German Traffic Sign Classification

May 19, 2024

[1]:

```
pip install opencv-python
```

```
Requirement already satisfied: opencv-python in c:\apps\anaconda\lib\site-
packages (4.9.0.80)
Requirement already satisfied: numpy>=1.21.2 in c:\apps\anaconda\lib\site-
packages (from opencv-python) (1.26.4)
Note: you may need to restart the kernel to use updated packages.
```

[2]:

```
!git clone https://bitbucket.org/jadslim/german-traffic-signs
!ls german-traffic-sign
import numpy as np
import matplotlib.pyplot as plt
import keras
from keras.models import Sequential
from keras.optimizers import Adam
from keras.layers import Dense
from keras.layers import Flatten, Dropout
from tensorflow.keras.utils import to_categorical
from tensorflow.keras.layers import Conv2D, MaxPool2D, Dense, Flatten, Dropout
import random
import pickle
import pandas as pd
import cv2
from PIL import Image
```

```
fatal: destination path 'german-traffic-signs' already exists and is not an
empty directory.
'ls' is not recognized as an internal or external command,
operable program or batch file.
```

[3]:

```
from keras.callbacks import LearningRateScheduler, ModelCheckpoint

%matplotlib inline
np.random.seed(0)
# TODO: Implement load the data here.
with open('german-traffic-signs/train.p', 'rb') as f:
    train_data = pickle.load(f)
with open('german-traffic-signs/valid.p', 'rb') as f:
    val_data = pickle.load(f)
```

```
# TODO: Load test data
with open('german-traffic-signs/test.p', 'rb') as f:
    test_data = pickle.load(f)
```

[4]:

```
# Spliting out features and labels
X_train, y_train = train_data['features'], train_data['labels']
X_val, y_val = val_data['features'], val_data['labels']
X_test, y_test = test_data['features'], test_data['labels']
```

[5]:

```
#already 4 dimensional
print(X_train.shape)
print(X_val.shape)
print(X_test.shape)
```

```
(34799, 32, 32, 3)
(4410, 32, 32, 3)
(12630, 32, 32, 3)
```

[6]:

```
assert(X_train.shape[0] == y_train.shape[0]), "The number of images is not␣
 ↪equal to the number of labels."
assert(X_train.shape[1:] == (32,32,3)), "The dimensions of the images are not␣
 ↪32 x 32 x 3."
assert(X_val.shape[0] == y_val.shape[0]), "The number of images is not equal to␣
 ↪the number of labels."
assert(X_val.shape[1:] == (32,32,3)), "The dimensions of the images are not 32␣
 ↪x 32 x 3."
assert(X_test.shape[0] == y_test.shape[0]), "The number of images is not equal␣
 ↪to the number of labels."
assert(X_test.shape[1:] == (32,32,3)), "The dimensions of the images are not 32␣
 ↪x 32 x 3."
```

[7]:

```
data = pd.read_csv('german-traffic-signs/signnames.csv')
print(data)
```

```
    ClassId                                           SignName
0         0                               Speed limit (20km/h)
1         1                               Speed limit (30km/h)
2         2                               Speed limit (50km/h)
3         3                               Speed limit (60km/h)
4         4                               Speed limit (70km/h)
5         5                               Speed limit (80km/h)
6         6                        End of speed limit (80km/h)
7         7                              Speed limit (100km/h)
8         8                              Speed limit (120km/h)
9         9                                         No passing
10       10       No passing for vechiles over 3.5 metric tons
11       11              Right-of-way at the next intersection
```

```
12       12                                      Priority road
13       13                                              Yield
14       14                                               Stop
15       15                                        No vechiles
16       16            Vechiles over 3.5 metric tons prohibited
17       17                                           No entry
18       18                                    General caution
19       19                        Dangerous curve to the left
20       20                       Dangerous curve to the right
21       21                                       Double curve
22       22                                         Bumpy road
23       23                                      Slippery road
24       24                          Road narrows on the right
25       25                                          Road work
26       26                                    Traffic signals
27       27                                        Pedestrians
28       28                                  Children crossing
29       29                                  Bicycles crossing
30       30                                 Beware of ice/snow
31       31                              Wild animals crossing
32       32                End of all speed and passing limits
33       33                                   Turn right ahead
34       34                                    Turn left ahead
35       35                                         Ahead only
36       36                               Go straight or right
37       37                                Go straight or left
38       38                                         Keep right
39       39                                          Keep left
40       40                               Roundabout mandatory
41       41                                  End of no passing
42       42  End of no passing by vechiles over 3.5 metric …
```

[8]:

```python
# Assuming 'data' contains the class names
data = pd.read_csv('german-traffic-signs/signnames.csv')
num_of_samples = []
cols = 5
num_classes = 43

# Ensuring that the number of subplots matches the number of classes
fig, axs = plt.subplots(nrows=num_classes, ncols=cols, figsize=(12, 50))
fig.tight_layout()

for i in range(cols):
      for j, row in data.iterrows():
        x_selected = X_train[y_train == j]
        axs[j][i].imshow(x_selected[random.randint(0,(len(x_selected) - 1)), :,␣
 ↪:], cmap=plt.get_cmap('gray'))
```

```
        axs[j][i].axis("off")
        if i == 2:
          axs[j][i].set_title(str(j) + " - " + row["SignName"])
          num_of_samples.append(len(x_selected))
```

0 - Speed limit (20km/h)

1 - Speed limit (30km/h)

2 - Speed limit (50km/h)

3 - Speed limit (60km/h)

4 - Speed limit (70km/h)

5 - Speed limit (80km/h)

6 - End of speed limit (80km/h)

7 - Speed limit (100km/h)

8 - Speed limit (120km/h)

9 - No passing

10 - No passing for vechiles over 3.5 metric tons

11 - Right-of-way at the next intersection

12 - Priority road

13 - Yield

14 - Stop

15 - No vechiles

16 - Vechiles over 3.5 metric tons prohibited

17 - No entry

18 - General caution

19 - Dangerous curve to the left

20 - Dangerous curve to the right

21 - Double curve

22 - Bumpy road

23 - Slippery road

24 - Road narrows on the right

25 - Road work

26 - Traffic signals

27 - Pedestrians

28 - Children crossing

29 - Bicycles crossing

30 - Beware of ice/snow

31 - Wild animals crossing

32 - End of all speed and passing limits

33 - Turn right ahead

34 - Turn left ahead

35 - Ahead only

36 - Go straight or right

37 - Go straight or left

38 - Keep right

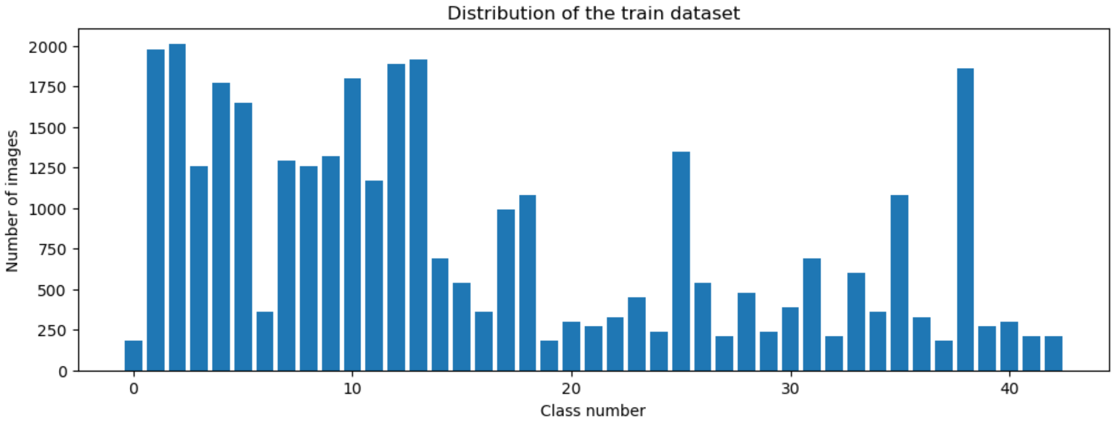
39 - Keep left

40 - Roundabout mandatory

41 - End of no passing

42 - End of no passing by vechiles over 3.5 metric tons

[9]:
```
plt.figure(figsize=(12, 4))
plt.bar(range(0, num_classes), num_of_samples)
plt.title("Distribution of the train dataset")
plt.xlabel("Class number")
plt.ylabel("Number of images")
plt.show()
```



[10]:
```
import cv2
import pandas as pd

# Defining grayscale and equalization functions
def grayscale(img):
    img_gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
    return img_gray

def equalize(img):
    img_equalized = cv2.equalizeHist(img)
    return img_equalized
```

[11]:
```
import cv2

plt.imshow(X_train[1000])
plt.axis("off")
print(X_train[1000].shape)
print(y_train[1000])
def grayscale(img):
    img = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
    return img
```

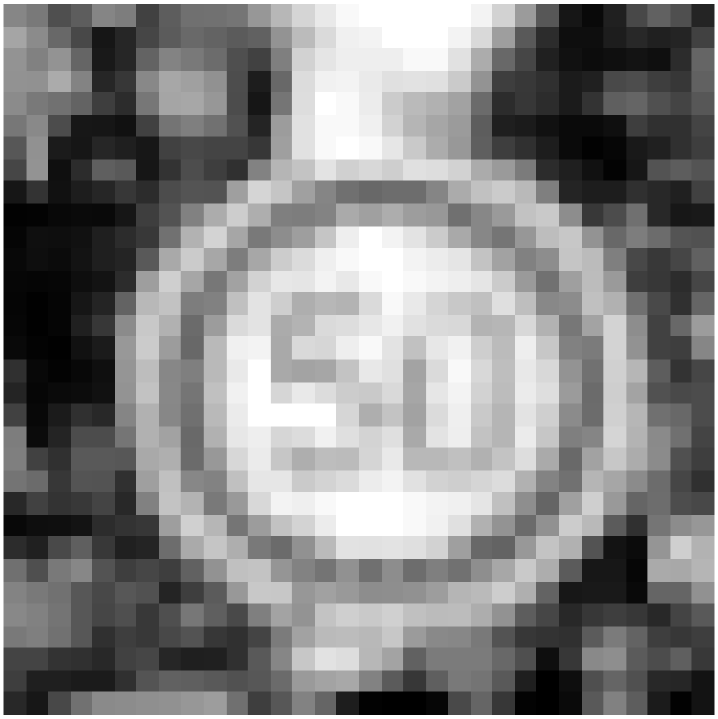
```
(32, 32, 3)
```

```
36
```

[12]:

```python
import matplotlib.pyplot as plt
import random

def grayscale(img):
    img = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
    return img

def equalize(img):
    img = cv2.equalizeHist(img)
    return img

def preprocess(img):
    img = grayscale(img)
    img = equalize(img)
    img = img / 255
    return img

X_train = np.array(list(map(preprocess, X_train)))
X_test = np.array(list(map(preprocess, X_test)))
X_val = np.array(list(map(preprocess, X_val)))
```

```
# Display a random grayscale image
plt.imshow(X_train[random.randint(0, len(X_train) - 1)], cmap='gray')
plt.axis('off')
plt.show()
print(X_train.shape)

# Reshape the data
X_train = X_train.reshape(34799, 32, 32, 1)
X_test = X_test.reshape(12630, 32, 32, 1)
X_val = X_val.reshape(4410, 32, 32, 1)
```



```
(34799, 32, 32)
```

[13]:
```
print(X_train.shape)
print(X_test.shape)
print(X_val.shape)
```

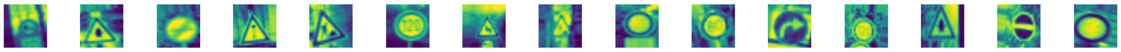
```
(34799, 32, 32, 1)
(12630, 32, 32, 1)
(4410, 32, 32, 1)
```

[14]:
```
from tensorflow.keras.utils import to_categorical
from tensorflow.keras.preprocessing.image import ImageDataGenerator
```

```
# Defining the data augmentation generator
datagen = ImageDataGenerator(
    width_shift_range=0.1,
    height_shift_range=0.1,
    zoom_range=0.2,
    shear_range=0.1,
    rotation_range=10)
# Fitting the data augmentation generator on the training data
datagen.fit(X_train)
```

[15]:

```
# Generating augmented data batches
batches = datagen.flow(X_train, y_train,batch_size=20)
X_batch, y_batch = next(batches)

# Visualizing the augmented images
fig, axs = plt.subplots(1, 15, figsize=(20, 5))
fig.tight_layout()

for i in range(15):
    axs[i].imshow(X_batch[i].reshape(32, 32)) # Assuming grayscale images
    axs[i].axis("off")
```



[16]:

```
# Converting the labels to one-hot encoded format for train, test, and␣
  ↪validation sets
y_train = to_categorical(y_train, 43)
y_test = to_categorical(y_test, 43)
y_val = to_categorical(y_val, 43)
```

[19]:

```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Flatten, Dense,␣
  ↪Dropout
from tensorflow.keras.optimizers import Adam

def modified_model():
    model = Sequential()
    model.add(Conv2D(60, (5, 5), input_shape=(32, 32, 1), activation='relu'))
    model.add(Conv2D(60, (5, 5), activation='relu'))
    model.add(MaxPooling2D(pool_size=(2, 2)))

    model.add(Conv2D(30, (3, 3), activation='relu'))
    model.add(Conv2D(30, (3, 3), activation='relu'))
    model.add(MaxPooling2D(pool_size=(2, 2)))

    model.add(Flatten())
    model.add(Dense(500, activation='relu'))
    model.add(Dropout(0.5))
    model.add(Dense(43, activation='softmax'))

    model.compile(optimizer=Adam(learning_rate=0.001), loss='categorical_crossentropy', metrics=['accuracy'])
    return model

model = modified_model()
print(model.summary())
```

```
Model: "sequential_2"


 Layer (type)                       Output Shape                Param #

 conv2d_8 (Conv2D)                  (None, 28, 28, 60)            1,560

 conv2d_9 (Conv2D)                  (None, 24, 24, 60)           90,060

 max_pooling2d_4 (MaxPooling2D)     (None, 12, 12, 60)                0

 conv2d_10 (Conv2D)                 (None, 10, 10, 30)           16,230

 conv2d_11 (Conv2D)                 (None, 8, 8, 30)              8,130

 max_pooling2d_5 (MaxPooling2D)     (None, 4, 4, 30)                  0

 flatten_2 (Flatten)                (None, 480)                       0

 dense_4 (Dense)                    (None, 500)                 240,500

 dropout_2 (Dropout)                (None, 500)                       0

 dense_5 (Dense)                    (None, 43)                   21,543


 Total params: 378,023 (1.44 MB)

 Trainable params: 378,023 (1.44 MB)

 Non-trainable params: 0 (0.00 B)
```

```
None
```

[21]:
```
history = model.fit(
    datagen.flow(X_train, y_train, batch_size=50),
    steps_per_epoch=2000,
    epochs=10,
    validation_data=(X_val, y_val),
    shuffle=True
)
```

```
Epoch 1/10
   3/2000            1:20 40ms/step -
accuracy: 0.0322 - loss: 3.7638
```

```
C:\Apps\Anaconda\Lib\site-
packages\keras\src\trainers\data_adapters\py_dataset_adapter.py:121:
UserWarning: Your `PyDataset` class should call `super().__init__(**kwargs)` in
its constructor. `**kwargs` can include `workers`, `use_multiprocessing`,
`max_queue_size`. Do not pass these arguments to `fit()`, as they will be
ignored.
  self._warn_if_super_not_called()
```

```
 695/2000            44s 34ms/step -
accuracy: 0.2941 - loss: 2.6157
```

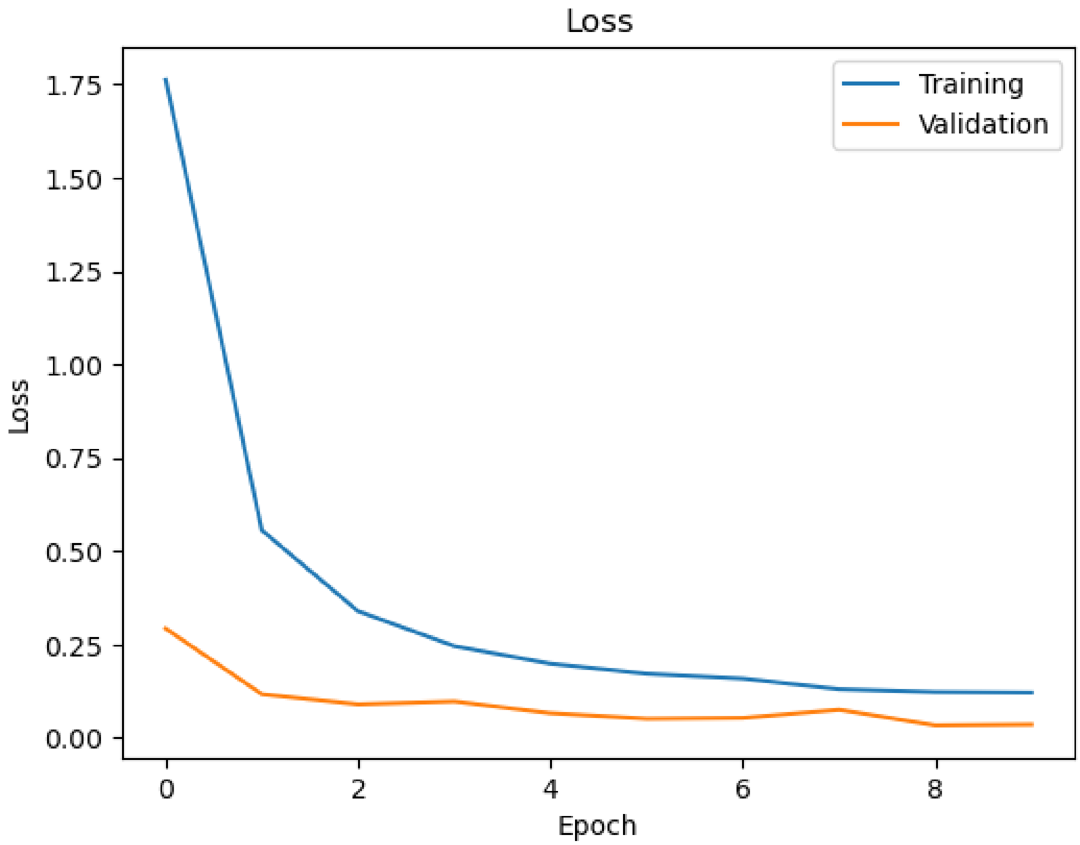
```
C:\Apps\Anaconda\Lib\contextlib.py:158: UserWarning: Your input ran out of data;
interrupting training. Make sure that your dataset or generator can generate at
least `steps_per_epoch * epochs` batches. You may need to use the `.repeat()`
function when building your dataset.
  self.gen.throw(typ, value, traceback)
```

```
2000/2000            27s 13ms/step -
accuracy: 0.4288 - loss: 2.0595 - val_accuracy: 0.9084 - val_loss: 0.2926
Epoch 2/10
2000/2000            30s 15ms/step -
accuracy: 0.8171 - loss: 0.5888 - val_accuracy: 0.9671 - val_loss: 0.1168
Epoch 3/10
2000/2000            31s 16ms/step -
accuracy: 0.8921 - loss: 0.3463 - val_accuracy: 0.9737 - val_loss: 0.0899
Epoch 4/10
2000/2000            34s 17ms/step -
accuracy: 0.9219 - loss: 0.2474 - val_accuracy: 0.9751 - val_loss: 0.0974
Epoch 5/10
2000/2000            34s 17ms/step -
accuracy: 0.9381 - loss: 0.2014 - val_accuracy: 0.9814 - val_loss: 0.0661
Epoch 6/10
2000/2000            34s 17ms/step -
accuracy: 0.9448 - loss: 0.1736 - val_accuracy: 0.9866 - val_loss: 0.0512
Epoch 7/10
2000/2000            34s 17ms/step -
```

```
accuracy: 0.9498 - loss: 0.1611 - val_accuracy: 0.9848 - val_loss: 0.0532
Epoch 8/10
2000/2000                36s 18ms/step -
accuracy: 0.9594 - loss: 0.1301 - val_accuracy: 0.9807 - val_loss: 0.0753
Epoch 9/10
2000/2000                39s 19ms/step -
accuracy: 0.9606 - loss: 0.1258 - val_accuracy: 0.9887 - val_loss: 0.0335
Epoch 10/10
2000/2000                35s 18ms/step -
accuracy: 0.9629 - loss: 0.1217 - val_accuracy: 0.9907 - val_loss: 0.0356
```

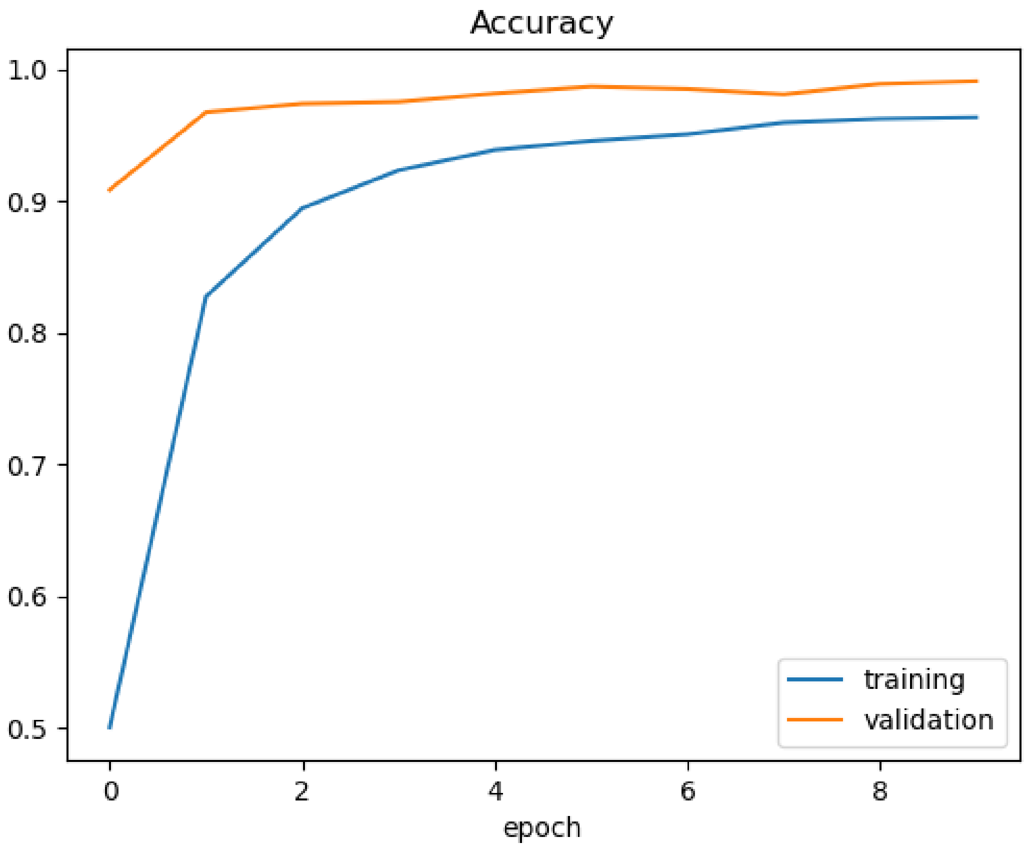
[46]:

```python
import matplotlib.pyplot as plt

plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.legend(['Training', 'Validation'])  # Corrected legend syntax
plt.title('Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')  # Added ylabel for clarity
plt.show()
```



[47]:
```
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.legend(['training','validation'])
plt.title('Accuracy')
plt.xlabel('epoch')
```

[47]:
```
Text(0.5, 0, 'epoch')
```



[48]:
```
# Evaluating model on test data
score = model.evaluate(X_test, y_test, verbose=0)
print('Test score:', score[0])
print('Test accuracy:', score[1])
```

```
Test score: 0.10784535109996796
Test accuracy: 0.9752969145774841
```

[49]:
```
# Evaluating model on training data
train_score = model.evaluate(X_train, y_train, verbose=0)
print('Training score:')
print('  Loss:', train_score[0])
print('  Accuracy:', train_score[1])

# Evaluating model on validation data
val_score = model.evaluate(X_val, y_val, verbose=0)
print('Validation score:')
print('  Loss:', val_score[0])
print('  Accuracy:', val_score[1])
```

```
Training score:
  Loss: 0.016071079298853874
  Accuracy: 0.9951435327529907
Validation score:
  Loss: 0.035643890500068665
  Accuracy: 0.9907029271125793
```

[42]:

```
# Predicting internet image
import requests
from PIL import Image
import numpy as np
import cv2

# URL of the image
url = 'https://c8.alamy.com/comp/J2MRAJ/
 ↪german-road-sign-bicycles-crossing-J2MRAJ.jpg'

# Downloading and loading the image
r = requests.get(url, stream=True)
img = Image.open(r.raw)
plt.imshow(img, cmap=plt.get_cmap('gray'))

# Converting the image to grayscale, resize, and preprocess
img = np.asarray(img)
img = cv2.resize(img, (32, 32))
img = preprocess(img)
img = img.reshape(1, 32, 32, 1)

# Predicting the class probabilities
predictions = model.predict(img)

# Getting the index with the highest probability
predicted_class = np.argmax(predictions)

print("Predicted class:", predicted_class)
```

```
1/1               0s 18ms/step
Predicted class: 29
```

THE END. THANK YOU!

```
[ ]:
```

```
[ ]:
```

```
[ ]:
```

```
[ ]:
```