EN2550 Exercise 11

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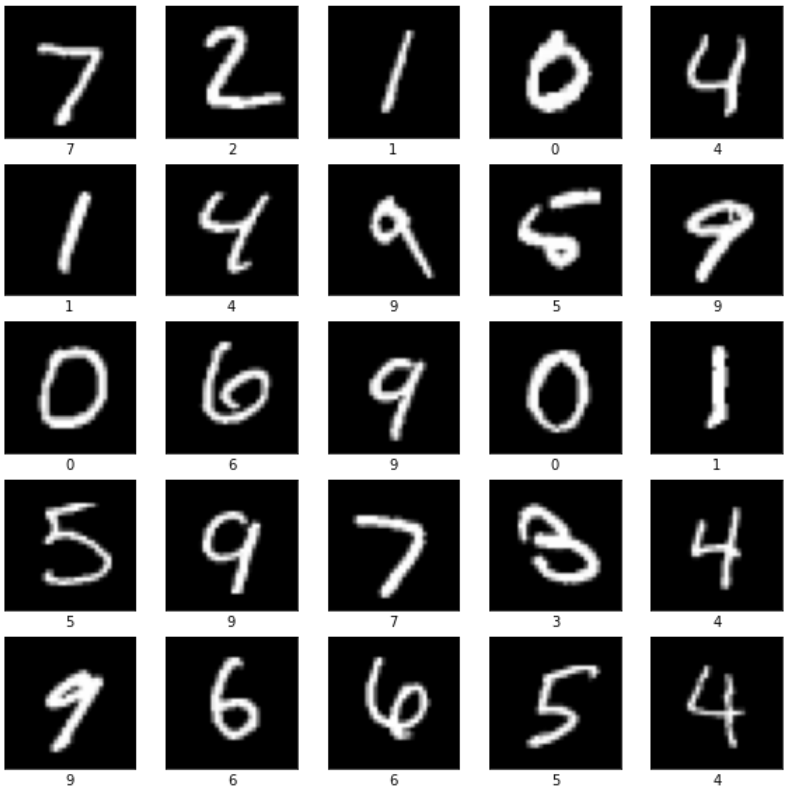
Index no - 190164M

In [ ]:
```
import tensorflow as tf
from tensorflow import keras
from keras import layers,datasets
import numpy as np
import matplotlib.pyplot as plt
```

Q1

In [ ]:
```
mnist = datasets.mnist
(train_images, train_labels), (test_images, test_labels) = mnist.load_data()

# Padding
paddings = tf.constant([[0, 0], [2, 2], [2, 2]])
train_images = tf.pad(train_images, paddings, constant_values=0)
test_images = tf.pad(test_images, paddings, constant_values=0)

print('train_images.shape: ', train_images.shape)
print('train_labels.shape: ', train_labels.shape)
print('test_images.shape:', test_images.shape)
print('test_labels.shape:', test_labels.shape)
class_names = ['0', '1', '2', '3', '4', '5', '6', '7', '8', '9']

train_images = tf.dtypes.cast(train_images, tf.float32)
test_images = tf.dtypes.cast(test_images, tf.float32)
train_images, test_images = train_images[..., np.newaxis]/255.0, test_images[..., np.newaxis]/255.0

plt.figure(figsize=(10,10))
for i in range(25):
    plt.subplot(5,5,i+1)
    plt.xticks([])
    plt.yticks([])
    plt.grid(False)
    plt.imshow(tf.reshape(test_images[i],[32,32]),cmap=plt.cm.gray)
    plt.xlabel(class_names[test_labels[i]])

plt.show()

model=keras.Sequential()
model.add(layers.Conv2D(6,(5,5),activation='relu',input_shape=(32,32,1)))
model.add(layers.AveragePooling2D((2,2)))
model.add(layers.Conv2D(16,(5,5),activation='relu'))
model.add(layers.AveragePooling2D((2,2)))
model.add(layers.Flatten())
model.add(layers.Dense(120,activation='relu'))
model.add(layers.Dense(84,activation='relu'))
model.add(layers.Dense(10))

model.compile(optimizer='adam',
loss=keras.losses.SparseCategoricalCrossentropy(from_logits=True),
metrics=['accuracy'])

print(model.summary())

model.fit(train_images,train_labels,epochs=5)

test_loss,test_acc=model.evaluate(test_images,test_labels,verbose=2)
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/mnist.npz
11490434/11490434 [==============================] - 1s 0us/step
train_images.shape:  (60000, 32, 32)
train_labels.shape:  (60000,)
test_images.shape: (10000, 32, 32)
test_labels.shape: (10000,)
```




```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 28, 28, 6)         156

 average_pooling2d (AverageP  (None, 14, 14, 6)        0
 ooling2D)

 conv2d_1 (Conv2D)           (None, 10, 10, 16)        2416

 average_pooling2d_1 (Averag  (None, 5, 5, 16)         0
 ePooling2D)

 flatten (Flatten)           (None, 400)               0

 dense (Dense)               (None, 120)               48120

 dense_1 (Dense)             (None, 84)                10164

 dense_2 (Dense)             (None, 10)                850

=================================================================
Total params: 61,706
Trainable params: 61,706
Non-trainable params: 0
_________________________________________________________________
None
Epoch 1/5
1875/1875 [==============================] - 11s 5ms/step - loss: 0.2187 - accuracy: 0.9337
Epoch 2/5
1875/1875 [==============================] - 10s 6ms/step - loss: 0.0729 - accuracy: 0.9777
Epoch 3/5
1875/1875 [==============================] - 11s 6ms/step - loss: 0.0512 - accuracy: 0.9840
Epoch 4/5
1875/1875 [==============================] - 11s 6ms/step - loss: 0.0397 - accuracy: 0.9872
Epoch 5/5
1875/1875 [==============================] - 11s 6ms/step - loss: 0.0318 - accuracy: 0.9898
313/313 - 1s - loss: 0.0447 - accuracy: 0.9852 - 724ms/epoch - 2ms/step
```

Q2

In [ ]:

```
(train_images, train_labels), (test_images, test_labels) = datasets.cifar10.load_data()
train_images,test_images=train_images/255.0,test_images/255.0
class_names=['airplane','autombile','bird','cat','deer','dog','frog','horse','ship','truck']

print('train_images.shape: ', train_images.shape)
print('train_labels.shape: ', train_labels.shape)
print('test_images.shape:', test_images.shape)
print('test_labels.shape:', test_labels.shape)

model=keras.Sequential()
model.add(layers.Conv2D(32,(5,5),activation='relu',input_shape=(32,32,3)))
model.add(layers.MaxPool2D((2,2)))
model.add(layers.Conv2D(64,(3,3),activation='relu'))
```

```
model.add(layers.MaxPool2D((2,2)))
model.add(layers.Conv2D(128,(3,3),activation='relu'))
model.add(layers.Flatten())
model.add(layers.Dense(64,activation='relu'))
model.add(layers.Dense(10))

model.compile(optimizer=keras.optimizers.Adam(learning_rate=0.001),
loss=keras.losses.SparseCategoricalCrossentropy(from_logits=True),
metrics=['accuracy'])

print(model.summary())

model.fit(train_images,train_labels,epochs=5)

test_loss,test_acc=model.evaluate(test_images,test_labels,verbose=2)
```

```
train_images.shape:  (50000, 32, 32, 3)
train_labels.shape:  (50000, 1)
test_images.shape: (10000, 32, 32, 3)
test_labels.shape: (10000, 1)
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_2 (Conv2D)           (None, 28, 28, 32)        2432

 max_pooling2d (MaxPooling2D  (None, 14, 14, 32)       0
 )

 conv2d_3 (Conv2D)           (None, 12, 12, 64)        18496

 max_pooling2d_1 (MaxPooling  (None, 6, 6, 64)         0
 2D)

 conv2d_4 (Conv2D)           (None, 4, 4, 128)         73856

 flatten_1 (Flatten)         (None, 2048)              0

 dense_3 (Dense)             (None, 64)                131136

 dense_4 (Dense)             (None, 10)                650

=================================================================
Total params: 226,570
Trainable params: 226,570
Non-trainable params: 0
_________________________________________________________________
None
Epoch 1/5
1563/1563 [==============================] - 24s 15ms/step - loss: 1.5016 - accuracy: 0.4530
Epoch 2/5
1563/1563 [==============================] - 27s 17ms/step - loss: 1.1469 - accuracy: 0.5922
Epoch 3/5
1563/1563 [==============================] - 24s 16ms/step - loss: 0.9867 - accuracy: 0.6540
Epoch 4/5
1563/1563 [==============================] - 25s 16ms/step - loss: 0.8723 - accuracy: 0.6937
Epoch 5/5
1563/1563 [==============================] - 24s 15ms/step - loss: 0.7918 - accuracy: 0.7228
313/313 - 2s - loss: 0.8790 - accuracy: 0.6945 - 2s/epoch - 5ms/step
```

Q3

In [ ]:

```
mnist = datasets.mnist
(train_images, train_labels), (test_images, test_labels) = mnist.load_data()

# Padding
paddings = tf.constant([[0, 0], [2, 2], [2, 2]])
train_images = tf.pad(train_images, paddings, constant_values=0)
test_images = tf.pad(test_images, paddings, constant_values=0)

class_names = ['0', '1', '2', '3', '4', '5', '6', '7', '8', '9']

train_images = tf.dtypes.cast(train_images, tf.float32)
test_images = tf.dtypes.cast(test_images, tf.float32)
train_images, test_images = train_images[..., np.newaxis]/255.0, test_images[..., np.newaxis]/255.0

model_base=keras.Sequential()
model_base.add(layers.Conv2D(32,(3,3),activation='relu',input_shape=(32,32,1)))
model_base.add(layers.MaxPool2D((2,2)))
model_base.add(layers.Conv2D(64,(3,3),activation='relu'))
model_base.add(layers.MaxPool2D((2,2)))
model_base.add(layers.Conv2D(64,(3,3),activation='relu'))
model_base.add(layers.Flatten())
model_base.add(layers.Dense(64,activation='relu'))
model_base.add(layers.Dense(10))

model_base.compile(optimizer=keras.optimizers.Adam(),
loss=keras.losses.SparseCategoricalCrossentropy(from_logits=True),
metrics=['accuracy'])
```

```
print(model_base.summary())

model_base.fit(train_images,train_labels,epochs=2)
test_loss,test_acc=model_base.evaluate(test_images,test_labels,verbose=2)
model_base.save_weights('saved_weights/')
```

```
Model: "sequential_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_5 (Conv2D)           (None, 30, 30, 32)        320

 max_pooling2d_2 (MaxPooling  (None, 15, 15, 32)       0
 2D)

 conv2d_6 (Conv2D)           (None, 13, 13, 64)        18496

 max_pooling2d_3 (MaxPooling  (None, 6, 6, 64)         0
 2D)

 conv2d_7 (Conv2D)           (None, 4, 4, 64)          36928

 flatten_2 (Flatten)         (None, 1024)              0

 dense_5 (Dense)             (None, 64)                65600

 dense_6 (Dense)             (None, 10)                650

=================================================================
Total params: 121,994
Trainable params: 121,994
Non-trainable params: 0
_________________________________________________________________
None
Epoch 1/2
1875/1875 [==============================] - 25s 13ms/step - loss: 0.1365 - accuracy: 0.9584
Epoch 2/2
1875/1875 [==============================] - 26s 14ms/step - loss: 0.0423 - accuracy: 0.9865
313/313 - 2s - loss: 0.0368 - accuracy: 0.9884 - 2s/epoch - 5ms/step
```

Q4

In [ ]:

```
model_lw=keras.Sequential()
model_lw.add(layers.Conv2D(32,(3,3),activation='relu',input_shape=(32,32,1)))
model_lw.add(layers.MaxPool2D((2,2)))
model_lw.add(layers.Conv2D(64,(3,3),activation='relu'))
model_lw.add(layers.MaxPool2D((2,2)))
model_lw.add(layers.Conv2D(64,(3,3),activation='relu'))
model_lw.add(layers.Flatten())
model_lw.add(layers.Dense(64,activation='relu'))
model_lw.add(layers.Dense(10))

model_lw.compile(optimizer=keras.optimizers.Adam(),
loss=keras.losses.SparseCategoricalCrossentropy(from_logits=True),
metrics=['accuracy'])

print(model_lw.summary())

model_lw.load_weights('saved_weights/')

model_lw.fit(train_images,train_labels,epochs=2)
test_loss,test_acc=model_lw.evaluate(test_images,test_labels,verbose=2)

model_lw.save('saved_model/')
```

```
Model: "sequential_3"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_8 (Conv2D)           (None, 30, 30, 32)        320

 max_pooling2d_4 (MaxPooling  (None, 15, 15, 32)       0
 2D)

 conv2d_9 (Conv2D)           (None, 13, 13, 64)        18496

 max_pooling2d_5 (MaxPooling  (None, 6, 6, 64)         0
 2D)

 conv2d_10 (Conv2D)          (None, 4, 4, 64)          36928

 flatten_3 (Flatten)         (None, 1024)              0

 dense_7 (Dense)             (None, 64)                65600

 dense_8 (Dense)             (None, 10)                650

=================================================================
Total params: 121,994
Trainable params: 121,994
Non-trainable params: 0
_________________________________________________________________
None
Epoch 1/2
1875/1875 [==============================] - 26s 14ms/step - loss: 0.0300 - accuracy: 0.9900
Epoch 2/2
1875/1875 [==============================] - 26s 14ms/step - loss: 0.0222 - accuracy: 0.9930
313/313 - 1s - loss: 0.0242 - accuracy: 0.9932 - 1s/epoch - 5ms/step
WARNING:absl:Found untraced functions such as _jit_compiled_convolution_op, _jit_compiled_convolution_op, _jit_compiled_convolution_op whil
e saving (showing 3 of 3). These functions will not be directly callable after loading.
INFO:tensorflow:Assets written to: saved_model/assets
INFO:tensorflow:Assets written to: saved_model/assets
```

Q5

In [ ]:
```
model_ld=keras.models.load_model('saved_model/')
print(model_ld.summary())
model_ld.evaluate(test_images,test_labels,verbose=2)
```

```
Model: "sequential_3"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_8 (Conv2D)           (None, 30, 30, 32)        320

 max_pooling2d_4 (MaxPooling  (None, 15, 15, 32)       0
 2D)

 conv2d_9 (Conv2D)           (None, 13, 13, 64)        18496

 max_pooling2d_5 (MaxPooling  (None, 6, 6, 64)         0
 2D)

 conv2d_10 (Conv2D)          (None, 4, 4, 64)          36928

 flatten_3 (Flatten)         (None, 1024)              0

 dense_7 (Dense)             (None, 64)                65600

 dense_8 (Dense)             (None, 10)                650

=================================================================
Total params: 121,994
Trainable params: 121,994
Non-trainable params: 0
_________________________________________________________________
None
313/313 - 1s - loss: 0.0242 - accuracy: 0.9932 - 1s/epoch - 4ms/step
```

Out[ ]:
```
[0.024189366027712822, 0.9932000041007996]
```

Q6

In [ ]:
```
base_innputs=model_ld.layers[0].input
base_ouputs=model_ld.layers[-2].output
output=layers.Dense(10)(base_ouputs)

new_model=keras.Model(inputs=base_innputs,outputs=output)
new_model.compile(optimizer=keras.optimizers.Adam(),
    loss=keras.losses.SparseCategoricalCrossentropy(from_logits=True),
    metrics=['accuracy'])
print(new_model.summary())
new_model.fit(train_images,train_labels,epochs=3,verbose=2)
new_model.evaluate(test_images,test_labels,verbose=2)
```

```
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_8_input (InputLayer)  [(None, 32, 32, 1)]      0

 conv2d_8 (Conv2D)           (None, 30, 30, 32)        320

 max_pooling2d_4 (MaxPooling  (None, 15, 15, 32)       0
 2D)

 conv2d_9 (Conv2D)           (None, 13, 13, 64)        18496

 max_pooling2d_5 (MaxPooling  (None, 6, 6, 64)         0
 2D)

 conv2d_10 (Conv2D)          (None, 4, 4, 64)          36928

 flatten_3 (Flatten)         (None, 1024)              0

 dense_7 (Dense)             (None, 64)                65600

 dense_9 (Dense)             (None, 10)                650

=================================================================
Total params: 121,994
Trainable params: 121,994
Non-trainable params: 0
_________________________________________________________________
None
Epoch 1/3
1875/1875 - 23s - loss: 0.0785 - accuracy: 0.9787 - 23s/epoch - 12ms/step
Epoch 2/3
1875/1875 - 24s - loss: 0.0198 - accuracy: 0.9939 - 24s/epoch - 13ms/step
Epoch 3/3
1875/1875 - 24s - loss: 0.0147 - accuracy: 0.9954 - 24s/epoch - 13ms/step
313/313 - 1s - loss: 0.0266 - accuracy: 0.9929 - 1s/epoch - 4ms/step
```

Out[ ]:
```
[0.026621611788868904, 0.992900013923645]
```

Q7

In [ ]:
```
model_tl=keras.models.load_model('saved_model/')
model_tl.trainable=False
for layer in model_tl.layers:
    assert layer.trainable==False

base_innputs=model_tl.layers[0].input
base_ouputs=model_tl.layers[-2].output
output=layers.Dense(10)(base_ouputs)

model_tl=keras.Model(inputs=base_innputs,outputs=output)
model_tl.compile(optimizer=keras.optimizers.Adam(),
    loss=keras.losses.SparseCategoricalCrossentropy(from_logits=True),
    metrics=['accuracy'])
print(model_tl.summary())
model_tl.fit(train_images,train_labels,epochs=3,verbose=2)
model_tl.evaluate(test_images,test_labels,verbose=2)
```

```
Model: "model_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_8_input (InputLayer)  [(None, 32, 32, 1)]      0

 conv2d_8 (Conv2D)           (None, 30, 30, 32)        320

 max_pooling2d_4 (MaxPooling  (None, 15, 15, 32)       0
 2D)

 conv2d_9 (Conv2D)           (None, 13, 13, 64)        18496

 max_pooling2d_5 (MaxPooling  (None, 6, 6, 64)         0
 2D)

 conv2d_10 (Conv2D)          (None, 4, 4, 64)          36928

 flatten_3 (Flatten)         (None, 1024)              0

 dense_7 (Dense)             (None, 64)                65600

 dense_10 (Dense)            (None, 10)                650

=================================================================
Total params: 121,994
Trainable params: 650
Non-trainable params: 121,344
_________________________________________________________________
None
Epoch 1/3
1875/1875 - 8s - loss: 0.1684 - accuracy: 0.9549 - 8s/epoch - 4ms/step
Epoch 2/3
1875/1875 - 8s - loss: 0.0134 - accuracy: 0.9960 - 8s/epoch - 4ms/step
Epoch 3/3
1875/1875 - 8s - loss: 0.0097 - accuracy: 0.9973 - 8s/epoch - 4ms/step
313/313 - 2s - loss: 0.0217 - accuracy: 0.9931 - 2s/epoch - 5ms/step
```

Out[ ]:
```
[0.021652016788721085, 0.9930999875068665]
```

Q8

In [ ]:
```
model_tl=keras.applications.resnet_v2.ResNet50V2()

model_tl.trainable=False
for layer in model_tl.layers:
    assert layer.trainable==False

base_innputs=model_tl.layers[0].input
base_ouputs=model_tl.layers[-2].output
output=layers.Dense(5)(base_ouputs)

model_tl=keras.Model(inputs=base_innputs,outputs=output)
model_tl.compile(optimizer=keras.optimizers.Adam(),
    loss=keras.losses.SparseCategoricalCrossentropy(from_logits=True),
    metrics=['accuracy'])
print(model_tl.summary())
```

Model: "model_3"

Layer (type)	Output Shape	Param #	Connected to
input_2 (InputLayer)	[(None, 224, 224, 3)]	0	[]
conv1_pad (ZeroPadding2D)	(None, 230, 230, 3)	0	['input_2[0][0]']
conv1_conv (Conv2D)	(None, 112, 112, 64)	9472	['conv1_pad[0][0]']
pool1_pad (ZeroPadding2D)	(None, 114, 114, 64)	0	['conv1_conv[0][0]']
pool1_pool (MaxPooling2D)	(None, 56, 56, 64)	0	['pool1_pad[0][0]']
conv2_block1_preact_bn (BatchNormalization)	(None, 56, 56, 64)	256	['pool1_pool[0][0]']
conv2_block1_preact_relu (Activation)	(None, 56, 56, 64)	0	['conv2_block1_preact_bn[0][0]']
conv2_block1_1_conv (Conv2D)	(None, 56, 56, 64)	4096	['conv2_block1_preact_relu[0][0]']
conv2_block1_1_bn (BatchNormalization)	(None, 56, 56, 64)	256	['conv2_block1_1_conv[0][0]']
conv2_block1_1_relu (Activation)	(None, 56, 56, 64)	0	['conv2_block1_1_bn[0][0]']
conv2_block1_2_pad (ZeroPadding2D)	(None, 58, 58, 64)	0	['conv2_block1_1_relu[0][0]']
conv2_block1_2_conv (Conv2D)	(None, 56, 56, 64)	36864	['conv2_block1_2_pad[0][0]']
conv2_block1_2_bn (BatchNormalization)	(None, 56, 56, 64)	256	['conv2_block1_2_conv[0][0]']
conv2_block1_2_relu (Activation)	(None, 56, 56, 64)	0	['conv2_block1_2_bn[0][0]']
conv2_block1_0_conv (Conv2D)	(None, 56, 56, 256)	16640	['conv2_block1_preact_relu[0][0]']
conv2_block1_3_conv (Conv2D)	(None, 56, 56, 256)	16640	['conv2_block1_2_relu[0][0]']
conv2_block1_out (Add)	(None, 56, 56, 256)	0	['conv2_block1_0_conv[0][0]', 'conv2_block1_3_conv[0][0]']
conv2_block2_preact_bn (BatchNormalization)	(None, 56, 56, 256)	1024	['conv2_block1_out[0][0]']
conv2_block2_preact_relu (Activation)	(None, 56, 56, 256)	0	['conv2_block2_preact_bn[0][0]']
conv2_block2_1_conv (Conv2D)	(None, 56, 56, 64)	16384	['conv2_block2_preact_relu[0][0]']
conv2_block2_1_bn (BatchNormalization)	(None, 56, 56, 64)	256	['conv2_block2_1_conv[0][0]']
conv2_block2_1_relu (Activation)	(None, 56, 56, 64)	0	['conv2_block2_1_bn[0][0]']
conv2_block2_2_pad (ZeroPadding2D)	(None, 58, 58, 64)	0	['conv2_block2_1_relu[0][0]']
conv2_block2_2_conv (Conv2D)	(None, 56, 56, 64)	36864	['conv2_block2_2_pad[0][0]']
conv2_block2_2_bn (BatchNormalization)	(None, 56, 56, 64)	256	['conv2_block2_2_conv[0][0]']
conv2_block2_2_relu (Activation)	(None, 56, 56, 64)	0	['conv2_block2_2_bn[0][0]']
conv2_block2_3_conv (Conv2D)	(None, 56, 56, 256)	16640	['conv2_block2_2_relu[0][0]']
conv2_block2_out (Add)	(None, 56, 56, 256)	0	['conv2_block1_out[0][0]', 'conv2_block2_3_conv[0][0]']
conv2_block3_preact_bn (BatchNormalization)	(None, 56, 56, 256)	1024	['conv2_block2_out[0][0]']
conv2_block3_preact_relu (Activation)	(None, 56, 56, 256)	0	['conv2_block3_preact_bn[0][0]']
conv2_block3_1_conv (Conv2D)	(None, 56, 56, 64)	16384	['conv2_block3_preact_relu[0][0]']

```
conv2_block3_1_bn (BatchNormal  (None, 56, 56, 64)  256         ['conv2_block3_1_conv[0][0]']
ization)

conv2_block3_1_relu (Activatio  (None, 56, 56, 64)  0           ['conv2_block3_1_bn[0][0]']
n)

conv2_block3_2_pad (ZeroPaddin  (None, 58, 58, 64)  0           ['conv2_block3_1_relu[0][0]']
g2D)

conv2_block3_2_conv (Conv2D)   (None, 28, 28, 64)   36864       ['conv2_block3_2_pad[0][0]']

conv2_block3_2_bn (BatchNormal  (None, 28, 28, 64)  256         ['conv2_block3_2_conv[0][0]']
ization)

conv2_block3_2_relu (Activatio  (None, 28, 28, 64)  0           ['conv2_block3_2_bn[0][0]']
n)

max_pooling2d_9 (MaxPooling2D)  (None, 28, 28, 256)  0         ['conv2_block2_out[0][0]']

conv2_block3_3_conv (Conv2D)   (None, 28, 28, 256)  16640       ['conv2_block3_2_relu[0][0]']

conv2_block3_out (Add)         (None, 28, 28, 256)  0           ['max_pooling2d_9[0][0]',
                                                                 'conv2_block3_3_conv[0][0]']

conv3_block1_preact_bn (BatchN  (None, 28, 28, 256)  1024       ['conv2_block3_out[0][0]']
ormalization)

conv3_block1_preact_relu (Acti  (None, 28, 28, 256)  0          ['conv3_block1_preact_bn[0][0]']
vation)

conv3_block1_1_conv (Conv2D)   (None, 28, 28, 128)  32768       ['conv3_block1_preact_relu[0][0]'
                                                                ]

conv3_block1_1_bn (BatchNormal  (None, 28, 28, 128)  512        ['conv3_block1_1_conv[0][0]']
ization)

conv3_block1_1_relu (Activatio  (None, 28, 28, 128)  0          ['conv3_block1_1_bn[0][0]']
n)

conv3_block1_2_pad (ZeroPaddin  (None, 30, 30, 128)  0          ['conv3_block1_1_relu[0][0]']
g2D)

conv3_block1_2_conv (Conv2D)   (None, 28, 28, 128)  147456      ['conv3_block1_2_pad[0][0]']

conv3_block1_2_bn (BatchNormal  (None, 28, 28, 128)  512        ['conv3_block1_2_conv[0][0]']
ization)

conv3_block1_2_relu (Activatio  (None, 28, 28, 128)  0          ['conv3_block1_2_bn[0][0]']
n)

conv3_block1_0_conv (Conv2D)   (None, 28, 28, 512)  131584      ['conv3_block1_preact_relu[0][0]'
                                                                ]

conv3_block1_3_conv (Conv2D)   (None, 28, 28, 512)  66048       ['conv3_block1_2_relu[0][0]']

conv3_block1_out (Add)         (None, 28, 28, 512)  0           ['conv3_block1_0_conv[0][0]',
                                                                 'conv3_block1_3_conv[0][0]']

conv3_block2_preact_bn (BatchN  (None, 28, 28, 512)  2048       ['conv3_block1_out[0][0]']
ormalization)

conv3_block2_preact_relu (Acti  (None, 28, 28, 512)  0          ['conv3_block2_preact_bn[0][0]']
vation)

conv3_block2_1_conv (Conv2D)   (None, 28, 28, 128)  65536       ['conv3_block2_preact_relu[0][0]'
                                                                ]

conv3_block2_1_bn (BatchNormal  (None, 28, 28, 128)  512        ['conv3_block2_1_conv[0][0]']
ization)

conv3_block2_1_relu (Activatio  (None, 28, 28, 128)  0          ['conv3_block2_1_bn[0][0]']
n)

conv3_block2_2_pad (ZeroPaddin  (None, 30, 30, 128)  0          ['conv3_block2_1_relu[0][0]']
g2D)

conv3_block2_2_conv (Conv2D)   (None, 28, 28, 128)  147456      ['conv3_block2_2_pad[0][0]']

conv3_block2_2_bn (BatchNormal  (None, 28, 28, 128)  512        ['conv3_block2_2_conv[0][0]']
ization)

conv3_block2_2_relu (Activatio  (None, 28, 28, 128)  0          ['conv3_block2_2_bn[0][0]']
n)

conv3_block2_3_conv (Conv2D)   (None, 28, 28, 512)  66048       ['conv3_block2_2_relu[0][0]']

conv3_block2_out (Add)         (None, 28, 28, 512)  0           ['conv3_block1_out[0][0]',
                                                                 'conv3_block2_3_conv[0][0]']

conv3_block3_preact_bn (BatchN  (None, 28, 28, 512)  2048       ['conv3_block2_out[0][0]']
ormalization)
```

```
conv3_block3_preact_relu (Acti  (None, 28, 28, 512)  0          ['conv3_block3_preact_bn[0][0]']
vation)

conv3_block3_1_conv (Conv2D)   (None, 28, 28, 128)  65536      ['conv3_block3_preact_relu[0][0]'
                                                                ]

conv3_block3_1_bn (BatchNormal  (None, 28, 28, 128)  512        ['conv3_block3_1_conv[0][0]']
ization)

conv3_block3_1_relu (Activatio  (None, 28, 28, 128)  0          ['conv3_block3_1_bn[0][0]']
n)

conv3_block3_2_pad (ZeroPaddin  (None, 30, 30, 128)  0          ['conv3_block3_1_relu[0][0]']
g2D)

conv3_block3_2_conv (Conv2D)   (None, 28, 28, 128)  147456     ['conv3_block3_2_pad[0][0]']

conv3_block3_2_bn (BatchNormal  (None, 28, 28, 128)  512        ['conv3_block3_2_conv[0][0]']
ization)

conv3_block3_2_relu (Activatio  (None, 28, 28, 128)  0          ['conv3_block3_2_bn[0][0]']
n)

conv3_block3_3_conv (Conv2D)   (None, 28, 28, 512)  66048      ['conv3_block3_2_relu[0][0]']

conv3_block3_out (Add)         (None, 28, 28, 512)  0          ['conv3_block2_out[0][0]',
                                                                 'conv3_block3_3_conv[0][0]']

conv3_block4_preact_bn (BatchN  (None, 28, 28, 512)  2048       ['conv3_block3_out[0][0]']
ormalization)

conv3_block4_preact_relu (Acti  (None, 28, 28, 512)  0          ['conv3_block4_preact_bn[0][0]']
vation)

conv3_block4_1_conv (Conv2D)   (None, 28, 28, 128)  65536      ['conv3_block4_preact_relu[0][0]'
                                                                ]

conv3_block4_1_bn (BatchNormal  (None, 28, 28, 128)  512        ['conv3_block4_1_conv[0][0]']
ization)

conv3_block4_1_relu (Activatio  (None, 28, 28, 128)  0          ['conv3_block4_1_bn[0][0]']
n)

conv3_block4_2_pad (ZeroPaddin  (None, 30, 30, 128)  0          ['conv3_block4_1_relu[0][0]']
g2D)

conv3_block4_2_conv (Conv2D)   (None, 14, 14, 128)  147456     ['conv3_block4_2_pad[0][0]']

conv3_block4_2_bn (BatchNormal  (None, 14, 14, 128)  512        ['conv3_block4_2_conv[0][0]']
ization)

conv3_block4_2_relu (Activatio  (None, 14, 14, 128)  0          ['conv3_block4_2_bn[0][0]']
n)

max_pooling2d_10 (MaxPooling2D  (None, 14, 14, 512)  0          ['conv3_block3_out[0][0]']
)

conv3_block4_3_conv (Conv2D)   (None, 14, 14, 512)  66048      ['conv3_block4_2_relu[0][0]']

conv3_block4_out (Add)         (None, 14, 14, 512)  0          ['max_pooling2d_10[0][0]',
                                                                 'conv3_block4_3_conv[0][0]']

conv4_block1_preact_bn (BatchN  (None, 14, 14, 512)  2048       ['conv3_block4_out[0][0]']
ormalization)

conv4_block1_preact_relu (Acti  (None, 14, 14, 512)  0          ['conv4_block1_preact_bn[0][0]']
vation)

conv4_block1_1_conv (Conv2D)   (None, 14, 14, 256)  131072     ['conv4_block1_preact_relu[0][0]'
                                                                ]

conv4_block1_1_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block1_1_conv[0][0]']
ization)

conv4_block1_1_relu (Activatio  (None, 14, 14, 256)  0          ['conv4_block1_1_bn[0][0]']
n)

conv4_block1_2_pad (ZeroPaddin  (None, 16, 16, 256)  0          ['conv4_block1_1_relu[0][0]']
g2D)

conv4_block1_2_conv (Conv2D)   (None, 14, 14, 256)  589824     ['conv4_block1_2_pad[0][0]']

conv4_block1_2_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block1_2_conv[0][0]']
ization)

conv4_block1_2_relu (Activatio  (None, 14, 14, 256)  0          ['conv4_block1_2_bn[0][0]']
n)

conv4_block1_0_conv (Conv2D)   (None, 14, 14, 1024  525312     ['conv4_block1_preact_relu[0][0]'
                               )                                ]
```

```
conv4_block1_3_conv (Conv2D)   (None, 14, 14, 1024  263168      ['conv4_block1_2_relu[0][0]']
                               )

conv4_block1_out (Add)         (None, 14, 14, 1024  0           ['conv4_block1_0_conv[0][0]',
                               )                                 'conv4_block1_3_conv[0][0]']

conv4_block2_preact_bn (BatchN  (None, 14, 14, 1024  4096       ['conv4_block1_out[0][0]']
ormalization)                  )

conv4_block2_preact_relu (Acti  (None, 14, 14, 1024  0           ['conv4_block2_preact_bn[0][0]']
vation)                        )

conv4_block2_1_conv (Conv2D)   (None, 14, 14, 256)  262144      ['conv4_block2_preact_relu[0][0]'
                                                                ]

conv4_block2_1_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block2_1_conv[0][0]']
ization)

conv4_block2_1_relu (Activatio  (None, 14, 14, 256)  0          ['conv4_block2_1_bn[0][0]']
n)

conv4_block2_2_pad (ZeroPaddin  (None, 16, 16, 256)  0          ['conv4_block2_1_relu[0][0]']
g2D)

conv4_block2_2_conv (Conv2D)   (None, 14, 14, 256)  589824      ['conv4_block2_2_pad[0][0]']

conv4_block2_2_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block2_2_conv[0][0]']
ization)

conv4_block2_2_relu (Activatio  (None, 14, 14, 256)  0          ['conv4_block2_2_bn[0][0]']
n)

conv4_block2_3_conv (Conv2D)   (None, 14, 14, 1024  263168      ['conv4_block2_2_relu[0][0]']
                               )

conv4_block2_out (Add)         (None, 14, 14, 1024  0           ['conv4_block1_out[0][0]',
                               )                                 'conv4_block2_3_conv[0][0]']

conv4_block3_preact_bn (BatchN  (None, 14, 14, 1024  4096       ['conv4_block2_out[0][0]']
ormalization)                  )

conv4_block3_preact_relu (Acti  (None, 14, 14, 1024  0           ['conv4_block3_preact_bn[0][0]']
vation)                        )

conv4_block3_1_conv (Conv2D)   (None, 14, 14, 256)  262144      ['conv4_block3_preact_relu[0][0]'
                                                                ]

conv4_block3_1_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block3_1_conv[0][0]']
ization)

conv4_block3_1_relu (Activatio  (None, 14, 14, 256)  0          ['conv4_block3_1_bn[0][0]']
n)

conv4_block3_2_pad (ZeroPaddin  (None, 16, 16, 256)  0          ['conv4_block3_1_relu[0][0]']
g2D)

conv4_block3_2_conv (Conv2D)   (None, 14, 14, 256)  589824      ['conv4_block3_2_pad[0][0]']

conv4_block3_2_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block3_2_conv[0][0]']
ization)

conv4_block3_2_relu (Activatio  (None, 14, 14, 256)  0          ['conv4_block3_2_bn[0][0]']
n)

conv4_block3_3_conv (Conv2D)   (None, 14, 14, 1024  263168      ['conv4_block3_2_relu[0][0]']
                               )

conv4_block3_out (Add)         (None, 14, 14, 1024  0           ['conv4_block2_out[0][0]',
                               )                                 'conv4_block3_3_conv[0][0]']

conv4_block4_preact_bn (BatchN  (None, 14, 14, 1024  4096       ['conv4_block3_out[0][0]']
ormalization)                  )

conv4_block4_preact_relu (Acti  (None, 14, 14, 1024  0           ['conv4_block4_preact_bn[0][0]']
vation)                        )

conv4_block4_1_conv (Conv2D)   (None, 14, 14, 256)  262144      ['conv4_block4_preact_relu[0][0]'
                                                                ]

conv4_block4_1_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block4_1_conv[0][0]']
ization)

conv4_block4_1_relu (Activatio  (None, 14, 14, 256)  0          ['conv4_block4_1_bn[0][0]']
n)

conv4_block4_2_pad (ZeroPaddin  (None, 16, 16, 256)  0          ['conv4_block4_1_relu[0][0]']
g2D)

conv4_block4_2_conv (Conv2D)   (None, 14, 14, 256)  589824      ['conv4_block4_2_pad[0][0]']
```

```
conv4_block4_2_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block4_2_conv[0][0]']
ization)

conv4_block4_2_relu (Activatio  (None, 14, 14, 256)  0         ['conv4_block4_2_bn[0][0]']
n)

conv4_block4_3_conv (Conv2D)   (None, 14, 14, 1024  263168      ['conv4_block4_2_relu[0][0]']
                               )

conv4_block4_out (Add)         (None, 14, 14, 1024  0           ['conv4_block3_out[0][0]',
                               )                                 'conv4_block4_3_conv[0][0]']

conv4_block5_preact_bn (BatchN  (None, 14, 14, 1024  4096       ['conv4_block4_out[0][0]']
ormalization)                  )

conv4_block5_preact_relu (Acti  (None, 14, 14, 1024  0         ['conv4_block5_preact_bn[0][0]']
vation)                        )

conv4_block5_1_conv (Conv2D)   (None, 14, 14, 256)  262144      ['conv4_block5_preact_relu[0][0]'
                                                               ]

conv4_block5_1_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block5_1_conv[0][0]']
ization)

conv4_block5_1_relu (Activatio  (None, 14, 14, 256)  0         ['conv4_block5_1_bn[0][0]']
n)

conv4_block5_2_pad (ZeroPaddin  (None, 16, 16, 256)  0         ['conv4_block5_1_relu[0][0]']
g2D)

conv4_block5_2_conv (Conv2D)   (None, 14, 14, 256)  589824      ['conv4_block5_2_pad[0][0]']

conv4_block5_2_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block5_2_conv[0][0]']
ization)

conv4_block5_2_relu (Activatio  (None, 14, 14, 256)  0         ['conv4_block5_2_bn[0][0]']
n)

conv4_block5_3_conv (Conv2D)   (None, 14, 14, 1024  263168      ['conv4_block5_2_relu[0][0]']
                               )

conv4_block5_out (Add)         (None, 14, 14, 1024  0           ['conv4_block4_out[0][0]',
                               )                                 'conv4_block5_3_conv[0][0]']

conv4_block6_preact_bn (BatchN  (None, 14, 14, 1024  4096       ['conv4_block5_out[0][0]']
ormalization)                  )

conv4_block6_preact_relu (Acti  (None, 14, 14, 1024  0         ['conv4_block6_preact_bn[0][0]']
vation)                        )

conv4_block6_1_conv (Conv2D)   (None, 14, 14, 256)  262144      ['conv4_block6_preact_relu[0][0]'
                                                               ]

conv4_block6_1_bn (BatchNormal  (None, 14, 14, 256)  1024       ['conv4_block6_1_conv[0][0]']
ization)

conv4_block6_1_relu (Activatio  (None, 14, 14, 256)  0         ['conv4_block6_1_bn[0][0]']
n)

conv4_block6_2_pad (ZeroPaddin  (None, 16, 16, 256)  0         ['conv4_block6_1_relu[0][0]']
g2D)

conv4_block6_2_conv (Conv2D)   (None, 7, 7, 256)    589824      ['conv4_block6_2_pad[0][0]']

conv4_block6_2_bn (BatchNormal  (None, 7, 7, 256)   1024       ['conv4_block6_2_conv[0][0]']
ization)

conv4_block6_2_relu (Activatio  (None, 7, 7, 256)   0          ['conv4_block6_2_bn[0][0]']
n)

max_pooling2d_11 (MaxPooling2D  (None, 7, 7, 1024)  0          ['conv4_block5_out[0][0]']
)

conv4_block6_3_conv (Conv2D)   (None, 7, 7, 1024)   263168      ['conv4_block6_2_relu[0][0]']

conv4_block6_out (Add)         (None, 7, 7, 1024)   0          ['max_pooling2d_11[0][0]',
                                                                'conv4_block6_3_conv[0][0]']

conv5_block1_preact_bn (BatchN  (None, 7, 7, 1024)  4096       ['conv4_block6_out[0][0]']
ormalization)

conv5_block1_preact_relu (Acti  (None, 7, 7, 1024)  0          ['conv5_block1_preact_bn[0][0]']
vation)

conv5_block1_1_conv (Conv2D)   (None, 7, 7, 512)    524288      ['conv5_block1_preact_relu[0][0]'
                                                               ]

conv5_block1_1_bn (BatchNormal  (None, 7, 7, 512)   2048       ['conv5_block1_1_conv[0][0]']
ization)

conv5_block1_1_relu (Activatio  (None, 7, 7, 512)   0          ['conv5_block1_1_bn[0][0]']
```

```
n)

conv5_block1_2_pad (ZeroPaddin  (None, 9, 9, 512)   0           ['conv5_block1_1_relu[0][0]']
g2D)

conv5_block1_2_conv (Conv2D)   (None, 7, 7, 512)    2359296     ['conv5_block1_2_pad[0][0]']

conv5_block1_2_bn (BatchNormal  (None, 7, 7, 512)   2048        ['conv5_block1_2_conv[0][0]']
ization)

conv5_block1_2_relu (Activatio  (None, 7, 7, 512)   0           ['conv5_block1_2_bn[0][0]']
n)

conv5_block1_0_conv (Conv2D)   (None, 7, 7, 2048)   2099200     ['conv5_block1_preact_relu[0][0]'
                                                                ]

conv5_block1_3_conv (Conv2D)   (None, 7, 7, 2048)   1050624     ['conv5_block1_2_relu[0][0]']

conv5_block1_out (Add)         (None, 7, 7, 2048)   0           ['conv5_block1_0_conv[0][0]',
                                                                 'conv5_block1_3_conv[0][0]']

conv5_block2_preact_bn (BatchN  (None, 7, 7, 2048)  8192        ['conv5_block1_out[0][0]']
ormalization)

conv5_block2_preact_relu (Acti  (None, 7, 7, 2048)  0           ['conv5_block2_preact_bn[0][0]']
vation)

conv5_block2_1_conv (Conv2D)   (None, 7, 7, 512)    1048576     ['conv5_block2_preact_relu[0][0]'
                                                                ]

conv5_block2_1_bn (BatchNormal  (None, 7, 7, 512)   2048        ['conv5_block2_1_conv[0][0]']
ization)

conv5_block2_1_relu (Activatio  (None, 7, 7, 512)   0           ['conv5_block2_1_bn[0][0]']
n)

conv5_block2_2_pad (ZeroPaddin  (None, 9, 9, 512)   0           ['conv5_block2_1_relu[0][0]']
g2D)

conv5_block2_2_conv (Conv2D)   (None, 7, 7, 512)    2359296     ['conv5_block2_2_pad[0][0]']

conv5_block2_2_bn (BatchNormal  (None, 7, 7, 512)   2048        ['conv5_block2_2_conv[0][0]']
ization)

conv5_block2_2_relu (Activatio  (None, 7, 7, 512)   0           ['conv5_block2_2_bn[0][0]']
n)

conv5_block2_3_conv (Conv2D)   (None, 7, 7, 2048)   1050624     ['conv5_block2_2_relu[0][0]']

conv5_block2_out (Add)         (None, 7, 7, 2048)   0           ['conv5_block1_out[0][0]',
                                                                 'conv5_block2_3_conv[0][0]']

conv5_block3_preact_bn (BatchN  (None, 7, 7, 2048)  8192        ['conv5_block2_out[0][0]']
ormalization)

conv5_block3_preact_relu (Acti  (None, 7, 7, 2048)  0           ['conv5_block3_preact_bn[0][0]']
vation)

conv5_block3_1_conv (Conv2D)   (None, 7, 7, 512)    1048576     ['conv5_block3_preact_relu[0][0]'
                                                                ]

conv5_block3_1_bn (BatchNormal  (None, 7, 7, 512)   2048        ['conv5_block3_1_conv[0][0]']
ization)

conv5_block3_1_relu (Activatio  (None, 7, 7, 512)   0           ['conv5_block3_1_bn[0][0]']
n)

conv5_block3_2_pad (ZeroPaddin  (None, 9, 9, 512)   0           ['conv5_block3_1_relu[0][0]']
g2D)

conv5_block3_2_conv (Conv2D)   (None, 7, 7, 512)    2359296     ['conv5_block3_2_pad[0][0]']

conv5_block3_2_bn (BatchNormal  (None, 7, 7, 512)   2048        ['conv5_block3_2_conv[0][0]']
ization)

conv5_block3_2_relu (Activatio  (None, 7, 7, 512)   0           ['conv5_block3_2_bn[0][0]']
n)

conv5_block3_3_conv (Conv2D)   (None, 7, 7, 2048)   1050624     ['conv5_block3_2_relu[0][0]']

conv5_block3_out (Add)         (None, 7, 7, 2048)   0           ['conv5_block2_out[0][0]',
                                                                 'conv5_block3_3_conv[0][0]']

post_bn (BatchNormalization)   (None, 7, 7, 2048)   8192        ['conv5_block3_out[0][0]']

post_relu (Activation)         (None, 7, 7, 2048)   0           ['post_bn[0][0]']

avg_pool (GlobalAveragePooling  (None, 2048)        0           ['post_relu[0][0]']
2D)

dense_12 (Dense)               (None, 5)            10245       ['avg_pool[0][0]']
```

```
=================================================================================================
Total params: 23,575,045
Trainable params: 10,245
Non-trainable params: 23,564,800
_________________________________________________________________________________________________
None
```

In [ ]:
```
train_images=tf.random.normal(shape=(5,224, 224, 3))
train_labels=tf.constant([0,1,2,3,4])

model_tl.fit(train_images,train_labels,epochs=20,verbose=2)
```

```
Epoch 1/20
1/1 - 2s - loss: 1.8387 - accuracy: 0.2000 - 2s/epoch - 2s/step
Epoch 2/20
1/1 - 0s - loss: 1.7171 - accuracy: 0.2000 - 187ms/epoch - 187ms/step
Epoch 3/20
1/1 - 0s - loss: 1.6301 - accuracy: 0.2000 - 186ms/epoch - 186ms/step
Epoch 4/20
1/1 - 0s - loss: 1.5757 - accuracy: 0.4000 - 185ms/epoch - 185ms/step
Epoch 5/20
1/1 - 0s - loss: 1.5405 - accuracy: 0.2000 - 187ms/epoch - 187ms/step
Epoch 6/20
1/1 - 0s - loss: 1.5137 - accuracy: 0.2000 - 198ms/epoch - 198ms/step
Epoch 7/20
1/1 - 0s - loss: 1.4896 - accuracy: 0.2000 - 189ms/epoch - 189ms/step
Epoch 8/20
1/1 - 0s - loss: 1.4649 - accuracy: 0.0000e+00 - 187ms/epoch - 187ms/step
Epoch 9/20
1/1 - 0s - loss: 1.4374 - accuracy: 0.2000 - 188ms/epoch - 188ms/step
Epoch 10/20
1/1 - 0s - loss: 1.4060 - accuracy: 0.2000 - 186ms/epoch - 186ms/step
Epoch 11/20
1/1 - 0s - loss: 1.3719 - accuracy: 0.4000 - 196ms/epoch - 196ms/step
Epoch 12/20
1/1 - 0s - loss: 1.3367 - accuracy: 0.4000 - 202ms/epoch - 202ms/step
Epoch 13/20
1/1 - 0s - loss: 1.3023 - accuracy: 0.6000 - 192ms/epoch - 192ms/step
Epoch 14/20
1/1 - 0s - loss: 1.2697 - accuracy: 0.8000 - 192ms/epoch - 192ms/step
Epoch 15/20
1/1 - 0s - loss: 1.2395 - accuracy: 0.8000 - 177ms/epoch - 177ms/step
Epoch 16/20
1/1 - 0s - loss: 1.2111 - accuracy: 1.0000 - 186ms/epoch - 186ms/step
Epoch 17/20
1/1 - 0s - loss: 1.1840 - accuracy: 1.0000 - 187ms/epoch - 187ms/step
Epoch 18/20
1/1 - 0s - loss: 1.1574 - accuracy: 1.0000 - 183ms/epoch - 183ms/step
Epoch 19/20
1/1 - 0s - loss: 1.1308 - accuracy: 1.0000 - 214ms/epoch - 214ms/step
Epoch 20/20
1/1 - 0s - loss: 1.1043 - accuracy: 1.0000 - 193ms/epoch - 193ms/step
```

Out[ ]:
```
<keras.callbacks.History at 0x29a5bace5f0>
```