.5s
[CV 3/3] END C=0.4, degree=4, gamma=scale, kernel=sigmoid;, score=0.707 total
time=   2.3s
[CV 1/3] END C=0.4, degree=4, gamma=auto, kernel=rbf;, score=0.075 total time=
5.5s
[CV 2/3] END C=0.4, degree=4, gamma=auto, kernel=rbf;, score=0.075 total time=
5.4s
[CV 3/3] END C=0.4, degree=4, gamma=auto, kernel=rbf;, score=0.075 total time=
5.5s
[CV 1/3] END C=0.4, degree=4, gamma=auto, kernel=linear;, score=0.862 total
time=   1.8s
[CV 2/3] END C=0.4, degree=4, gamma=auto, kernel=linear;, score=0.844 total
time=   1.9s
[CV 3/3] END C=0.4, degree=4, gamma=auto, kernel=linear;, score=0.845 total
time=   2.0s
[CV 1/3] END C=0.4, degree=4, gamma=auto, kernel=poly;, score=0.075 total time=
4.4s
[CV 2/3] END C=0.4, degree=4, gamma=auto, kernel=poly;, score=0.075 total time=
4.2s
[CV 3/3] END C=0.4, degree=4, gamma=auto, kernel=poly;, score=0.075 total time=
4.4s
[CV 1/3] END C=0.4, degree=4, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.3s
[CV 2/3] END C=0.4, degree=4, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.4s
[CV 3/3] END C=0.4, degree=4, gamma=auto, kernel=sigmoid;, score=0.075 total
time=   4.4s
[CV 1/3] END C=0.4, degree=4, gamma=0.1, kernel=rbf;, score=0.719 total time=
4.6s
[CV 2/3] END C=0.4, degree=4, gamma=0.1, kernel=rbf;, score=0.728 total time=
5.0s
[CV 3/3] END C=0.4, degree=4, gamma=0.1, kernel=rbf;, score=0.727 total time=
4.6s
[CV 1/3] END C=0.4, degree=4, gamma=0.1, kernel=linear;, score=0.862 total time=
2.1s
[CV 2/3] END C=0.4, degree=4, gamma=0.1, kernel=linear;, score=0.844 total time=
1.9s
[CV 3/3] END C=0.4, degree=4, gamma=0.1, kernel=linear;, score=0.845 total time=
2.1s
[CV 1/3] END C=0.4, degree=4, gamma=0.1, kernel=poly;, score=0.886 total time=
3.9s
[CV 2/3] END C=0.4, degree=4, gamma=0.1, kernel=poly;, score=0.875 total time=
3.9s
[CV 3/3] END C=0.4, degree=4, gamma=0.1, kernel=poly;, score=0.856 total time=
3.9s
[CV 1/3] END C=0.4, degree=4, gamma=0.1, kernel=sigmoid;, score=0.672 total
time=   2.3s
```

```
[CV 2/3] END C=0.4, degree=4, gamma=0.1, kernel=sigmoid;, score=0.684 total
time=   2.5s
[CV 3/3] END C=0.4, degree=4, gamma=0.1, kernel=sigmoid;, score=0.659 total
time=   2.4s
[CV 1/3] END C=0.4, degree=4, gamma=0.01, kernel=rbf;, score=0.633 total time=
3.9s
[CV 2/3] END C=0.4, degree=4, gamma=0.01, kernel=rbf;, score=0.590 total time=
3.8s
[CV 3/3] END C=0.4, degree=4, gamma=0.01, kernel=rbf;, score=0.659 total time=
3.7s
[CV 1/3] END C=0.4, degree=4, gamma=0.01, kernel=linear;, score=0.862 total
time=   1.9s
[CV 2/3] END C=0.4, degree=4, gamma=0.01, kernel=linear;, score=0.844 total
time=   2.0s
[CV 3/3] END C=0.4, degree=4, gamma=0.01, kernel=linear;, score=0.845 total
time=   2.0s
[CV 1/3] END C=0.4, degree=4, gamma=0.01, kernel=poly;, score=0.075 total time=
4.5s
[CV 2/3] END C=0.4, degree=4, gamma=0.01, kernel=poly;, score=0.075 total time=
4.5s
[CV 3/3] END C=0.4, degree=4, gamma=0.01, kernel=poly;, score=0.075 total time=
4.4s
[CV 1/3] END C=0.4, degree=4, gamma=0.01, kernel=sigmoid;, score=0.563 total
time=   3.1s
[CV 2/3] END C=0.4, degree=4, gamma=0.01, kernel=sigmoid;, score=0.550 total
time=   3.1s
[CV 3/3] END C=0.4, degree=4, gamma=0.01, kernel=sigmoid;, score=0.555 total
time=   3.0s
[CV 1/3] END C=0.4, degree=4, gamma=0.001, kernel=rbf;, score=0.452 total time=
5.3s
[CV 2/3] END C=0.4, degree=4, gamma=0.001, kernel=rbf;, score=0.462 total time=
5.5s
[CV 3/3] END C=0.4, degree=4, gamma=0.001, kernel=rbf;, score=0.461 total time=
5.8s
[CV 1/3] END C=0.4, degree=4, gamma=0.001, kernel=linear;, score=0.862 total
time=   2.3s
[CV 2/3] END C=0.4, degree=4, gamma=0.001, kernel=linear;, score=0.844 total
time=   2.0s
[CV 3/3] END C=0.4, degree=4, gamma=0.001, kernel=linear;, score=0.845 total
time=   2.0s
[CV 1/3] END C=0.4, degree=4, gamma=0.001, kernel=poly;, score=0.075 total time=
4.9s
[CV 2/3] END C=0.4, degree=4, gamma=0.001, kernel=poly;, score=0.075 total time=
4.5s
[CV 3/3] END C=0.4, degree=4, gamma=0.001, kernel=poly;, score=0.075 total time=
4.8s
[CV 1/3] END C=0.4, degree=4, gamma=0.001, kernel=sigmoid;, score=0.350 total
time=   4.8s
```

```
[CV 2/3] END C=0.4, degree=4, gamma=0.001, kernel=sigmoid;, score=0.255 total
time=   4.7s
[CV 3/3] END C=0.4, degree=4, gamma=0.001, kernel=sigmoid;, score=0.289 total
time=   4.7s

GridSearchCV(cv=3, estimator=SVC(),
             param_grid={'C': [0.1, 0.2, 0.3, 0.4], 'degree': [2, 3, 4],
                         'gamma': ['scale', 'auto', 0.1, 0.01, 0.001],
                         'kernel': ['rbf', 'linear', 'poly', 'sigmoid']},
             scoring='f1_macro', verbose=3)
```

```
best_svm = grid_search_svm.best_estimator_
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': 0.2, 'degree': 3, 'gamma': 0.1, 'kernel': 'poly'}

['e:\\Documents\\CS231\\project_temp\\Traffic-Sign-Classification-through-
Images\\joblib\\best_svm_model.joblib']
```

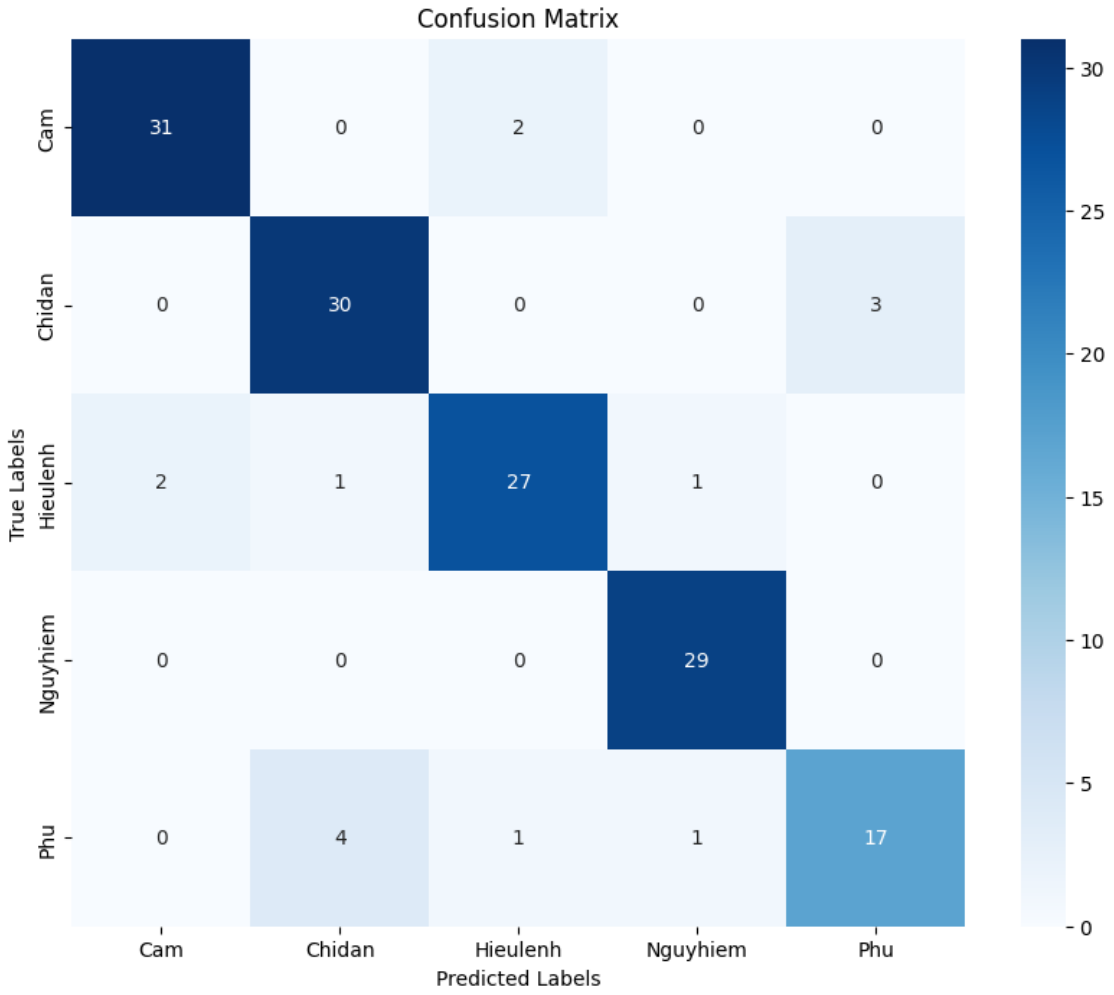
8 Predict on test images for KNN

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

```
              precision    recall  f1-score   support

         Cam       0.94      0.94      0.94        33
      Chidan       0.86      0.91      0.88        33
    Hieulenh       0.90      0.87      0.89        31
    Nguyhiem       0.94      1.00      0.97        29
         Phu       0.85      0.74      0.79        23

    accuracy                           0.90       149
   macro avg       0.90      0.89      0.89       149
weighted avg       0.90      0.90      0.90       149
```

```
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
```

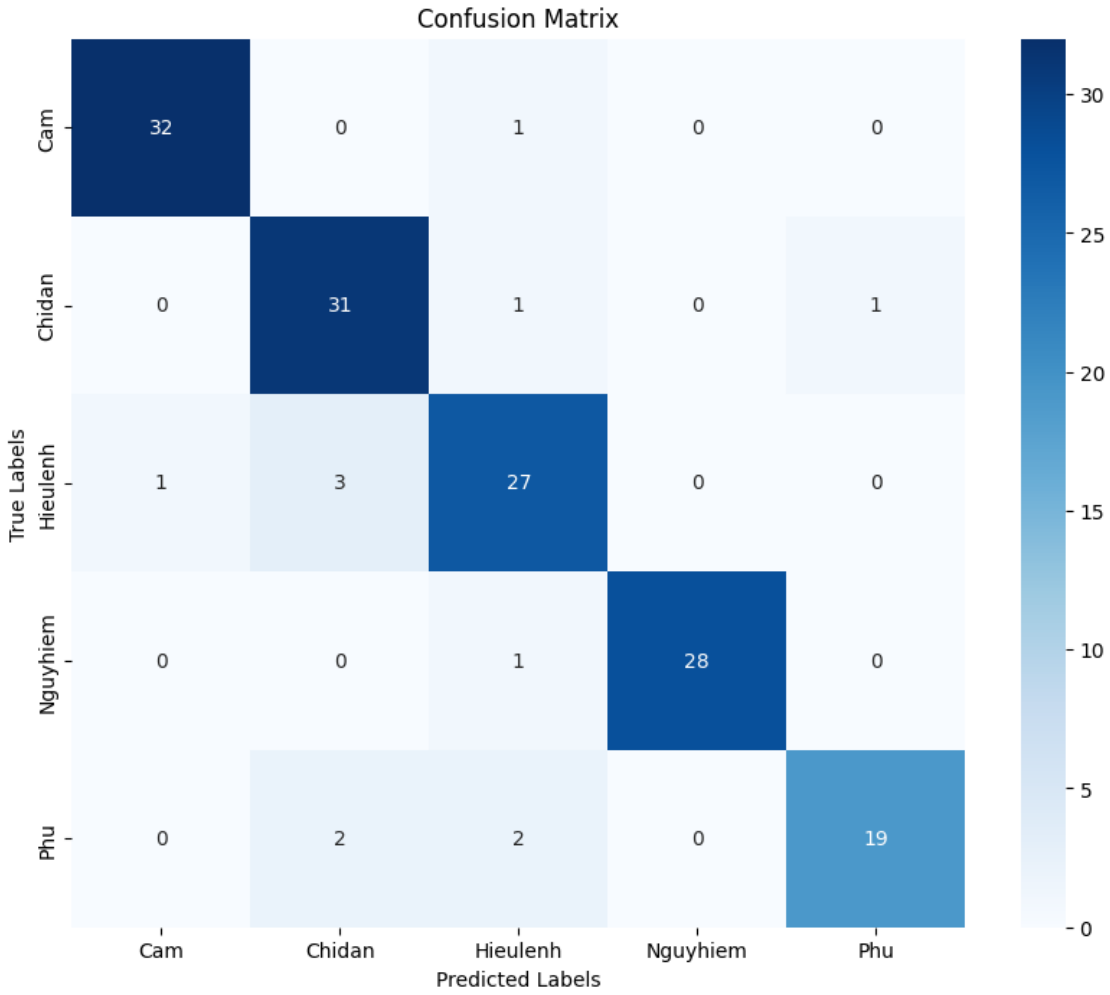
```
    axes[row, col].imshow(image)
    axes[row, col].set_title(f'True: {label_encoder.classes_[true_label]}\nPred:
 ↪ {label_encoder.classes_[pred_label]}')
    axes[row, col].axis('off')

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       0.97      0.97      0.97        33
      Chidan       0.86      0.94      0.90        33
    Hieulenh       0.84      0.87      0.86        31
    Nguyhiem       1.00      0.97      0.98        29
         Phu       0.95      0.83      0.88        23

    accuracy                           0.92       149
   macro avg       0.92      0.91      0.92       149
weighted avg       0.92      0.92      0.92       149
```

```
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: e:\Documents\CS231\project_temp\Traffic-Sign-
Classification-through-
```

```
Images\grid_search_results\notebook_export_2024-12-23_21_23_50.pdf
```

```
'e:\\Documents\\CS231\\project_temp\\Traffic-Sign-Classification-through-
Images\\grid_search_results\\notebook_export_2024-12-23_21_23_50.pdf'
```

param_grid_KNN = { ‘n_neighbors’: [3, 4, 5, 6, 7, 10], ‘weights’: [‘uniform’, ‘distance’], ‘metric’: [cityblock, cosine, sqeuclidean, chi_square_distance, bhattacharyya_distance, intersection_distance] }

Best Params: {‘metric’: , ‘n_neighbors’: 4, ‘weights’: ‘distance’}

param_grid_SVC = { ‘C’: [0.1, 0.2, 0.3, 0.4],
‘kernel’: [‘rbf’, ‘linear’, ‘poly’, ‘sigmoid’], ‘gamma’: [‘scale’, ‘auto’, 0.1, 0.01, 0.001],
‘degree’: [2, 3, 4],
}

Best parameters: {‘C’: 0.1, ‘degree’: 4, ‘gamma’: ‘scale’, ‘kernel’: ‘poly’}