Notebook

December 9, 2024

1 Import libraries

```python
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
```

2 Load data

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

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

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


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

```python
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)
```

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

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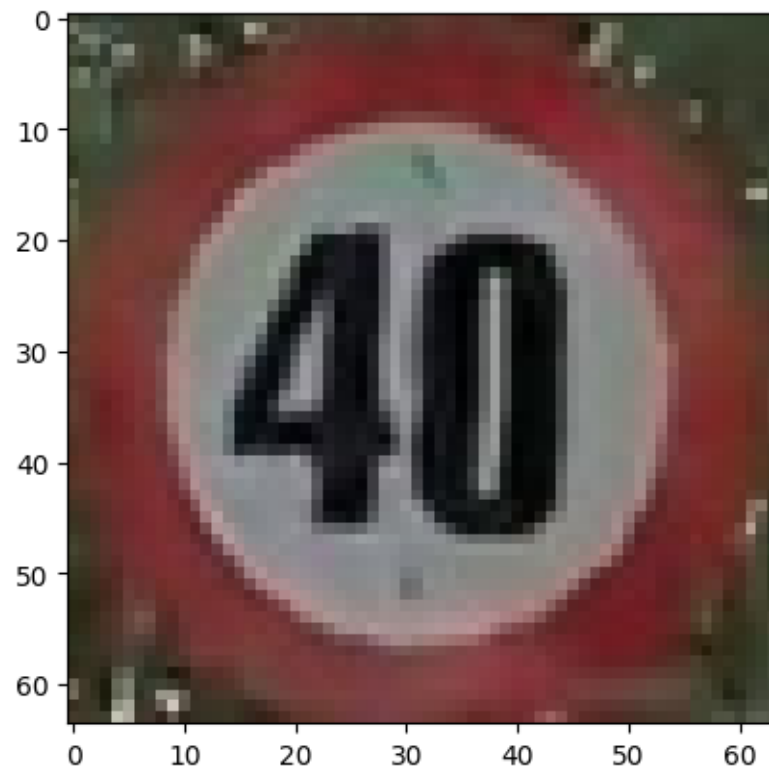
```
['e:\\Documents\\CS231\\project\\Traffic-Sign-Classification-through-
Images\\joblib\\label_encoder.joblib']
```

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

<matplotlib.image.AxesImage at 0x1eb08f043e0>


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

<matplotlib.image.AxesImage at 0x1eb08786b40>

3 Extract features

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

```python
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
```

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

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

```python
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
```

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

```
Blur Images: 100%|      | 1415/1415 [00:00<00:00, 4204.85it/s]
Extracting Color Features: 100%|      | 1415/1415 [00:00<00:00,
32921.78it/s]
Extracting HOG Features: 100%|      | 1415/1415 [00:02<00:00, 704.46it/s]
Combining Features: 1415it [00:00, 83234.32it/s]
```

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

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

```
Blur Images: 100%|      | 150/150 [00:00<00:00, 4404.95it/s]
Extracting Color Features: 100%|      | 150/150 [00:00<00:00, 30003.61it/s]
Extracting HOG Features: 100%|      | 150/150 [00:00<00:00, 681.40it/s]
Combining Features: 150it [00:00, 75005.44it/s]
```

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

4 Distance metrics KNN

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

```python
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

```python
# 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)
```

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

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

6 Gridsearch KNN

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

```python
param_grid = {
    'n_neighbors': [3, 4, 5, 6, 7, 10],
    'weights': ['uniform', 'distance'],
    'metric': [
        cityblock,
        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 72 candidates, totalling 216 fits
[CV 1/3] END metric=<function cityblock at 0x000001EB76488040>, n_neighbors=3,
weights=uniform;, score=0.857 total time=   2.3s
[CV 2/3] END metric=<function cityblock at 0x000001EB76488040>, n_neighbors=3,
weights=uniform;, score=0.814 total time=   2.3s
[CV 3/3] END metric=<function cityblock at 0x000001EB76488040>, n_neighbors=3,
weights=uniform;, score=0.830 total time=   2.3s
[CV 1/3] END metric=<function cityblock at 0x000001EB76488040>, n_neighbors=3,
weights=distance;, score=0.858 total time=   2.3s
[CV 2/3] END metric=<function cityblock at 0x000001EB76488040>, n_neighbors=3,
weights=distance;, score=0.816 total time=   2.3s
[CV 3/3] END metric=<function cityblock at 0x000001EB76488040>, n_neighbors=3,
weights=distance;, score=0.850 total time=   2.3s
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weights=uniform;, score=0.839 total time=   2.3s
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weights=distance;, score=0.830 total time=   2.3s
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[CV 3/3] END metric=<function cityblock at 0x000001EB76488040>, n_neighbors=5,
weights=uniform;, score=0.808 total time=   2.3s
[CV 1/3] END metric=<function cityblock at 0x000001EB76488040>, n_neighbors=5,
weights=distance;, score=0.854 total time=   2.3s
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weights=distance;, score=0.808 total time=   2.3s
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weights=uniform;, score=0.826 total time=   2.3s
```

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weights=distance;, score=0.824 total time=   2.3s
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weights=distance;, score=0.809 total time=   2.3s
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weights=uniform;, score=0.823 total time=   2.3s
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weights=uniform;, score=0.766 total time=   2.3s
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[CV 1/3] END metric=<function cosine at 0x000001EB7645FCE0>, n_neighbors=6,
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```
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[CV 3/3] END metric=<function sqeuclidean at 0x000001EB7645FBA0>, n_neighbors=4,
weights=distance;, score=0.798 total time=   2.1s
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[CV 2/3] END metric=<function sqeuclidean at 0x000001EB7645FBA0>, n_neighbors=5,
weights=uniform;, score=0.773 total time=   2.1s
[CV 3/3] END metric=<function sqeuclidean at 0x000001EB7645FBA0>, n_neighbors=5,
weights=uniform;, score=0.767 total time=   2.1s
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weights=distance;, score=0.850 total time=   2.1s
[CV 2/3] END metric=<function sqeuclidean at 0x000001EB7645FBA0>, n_neighbors=5,
weights=distance;, score=0.791 total time=   2.1s
[CV 3/3] END metric=<function sqeuclidean at 0x000001EB7645FBA0>, n_neighbors=5,
weights=distance;, score=0.792 total time=   2.1s
[CV 1/3] END metric=<function sqeuclidean at 0x000001EB7645FBA0>, n_neighbors=6,
weights=uniform;, score=0.814 total time=   2.1s
```

[CV 2/3] END metric=<function sqeuclidean at 0x000001EB7645FBA0>, n_neighbors=6, weights=uniform;, score=0.759 total time=   2.1s
[CV 3/3] END metric=<function sqeuclidean at 0x000001EB7645FBA0>, n_neighbors=6, weights=uniform;, score=0.767 total time=   2.1s
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[CV 2/3] END metric=<function sqeuclidean at 0x000001EB7645FBA0>, n_neighbors=6, weights=distance;, score=0.798 total time=   2.1s
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[CV 2/3] END metric=<function sqeuclidean at 0x000001EB7645FBA0>, n_neighbors=7, weights=distance;, score=0.789 total time=   2.1s
[CV 3/3] END metric=<function sqeuclidean at 0x000001EB7645FBA0>, n_neighbors=7, weights=distance;, score=0.773 total time=   2.1s
[CV 1/3] END metric=<function sqeuclidean at 0x000001EB7645FBA0>, n_neighbors=10, weights=uniform;, score=0.803 total time=   2.1s
[CV 2/3] END metric=<function sqeuclidean at 0x000001EB7645FBA0>, n_neighbors=10, weights=uniform;, score=0.747 total time=   2.1s
[CV 3/3] END metric=<function sqeuclidean at 0x000001EB7645FBA0>, n_neighbors=10, weights=uniform;, score=0.737 total time=   2.1s
[CV 1/3] END metric=<function sqeuclidean at 0x000001EB7645FBA0>, n_neighbors=10, weights=distance;, score=0.836 total time=   2.1s
[CV 2/3] END metric=<function sqeuclidean at 0x000001EB7645FBA0>, n_neighbors=10, weights=distance;, score=0.767 total time=   2.1s
[CV 3/3] END metric=<function sqeuclidean at 0x000001EB7645FBA0>, n_neighbors=10, weights=distance;, score=0.767 total time=   2.1s
[CV 1/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>, n_neighbors=3, weights=uniform;, score=0.716 total time=   2.7s
[CV 2/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>, n_neighbors=3, weights=uniform;, score=0.713 total time=   2.7s
[CV 3/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>, n_neighbors=3, weights=uniform;, score=0.678 total time=   2.7s
[CV 1/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>, n_neighbors=3, weights=distance;, score=0.728 total time=   2.7s
[CV 2/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>, n_neighbors=3, weights=distance;, score=0.720 total time=   2.8s
[CV 3/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>, n_neighbors=3, weights=distance;, score=0.692 total time=   2.8s
[CV 1/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>, n_neighbors=4, weights=uniform;, score=0.713 total time=   2.8s

```
[CV 2/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=4, weights=uniform;, score=0.698 total time=   2.8s
[CV 3/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=4, weights=uniform;, score=0.686 total time=   2.8s
[CV 1/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=4, weights=distance;, score=0.732 total time=   2.7s
[CV 2/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=4, weights=distance;, score=0.734 total time=   2.8s
[CV 3/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=4, weights=distance;, score=0.705 total time=   2.8s
[CV 1/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=5, weights=uniform;, score=0.716 total time=   2.8s
[CV 2/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=5, weights=uniform;, score=0.700 total time=   2.8s
[CV 3/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=5, weights=uniform;, score=0.676 total time=   2.8s
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n_neighbors=5, weights=distance;, score=0.730 total time=   2.7s
[CV 2/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=5, weights=distance;, score=0.734 total time=   2.8s
[CV 3/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=5, weights=distance;, score=0.707 total time=   2.8s
[CV 1/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=6, weights=uniform;, score=0.709 total time=   2.8s
[CV 2/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=6, weights=uniform;, score=0.692 total time=   2.8s
[CV 3/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=6, weights=uniform;, score=0.655 total time=   2.8s
[CV 1/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=6, weights=distance;, score=0.728 total time=   2.8s
[CV 2/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=6, weights=distance;, score=0.716 total time=   2.8s
[CV 3/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=6, weights=distance;, score=0.714 total time=   2.8s
[CV 1/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=7, weights=uniform;, score=0.719 total time=   2.7s
[CV 2/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=7, weights=uniform;, score=0.707 total time=   2.8s
[CV 3/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=7, weights=uniform;, score=0.669 total time=   2.8s
[CV 1/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=7, weights=distance;, score=0.751 total time=   2.8s
[CV 2/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=7, weights=distance;, score=0.726 total time=   2.8s
[CV 3/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=7, weights=distance;, score=0.713 total time=   2.8s
[CV 1/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=10, weights=uniform;, score=0.684 total time=   2.8s
```

```
[CV 2/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=10, weights=uniform;, score=0.697 total time=   2.8s
[CV 3/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=10, weights=uniform;, score=0.678 total time=   2.8s
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n_neighbors=10, weights=distance;, score=0.725 total time=   2.7s
[CV 2/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=10, weights=distance;, score=0.712 total time=   2.8s
[CV 3/3] END metric=<function chi_square_distance at 0x000001EB04B32F20>,
n_neighbors=10, weights=distance;, score=0.716 total time=   2.8s
[CV 1/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=3, weights=uniform;, score=0.827 total time=   2.9s
[CV 2/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=3, weights=uniform;, score=0.741 total time=   2.9s
[CV 3/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=3, weights=uniform;, score=0.731 total time=   2.9s
[CV 1/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=3, weights=distance;, score=0.846 total time=   2.8s
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n_neighbors=3, weights=distance;, score=0.749 total time=   2.9s
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n_neighbors=3, weights=distance;, score=0.750 total time=   2.8s
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n_neighbors=4, weights=uniform;, score=0.797 total time=   2.8s
[CV 2/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=4, weights=uniform;, score=0.719 total time=   2.8s
[CV 3/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=4, weights=uniform;, score=0.719 total time=   2.8s
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n_neighbors=4, weights=distance;, score=0.850 total time=   2.8s
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n_neighbors=4, weights=distance;, score=0.762 total time=   2.8s
[CV 3/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=4, weights=distance;, score=0.744 total time=   2.8s
[CV 1/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=5, weights=uniform;, score=0.826 total time=   2.9s
[CV 2/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=5, weights=uniform;, score=0.715 total time=   2.8s
[CV 3/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=5, weights=uniform;, score=0.713 total time=   2.9s
[CV 1/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=5, weights=distance;, score=0.837 total time=   2.8s
[CV 2/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=5, weights=distance;, score=0.739 total time=   2.9s
[CV 3/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=5, weights=distance;, score=0.734 total time=   2.8s
[CV 1/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=6, weights=uniform;, score=0.812 total time=   2.9s
```

```
[CV 2/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=6, weights=uniform;, score=0.707 total time=   2.9s
[CV 3/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=6, weights=uniform;, score=0.731 total time=   2.9s
[CV 1/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=6, weights=distance;, score=0.832 total time=   2.8s
[CV 2/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=6, weights=distance;, score=0.743 total time=   2.8s
[CV 3/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=6, weights=distance;, score=0.741 total time=   2.9s
[CV 1/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=7, weights=uniform;, score=0.812 total time=   2.8s
[CV 2/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=7, weights=uniform;, score=0.719 total time=   2.9s
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n_neighbors=7, weights=uniform;, score=0.718 total time=   2.9s
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n_neighbors=7, weights=distance;, score=0.822 total time=   2.9s
[CV 2/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=7, weights=distance;, score=0.729 total time=   2.9s
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n_neighbors=10, weights=uniform;, score=0.796 total time=   3.0s
[CV 2/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=10, weights=uniform;, score=0.713 total time=   2.9s
[CV 3/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=10, weights=uniform;, score=0.717 total time=   2.9s
[CV 1/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=10, weights=distance;, score=0.823 total time=   2.9s
[CV 2/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
n_neighbors=10, weights=distance;, score=0.743 total time=   2.8s
[CV 3/3] END metric=<function bhattacharyya_distance at 0x000001EB04A89620>,
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n_neighbors=3, weights=uniform;, score=0.779 total time=   2.1s
[CV 2/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=3, weights=uniform;, score=0.664 total time=   2.1s
[CV 3/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=3, weights=uniform;, score=0.678 total time=   2.1s
[CV 1/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=3, weights=distance;, score=0.076 total time=   2.1s
[CV 2/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=3, weights=distance;, score=0.076 total time=   2.1s
[CV 3/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=3, weights=distance;, score=0.076 total time=   2.1s
[CV 1/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=4, weights=uniform;, score=0.761 total time=   2.1s
```

```
[CV 2/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=4, weights=uniform;, score=0.656 total time=   2.1s
[CV 3/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=4, weights=uniform;, score=0.683 total time=   2.1s
[CV 1/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=4, weights=distance;, score=0.076 total time=   2.1s
[CV 2/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=4, weights=distance;, score=0.076 total time=   2.1s
[CV 3/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=4, weights=distance;, score=0.076 total time=   2.1s
[CV 1/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=5, weights=uniform;, score=0.775 total time=   2.1s
[CV 2/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=5, weights=uniform;, score=0.666 total time=   2.1s
[CV 3/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
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[CV 1/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=5, weights=distance;, score=0.076 total time=   2.1s
[CV 2/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=5, weights=distance;, score=0.076 total time=   2.1s
[CV 3/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=5, weights=distance;, score=0.076 total time=   2.1s
[CV 1/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=6, weights=uniform;, score=0.755 total time=   2.1s
[CV 2/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=6, weights=uniform;, score=0.650 total time=   2.1s
[CV 3/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=6, weights=uniform;, score=0.677 total time=   2.1s
[CV 1/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=6, weights=distance;, score=0.076 total time=   2.1s
[CV 2/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=6, weights=distance;, score=0.076 total time=   2.1s
[CV 3/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=6, weights=distance;, score=0.076 total time=   2.1s
[CV 1/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=7, weights=uniform;, score=0.728 total time=   2.1s
[CV 2/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=7, weights=uniform;, score=0.667 total time=   2.1s
[CV 3/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=7, weights=uniform;, score=0.676 total time=   2.1s
[CV 1/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=7, weights=distance;, score=0.076 total time=   2.1s
[CV 2/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=7, weights=distance;, score=0.076 total time=   2.1s
[CV 3/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=7, weights=distance;, score=0.076 total time=   2.1s
[CV 1/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=10, weights=uniform;, score=0.732 total time=   2.1s
```

```
[CV 2/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=10, weights=uniform;, score=0.656 total time=   2.1s
[CV 3/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=10, weights=uniform;, score=0.662 total time=   2.1s
[CV 1/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=10, weights=distance;, score=0.076 total time=   2.1s
[CV 2/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=10, weights=distance;, score=0.076 total time=   2.1s
[CV 3/3] END metric=<function intersection_distance at 0x000001EB04A8B420>,
n_neighbors=10, weights=distance;, score=0.076 total time=   2.1s

GridSearchCV(cv=3, estimator=KNeighborsClassifier(),
             param_grid={'metric': [<function cityblock at 0x000001EB76488040>,
                                     <function cosine at 0x000001EB7645FCE0>,
                                     <function sqeuclidean at
0x000001EB7645FBA0>,
                                     <function chi_square_distance at
0x000001EB04B32F20>,
                                     <function bhattacharyya_distance at
0x000001EB04A89620>,
                                     <function intersection_distance at
0x000001EB04A8B420>],
                         'n_neighbors': [3, 4, 5, 6, 7, 10],
                         'weights': ['uniform', 'distance']},
             scoring='f1_macro', verbose=3)
```

```python
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 0x000001EB76488040>,
'n_neighbors': 4, 'weights': 'distance'}
Thuật toán sử dụng: auto

['e:\\Documents\\CS231\\project\\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=0.521 total time=
0.5s
[CV 2/3] END C=0.1, degree=2, gamma=scale, kernel=rbf;, score=0.538 total time=
0.5s
[CV 3/3] END C=0.1, degree=2, gamma=scale, kernel=rbf;, score=0.517 total time=
0.5s
[CV 1/3] END C=0.1, degree=2, gamma=scale, kernel=linear;, score=0.840 total
time=   0.1s
[CV 2/3] END C=0.1, degree=2, gamma=scale, kernel=linear;, score=0.805 total
time=   0.1s
[CV 3/3] END C=0.1, degree=2, gamma=scale, kernel=linear;, score=0.798 total
time=   0.1s
[CV 1/3] END C=0.1, degree=2, gamma=scale, kernel=poly;, score=0.755 total time=
0.2s
[CV 2/3] END C=0.1, degree=2, gamma=scale, kernel=poly;, score=0.734 total time=
0.2s
[CV 3/3] END C=0.1, degree=2, gamma=scale, kernel=poly;, score=0.660 total time=
0.2s
[CV 1/3] END C=0.1, degree=2, gamma=scale, kernel=sigmoid;, score=0.512 total
time=   0.2s
[CV 2/3] END C=0.1, degree=2, gamma=scale, kernel=sigmoid;, score=0.503 total
time=   0.3s
```

```
[CV 3/3] END C=0.1, degree=2, gamma=scale, kernel=sigmoid;, score=0.497 total
time=   0.3s
[CV 1/3] END C=0.1, degree=2, gamma=auto, kernel=rbf;, score=0.076 total time=
0.6s
[CV 2/3] END C=0.1, degree=2, gamma=auto, kernel=rbf;, score=0.076 total time=
0.6s
[CV 3/3] END C=0.1, degree=2, gamma=auto, kernel=rbf;, score=0.076 total time=
0.6s
[CV 1/3] END C=0.1, degree=2, gamma=auto, kernel=linear;, score=0.840 total
time=   0.1s
[CV 2/3] END C=0.1, degree=2, gamma=auto, kernel=linear;, score=0.805 total
time=   0.1s
[CV 3/3] END C=0.1, degree=2, gamma=auto, kernel=linear;, score=0.798 total
time=   0.1s
[CV 1/3] END C=0.1, degree=2, gamma=auto, kernel=poly;, score=0.076 total time=
0.3s
[CV 2/3] END C=0.1, degree=2, gamma=auto, kernel=poly;, score=0.076 total time=
0.3s
[CV 3/3] END C=0.1, degree=2, gamma=auto, kernel=poly;, score=0.076 total time=
0.3s
[CV 1/3] END C=0.1, degree=2, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.3s
[CV 2/3] END C=0.1, degree=2, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.3s
[CV 3/3] END C=0.1, degree=2, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.4s
[CV 1/3] END C=0.1, degree=2, gamma=0.1, kernel=rbf;, score=0.392 total time=
0.6s
[CV 2/3] END C=0.1, degree=2, gamma=0.1, kernel=rbf;, score=0.420 total time=
0.6s
[CV 3/3] END C=0.1, degree=2, gamma=0.1, kernel=rbf;, score=0.372 total time=
0.6s
[CV 1/3] END C=0.1, degree=2, gamma=0.1, kernel=linear;, score=0.840 total time=
0.1s
[CV 2/3] END C=0.1, degree=2, gamma=0.1, kernel=linear;, score=0.805 total time=
0.1s
[CV 3/3] END C=0.1, degree=2, gamma=0.1, kernel=linear;, score=0.798 total time=
0.1s
[CV 1/3] END C=0.1, degree=2, gamma=0.1, kernel=poly;, score=0.881 total time=
0.1s
[CV 2/3] END C=0.1, degree=2, gamma=0.1, kernel=poly;, score=0.852 total time=
0.1s
[CV 3/3] END C=0.1, degree=2, gamma=0.1, kernel=poly;, score=0.818 total time=
0.1s
[CV 1/3] END C=0.1, degree=2, gamma=0.1, kernel=sigmoid;, score=0.325 total
time=   0.4s
[CV 2/3] END C=0.1, degree=2, gamma=0.1, kernel=sigmoid;, score=0.313 total
time=   0.4s
```

```
[CV 3/3] END C=0.1, degree=2, gamma=0.1, kernel=sigmoid;, score=0.308 total
time=   0.4s
[CV 1/3] END C=0.1, degree=2, gamma=0.01, kernel=rbf;, score=0.475 total time=
0.5s
[CV 2/3] END C=0.1, degree=2, gamma=0.01, kernel=rbf;, score=0.513 total time=
0.5s
[CV 3/3] END C=0.1, degree=2, gamma=0.01, kernel=rbf;, score=0.487 total time=
0.5s
[CV 1/3] END C=0.1, degree=2, gamma=0.01, kernel=linear;, score=0.840 total
time=   0.1s
[CV 2/3] END C=0.1, degree=2, gamma=0.01, kernel=linear;, score=0.805 total
time=   0.1s
[CV 3/3] END C=0.1, degree=2, gamma=0.01, kernel=linear;, score=0.798 total
time=   0.1s
[CV 1/3] END C=0.1, degree=2, gamma=0.01, kernel=poly;, score=0.445 total time=
0.3s
[CV 2/3] END C=0.1, degree=2, gamma=0.01, kernel=poly;, score=0.460 total time=
0.3s
[CV 3/3] END C=0.1, degree=2, gamma=0.01, kernel=poly;, score=0.429 total time=
0.3s
[CV 1/3] END C=0.1, degree=2, gamma=0.01, kernel=sigmoid;, score=0.447 total
time=   0.3s
[CV 2/3] END C=0.1, degree=2, gamma=0.01, kernel=sigmoid;, score=0.469 total
time=   0.3s
[CV 3/3] END C=0.1, degree=2, gamma=0.01, kernel=sigmoid;, score=0.452 total
time=   0.3s
[CV 1/3] END C=0.1, degree=2, gamma=0.001, kernel=rbf;, score=0.076 total time=
0.6s
[CV 2/3] END C=0.1, degree=2, gamma=0.001, kernel=rbf;, score=0.076 total time=
0.5s
[CV 3/3] END C=0.1, degree=2, gamma=0.001, kernel=rbf;, score=0.076 total time=
0.6s
[CV 1/3] END C=0.1, degree=2, gamma=0.001, kernel=linear;, score=0.840 total
time=   0.1s
[CV 2/3] END C=0.1, degree=2, gamma=0.001, kernel=linear;, score=0.805 total
time=   0.1s
[CV 3/3] END C=0.1, degree=2, gamma=0.001, kernel=linear;, score=0.798 total
time=   0.1s
[CV 1/3] END C=0.1, degree=2, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 2/3] END C=0.1, degree=2, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 3/3] END C=0.1, degree=2, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 1/3] END C=0.1, degree=2, gamma=0.001, kernel=sigmoid;, score=0.076 total
time=   0.3s
[CV 2/3] END C=0.1, degree=2, gamma=0.001, kernel=sigmoid;, score=0.076 total
time=   0.3s
```

[CV 3/3] END C=0.1, degree=2, gamma=0.001, kernel=sigmoid;, score=0.076 total time=   0.3s
[CV 1/3] END C=0.1, degree=3, gamma=scale, kernel=rbf;, score=0.521 total time=   0.4s
[CV 2/3] END C=0.1, degree=3, gamma=scale, kernel=rbf;, score=0.538 total time=   0.5s
[CV 3/3] END C=0.1, degree=3, gamma=scale, kernel=rbf;, score=0.517 total time=   0.5s
[CV 1/3] END C=0.1, degree=3, gamma=scale, kernel=linear;, score=0.840 total time=   0.1s
[CV 2/3] END C=0.1, degree=3, gamma=scale, kernel=linear;, score=0.805 total time=   0.1s
[CV 3/3] END C=0.1, degree=3, gamma=scale, kernel=linear;, score=0.798 total time=   0.1s
[CV 1/3] END C=0.1, degree=3, gamma=scale, kernel=poly;, score=0.804 total time=   0.2s
[CV 2/3] END C=0.1, degree=3, gamma=scale, kernel=poly;, score=0.778 total time=   0.2s
[CV 3/3] END C=0.1, degree=3, gamma=scale, kernel=poly;, score=0.709 total time=   0.2s
[CV 1/3] END C=0.1, degree=3, gamma=scale, kernel=sigmoid;, score=0.512 total time=   0.2s
[CV 2/3] END C=0.1, degree=3, gamma=scale, kernel=sigmoid;, score=0.503 total time=   0.3s
[CV 3/3] END C=0.1, degree=3, gamma=scale, kernel=sigmoid;, score=0.497 total time=   0.3s
[CV 1/3] END C=0.1, degree=3, gamma=auto, kernel=rbf;, score=0.076 total time=   0.6s
[CV 2/3] END C=0.1, degree=3, gamma=auto, kernel=rbf;, score=0.076 total time=   0.6s
[CV 3/3] END C=0.1, degree=3, gamma=auto, kernel=rbf;, score=0.076 total time=   0.6s
[CV 1/3] END C=0.1, degree=3, gamma=auto, kernel=linear;, score=0.840 total time=   0.1s
[CV 2/3] END C=0.1, degree=3, gamma=auto, kernel=linear;, score=0.805 total time=   0.1s
[CV 3/3] END C=0.1, degree=3, gamma=auto, kernel=linear;, score=0.798 total time=   0.1s
[CV 1/3] END C=0.1, degree=3, gamma=auto, kernel=poly;, score=0.076 total time=   0.3s
[CV 2/3] END C=0.1, degree=3, gamma=auto, kernel=poly;, score=0.076 total time=   0.4s
[CV 3/3] END C=0.1, degree=3, gamma=auto, kernel=poly;, score=0.076 total time=   0.3s
[CV 1/3] END C=0.1, degree=3, gamma=auto, kernel=sigmoid;, score=0.076 total time=   0.4s
[CV 2/3] END C=0.1, degree=3, gamma=auto, kernel=sigmoid;, score=0.076 total time=   0.3s

```
[CV 3/3] END C=0.1, degree=3, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.3s
[CV 1/3] END C=0.1, degree=3, gamma=0.1, kernel=rbf;, score=0.392 total time=
0.6s
[CV 2/3] END C=0.1, degree=3, gamma=0.1, kernel=rbf;, score=0.420 total time=
0.6s
[CV 3/3] END C=0.1, degree=3, gamma=0.1, kernel=rbf;, score=0.372 total time=
0.6s
[CV 1/3] END C=0.1, degree=3, gamma=0.1, kernel=linear;, score=0.840 total time=
0.1s
[CV 2/3] END C=0.1, degree=3, gamma=0.1, kernel=linear;, score=0.805 total time=
0.1s
[CV 3/3] END C=0.1, degree=3, gamma=0.1, kernel=linear;, score=0.798 total time=
0.1s
[CV 1/3] END C=0.1, degree=3, gamma=0.1, kernel=poly;, score=0.883 total time=
0.2s
[CV 2/3] END C=0.1, degree=3, gamma=0.1, kernel=poly;, score=0.865 total time=
0.2s
[CV 3/3] END C=0.1, degree=3, gamma=0.1, kernel=poly;, score=0.823 total time=
0.2s
[CV 1/3] END C=0.1, degree=3, gamma=0.1, kernel=sigmoid;, score=0.325 total
time=   0.3s
[CV 2/3] END C=0.1, degree=3, gamma=0.1, kernel=sigmoid;, score=0.313 total
time=   0.4s
[CV 3/3] END C=0.1, degree=3, gamma=0.1, kernel=sigmoid;, score=0.308 total
time=   0.4s
[CV 1/3] END C=0.1, degree=3, gamma=0.01, kernel=rbf;, score=0.475 total time=
0.5s
[CV 2/3] END C=0.1, degree=3, gamma=0.01, kernel=rbf;, score=0.513 total time=
0.5s
[CV 3/3] END C=0.1, degree=3, gamma=0.01, kernel=rbf;, score=0.487 total time=
0.5s
[CV 1/3] END C=0.1, degree=3, gamma=0.01, kernel=linear;, score=0.840 total
time=   0.1s
[CV 2/3] END C=0.1, degree=3, gamma=0.01, kernel=linear;, score=0.805 total
time=   0.1s
[CV 3/3] END C=0.1, degree=3, gamma=0.01, kernel=linear;, score=0.798 total
time=   0.1s
[CV 1/3] END C=0.1, degree=3, gamma=0.01, kernel=poly;, score=0.076 total time=
0.4s
[CV 2/3] END C=0.1, degree=3, gamma=0.01, kernel=poly;, score=0.076 total time=
0.3s
[CV 3/3] END C=0.1, degree=3, gamma=0.01, kernel=poly;, score=0.076 total time=
0.3s
[CV 1/3] END C=0.1, degree=3, gamma=0.01, kernel=sigmoid;, score=0.447 total
time=   0.3s
[CV 2/3] END C=0.1, degree=3, gamma=0.01, kernel=sigmoid;, score=0.469 total
time=   0.3s
```

[CV 3/3] END C=0.1, degree=3, gamma=0.01, kernel=sigmoid;, score=0.452 total
time=   0.3s
[CV 1/3] END C=0.1, degree=3, gamma=0.001, kernel=rbf;, score=0.076 total time=
0.6s
[CV 2/3] END C=0.1, degree=3, gamma=0.001, kernel=rbf;, score=0.076 total time=
0.6s
[CV 3/3] END C=0.1, degree=3, gamma=0.001, kernel=rbf;, score=0.076 total time=
0.6s
[CV 1/3] END C=0.1, degree=3, gamma=0.001, kernel=linear;, score=0.840 total
time=   0.1s
[CV 2/3] END C=0.1, degree=3, gamma=0.001, kernel=linear;, score=0.805 total
time=   0.1s
[CV 3/3] END C=0.1, degree=3, gamma=0.001, kernel=linear;, score=0.798 total
time=   0.1s
[CV 1/3] END C=0.1, degree=3, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 2/3] END C=0.1, degree=3, gamma=0.001, kernel=poly;, score=0.076 total time=
0.4s
[CV 3/3] END C=0.1, degree=3, gamma=0.001, kernel=poly;, score=0.076 total time=
0.4s
[CV 1/3] END C=0.1, degree=3, gamma=0.001, kernel=sigmoid;, score=0.076 total
time=   0.4s
[CV 2/3] END C=0.1, degree=3, gamma=0.001, kernel=sigmoid;, score=0.076 total
time=   0.4s
[CV 3/3] END C=0.1, degree=3, gamma=0.001, kernel=sigmoid;, score=0.076 total
time=   0.3s
[CV 1/3] END C=0.1, degree=4, gamma=scale, kernel=rbf;, score=0.521 total time=
0.4s
[CV 2/3] END C=0.1, degree=4, gamma=scale, kernel=rbf;, score=0.538 total time=
0.5s
[CV 3/3] END C=0.1, degree=4, gamma=scale, kernel=rbf;, score=0.517 total time=
0.4s
[CV 1/3] END C=0.1, degree=4, gamma=scale, kernel=linear;, score=0.840 total
time=   0.1s
[CV 2/3] END C=0.1, degree=4, gamma=scale, kernel=linear;, score=0.805 total
time=   0.1s
[CV 3/3] END C=0.1, degree=4, gamma=scale, kernel=linear;, score=0.798 total
time=   0.1s
[CV 1/3] END C=0.1, degree=4, gamma=scale, kernel=poly;, score=0.834 total time=
0.2s
[CV 2/3] END C=0.1, degree=4, gamma=scale, kernel=poly;, score=0.814 total time=
0.2s
[CV 3/3] END C=0.1, degree=4, gamma=scale, kernel=poly;, score=0.751 total time=
0.2s
[CV 1/3] END C=0.1, degree=4, gamma=scale, kernel=sigmoid;, score=0.512 total
time=   0.2s
[CV 2/3] END C=0.1, degree=4, gamma=scale, kernel=sigmoid;, score=0.503 total
time=   0.2s

[CV 3/3] END C=0.1, degree=4, gamma=scale, kernel=sigmoid;, score=0.497 total time=   0.2s
[CV 1/3] END C=0.1, degree=4, gamma=auto, kernel=rbf;, score=0.076 total time= 0.6s
[CV 2/3] END C=0.1, degree=4, gamma=auto, kernel=rbf;, score=0.076 total time= 0.6s
[CV 3/3] END C=0.1, degree=4, gamma=auto, kernel=rbf;, score=0.076 total time= 0.6s
[CV 1/3] END C=0.1, degree=4, gamma=auto, kernel=linear;, score=0.840 total time=   0.1s
[CV 2/3] END C=0.1, degree=4, gamma=auto, kernel=linear;, score=0.805 total time=   0.1s
[CV 3/3] END C=0.1, degree=4, gamma=auto, kernel=linear;, score=0.798 total time=   0.1s
[CV 1/3] END C=0.1, degree=4, gamma=auto, kernel=poly;, score=0.076 total time= 0.3s
[CV 2/3] END C=0.1, degree=4, gamma=auto, kernel=poly;, score=0.076 total time= 0.3s
[CV 3/3] END C=0.1, degree=4, gamma=auto, kernel=poly;, score=0.076 total time= 0.3s
[CV 1/3] END C=0.1, degree=4, gamma=auto, kernel=sigmoid;, score=0.076 total time=   0.3s
[CV 2/3] END C=0.1, degree=4, gamma=auto, kernel=sigmoid;, score=0.076 total time=   0.3s
[CV 3/3] END C=0.1, degree=4, gamma=auto, kernel=sigmoid;, score=0.076 total time=   0.4s
[CV 1/3] END C=0.1, degree=4, gamma=0.1, kernel=rbf;, score=0.392 total time= 0.6s
[CV 2/3] END C=0.1, degree=4, gamma=0.1, kernel=rbf;, score=0.420 total time= 0.6s
[CV 3/3] END C=0.1, degree=4, gamma=0.1, kernel=rbf;, score=0.372 total time= 0.6s
[CV 1/3] END C=0.1, degree=4, gamma=0.1, kernel=linear;, score=0.840 total time= 0.1s
[CV 2/3] END C=0.1, degree=4, gamma=0.1, kernel=linear;, score=0.805 total time= 0.1s
[CV 3/3] END C=0.1, degree=4, gamma=0.1, kernel=linear;, score=0.798 total time= 0.1s
[CV 1/3] END C=0.1, degree=4, gamma=0.1, kernel=poly;, score=0.873 total time= 0.2s
[CV 2/3] END C=0.1, degree=4, gamma=0.1, kernel=poly;, score=0.854 total time= 0.2s
[CV 3/3] END C=0.1, degree=4, gamma=0.1, kernel=poly;, score=0.825 total time= 0.3s
[CV 1/3] END C=0.1, degree=4, gamma=0.1, kernel=sigmoid;, score=0.325 total time=   0.4s
[CV 2/3] END C=0.1, degree=4, gamma=0.1, kernel=sigmoid;, score=0.313 total time=   0.3s

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[CV 3/3] END C=0.1, degree=4, gamma=0.1, kernel=sigmoid;, score=0.308 total time=   0.4s
[CV 1/3] END C=0.1, degree=4, gamma=0.01, kernel=rbf;, score=0.475 total time=   0.5s
[CV 2/3] END C=0.1, degree=4, gamma=0.01, kernel=rbf;, score=0.513 total time=   0.5s
[CV 3/3] END C=0.1, degree=4, gamma=0.01, kernel=rbf;, score=0.487 total time=   0.5s
[CV 1/3] END C=0.1, degree=4, gamma=0.01, kernel=linear;, score=0.840 total time=   0.1s
[CV 2/3] END C=0.1, degree=4, gamma=0.01, kernel=linear;, score=0.805 total time=   0.1s
[CV 3/3] END C=0.1, degree=4, gamma=0.01, kernel=linear;, score=0.798 total time=   0.1s
[CV 1/3] END C=0.1, degree=4, gamma=0.01, kernel=poly;, score=0.076 total time=   0.4s
[CV 2/3] END C=0.1, degree=4, gamma=0.01, kernel=poly;, score=0.076 total time=   0.4s
[CV 3/3] END C=0.1, degree=4, gamma=0.01, kernel=poly;, score=0.076 total time=   0.3s
[CV 1/3] END C=0.1, degree=4, gamma=0.01, kernel=sigmoid;, score=0.447 total time=   0.3s
[CV 2/3] END C=0.1, degree=4, gamma=0.01, kernel=sigmoid;, score=0.469 total time=   0.3s
[CV 3/3] END C=0.1, degree=4, gamma=0.01, kernel=sigmoid;, score=0.452 total time=   0.3s
[CV 1/3] END C=0.1, degree=4, gamma=0.001, kernel=rbf;, score=0.076 total time=   0.6s
[CV 2/3] END C=0.1, degree=4, gamma=0.001, kernel=rbf;, score=0.076 total time=   0.5s
[CV 3/3] END C=0.1, degree=4, gamma=0.001, kernel=rbf;, score=0.076 total time=   0.6s
[CV 1/3] END C=0.1, degree=4, gamma=0.001, kernel=linear;, score=0.840 total time=   0.1s
[CV 2/3] END C=0.1, degree=4, gamma=0.001, kernel=linear;, score=0.805 total time=   0.1s
[CV 3/3] END C=0.1, degree=4, gamma=0.001, kernel=linear;, score=0.798 total time=   0.1s
[CV 1/3] END C=0.1, degree=4, gamma=0.001, kernel=poly;, score=0.076 total time=   0.3s
[CV 2/3] END C=0.1, degree=4, gamma=0.001, kernel=poly;, score=0.076 total time=   0.3s
[CV 3/3] END C=0.1, degree=4, gamma=0.001, kernel=poly;, score=0.076 total time=   0.3s
[CV 1/3] END C=0.1, degree=4, gamma=0.001, kernel=sigmoid;, score=0.076 total time=   0.3s
[CV 2/3] END C=0.1, degree=4, gamma=0.001, kernel=sigmoid;, score=0.076 total time=   0.4s

```
[CV 3/3] END C=0.1, degree=4, gamma=0.001, kernel=sigmoid;, score=0.076 total
time=   0.3s
[CV 1/3] END C=0.2, degree=2, gamma=scale, kernel=rbf;, score=0.610 total time=
0.4s
[CV 2/3] END C=0.2, degree=2, gamma=scale, kernel=rbf;, score=0.585 total time=
0.4s
[CV 3/3] END C=0.2, degree=2, gamma=scale, kernel=rbf;, score=0.584 total time=
0.4s
[CV 1/3] END C=0.2, degree=2, gamma=scale, kernel=linear;, score=0.853 total
time=   0.1s
[CV 2/3] END C=0.2, degree=2, gamma=scale, kernel=linear;, score=0.792 total
time=   0.1s
[CV 3/3] END C=0.2, degree=2, gamma=scale, kernel=linear;, score=0.802 total
time=   0.1s
[CV 1/3] END C=0.2, degree=2, gamma=scale, kernel=poly;, score=0.806 total time=
0.1s
[CV 2/3] END C=0.2, degree=2, gamma=scale, kernel=poly;, score=0.786 total time=
0.1s
[CV 3/3] END C=0.2, degree=2, gamma=scale, kernel=poly;, score=0.735 total time=
0.1s
[CV 1/3] END C=0.2, degree=2, gamma=scale, kernel=sigmoid;, score=0.542 total
time=   0.2s
[CV 2/3] END C=0.2, degree=2, gamma=scale, kernel=sigmoid;, score=0.527 total
time=   0.2s
[CV 3/3] END C=0.2, degree=2, gamma=scale, kernel=sigmoid;, score=0.540 total
time=   0.2s
[CV 1/3] END C=0.2, degree=2, gamma=auto, kernel=rbf;, score=0.076 total time=
0.6s
[CV 2/3] END C=0.2, degree=2, gamma=auto, kernel=rbf;, score=0.076 total time=
0.5s
[CV 3/3] END C=0.2, degree=2, gamma=auto, kernel=rbf;, score=0.076 total time=
0.6s
[CV 1/3] END C=0.2, degree=2, gamma=auto, kernel=linear;, score=0.853 total
time=   0.1s
[CV 2/3] END C=0.2, degree=2, gamma=auto, kernel=linear;, score=0.792 total
time=   0.1s
[CV 3/3] END C=0.2, degree=2, gamma=auto, kernel=linear;, score=0.802 total
time=   0.1s
[CV 1/3] END C=0.2, degree=2, gamma=auto, kernel=poly;, score=0.076 total time=
0.3s
[CV 2/3] END C=0.2, degree=2, gamma=auto, kernel=poly;, score=0.076 total time=
0.3s
[CV 3/3] END C=0.2, degree=2, gamma=auto, kernel=poly;, score=0.076 total time=
0.4s
[CV 1/3] END C=0.2, degree=2, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.3s
[CV 2/3] END C=0.2, degree=2, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.3s
```

```
[CV 3/3] END C=0.2, degree=2, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.3s
[CV 1/3] END C=0.2, degree=2, gamma=0.1, kernel=rbf;, score=0.417 total time=
0.6s
[CV 2/3] END C=0.2, degree=2, gamma=0.1, kernel=rbf;, score=0.440 total time=
0.5s
[CV 3/3] END C=0.2, degree=2, gamma=0.1, kernel=rbf;, score=0.382 total time=
0.5s
[CV 1/3] END C=0.2, degree=2, gamma=0.1, kernel=linear;, score=0.853 total time=
0.1s
[CV 2/3] END C=0.2, degree=2, gamma=0.1, kernel=linear;, score=0.792 total time=
0.1s
[CV 3/3] END C=0.2, degree=2, gamma=0.1, kernel=linear;, score=0.802 total time=
0.1s
[CV 1/3] END C=0.2, degree=2, gamma=0.1, kernel=poly;, score=0.887 total time=
0.2s
[CV 2/3] END C=0.2, degree=2, gamma=0.1, kernel=poly;, score=0.848 total time=
0.2s
[CV 3/3] END C=0.2, degree=2, gamma=0.1, kernel=poly;, score=0.825 total time=
0.2s
[CV 1/3] END C=0.2, degree=2, gamma=0.1, kernel=sigmoid;, score=0.420 total
time=   0.3s
[CV 2/3] END C=0.2, degree=2, gamma=0.1, kernel=sigmoid;, score=0.432 total
time=   0.3s
[CV 3/3] END C=0.2, degree=2, gamma=0.1, kernel=sigmoid;, score=0.435 total
time=   0.4s
[CV 1/3] END C=0.2, degree=2, gamma=0.01, kernel=rbf;, score=0.558 total time=
0.4s
[CV 2/3] END C=0.2, degree=2, gamma=0.01, kernel=rbf;, score=0.547 total time=
0.4s
[CV 3/3] END C=0.2, degree=2, gamma=0.01, kernel=rbf;, score=0.537 total time=
0.4s
[CV 1/3] END C=0.2, degree=2, gamma=0.01, kernel=linear;, score=0.853 total
time=   0.1s
[CV 2/3] END C=0.2, degree=2, gamma=0.01, kernel=linear;, score=0.792 total
time=   0.1s
[CV 3/3] END C=0.2, degree=2, gamma=0.01, kernel=linear;, score=0.802 total
time=   0.1s
[CV 1/3] END C=0.2, degree=2, gamma=0.01, kernel=poly;, score=0.455 total time=
0.3s
[CV 2/3] END C=0.2, degree=2, gamma=0.01, kernel=poly;, score=0.489 total time=
0.3s
[CV 3/3] END C=0.2, degree=2, gamma=0.01, kernel=poly;, score=0.472 total time=
0.3s
[CV 1/3] END C=0.2, degree=2, gamma=0.01, kernel=sigmoid;, score=0.533 total
time=   0.2s
[CV 2/3] END C=0.2, degree=2, gamma=0.01, kernel=sigmoid;, score=0.519 total
time=   0.2s
```

[CV 3/3] END C=0.2, degree=2, gamma=0.01, kernel=sigmoid;, score=0.516 total
time=   0.2s
[CV 1/3] END C=0.2, degree=2, gamma=0.001, kernel=rbf;, score=0.384 total time=
0.6s
[CV 2/3] END C=0.2, degree=2, gamma=0.001, kernel=rbf;, score=0.391 total time=
0.6s
[CV 3/3] END C=0.2, degree=2, gamma=0.001, kernel=rbf;, score=0.372 total time=
0.5s
[CV 1/3] END C=0.2, degree=2, gamma=0.001, kernel=linear;, score=0.853 total
time=   0.1s
[CV 2/3] END C=0.2, degree=2, gamma=0.001, kernel=linear;, score=0.792 total
time=   0.1s
[CV 3/3] END C=0.2, degree=2, gamma=0.001, kernel=linear;, score=0.802 total
time=   0.1s
[CV 1/3] END C=0.2, degree=2, gamma=0.001, kernel=poly;, score=0.076 total time=
0.4s
[CV 2/3] END C=0.2, degree=2, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 3/3] END C=0.2, degree=2, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 1/3] END C=0.2, degree=2, gamma=0.001, kernel=sigmoid;, score=0.076 total
time=   0.3s
[CV 2/3] END C=0.2, degree=2, gamma=0.001, kernel=sigmoid;, score=0.076 total
time=   0.3s
[CV 3/3] END C=0.2, degree=2, gamma=0.001, kernel=sigmoid;, score=0.076 total
time=   0.3s
[CV 1/3] END C=0.2, degree=3, gamma=scale, kernel=rbf;, score=0.610 total time=
0.4s
[CV 2/3] END C=0.2, degree=3, gamma=scale, kernel=rbf;, score=0.585 total time=
0.4s
[CV 3/3] END C=0.2, degree=3, gamma=scale, kernel=rbf;, score=0.584 total time=
0.4s
[CV 1/3] END C=0.2, degree=3, gamma=scale, kernel=linear;, score=0.853 total
time=   0.1s
[CV 2/3] END C=0.2, degree=3, gamma=scale, kernel=linear;, score=0.792 total
time=   0.1s
[CV 3/3] END C=0.2, degree=3, gamma=scale, kernel=linear;, score=0.802 total
time=   0.1s
[CV 1/3] END C=0.2, degree=3, gamma=scale, kernel=poly;, score=0.848 total time=
0.2s
[CV 2/3] END C=0.2, degree=3, gamma=scale, kernel=poly;, score=0.834 total time=
0.2s
[CV 3/3] END C=0.2, degree=3, gamma=scale, kernel=poly;, score=0.774 total time=
0.2s
[CV 1/3] END C=0.2, degree=3, gamma=scale, kernel=sigmoid;, score=0.542 total
time=   0.2s
[CV 2/3] END C=0.2, degree=3, gamma=scale, kernel=sigmoid;, score=0.527 total
time=   0.2s

```
[CV 3/3] END C=0.2, degree=3, gamma=scale, kernel=sigmoid;, score=0.540 total
time=   0.2s
[CV 1/3] END C=0.2, degree=3, gamma=auto, kernel=rbf;, score=0.076 total time=
0.6s
[CV 2/3] END C=0.2, degree=3, gamma=auto, kernel=rbf;, score=0.076 total time=
0.6s
[CV 3/3] END C=0.2, degree=3, gamma=auto, kernel=rbf;, score=0.076 total time=
0.6s
[CV 1/3] END C=0.2, degree=3, gamma=auto, kernel=linear;, score=0.853 total
time=   0.1s
[CV 2/3] END C=0.2, degree=3, gamma=auto, kernel=linear;, score=0.792 total
time=   0.1s
[CV 3/3] END C=0.2, degree=3, gamma=auto, kernel=linear;, score=0.802 total
time=   0.1s
[CV 1/3] END C=0.2, degree=3, gamma=auto, kernel=poly;, score=0.076 total time=
0.3s
[CV 2/3] END C=0.2, degree=3, gamma=auto, kernel=poly;, score=0.076 total time=
0.3s
[CV 3/3] END C=0.2, degree=3, gamma=auto, kernel=poly;, score=0.076 total time=
0.3s
[CV 1/3] END C=0.2, degree=3, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.3s
[CV 2/3] END C=0.2, degree=3, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.3s
[CV 3/3] END C=0.2, degree=3, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.3s
[CV 1/3] END C=0.2, degree=3, gamma=0.1, kernel=rbf;, score=0.417 total time=
0.5s
[CV 2/3] END C=0.2, degree=3, gamma=0.1, kernel=rbf;, score=0.440 total time=
0.5s
[CV 3/3] END C=0.2, degree=3, gamma=0.1, kernel=rbf;, score=0.382 total time=
0.5s
[CV 1/3] END C=0.2, degree=3, gamma=0.1, kernel=linear;, score=0.853 total time=
0.1s
[CV 2/3] END C=0.2, degree=3, gamma=0.1, kernel=linear;, score=0.792 total time=
0.1s
[CV 3/3] END C=0.2, degree=3, gamma=0.1, kernel=linear;, score=0.802 total time=
0.1s
[CV 1/3] END C=0.2, degree=3, gamma=0.1, kernel=poly;, score=0.883 total time=
0.2s
[CV 2/3] END C=0.2, degree=3, gamma=0.1, kernel=poly;, score=0.865 total time=
0.2s
[CV 3/3] END C=0.2, degree=3, gamma=0.1, kernel=poly;, score=0.823 total time=
0.2s
[CV 1/3] END C=0.2, degree=3, gamma=0.1, kernel=sigmoid;, score=0.420 total
time=   0.3s
[CV 2/3] END C=0.2, degree=3, gamma=0.1, kernel=sigmoid;, score=0.432 total
time=   0.3s
```

```
[CV 3/3] END C=0.2, degree=3, gamma=0.1, kernel=sigmoid;, score=0.435 total
time=   0.3s
[CV 1/3] END C=0.2, degree=3, gamma=0.01, kernel=rbf;, score=0.558 total time=
0.4s
[CV 2/3] END C=0.2, degree=3, gamma=0.01, kernel=rbf;, score=0.547 total time=
0.4s
[CV 3/3] END C=0.2, degree=3, gamma=0.01, kernel=rbf;, score=0.537 total time=
0.4s
[CV 1/3] END C=0.2, degree=3, gamma=0.01, kernel=linear;, score=0.853 total
time=   0.1s
[CV 2/3] END C=0.2, degree=3, gamma=0.01, kernel=linear;, score=0.792 total
time=   0.1s
[CV 3/3] END C=0.2, degree=3, gamma=0.01, kernel=linear;, score=0.802 total
time=   0.1s
[CV 1/3] END C=0.2, degree=3, gamma=0.01, kernel=poly;, score=0.419 total time=
0.3s
[CV 2/3] END C=0.2, degree=3, gamma=0.01, kernel=poly;, score=0.428 total time=
0.3s
[CV 3/3] END C=0.2, degree=3, gamma=0.01, kernel=poly;, score=0.399 total time=
0.4s
[CV 1/3] END C=0.2, degree=3, gamma=0.01, kernel=sigmoid;, score=0.533 total
time=   0.3s
[CV 2/3] END C=0.2, degree=3, gamma=0.01, kernel=sigmoid;, score=0.519 total
time=   0.3s
[CV 3/3] END C=0.2, degree=3, gamma=0.01, kernel=sigmoid;, score=0.516 total
time=   0.2s
[CV 1/3] END C=0.2, degree=3, gamma=0.001, kernel=rbf;, score=0.384 total time=
0.6s
[CV 2/3] END C=0.2, degree=3, gamma=0.001, kernel=rbf;, score=0.391 total time=
0.5s
[CV 3/3] END C=0.2, degree=3, gamma=0.001, kernel=rbf;, score=0.372 total time=
0.5s
[CV 1/3] END C=0.2, degree=3, gamma=0.001, kernel=linear;, score=0.853 total
time=   0.1s
[CV 2/3] END C=0.2, degree=3, gamma=0.001, kernel=linear;, score=0.792 total
time=   0.1s
[CV 3/3] END C=0.2, degree=3, gamma=0.001, kernel=linear;, score=0.802 total
time=   0.1s
[CV 1/3] END C=0.2, degree=3, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 2/3] END C=0.2, degree=3, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 3/3] END C=0.2, degree=3, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 1/3] END C=0.2, degree=3, gamma=0.001, kernel=sigmoid;, score=0.076 total
time=   0.3s
[CV 2/3] END C=0.2, degree=3, gamma=0.001, kernel=sigmoid;, score=0.076 total
time=   0.4s
```

[CV 3/3] END C=0.2, degree=3, gamma=0.001, kernel=sigmoid;, score=0.076 total
time=   0.3s
[CV 1/3] END C=0.2, degree=4, gamma=scale, kernel=rbf;, score=0.610 total time=
0.4s
[CV 2/3] END C=0.2, degree=4, gamma=scale, kernel=rbf;, score=0.585 total time=
0.4s
[CV 3/3] END C=0.2, degree=4, gamma=scale, kernel=rbf;, score=0.584 total time=
0.4s
[CV 1/3] END C=0.2, degree=4, gamma=scale, kernel=linear;, score=0.853 total
time=   0.1s
[CV 2/3] END C=0.2, degree=4, gamma=scale, kernel=linear;, score=0.792 total
time=   0.1s
[CV 3/3] END C=0.2, degree=4, gamma=scale, kernel=linear;, score=0.802 total
time=   0.1s
[CV 1/3] END C=0.2, degree=4, gamma=scale, kernel=poly;, score=0.873 total time=
0.2s
[CV 2/3] END C=0.2, degree=4, gamma=scale, kernel=poly;, score=0.841 total time=
0.2s
[CV 3/3] END C=0.2, degree=4, gamma=scale, kernel=poly;, score=0.822 total time=
0.2s
[CV 1/3] END C=0.2, degree=4, gamma=scale, kernel=sigmoid;, score=0.542 total
time=   0.2s
[CV 2/3] END C=0.2, degree=4, gamma=scale, kernel=sigmoid;, score=0.527 total
time=   0.2s
[CV 3/3] END C=0.2, degree=4, gamma=scale, kernel=sigmoid;, score=0.540 total
time=   0.2s
[CV 1/3] END C=0.2, degree=4, gamma=auto, kernel=rbf;, score=0.076 total time=
0.6s
[CV 2/3] END C=0.2, degree=4, gamma=auto, kernel=rbf;, score=0.076 total time=
0.5s
[CV 3/3] END C=0.2, degree=4, gamma=auto, kernel=rbf;, score=0.076 total time=
0.5s
[CV 1/3] END C=0.2, degree=4, gamma=auto, kernel=linear;, score=0.853 total
time=   0.1s
[CV 2/3] END C=0.2, degree=4, gamma=auto, kernel=linear;, score=0.792 total
time=   0.1s
[CV 3/3] END C=0.2, degree=4, gamma=auto, kernel=linear;, score=0.802 total
time=   0.1s
[CV 1/3] END C=0.2, degree=4, gamma=auto, kernel=poly;, score=0.076 total time=
0.3s
[CV 2/3] END C=0.2, degree=4, gamma=auto, kernel=poly;, score=0.076 total time=
0.4s
[CV 3/3] END C=0.2, degree=4, gamma=auto, kernel=poly;, score=0.076 total time=
0.3s
[CV 1/3] END C=0.2, degree=4, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.3s
[CV 2/3] END C=0.2, degree=4, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.3s

```
[CV 3/3] END C=0.2, degree=4, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.3s
[CV 1/3] END C=0.2, degree=4, gamma=0.1, kernel=rbf;, score=0.417 total time=
0.5s
[CV 2/3] END C=0.2, degree=4, gamma=0.1, kernel=rbf;, score=0.440 total time=
0.5s
[CV 3/3] END C=0.2, degree=4, gamma=0.1, kernel=rbf;, score=0.382 total time=
0.6s
[CV 1/3] END C=0.2, degree=4, gamma=0.1, kernel=linear;, score=0.853 total time=
0.1s
[CV 2/3] END C=0.2, degree=4, gamma=0.1, kernel=linear;, score=0.792 total time=
0.1s
[CV 3/3] END C=0.2, degree=4, gamma=0.1, kernel=linear;, score=0.802 total time=
0.1s
[CV 1/3] END C=0.2, degree=4, gamma=0.1, kernel=poly;, score=0.873 total time=
0.2s
[CV 2/3] END C=0.2, degree=4, gamma=0.1, kernel=poly;, score=0.854 total time=
0.2s
[CV 3/3] END C=0.2, degree=4, gamma=0.1, kernel=poly;, score=0.825 total time=
0.3s
[CV 1/3] END C=0.2, degree=4, gamma=0.1, kernel=sigmoid;, score=0.420 total
time=   0.3s
[CV 2/3] END C=0.2, degree=4, gamma=0.1, kernel=sigmoid;, score=0.432 total
time=   0.3s
[CV 3/3] END C=0.2, degree=4, gamma=0.1, kernel=sigmoid;, score=0.435 total
time=   0.3s
[CV 1/3] END C=0.2, degree=4, gamma=0.01, kernel=rbf;, score=0.558 total time=
0.5s
[CV 2/3] END C=0.2, degree=4, gamma=0.01, kernel=rbf;, score=0.547 total time=
0.4s
[CV 3/3] END C=0.2, degree=4, gamma=0.01, kernel=rbf;, score=0.537 total time=
0.4s
[CV 1/3] END C=0.2, degree=4, gamma=0.01, kernel=linear;, score=0.853 total
time=   0.1s
[CV 2/3] END C=0.2, degree=4, gamma=0.01, kernel=linear;, score=0.792 total
time=   0.1s
[CV 3/3] END C=0.2, degree=4, gamma=0.01, kernel=linear;, score=0.802 total
time=   0.1s
[CV 1/3] END C=0.2, degree=4, gamma=0.01, kernel=poly;, score=0.076 total time=
0.4s
[CV 2/3] END C=0.2, degree=4, gamma=0.01, kernel=poly;, score=0.076 total time=
0.3s
[CV 3/3] END C=0.2, degree=4, gamma=0.01, kernel=poly;, score=0.076 total time=
0.3s
[CV 1/3] END C=0.2, degree=4, gamma=0.01, kernel=sigmoid;, score=0.533 total
time=   0.2s
[CV 2/3] END C=0.2, degree=4, gamma=0.01, kernel=sigmoid;, score=0.519 total
time=   0.2s
```

[CV 3/3] END C=0.2, degree=4, gamma=0.01, kernel=sigmoid;, score=0.516 total time=   0.2s
[CV 1/3] END C=0.2, degree=4, gamma=0.001, kernel=rbf;, score=0.384 total time= 0.6s
[CV 2/3] END C=0.2, degree=4, gamma=0.001, kernel=rbf;, score=0.391 total time= 0.5s
[CV 3/3] END C=0.2, degree=4, gamma=0.001, kernel=rbf;, score=0.372 total time= 0.5s
[CV 1/3] END C=0.2, degree=4, gamma=0.001, kernel=linear;, score=0.853 total time=   0.1s
[CV 2/3] END C=0.2, degree=4, gamma=0.001, kernel=linear;, score=0.792 total time=   0.1s
[CV 3/3] END C=0.2, degree=4, gamma=0.001, kernel=linear;, score=0.802 total time=   0.1s
[CV 1/3] END C=0.2, degree=4, gamma=0.001, kernel=poly;, score=0.076 total time= 0.3s
[CV 2/3] END C=0.2, degree=4, gamma=0.001, kernel=poly;, score=0.076 total time= 0.3s
[CV 3/3] END C=0.2, degree=4, gamma=0.001, kernel=poly;, score=0.076 total time= 0.3s
[CV 1/3] END C=0.2, degree=4, gamma=0.001, kernel=sigmoid;, score=0.076 total time=   0.3s
[CV 2/3] END C=0.2, degree=4, gamma=0.001, kernel=sigmoid;, score=0.076 total time=   0.4s
[CV 3/3] END C=0.2, degree=4, gamma=0.001, kernel=sigmoid;, score=0.076 total time=   0.3s
[CV 1/3] END C=0.3, degree=2, gamma=scale, kernel=rbf;, score=0.743 total time= 0.4s
[CV 2/3] END C=0.3, degree=2, gamma=scale, kernel=rbf;, score=0.714 total time= 0.4s
[CV 3/3] END C=0.3, degree=2, gamma=scale, kernel=rbf;, score=0.668 total time= 0.4s
[CV 1/3] END C=0.3, degree=2, gamma=scale, kernel=linear;, score=0.842 total time=   0.1s
[CV 2/3] END C=0.3, degree=2, gamma=scale, kernel=linear;, score=0.796 total time=   0.1s
[CV 3/3] END C=0.3, degree=2, gamma=scale, kernel=linear;, score=0.792 total time=   0.1s
[CV 1/3] END C=0.3, degree=2, gamma=scale, kernel=poly;, score=0.836 total time= 0.1s
[CV 2/3] END C=0.3, degree=2, gamma=scale, kernel=poly;, score=0.811 total time= 0.2s
[CV 3/3] END C=0.3, degree=2, gamma=scale, kernel=poly;, score=0.763 total time= 0.1s
[CV 1/3] END C=0.3, degree=2, gamma=scale, kernel=sigmoid;, score=0.588 total time=   0.2s
[CV 2/3] END C=0.3, degree=2, gamma=scale, kernel=sigmoid;, score=0.607 total time=   0.2s

[CV 3/3] END C=0.3, degree=2, gamma=scale, kernel=sigmoid;, score=0.604 total time=   0.2s
[CV 1/3] END C=0.3, degree=2, gamma=auto, kernel=rbf;, score=0.347 total time= 0.6s
[CV 2/3] END C=0.3, degree=2, gamma=auto, kernel=rbf;, score=0.318 total time= 0.6s
[CV 3/3] END C=0.3, degree=2, gamma=auto, kernel=rbf;, score=0.267 total time= 0.5s
[CV 1/3] END C=0.3, degree=2, gamma=auto, kernel=linear;, score=0.842 total time=   0.1s
[CV 2/3] END C=0.3, degree=2, gamma=auto, kernel=linear;, score=0.796 total time=   0.1s
[CV 3/3] END C=0.3, degree=2, gamma=auto, kernel=linear;, score=0.792 total time=   0.1s
[CV 1/3] END C=0.3, degree=2, gamma=auto, kernel=poly;, score=0.076 total time= 0.3s
[CV 2/3] END C=0.3, degree=2, gamma=auto, kernel=poly;, score=0.076 total time= 0.3s
[CV 3/3] END C=0.3, degree=2, gamma=auto, kernel=poly;, score=0.076 total time= 0.4s
[CV 1/3] END C=0.3, degree=2, gamma=auto, kernel=sigmoid;, score=0.076 total time=   0.3s
[CV 2/3] END C=0.3, degree=2, gamma=auto, kernel=sigmoid;, score=0.076 total time=   0.3s
[CV 3/3] END C=0.3, degree=2, gamma=auto, kernel=sigmoid;, score=0.076 total time=   0.3s
[CV 1/3] END C=0.3, degree=2, gamma=0.1, kernel=rbf;, score=0.450 total time= 0.5s
[CV 2/3] END C=0.3, degree=2, gamma=0.1, kernel=rbf;, score=0.465 total time= 0.5s
[CV 3/3] END C=0.3, degree=2, gamma=0.1, kernel=rbf;, score=0.420 total time= 0.5s
[CV 1/3] END C=0.3, degree=2, gamma=0.1, kernel=linear;, score=0.842 total time= 0.1s
[CV 2/3] END C=0.3, degree=2, gamma=0.1, kernel=linear;, score=0.796 total time= 0.1s
[CV 3/3] END C=0.3, degree=2, gamma=0.1, kernel=linear;, score=0.792 total time= 0.1s
[CV 1/3] END C=0.3, degree=2, gamma=0.1, kernel=poly;, score=0.887 total time= 0.1s
[CV 2/3] END C=0.3, degree=2, gamma=0.1, kernel=poly;, score=0.846 total time= 0.2s
[CV 3/3] END C=0.3, degree=2, gamma=0.1, kernel=poly;, score=0.818 total time= 0.2s
[CV 1/3] END C=0.3, degree=2, gamma=0.1, kernel=sigmoid;, score=0.432 total time=   0.3s
[CV 2/3] END C=0.3, degree=2, gamma=0.1, kernel=sigmoid;, score=0.446 total time=   0.3s

```
[CV 3/3] END C=0.3, degree=2, gamma=0.1, kernel=sigmoid;, score=0.453 total
time=   0.3s
[CV 1/3] END C=0.3, degree=2, gamma=0.01, kernel=rbf;, score=0.593 total time=
0.4s
[CV 2/3] END C=0.3, degree=2, gamma=0.01, kernel=rbf;, score=0.604 total time=
0.4s
[CV 3/3] END C=0.3, degree=2, gamma=0.01, kernel=rbf;, score=0.574 total time=
0.4s
[CV 1/3] END C=0.3, degree=2, gamma=0.01, kernel=linear;, score=0.842 total
time=   0.1s
[CV 2/3] END C=0.3, degree=2, gamma=0.01, kernel=linear;, score=0.796 total
time=   0.1s
[CV 3/3] END C=0.3, degree=2, gamma=0.01, kernel=linear;, score=0.792 total
time=   0.1s
[CV 1/3] END C=0.3, degree=2, gamma=0.01, kernel=poly;, score=0.531 total time=
0.2s
[CV 2/3] END C=0.3, degree=2, gamma=0.01, kernel=poly;, score=0.533 total time=
0.2s
[CV 3/3] END C=0.3, degree=2, gamma=0.01, kernel=poly;, score=0.518 total time=
0.2s
[CV 1/3] END C=0.3, degree=2, gamma=0.01, kernel=sigmoid;, score=0.553 total
time=   0.2s
[CV 2/3] END C=0.3, degree=2, gamma=0.01, kernel=sigmoid;, score=0.531 total
time=   0.2s
[CV 3/3] END C=0.3, degree=2, gamma=0.01, kernel=sigmoid;, score=0.535 total
time=   0.2s
[CV 1/3] END C=0.3, degree=2, gamma=0.001, kernel=rbf;, score=0.442 total time=
0.5s
[CV 2/3] END C=0.3, degree=2, gamma=0.001, kernel=rbf;, score=0.462 total time=
0.6s
[CV 3/3] END C=0.3, degree=2, gamma=0.001, kernel=rbf;, score=0.443 total time=
0.5s
[CV 1/3] END C=0.3, degree=2, gamma=0.001, kernel=linear;, score=0.842 total
time=   0.1s
[CV 2/3] END C=0.3, degree=2, gamma=0.001, kernel=linear;, score=0.796 total
time=   0.1s
[CV 3/3] END C=0.3, degree=2, gamma=0.001, kernel=linear;, score=0.792 total
time=   0.1s
[CV 1/3] END C=0.3, degree=2, gamma=0.001, kernel=poly;, score=0.076 total time=
0.4s
[CV 2/3] END C=0.3, degree=2, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 3/3] END C=0.3, degree=2, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 1/3] END C=0.3, degree=2, gamma=0.001, kernel=sigmoid;, score=0.323 total
time=   0.3s
[CV 2/3] END C=0.3, degree=2, gamma=0.001, kernel=sigmoid;, score=0.286 total
time=   0.4s
```

[CV 3/3] END C=0.3, degree=2, gamma=0.001, kernel=sigmoid;, score=0.247 total time=   0.3s
[CV 1/3] END C=0.3, degree=3, gamma=scale, kernel=rbf;, score=0.743 total time=   0.4s
[CV 2/3] END C=0.3, degree=3, gamma=scale, kernel=rbf;, score=0.714 total time=   0.4s
[CV 3/3] END C=0.3, degree=3, gamma=scale, kernel=rbf;, score=0.668 total time=   0.4s
[CV 1/3] END C=0.3, degree=3, gamma=scale, kernel=linear;, score=0.842 total time=   0.1s
[CV 2/3] END C=0.3, degree=3, gamma=scale, kernel=linear;, score=0.796 total time=   0.1s
[CV 3/3] END C=0.3, degree=3, gamma=scale, kernel=linear;, score=0.792 total time=   0.1s
[CV 1/3] END C=0.3, degree=3, gamma=scale, kernel=poly;, score=0.868 total time=   0.2s
[CV 2/3] END C=0.3, degree=3, gamma=scale, kernel=poly;, score=0.854 total time=   0.2s
[CV 3/3] END C=0.3, degree=3, gamma=scale, kernel=poly;, score=0.806 total time=   0.2s
[CV 1/3] END C=0.3, degree=3, gamma=scale, kernel=sigmoid;, score=0.588 total time=   0.2s
[CV 2/3] END C=0.3, degree=3, gamma=scale, kernel=sigmoid;, score=0.607 total time=   0.2s
[CV 3/3] END C=0.3, degree=3, gamma=scale, kernel=sigmoid;, score=0.604 total time=   0.2s
[CV 1/3] END C=0.3, degree=3, gamma=auto, kernel=rbf;, score=0.347 total time=   0.6s
[CV 2/3] END C=0.3, degree=3, gamma=auto, kernel=rbf;, score=0.318 total time=   0.6s
[CV 3/3] END C=0.3, degree=3, gamma=auto, kernel=rbf;, score=0.267 total time=   0.6s
[CV 1/3] END C=0.3, degree=3, gamma=auto, kernel=linear;, score=0.842 total time=   0.1s
[CV 2/3] END C=0.3, degree=3, gamma=auto, kernel=linear;, score=0.796 total time=   0.1s
[CV 3/3] END C=0.3, degree=3, gamma=auto, kernel=linear;, score=0.792 total time=   0.1s
[CV 1/3] END C=0.3, degree=3, gamma=auto, kernel=poly;, score=0.076 total time=   0.4s
[CV 2/3] END C=0.3, degree=3, gamma=auto, kernel=poly;, score=0.076 total time=   0.4s
[CV 3/3] END C=0.3, degree=3, gamma=auto, kernel=poly;, score=0.076 total time=   0.4s
[CV 1/3] END C=0.3, degree=3, gamma=auto, kernel=sigmoid;, score=0.076 total time=   0.3s
[CV 2/3] END C=0.3, degree=3, gamma=auto, kernel=sigmoid;, score=0.076 total time=   0.3s

```
[CV 3/3] END C=0.3, degree=3, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.3s
[CV 1/3] END C=0.3, degree=3, gamma=0.1, kernel=rbf;, score=0.450 total time=
0.5s
[CV 2/3] END C=0.3, degree=3, gamma=0.1, kernel=rbf;, score=0.465 total time=
0.6s
[CV 3/3] END C=0.3, degree=3, gamma=0.1, kernel=rbf;, score=0.420 total time=
0.5s
[CV 1/3] END C=0.3, degree=3, gamma=0.1, kernel=linear;, score=0.842 total time=
0.1s
[CV 2/3] END C=0.3, degree=3, gamma=0.1, kernel=linear;, score=0.796 total time=
0.1s
[CV 3/3] END C=0.3, degree=3, gamma=0.1, kernel=linear;, score=0.792 total time=
0.1s
[CV 1/3] END C=0.3, degree=3, gamma=0.1, kernel=poly;, score=0.883 total time=
0.2s
[CV 2/3] END C=0.3, degree=3, gamma=0.1, kernel=poly;, score=0.865 total time=
0.2s
[CV 3/3] END C=0.3, degree=3, gamma=0.1, kernel=poly;, score=0.823 total time=
0.2s
[CV 1/3] END C=0.3, degree=3, gamma=0.1, kernel=sigmoid;, score=0.432 total
time=   0.3s
[CV 2/3] END C=0.3, degree=3, gamma=0.1, kernel=sigmoid;, score=0.446 total
time=   0.3s
[CV 3/3] END C=0.3, degree=3, gamma=0.1, kernel=sigmoid;, score=0.453 total
time=   0.3s
[CV 1/3] END C=0.3, degree=3, gamma=0.01, kernel=rbf;, score=0.593 total time=
0.4s
[CV 2/3] END C=0.3, degree=3, gamma=0.01, kernel=rbf;, score=0.604 total time=
0.4s
[CV 3/3] END C=0.3, degree=3, gamma=0.01, kernel=rbf;, score=0.574 total time=
0.4s
[CV 1/3] END C=0.3, degree=3, gamma=0.01, kernel=linear;, score=0.842 total
time=   0.1s
[CV 2/3] END C=0.3, degree=3, gamma=0.01, kernel=linear;, score=0.796 total
time=   0.1s
[CV 3/3] END C=0.3, degree=3, gamma=0.01, kernel=linear;, score=0.792 total
time=   0.1s
[CV 1/3] END C=0.3, degree=3, gamma=0.01, kernel=poly;, score=0.448 total time=
0.3s
[CV 2/3] END C=0.3, degree=3, gamma=0.01, kernel=poly;, score=0.465 total time=
0.3s
[CV 3/3] END C=0.3, degree=3, gamma=0.01, kernel=poly;, score=0.425 total time=
0.3s
[CV 1/3] END C=0.3, degree=3, gamma=0.01, kernel=sigmoid;, score=0.553 total
time=   0.2s
[CV 2/3] END C=0.3, degree=3, gamma=0.01, kernel=sigmoid;, score=0.531 total
time=   0.2s
```

```
[CV 3/3] END C=0.3, degree=3, gamma=0.01, kernel=sigmoid;, score=0.535 total
time=    0.2s
[CV 1/3] END C=0.3, degree=3, gamma=0.001, kernel=rbf;, score=0.442 total time=
0.6s
[CV 2/3] END C=0.3, degree=3, gamma=0.001, kernel=rbf;, score=0.462 total time=
0.6s
[CV 3/3] END C=0.3, degree=3, gamma=0.001, kernel=rbf;, score=0.443 total time=
0.6s
[CV 1/3] END C=0.3, degree=3, gamma=0.001, kernel=linear;, score=0.842 total
time=    0.1s
[CV 2/3] END C=0.3, degree=3, gamma=0.001, kernel=linear;, score=0.796 total
time=    0.1s
[CV 3/3] END C=0.3, degree=3, gamma=0.001, kernel=linear;, score=0.792 total
time=    0.1s
[CV 1/3] END C=0.3, degree=3, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 2/3] END C=0.3, degree=3, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 3/3] END C=0.3, degree=3, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 1/3] END C=0.3, degree=3, gamma=0.001, kernel=sigmoid;, score=0.323 total
time=    0.3s
[CV 2/3] END C=0.3, degree=3, gamma=0.001, kernel=sigmoid;, score=0.286 total
time=    0.3s
[CV 3/3] END C=0.3, degree=3, gamma=0.001, kernel=sigmoid;, score=0.247 total
time=    0.3s
[CV 1/3] END C=0.3, degree=4, gamma=scale, kernel=rbf;, score=0.743 total time=
0.4s
[CV 2/3] END C=0.3, degree=4, gamma=scale, kernel=rbf;, score=0.714 total time=
0.4s
[CV 3/3] END C=0.3, degree=4, gamma=scale, kernel=rbf;, score=0.668 total time=
0.4s
[CV 1/3] END C=0.3, degree=4, gamma=scale, kernel=linear;, score=0.842 total
time=    0.1s
[CV 2/3] END C=0.3, degree=4, gamma=scale, kernel=linear;, score=0.796 total
time=    0.1s
[CV 3/3] END C=0.3, degree=4, gamma=scale, kernel=linear;, score=0.792 total
time=    0.1s
[CV 1/3] END C=0.3, degree=4, gamma=scale, kernel=poly;, score=0.871 total time=
0.2s
[CV 2/3] END C=0.3, degree=4, gamma=scale, kernel=poly;, score=0.854 total time=
0.3s
[CV 3/3] END C=0.3, degree=4, gamma=scale, kernel=poly;, score=0.827 total time=
0.2s
[CV 1/3] END C=0.3, degree=4, gamma=scale, kernel=sigmoid;, score=0.588 total
time=    0.2s
[CV 2/3] END C=0.3, degree=4, gamma=scale, kernel=sigmoid;, score=0.607 total
time=    0.2s
```

[CV 3/3] END C=0.3, degree=4, gamma=scale, kernel=sigmoid;, score=0.604 total
time=   0.2s
[CV 1/3] END C=0.3, degree=4, gamma=auto, kernel=rbf;, score=0.347 total time=
0.6s
[CV 2/3] END C=0.3, degree=4, gamma=auto, kernel=rbf;, score=0.318 total time=
0.6s
[CV 3/3] END C=0.3, degree=4, gamma=auto, kernel=rbf;, score=0.267 total time=
0.5s
[CV 1/3] END C=0.3, degree=4, gamma=auto, kernel=linear;, score=0.842 total
time=   0.1s
[CV 2/3] END C=0.3, degree=4, gamma=auto, kernel=linear;, score=0.796 total
time=   0.1s
[CV 3/3] END C=0.3, degree=4, gamma=auto, kernel=linear;, score=0.792 total
time=   0.1s
[CV 1/3] END C=0.3, degree=4, gamma=auto, kernel=poly;, score=0.076 total time=
0.4s
[CV 2/3] END C=0.3, degree=4, gamma=auto, kernel=poly;, score=0.076 total time=
0.3s
[CV 3/3] END C=0.3, degree=4, gamma=auto, kernel=poly;, score=0.076 total time=
0.4s
[CV 1/3] END C=0.3, degree=4, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.3s
[CV 2/3] END C=0.3, degree=4, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.4s
[CV 3/3] END C=0.3, degree=4, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.4s
[CV 1/3] END C=0.3, degree=4, gamma=0.1, kernel=rbf;, score=0.450 total time=
0.6s
[CV 2/3] END C=0.3, degree=4, gamma=0.1, kernel=rbf;, score=0.465 total time=
0.5s
[CV 3/3] END C=0.3, degree=4, gamma=0.1, kernel=rbf;, score=0.420 total time=
0.5s
[CV 1/3] END C=0.3, degree=4, gamma=0.1, kernel=linear;, score=0.842 total time=
0.1s
[CV 2/3] END C=0.3, degree=4, gamma=0.1, kernel=linear;, score=0.796 total time=
0.1s
[CV 3/3] END C=0.3, degree=4, gamma=0.1, kernel=linear;, score=0.792 total time=
0.1s
[CV 1/3] END C=0.3, degree=4, gamma=0.1, kernel=poly;, score=0.873 total time=
0.3s
[CV 2/3] END C=0.3, degree=4, gamma=0.1, kernel=poly;, score=0.854 total time=
0.3s
[CV 3/3] END C=0.3, degree=4, gamma=0.1, kernel=poly;, score=0.825 total time=
0.2s
[CV 1/3] END C=0.3, degree=4, gamma=0.1, kernel=sigmoid;, score=0.432 total
time=   0.3s
[CV 2/3] END C=0.3, degree=4, gamma=0.1, kernel=sigmoid;, score=0.446 total
time=   0.4s

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[CV 3/3] END C=0.3, degree=4, gamma=0.1, kernel=sigmoid;, score=0.453 total
time=   0.3s
[CV 1/3] END C=0.3, degree=4, gamma=0.01, kernel=rbf;, score=0.593 total time=
0.4s
[CV 2/3] END C=0.3, degree=4, gamma=0.01, kernel=rbf;, score=0.604 total time=
0.4s
[CV 3/3] END C=0.3, degree=4, gamma=0.01, kernel=rbf;, score=0.574 total time=
0.4s
[CV 1/3] END C=0.3, degree=4, gamma=0.01, kernel=linear;, score=0.842 total
time=   0.1s
[CV 2/3] END C=0.3, degree=4, gamma=0.01, kernel=linear;, score=0.796 total
time=   0.1s
[CV 3/3] END C=0.3, degree=4, gamma=0.01, kernel=linear;, score=0.792 total
time=   0.1s
[CV 1/3] END C=0.3, degree=4, gamma=0.01, kernel=poly;, score=0.112 total time=
0.3s
[CV 2/3] END C=0.3, degree=4, gamma=0.01, kernel=poly;, score=0.076 total time=
0.3s
[CV 3/3] END C=0.3, degree=4, gamma=0.01, kernel=poly;, score=0.121 total time=
0.3s
[CV 1/3] END C=0.3, degree=4, gamma=0.01, kernel=sigmoid;, score=0.553 total
time=   0.2s
[CV 2/3] END C=0.3, degree=4, gamma=0.01, kernel=sigmoid;, score=0.531 total
time=   0.2s
[CV 3/3] END C=0.3, degree=4, gamma=0.01, kernel=sigmoid;, score=0.535 total
time=   0.2s
[CV 1/3] END C=0.3, degree=4, gamma=0.001, kernel=rbf;, score=0.442 total time=
0.5s
[CV 2/3] END C=0.3, degree=4, gamma=0.001, kernel=rbf;, score=0.462 total time=
0.5s
[CV 3/3] END C=0.3, degree=4, gamma=0.001, kernel=rbf;, score=0.443 total time=
0.6s
[CV 1/3] END C=0.3, degree=4, gamma=0.001, kernel=linear;, score=0.842 total
time=   0.1s
[CV 2/3] END C=0.3, degree=4, gamma=0.001, kernel=linear;, score=0.796 total
time=   0.1s
[CV 3/3] END C=0.3, degree=4, gamma=0.001, kernel=linear;, score=0.792 total
time=   0.1s
[CV 1/3] END C=0.3, degree=4, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 2/3] END C=0.3, degree=4, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 3/3] END C=0.3, degree=4, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 1/3] END C=0.3, degree=4, gamma=0.001, kernel=sigmoid;, score=0.323 total
time=   0.4s
[CV 2/3] END C=0.3, degree=4, gamma=0.001, kernel=sigmoid;, score=0.286 total
time=   0.4s
```

```
[CV 3/3] END C=0.3, degree=4, gamma=0.001, kernel=sigmoid;, score=0.247 total
time=    0.4s
[CV 1/3] END C=0.4, degree=2, gamma=scale, kernel=rbf;, score=0.787 total time=
0.4s
[CV 2/3] END C=0.4, degree=2, gamma=scale, kernel=rbf;, score=0.769 total time=
0.4s
[CV 3/3] END C=0.4, degree=2, gamma=scale, kernel=rbf;, score=0.697 total time=
0.4s
[CV 1/3] END C=0.4, degree=2, gamma=scale, kernel=linear;, score=0.842 total
time=    0.1s
[CV 2/3] END C=0.4, degree=2, gamma=scale, kernel=linear;, score=0.796 total
time=    0.1s
[CV 3/3] END C=0.4, degree=2, gamma=scale, kernel=linear;, score=0.792 total
time=    0.1s
[CV 1/3] END C=0.4, degree=2, gamma=scale, kernel=poly;, score=0.849 total time=
0.1s
[CV 2/3] END C=0.4, degree=2, gamma=scale, kernel=poly;, score=0.832 total time=
0.1s
[CV 3/3] END C=0.4, degree=2, gamma=scale, kernel=poly;, score=0.781 total time=
0.1s
[CV 1/3] END C=0.4, degree=2, gamma=scale, kernel=sigmoid;, score=0.664 total
time=    0.2s
[CV 2/3] END C=0.4, degree=2, gamma=scale, kernel=sigmoid;, score=0.681 total
time=    0.2s
[CV 3/3] END C=0.4, degree=2, gamma=scale, kernel=sigmoid;, score=0.643 total
time=    0.2s
[CV 1/3] END C=0.4, degree=2, gamma=auto, kernel=rbf;, score=0.408 total time=
0.6s
[CV 2/3] END C=0.4, degree=2, gamma=auto, kernel=rbf;, score=0.417 total time=
0.5s
[CV 3/3] END C=0.4, degree=2, gamma=auto, kernel=rbf;, score=0.405 total time=
0.5s
[CV 1/3] END C=0.4, degree=2, gamma=auto, kernel=linear;, score=0.842 total
time=    0.1s
[CV 2/3] END C=0.4, degree=2, gamma=auto, kernel=linear;, score=0.796 total
time=    0.1s
[CV 3/3] END C=0.4, degree=2, gamma=auto, kernel=linear;, score=0.792 total
time=    0.1s
[CV 1/3] END C=0.4, degree=2, gamma=auto, kernel=poly;, score=0.076 total time=
0.3s
[CV 2/3] END C=0.4, degree=2, gamma=auto, kernel=poly;, score=0.076 total time=
0.3s
[CV 3/3] END C=0.4, degree=2, gamma=auto, kernel=poly;, score=0.076 total time=
0.3s
[CV 1/3] END C=0.4, degree=2, gamma=auto, kernel=sigmoid;, score=0.076 total
time=    0.3s
[CV 2/3] END C=0.4, degree=2, gamma=auto, kernel=sigmoid;, score=0.076 total
time=    0.3s
```

[CV 3/3] END C=0.4, degree=2, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.4s
[CV 1/3] END C=0.4, degree=2, gamma=0.1, kernel=rbf;, score=0.474 total time=
0.5s
[CV 2/3] END C=0.4, degree=2, gamma=0.1, kernel=rbf;, score=0.498 total time=
0.6s
[CV 3/3] END C=0.4, degree=2, gamma=0.1, kernel=rbf;, score=0.466 total time=
0.5s
[CV 1/3] END C=0.4, degree=2, gamma=0.1, kernel=linear;, score=0.842 total time=
0.1s
[CV 2/3] END C=0.4, degree=2, gamma=0.1, kernel=linear;, score=0.796 total time=
0.1s
[CV 3/3] END C=0.4, degree=2, gamma=0.1, kernel=linear;, score=0.792 total time=
0.1s
[CV 1/3] END C=0.4, degree=2, gamma=0.1, kernel=poly;, score=0.887 total time=
0.2s
[CV 2/3] END C=0.4, degree=2, gamma=0.1, kernel=poly;, score=0.846 total time=
0.2s
[CV 3/3] END C=0.4, degree=2, gamma=0.1, kernel=poly;, score=0.818 total time=
0.2s
[CV 1/3] END C=0.4, degree=2, gamma=0.1, kernel=sigmoid;, score=0.430 total
time=   0.3s
[CV 2/3] END C=0.4, degree=2, gamma=0.1, kernel=sigmoid;, score=0.453 total
time=   0.3s
[CV 3/3] END C=0.4, degree=2, gamma=0.1, kernel=sigmoid;, score=0.474 total
time=   0.4s
[CV 1/3] END C=0.4, degree=2, gamma=0.01, kernel=rbf;, score=0.706 total time=
0.3s
[CV 2/3] END C=0.4, degree=2, gamma=0.01, kernel=rbf;, score=0.691 total time=
0.4s
[CV 3/3] END C=0.4, degree=2, gamma=0.01, kernel=rbf;, score=0.649 total time=
0.4s
[CV 1/3] END C=0.4, degree=2, gamma=0.01, kernel=linear;, score=0.842 total
time=   0.1s
[CV 2/3] END C=0.4, degree=2, gamma=0.01, kernel=linear;, score=0.796 total
time=   0.1s
[CV 3/3] END C=0.4, degree=2, gamma=0.01, kernel=linear;, score=0.792 total
time=   0.1s
[CV 1/3] END C=0.4, degree=2, gamma=0.01, kernel=poly;, score=0.565 total time=
0.2s
[CV 2/3] END C=0.4, degree=2, gamma=0.01, kernel=poly;, score=0.548 total time=
0.2s
[CV 3/3] END C=0.4, degree=2, gamma=0.01, kernel=poly;, score=0.534 total time=
0.2s
[CV 1/3] END C=0.4, degree=2, gamma=0.01, kernel=sigmoid;, score=0.569 total
time=   0.2s
[CV 2/3] END C=0.4, degree=2, gamma=0.01, kernel=sigmoid;, score=0.566 total
time=   0.2s

[CV 3/3] END C=0.4, degree=2, gamma=0.01, kernel=sigmoid;, score=0.561 total time=   0.2s
[CV 1/3] END C=0.4, degree=2, gamma=0.001, kernel=rbf;, score=0.445 total time=   0.5s
[CV 2/3] END C=0.4, degree=2, gamma=0.001, kernel=rbf;, score=0.469 total time=   0.5s
[CV 3/3] END C=0.4, degree=2, gamma=0.001, kernel=rbf;, score=0.443 total time=   0.5s
[CV 1/3] END C=0.4, degree=2, gamma=0.001, kernel=linear;, score=0.842 total time=   0.1s
[CV 2/3] END C=0.4, degree=2, gamma=0.001, kernel=linear;, score=0.796 total time=   0.1s
[CV 3/3] END C=0.4, degree=2, gamma=0.001, kernel=linear;, score=0.792 total time=   0.1s
[CV 1/3] END C=0.4, degree=2, gamma=0.001, kernel=poly;, score=0.076 total time=   0.3s
[CV 2/3] END C=0.4, degree=2, gamma=0.001, kernel=poly;, score=0.076 total time=   0.3s
[CV 3/3] END C=0.4, degree=2, gamma=0.001, kernel=poly;, score=0.076 total time=   0.3s
[CV 1/3] END C=0.4, degree=2, gamma=0.001, kernel=sigmoid;, score=0.396 total time=   0.3s
[CV 2/3] END C=0.4, degree=2, gamma=0.001, kernel=sigmoid;, score=0.404 total time=   0.4s
[CV 3/3] END C=0.4, degree=2, gamma=0.001, kernel=sigmoid;, score=0.382 total time=   0.3s
[CV 1/3] END C=0.4, degree=3, gamma=scale, kernel=rbf;, score=0.787 total time=   0.4s
[CV 2/3] END C=0.4, degree=3, gamma=scale, kernel=rbf;, score=0.769 total time=   0.4s
[CV 3/3] END C=0.4, degree=3, gamma=scale, kernel=rbf;, score=0.697 total time=   0.4s
[CV 1/3] END C=0.4, degree=3, gamma=scale, kernel=linear;, score=0.842 total time=   0.1s
[CV 2/3] END C=0.4, degree=3, gamma=scale, kernel=linear;, score=0.796 total time=   0.1s
[CV 3/3] END C=0.4, degree=3, gamma=scale, kernel=linear;, score=0.792 total time=   0.1s
[CV 1/3] END C=0.4, degree=3, gamma=scale, kernel=poly;, score=0.874 total time=   0.2s
[CV 2/3] END C=0.4, degree=3, gamma=scale, kernel=poly;, score=0.856 total time=   0.2s
[CV 3/3] END C=0.4, degree=3, gamma=scale, kernel=poly;, score=0.824 total time=   0.2s
[CV 1/3] END C=0.4, degree=3, gamma=scale, kernel=sigmoid;, score=0.664 total time=   0.2s
[CV 2/3] END C=0.4, degree=3, gamma=scale, kernel=sigmoid;, score=0.681 total time=   0.2s

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[CV 3/3] END C=0.4, degree=3, gamma=scale, kernel=sigmoid;, score=0.643 total time=   0.2s
[CV 1/3] END C=0.4, degree=3, gamma=auto, kernel=rbf;, score=0.408 total time=   0.6s
[CV 2/3] END C=0.4, degree=3, gamma=auto, kernel=rbf;, score=0.417 total time=   0.5s
[CV 3/3] END C=0.4, degree=3, gamma=auto, kernel=rbf;, score=0.405 total time=   0.6s
[CV 1/3] END C=0.4, degree=3, gamma=auto, kernel=linear;, score=0.842 total time=   0.1s
[CV 2/3] END C=0.4, degree=3, gamma=auto, kernel=linear;, score=0.796 total time=   0.1s
[CV 3/3] END C=0.4, degree=3, gamma=auto, kernel=linear;, score=0.792 total time=   0.1s
[CV 1/3] END C=0.4, degree=3, gamma=auto, kernel=poly;, score=0.076 total time=   0.3s
[CV 2/3] END C=0.4, degree=3, gamma=auto, kernel=poly;, score=0.076 total time=   0.3s
[CV 3/3] END C=0.4, degree=3, gamma=auto, kernel=poly;, score=0.076 total time=   0.4s
[CV 1/3] END C=0.4, degree=3, gamma=auto, kernel=sigmoid;, score=0.076 total time=   0.3s
[CV 2/3] END C=0.4, degree=3, gamma=auto, kernel=sigmoid;, score=0.076 total time=   0.4s
[CV 3/3] END C=0.4, degree=3, gamma=auto, kernel=sigmoid;, score=0.076 total time=   0.4s
[CV 1/3] END C=0.4, degree=3, gamma=0.1, kernel=rbf;, score=0.474 total time=   0.5s
[CV 2/3] END C=0.4, degree=3, gamma=0.1, kernel=rbf;, score=0.498 total time=   0.5s
[CV 3/3] END C=0.4, degree=3, gamma=0.1, kernel=rbf;, score=0.466 total time=   0.5s
[CV 1/3] END C=0.4, degree=3, gamma=0.1, kernel=linear;, score=0.842 total time=   0.1s
[CV 2/3] END C=0.4, degree=3, gamma=0.1, kernel=linear;, score=0.796 total time=   0.1s
[CV 3/3] END C=0.4, degree=3, gamma=0.1, kernel=linear;, score=0.792 total time=   0.1s
[CV 1/3] END C=0.4, degree=3, gamma=0.1, kernel=poly;, score=0.883 total time=   0.2s
[CV 2/3] END C=0.4, degree=3, gamma=0.1, kernel=poly;, score=0.865 total time=   0.2s
[CV 3/3] END C=0.4, degree=3, gamma=0.1, kernel=poly;, score=0.823 total time=   0.2s
[CV 1/3] END C=0.4, degree=3, gamma=0.1, kernel=sigmoid;, score=0.430 total time=   0.3s
[CV 2/3] END C=0.4, degree=3, gamma=0.1, kernel=sigmoid;, score=0.453 total time=   0.3s

```
[CV 3/3] END C=0.4, degree=3, gamma=0.1, kernel=sigmoid;, score=0.474 total
time=   0.4s
[CV 1/3] END C=0.4, degree=3, gamma=0.01, kernel=rbf;, score=0.706 total time=
0.4s
[CV 2/3] END C=0.4, degree=3, gamma=0.01, kernel=rbf;, score=0.691 total time=
0.4s
[CV 3/3] END C=0.4, degree=3, gamma=0.01, kernel=rbf;, score=0.649 total time=
0.3s
[CV 1/3] END C=0.4, degree=3, gamma=0.01, kernel=linear;, score=0.842 total
time=   0.1s
[CV 2/3] END C=0.4, degree=3, gamma=0.01, kernel=linear;, score=0.796 total
time=   0.1s
[CV 3/3] END C=0.4, degree=3, gamma=0.01, kernel=linear;, score=0.792 total
time=   0.1s
[CV 1/3] END C=0.4, degree=3, gamma=0.01, kernel=poly;, score=0.452 total time=
0.3s
[CV 2/3] END C=0.4, degree=3, gamma=0.01, kernel=poly;, score=0.472 total time=
0.3s
[CV 3/3] END C=0.4, degree=3, gamma=0.01, kernel=poly;, score=0.433 total time=
0.4s
[CV 1/3] END C=0.4, degree=3, gamma=0.01, kernel=sigmoid;, score=0.569 total
time=   0.2s
[CV 2/3] END C=0.4, degree=3, gamma=0.01, kernel=sigmoid;, score=0.566 total
time=   0.2s
[CV 3/3] END C=0.4, degree=3, gamma=0.01, kernel=sigmoid;, score=0.561 total
time=   0.2s
[CV 1/3] END C=0.4, degree=3, gamma=0.001, kernel=rbf;, score=0.445 total time=
0.5s
[CV 2/3] END C=0.4, degree=3, gamma=0.001, kernel=rbf;, score=0.469 total time=
0.5s
[CV 3/3] END C=0.4, degree=3, gamma=0.001, kernel=rbf;, score=0.443 total time=
0.5s
[CV 1/3] END C=0.4, degree=3, gamma=0.001, kernel=linear;, score=0.842 total
time=   0.1s
[CV 2/3] END C=0.4, degree=3, gamma=0.001, kernel=linear;, score=0.796 total
time=   0.1s
[CV 3/3] END C=0.4, degree=3, gamma=0.001, kernel=linear;, score=0.792 total
time=   0.1s
[CV 1/3] END C=0.4, degree=3, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 2/3] END C=0.4, degree=3, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 3/3] END C=0.4, degree=3, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 1/3] END C=0.4, degree=3, gamma=0.001, kernel=sigmoid;, score=0.396 total
time=   0.3s
[CV 2/3] END C=0.4, degree=3, gamma=0.001, kernel=sigmoid;, score=0.404 total
time=   0.3s
```

[CV 3/3] END C=0.4, degree=3, gamma=0.001, kernel=sigmoid;, score=0.382 total
time=   0.3s
[CV 1/3] END C=0.4, degree=4, gamma=scale, kernel=rbf;, score=0.787 total time=
0.4s
[CV 2/3] END C=0.4, degree=4, gamma=scale, kernel=rbf;, score=0.769 total time=
0.4s
[CV 3/3] END C=0.4, degree=4, gamma=scale, kernel=rbf;, score=0.697 total time=
0.4s
[CV 1/3] END C=0.4, degree=4, gamma=scale, kernel=linear;, score=0.842 total
time=   0.1s
[CV 2/3] END C=0.4, degree=4, gamma=scale, kernel=linear;, score=0.796 total
time=   0.1s
[CV 3/3] END C=0.4, degree=4, gamma=scale, kernel=linear;, score=0.792 total
time=   0.1s
[CV 1/3] END C=0.4, degree=4, gamma=scale, kernel=poly;, score=0.873 total time=
0.2s
[CV 2/3] END C=0.4, degree=4, gamma=scale, kernel=poly;, score=0.854 total time=
0.3s
[CV 3/3] END C=0.4, degree=4, gamma=scale, kernel=poly;, score=0.825 total time=
0.2s
[CV 1/3] END C=0.4, degree=4, gamma=scale, kernel=sigmoid;, score=0.664 total
time=   0.2s
[CV 2/3] END C=0.4, degree=4, gamma=scale, kernel=sigmoid;, score=0.681 total
time=   0.2s
[CV 3/3] END C=0.4, degree=4, gamma=scale, kernel=sigmoid;, score=0.643 total
time=   0.2s
[CV 1/3] END C=0.4, degree=4, gamma=auto, kernel=rbf;, score=0.408 total time=
0.6s
[CV 2/3] END C=0.4, degree=4, gamma=auto, kernel=rbf;, score=0.417 total time=
0.5s
[CV 3/3] END C=0.4, degree=4, gamma=auto, kernel=rbf;, score=0.405 total time=
0.6s
[CV 1/3] END C=0.4, degree=4, gamma=auto, kernel=linear;, score=0.842 total
time=   0.1s
[CV 2/3] END C=0.4, degree=4, gamma=auto, kernel=linear;, score=0.796 total
time=   0.1s
[CV 3/3] END C=0.4, degree=4, gamma=auto, kernel=linear;, score=0.792 total
time=   0.1s
[CV 1/3] END C=0.4, degree=4, gamma=auto, kernel=poly;, score=0.076 total time=
0.3s
[CV 2/3] END C=0.4, degree=4, gamma=auto, kernel=poly;, score=0.076 total time=
0.3s
[CV 3/3] END C=0.4, degree=4, gamma=auto, kernel=poly;, score=0.076 total time=
0.3s
[CV 1/3] END C=0.4, degree=4, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.4s
[CV 2/3] END C=0.4, degree=4, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.3s

[CV 3/3] END C=0.4, degree=4, gamma=auto, kernel=sigmoid;, score=0.076 total
time=   0.4s
[CV 1/3] END C=0.4, degree=4, gamma=0.1, kernel=rbf;, score=0.474 total time=
0.6s
[CV 2/3] END C=0.4, degree=4, gamma=0.1, kernel=rbf;, score=0.498 total time=
0.5s
[CV 3/3] END C=0.4, degree=4, gamma=0.1, kernel=rbf;, score=0.466 total time=
0.5s
[CV 1/3] END C=0.4, degree=4, gamma=0.1, kernel=linear;, score=0.842 total time=
0.1s
[CV 2/3] END C=0.4, degree=4, gamma=0.1, kernel=linear;, score=0.796 total time=
0.1s
[CV 3/3] END C=0.4, degree=4, gamma=0.1, kernel=linear;, score=0.792 total time=
0.1s
[CV 1/3] END C=0.4, degree=4, gamma=0.1, kernel=poly;, score=0.873 total time=
0.2s
[CV 2/3] END C=0.4, degree=4, gamma=0.1, kernel=poly;, score=0.854 total time=
0.2s
[CV 3/3] END C=0.4, degree=4, gamma=0.1, kernel=poly;, score=0.825 total time=
0.2s
[CV 1/3] END C=0.4, degree=4, gamma=0.1, kernel=sigmoid;, score=0.430 total
time=   0.3s
[CV 2/3] END C=0.4, degree=4, gamma=0.1, kernel=sigmoid;, score=0.453 total
time=   0.3s
[CV 3/3] END C=0.4, degree=4, gamma=0.1, kernel=sigmoid;, score=0.474 total
time=   0.3s
[CV 1/3] END C=0.4, degree=4, gamma=0.01, kernel=rbf;, score=0.706 total time=
0.3s
[CV 2/3] END C=0.4, degree=4, gamma=0.01, kernel=rbf;, score=0.691 total time=
0.4s
[CV 3/3] END C=0.4, degree=4, gamma=0.01, kernel=rbf;, score=0.649 total time=
0.4s
[CV 1/3] END C=0.4, degree=4, gamma=0.01, kernel=linear;, score=0.842 total
time=   0.1s
[CV 2/3] END C=0.4, degree=4, gamma=0.01, kernel=linear;, score=0.796 total
time=   0.1s
[CV 3/3] END C=0.4, degree=4, gamma=0.01, kernel=linear;, score=0.792 total
time=   0.1s
[CV 1/3] END C=0.4, degree=4, gamma=0.01, kernel=poly;, score=0.359 total time=
0.3s
[CV 2/3] END C=0.4, degree=4, gamma=0.01, kernel=poly;, score=0.344 total time=
0.3s
[CV 3/3] END C=0.4, degree=4, gamma=0.01, kernel=poly;, score=0.334 total time=
0.4s
[CV 1/3] END C=0.4, degree=4, gamma=0.01, kernel=sigmoid;, score=0.569 total
time=   0.2s
[CV 2/3] END C=0.4, degree=4, gamma=0.01, kernel=sigmoid;, score=0.566 total
time=   0.2s

```
[CV 3/3] END C=0.4, degree=4, gamma=0.01, kernel=sigmoid;, score=0.561 total
time=   0.2s
[CV 1/3] END C=0.4, degree=4, gamma=0.001, kernel=rbf;, score=0.445 total time=
0.5s
[CV 2/3] END C=0.4, degree=4, gamma=0.001, kernel=rbf;, score=0.469 total time=
0.5s
[CV 3/3] END C=0.4, degree=4, gamma=0.001, kernel=rbf;, score=0.443 total time=
0.5s
[CV 1/3] END C=0.4, degree=4, gamma=0.001, kernel=linear;, score=0.842 total
time=   0.1s
[CV 2/3] END C=0.4, degree=4, gamma=0.001, kernel=linear;, score=0.796 total
time=   0.1s
[CV 3/3] END C=0.4, degree=4, gamma=0.001, kernel=linear;, score=0.792 total
time=   0.1s
[CV 1/3] END C=0.4, degree=4, gamma=0.001, kernel=poly;, score=0.076 total time=
0.3s
[CV 2/3] END C=0.4, degree=4, gamma=0.001, kernel=poly;, score=0.076 total time=
0.4s
[CV 3/3] END C=0.4, degree=4, gamma=0.001, kernel=poly;, score=0.076 total time=
0.4s
[CV 1/3] END C=0.4, degree=4, gamma=0.001, kernel=sigmoid;, score=0.396 total
time=   0.5s
[CV 2/3] END C=0.4, degree=4, gamma=0.001, kernel=sigmoid;, score=0.404 total
time=   0.4s
[CV 3/3] END C=0.4, degree=4, gamma=0.001, kernel=sigmoid;, score=0.382 total
time=   0.4s

 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)
```

```python
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': 0.1, 'degree': 3, 'gamma': 0.1, 'kernel': 'poly'}

['e:\\Documents\\CS231\\project\\Traffic-Sign-Classification-through-
Images\\joblib\\best_svm_model.joblib']
```
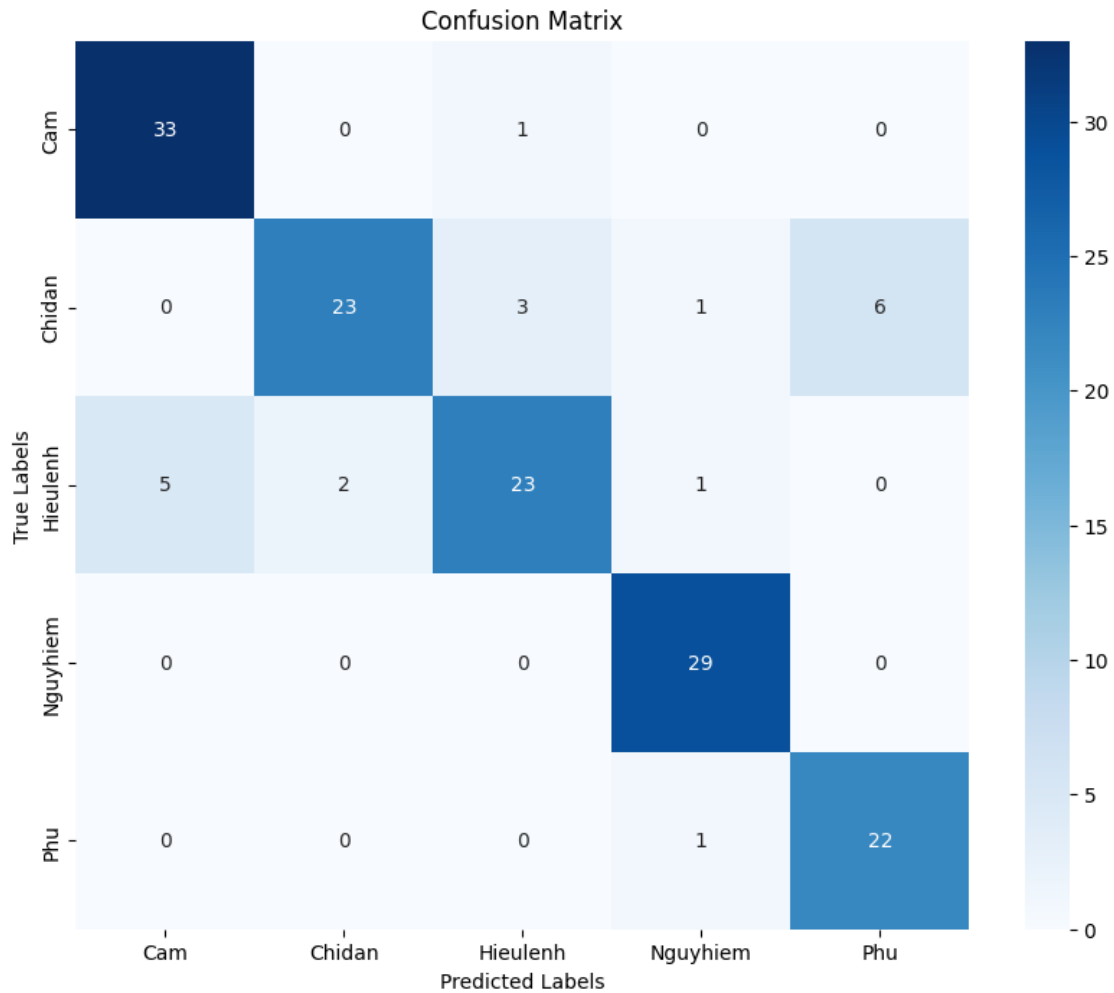
8 Predict on test images for KNN

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

```
              precision    recall  f1-score   support

         Cam       0.87      0.97      0.92        34
      Chidan       0.92      0.70      0.79        33
    Hieulenh       0.85      0.74      0.79        31
    Nguyhiem       0.91      1.00      0.95        29
         Phu       0.79      0.96      0.86        23

    accuracy                           0.87       150
   macro avg       0.87      0.87      0.86       150
weighted avg       0.87      0.87      0.86       150
```

```
heatmap_label_knn = confusion_matrix(test_labels_encoded, y_pred_knn)

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

Confusion Matrix

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

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

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

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

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

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

9 Predict on test images for SVM

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

```
              precision    recall  f1-score   support

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

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

```
heatmap_label_svm = confusion_matrix(test_labels_encoded, y_pred_svm)

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

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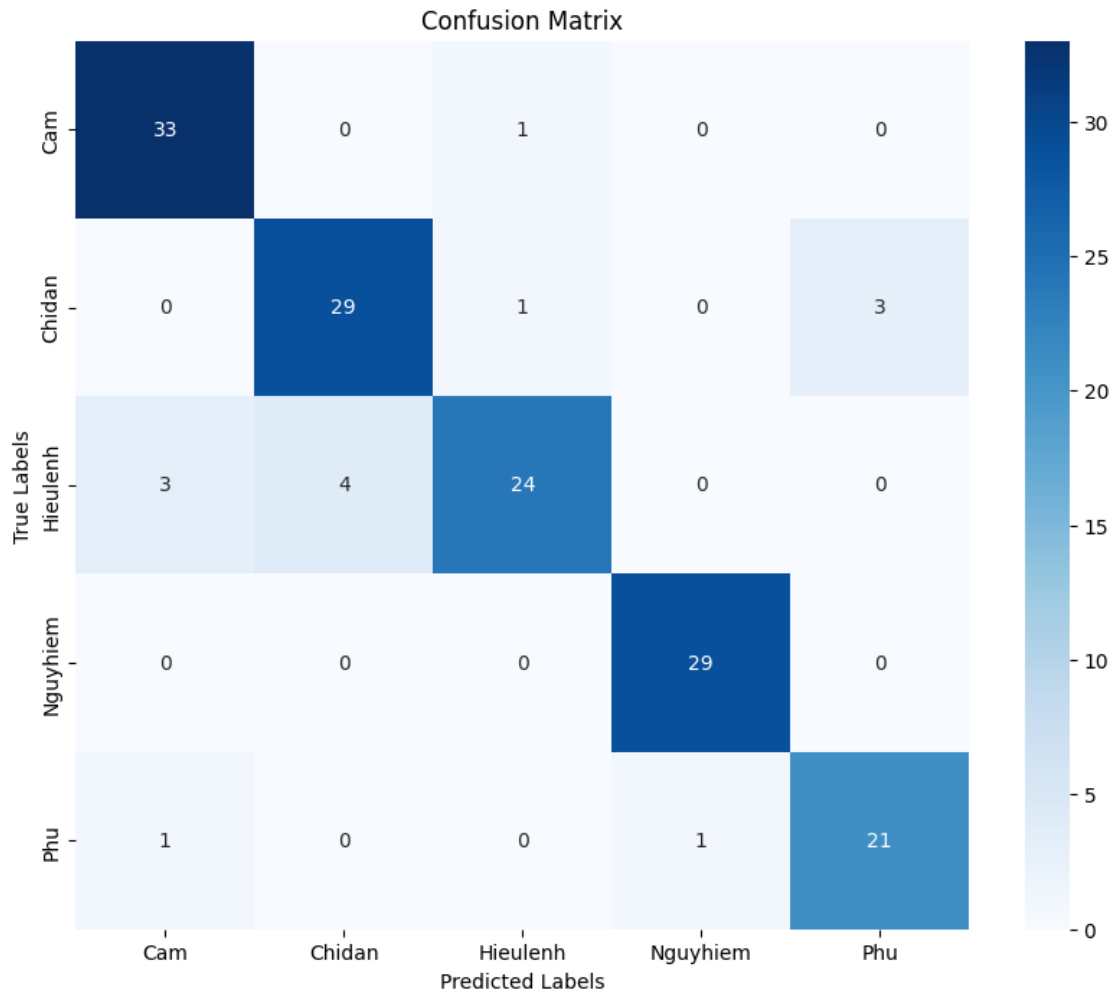
```
n_columns = 10
n_rows = math.ceil(len(test_images) / n_columns)

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')
```

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

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

10 Save grid search results

```python
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
```

```python
# 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\Traffic-Sign-
Classification-through-

```
Images\grid_search_results\notebook_export_2024-12-09_21_28_12.pdf
```

```
'e:\\Documents\\CS231\\project\\Traffic-Sign-Classification-through-
Images\\grid_search_results\\notebook_export_2024-12-09_21_28_12.pdf'
```