```
import pandas as pd
import tensorflow as tf
import numpy as np
from tensorflow.keras.preprocessing.image import ImageDataGenerator, array_to_img, load_img
import matplotlib.pyplot as plt
import string
```

```
# Load the dataset from the specified path in Google Drive
file_path = 'sign_mnist_train.csv'
train_df = pd.read_csv(file_path)
test_df = pd.read_csv(file_path)
train_df = train_df[:math.floor(0.7*len(train_df))]
test_df = test_df[math.ceil(0.7*len(train_df)):]
# Display the first few rows of the training dataset
train_df.head()
```

	label	pixel1	pixel2	pixel3	pixel4	pixel5	pixel6	pixel7	pixel8	pixel9	...	pixel775	pixel776	pixel777	pixel778	pixel7
0	3	107	118	127	134	139	143	146	150	153	...	207	207	207	207	2(
1	6	155	157	156	156	156	157	156	158	158	...	69	149	128	87	9
2	2	187	188	188	187	187	186	187	188	187	...	202	201	200	199	1(
3	2	211	211	212	212	211	210	211	210	210	...	235	234	233	231	2:
4	13	164	167	170	172	176	179	180	184	185	...	92	105	105	108	1:

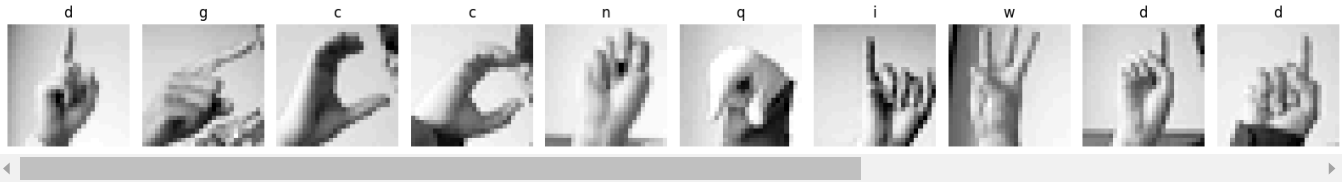
5 rows × 785 columns

```
X_train, y_train = np.array(train_df.iloc[:, 1:]).reshape(-1, 28, 28).astype('float64'), np.array(train_df.label).astype('float64')
X_test, y_test = np.array(test_df.iloc[:, 1:]).reshape(-1, 28, 28).astype('float64'), np.array(test_df.label).astype('float64')

print(X_train.shape, y_train.shape)
print(X_test.shape, y_test.shape)
```

```
(19218, 28, 28) (19218,)
(14002, 28, 28) (14002,)
```

```
train_datagen = ImageDataGenerator(rescale=1.0/255.0,
                                   zoom_range=0.2,
                                   width_shift_range=0.2,
                                   height_shift_range=0.2)

train_generator = train_datagen.flow(x=np.expand_dims(X_train, axis=-1), y=y_train,
                  batch_size=32)

test_datagen = ImageDataGenerator(rescale=1.0/255.0)

test_generator = test_datagen.flow(x=np.expand_dims(X_test, axis=-1), y=y_test,
                  batch_size=32)
```

```
# Plot a sample of 10 images from the training set
def plot_categories(training_images, training_labels):
  fig, axes = plt.subplots(1, 10, figsize=(16, 15))
  axes = axes.flatten()
  letters = list(string.ascii_lowercase)

  for k in range(10):
    img = training_images[k]
    img = np.expand_dims(img, axis=-1)
    img = array_to_img(img)
    ax = axes[k]
    ax.imshow(img, cmap="Greys_r")
    ax.set_title(f"{letters[int(training_labels[k])]}")
    ax.set_axis_off()

  plt.tight_layout()
  plt.show()

plot_categories(X_train, y_train)
```



```
from tensorflow.keras import Sequential
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Flatten, Dense, Dropout

tf.random.set_seed(1234)

model = tf.keras.Sequential([
    Conv2D(16, (3, 3), activation='relu', input_shape=(28, 28, 1)),
    MaxPooling2D(2, 2),
    Conv2D(32, (3, 3), activation='relu'),
    MaxPooling2D(2, 2),
    Flatten(),
    Dense(256, activation='relu'),
    Dropout(0.2),
    Dense(26, activation='softmax')
])

model.compile(
    optimizer='adam',
    loss='sparse_categorical_crossentropy',
    metrics=['accuracy']
)

model.summary()
```

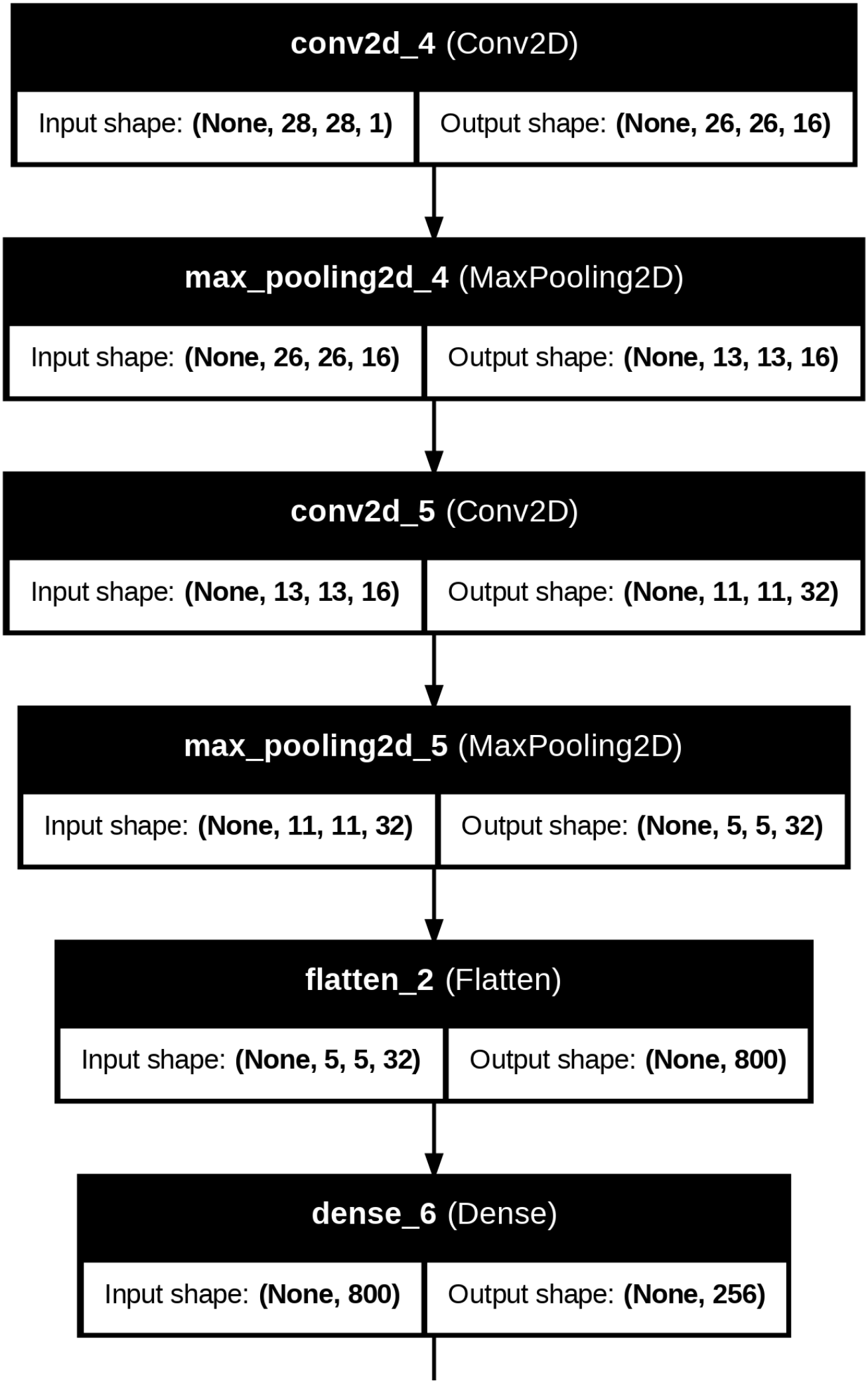
```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/convolutional/base_conv.py:107: UserWarning: Do not pass an `input_shape`/`
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

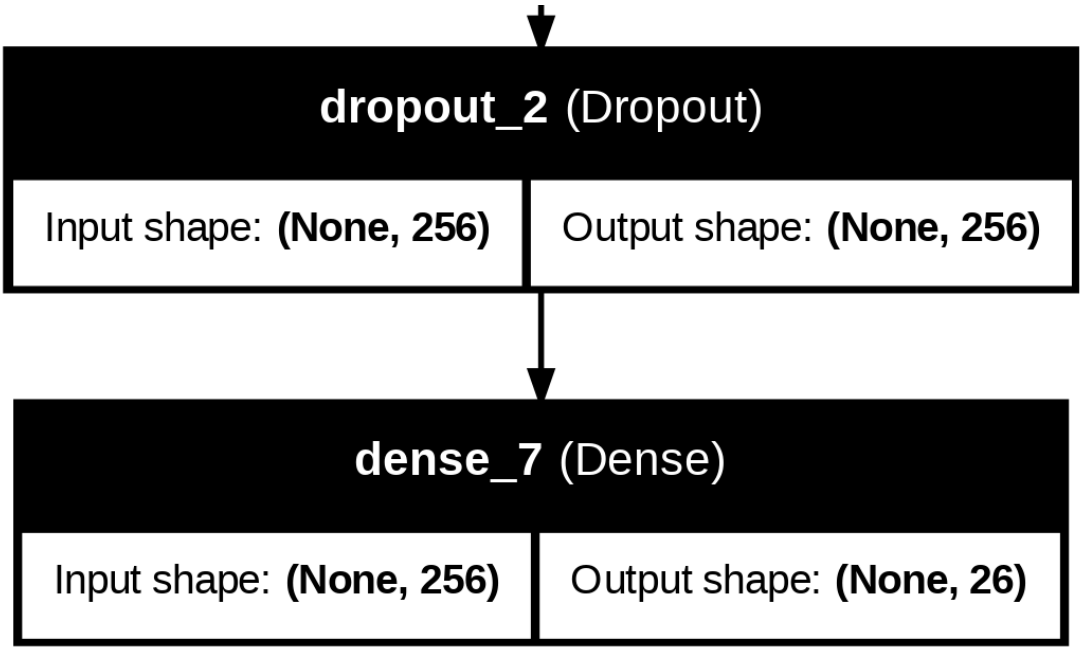
Model: "sequential_2"

Layer (type)	Output Shape	Param #
conv2d_4 (Conv2D)	(None, 26, 26, 16)	160
max_pooling2d_4 (MaxPooling2D)	(None, 13, 13, 16)	0
conv2d_5 (Conv2D)	(None, 11, 11, 32)	4,640
max_pooling2d_5 (MaxPooling2D)	(None, 5, 5, 32)	0
flatten_2 (Flatten)	(None, 800)	0
dense_6 (Dense)	(None, 256)	205,056
dropout_2 (Dropout)	(None, 256)	0
dense_7 (Dense)	(None, 26)	6,682

Total params: 216,538 (845.85 KB)
Trainable params: 216,538 (845.85 KB)

```
from tensorflow.keras.utils import plot_model

# Assuming 'model' is your defined CNN model
plot_model(model, to_file='model_plot.png', show_shapes=True, show_layer_names=True)

```

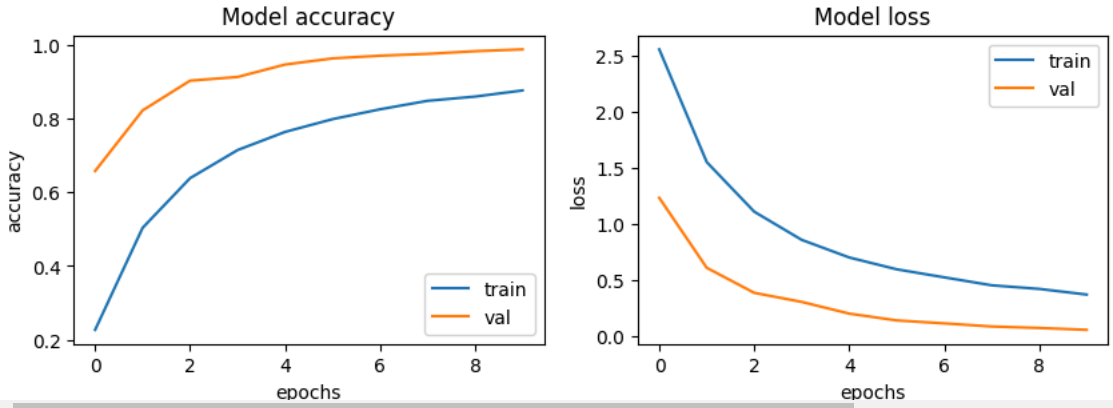

conv2d_4 (Conv2D)
Input shape: (None, 28, 28, 1)
Output shape: (None, 26, 26, 16)
max_pooling2d_4 (MaxPooling2D)
Input shape: (None, 26, 26, 16)
Output shape: (None, 13, 13, 16)
conv2d_5 (Conv2D)
Input shape: (None, 13, 13, 16)
Output shape: (None, 11, 11, 32)
max_pooling2d_5 (MaxPooling2D)
Input shape: (None, 11, 11, 32)
Output shape: (None, 5, 5, 32)
flatten_2 (Flatten)
Input shape: (None, 5, 5, 32)
Output shape: (None, 800)
dense_6 (Dense)
Input shape: (None, 800)
Output shape: (None, 256)




```
history = model.fit(train_generator, validation_data=test_generator, epochs=10)
```

```
Epoch 1/10
  3/601 ━━━━━━━━━━━━━━━━━━━━ 17s 29ms/step - accuracy: 0.0625 - loss: 3.2779/usr/local/lib/python3.10/dist-packages/keras/src/traine
  self._warn_if_super_not_called()
601/601 ━━━━━━━━━━━━━━━━━━━━ 24s 37ms/step - accuracy: 0.1277 - loss: 2.9223 - val_accuracy: 0.6578 - val_loss: 1.2369
Epoch 2/10
601/601 ━━━━━━━━━━━━━━━━━━━━ 43s 40ms/step - accuracy: 0.4504 - loss: 1.7381 - val_accuracy: 0.8224 - val_loss: 0.6129
Epoch 3/10
601/601 ━━━━━━━━━━━━━━━━━━━━ 23s 37ms/step - accuracy: 0.6138 - loss: 1.1976 - val_accuracy: 0.9032 - val_loss: 0.3897
Epoch 4/10
601/601 ━━━━━━━━━━━━━━━━━━━━ 25s 42ms/step - accuracy: 0.7040 - loss: 0.9054 - val_accuracy: 0.9131 - val_loss: 0.3088
Epoch 5/10
601/601 ━━━━━━━━━━━━━━━━━━━━ 41s 42ms/step - accuracy: 0.7548 - loss: 0.7298 - val_accuracy: 0.9469 - val_loss: 0.2043
Epoch 6/10
601/601 ━━━━━━━━━━━━━━━━━━━━ 42s 43ms/step - accuracy: 0.7832 - loss: 0.6304 - val_accuracy: 0.9635 - val_loss: 0.1436
Epoch 7/10
601/601 ━━━━━━━━━━━━━━━━━━━━ 24s 40ms/step - accuracy: 0.8202 - loss: 0.5432 - val_accuracy: 0.9709 - val_loss: 0.1173
Epoch 8/10
601/601 ━━━━━━━━━━━━━━━━━━━━ 41s 39ms/step - accuracy: 0.8512 - loss: 0.4591 - val_accuracy: 0.9759 - val_loss: 0.0895
Epoch 9/10
601/601 ━━━━━━━━━━━━━━━━━━━━ 41s 39ms/step - accuracy: 0.8555 - loss: 0.4475 - val_accuracy: 0.9831 - val_loss: 0.0763
Epoch 10/10
601/601 ━━━━━━━━━━━━━━━━━━━━ 41s 40ms/step - accuracy: 0.8749 - loss: 0.3773 - val_accuracy: 0.9880 - val_loss: 0.0598
```

```
fig, ax = plt.subplots(1, 2, figsize=(10, 3))
ax = ax.ravel()

for i, met in enumerate(['accuracy', 'loss']):
    ax[i].plot(history.history[met])
    ax[i].plot(history.history['val_' + met])
    ax[i].set_title('Model {}'.format(met))
    ax[i].set_xlabel('epochs')
    ax[i].set_ylabel(met)
    ax[i].legend(['train', 'val'])
```




```
import pandas as pd
import numpy as np
import tensorflow as tf
import math
from tensorflow.keras.preprocessing.image import ImageDataGenerator

# Load dataset
train_df = pd.read_csv('sign_mnist_train.csv')
test_df = pd.read_csv('sign_mnist_train.csv')

train_df = train_df[:math.floor(0.7*len(train_df))]
test_df = test_df[math.ceil(0.7*len(train_df)):]

# Extract features and labels
X_train = np.array(train_df.iloc[:, 1:]).reshape(-1, 28, 28, 1).astype('float32') / 255.0
y_train = np.array(train_df['label']).astype('float32')
X_test = np.array(test_df.iloc[:, 1:]).reshape(-1, 28, 28, 1).astype('float32') / 255.0
y_test = np.array(test_df['label']).astype('float32')

# Resize images to (128, 128, 3)
X_train_resized = tf.image.resize(X_train.repeat(3, axis=-1), [128, 128])
X_test_resized = tf.image.resize(X_test.repeat(3, axis=-1), [128, 128])

# Data generators
train_datagen = ImageDataGenerator(
    zoom_range=0.2, width_shift_range=0.2, height_shift_range=0.2, horizontal_flip=True
)
test_datagen = ImageDataGenerator()

train_generator = train_datagen.flow(X_train_resized, y_train, batch_size=32)
test_generator = test_datagen.flow(X_test_resized, y_test, batch_size=32)

```

```
from tensorflow.keras.applications import ResNet50
from tensorflow.keras.models import Model
from tensorflow.keras.layers import Dense, GlobalAveragePooling2D
from tensorflow.keras.optimizers import Adam

# Load ResNet50 with pretrained weights
base_model = ResNet50(weights='imagenet', include_top=False, input_shape=(128, 128, 3))
for layer in base_model.layers:
    layer.trainable = False

# Add custom layers for classification
x = base_model.output
x = GlobalAveragePooling2D()(x)
x = Dense(1024, activation='relu')(x)
output = Dense(26, activation='softmax')(x)

resnet_model = Model(inputs=base_model.input, outputs=output)
resnet_model.compile(
    optimizer=Adam(learning_rate=0.0001),
    loss='sparse_categorical_crossentropy',
    metrics=['accuracy']
)

```

```
history_resnet = resnet_model.fit(
    train_generator,
    validation_data=test_generator,
    epochs=1
)
```