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Index No. : 190128H

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

mnist = keras.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
```

```
train_images.shape:  (60000, 32, 32)
train_labels.shape:  (60000,)
test_images.shape: (10000, 32, 32)
test_labels.shape: (10000,)
```

In [ ]:
```
model = models.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 = tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),metrics = ['accuracy'])
print(model.summary())
```

```
model.fit(train_images,train_labels,epochs = 5)
test_loss, test_accuracy = model.evaluate(test_images,test_labels,verbose = 2)
```

```
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 [==============================] - 10s 5ms/step - loss: 0.2112 - accuracy: 0.9355
Epoch 2/5
1875/1875 [==============================] - 10s 5ms/step - loss: 0.0682 - accuracy: 0.9789
Epoch 3/5
1875/1875 [==============================] - 10s 5ms/step - loss: 0.0485 - accuracy: 0.9848
Epoch 4/5
1875/1875 [==============================] - 11s 6ms/step - loss: 0.0372 - accuracy: 0.9882
Epoch 5/5
1875/1875 [==============================] - 10s 5ms/step - loss: 0.0300 - accuracy: 0.9910
313/313 - 1s - loss: 0.0366 - accuracy: 0.9877 - 775ms/epoch - 2ms/step
```

In [ ]:

```
from tensorflow.keras.datasets import cifar10, mnist

(train_images, train_labels), (test_images, test_labels) = datasets.cifar10.load_data()

# Normalize pixel values to be between 0 and 1
train_images, test_images = train_images / 255.0, test_images / 255.0
class_names = ['airplane', 'automobile', '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)
```

```
train_images.shape:  (50000, 32, 32, 3)
train_labels.shape:  (50000, 1)
test_images.shape: (10000, 32, 32, 3)
test_labels.shape: (10000, 1)
```

In [ ]:

```
model = models.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.MaxPool2D((2,2)))
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 = tf.keras.losses.SparseCategoricalCrossentropy(from_log
print(model.summary())

model.fit(train_images,train_labels,epochs = 5)
test_loss, test_accuracy = model.evaluate(test_images,test_labels,verbose = 2)
print(test_accuracy)
```

```
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

 max_pooling2d_2 (MaxPooling  (None, 2, 2, 128)        0
 2D)

 flatten_1 (Flatten)         (None, 512)               0

 dense_3 (Dense)             (None, 64)                32832

 dense_4 (Dense)             (None, 10)                650

=================================================================
Total params: 128,266
Trainable params: 128,266
Non-trainable params: 0
_________________________________________________________________
None
Epoch 1/5
1563/1563 [==============================] - 26s 16ms/step - loss: 1.5484 - accuracy: 0.4326
Epoch 2/5
1563/1563 [==============================] - 28s 18ms/step - loss: 1.1860 - accuracy: 0.5783
Epoch 3/5
1563/1563 [==============================] - 27s 18ms/step - loss: 1.0196 - accuracy: 0.6414
Epoch 4/5
1563/1563 [==============================] - 27s 17ms/step - loss: 0.9120 - accuracy: 0.6805
Epoch 5/5
1563/1563 [==============================] - 26s 16ms/step - loss: 0.8279 - accuracy: 0.7088
313/313 - 2s - loss: 0.9905 - accuracy: 0.6587 - 2s/epoch - 5ms/step
0.6586999893188477
```

In [ ]:

```python
mnist = keras.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

model_base = models.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 = tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),metri
print(model_base.summary())

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

```
train_images.shape:  (60000, 32, 32)
train_labels.shape:  (60000,)
test_images.shape: (10000, 32, 32)
test_labels.shape: (10000,)
Model: "sequential_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_5 (Conv2D)           (None, 30, 30, 32)        320

 max_pooling2d_3 (MaxPooling  (None, 15, 15, 32)       0
 2D)

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

 max_pooling2d_4 (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 [==============================] - 28s 15ms/step - loss: 0.1296 - accuracy: 0.9605
Epoch 2/2
1875/1875 [==============================] - 28s 15ms/step - loss: 0.0428 - accuracy: 0.9866
313/313 - 2s - loss: 0.0360 - accuracy: 0.9885 - 2s/epoch - 5ms/step
```

In [ ]:

```python
model_lw = models.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 = tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),metrics
```

```
print(model_lw.summary())

model_lw.fit(train_images,train_labels,epochs = 2)
test_loss, test_accuracy = 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_5 (MaxPooling  (None, 15, 15, 32)       0
 2D)

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

 max_pooling2d_6 (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 [==============================] - 30s 16ms/step - loss: 0.1426 - accuracy: 0.9544
Epoch 2/2
1875/1875 [==============================] - 28s 15ms/step - loss: 0.0427 - accuracy: 0.9866
313/313 - 2s - loss: 0.0409 - accuracy: 0.9868 - 2s/epoch - 5ms/step
WARNING:absl:Found untraced functions such as _jit_compiled_convolution_op, _jit_compiled_convolution_op, _jit_compiled_convoluti
on_op while 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
```

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_5 (MaxPooling  (None, 15, 15, 32)       0
 2D)

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

 max_pooling2d_6 (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 - 2s - loss: 0.0409 - accuracy: 0.9868 - 2s/epoch - 5ms/step
```

Out[ ]:
```
[0.040852513164281845, 0.9868000149726868]
```

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

new_model = keras.Model(inputs=base_inputs, outputs = output)
new_model.compile(optimizer =keras.optimizers.Adam(),loss = tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),metric
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_5 (MaxPooling  (None, 15, 15, 32)       0
 2D)

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

 max_pooling2d_6 (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 - 30s - loss: 0.0909 - accuracy: 0.9735 - 30s/epoch - 16ms/step
Epoch 2/3
1875/1875 - 27s - loss: 0.0253 - accuracy: 0.9919 - 27s/epoch - 14ms/step
Epoch 3/3
1875/1875 - 29s - loss: 0.0208 - accuracy: 0.9931 - 29s/epoch - 15ms/step
313/313 - 2s - loss: 0.0272 - accuracy: 0.9913 - 2s/epoch - 6ms/step
[0.027160117402672768, 0.9912999868392944]
```

Out[ ]:

In [ ]:

```python
model_for_tl =keras.models.load_model('saved_model/')
model_for_tl.trainable = False
for layer in model_for_tl.layers:
    assert layer.trainable == False

base_inputs = model_for_tl.layers[0].input
base_outputs = model_for_tl.layers[-2].output
output = layers.Dense(10)(base_outputs)

new_model = keras.Model(inputs=base_inputs, outputs = output)
```

```
new_model.compile(optimizer =keras.optimizers.Adam(),loss = tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),metric
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_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_5 (MaxPooling  (None, 15, 15, 32)       0
 2D)

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

 max_pooling2d_6 (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 - 11s - loss: 0.2156 - accuracy: 0.9448 - 11s/epoch - 6ms/step
Epoch 2/3
1875/1875 - 9s - loss: 0.0271 - accuracy: 0.9924 - 9s/epoch - 5ms/step
Epoch 3/3
1875/1875 - 11s - loss: 0.0216 - accuracy: 0.9939 - 11s/epoch - 6ms/step
313/313 - 2s - loss: 0.0246 - accuracy: 0.9918 - 2s/epoch - 6ms/step
```

Out[ ]:
```
[0.024634189903736115, 0.9918000102043152]
```

In [ ]:
```
tl_model=keras.applications.resnet_v2.ResNet50V2()
tl_model.trainable=False

for layer in tl_model.layers:
```

```
    assert layer.trainable==False

base_inputs=tl_model.layers[0].input
base_ouputs=tl_model.layers[-2].output
output=layers.Dense(5)(base_ouputs)

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

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

tl_model.fit(train_images,train_labels,epochs=18,verbose=2)
```

Model: "model_5"

Layer (type)	Output Shape	Param #	Connected to
input_4 (InputLayer)	[(None, 224, 224, 3)]	0	[]
conv1_pad (ZeroPadding2D)	(None, 230, 230, 3)	0	['input_4[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 (BatchN  (None, 56, 56, 256)  1024       ['conv2_block1_out[0][0]']
ormalization)

conv2_block2_preact_relu (Acti  (None, 56, 56, 256)  0         ['conv2_block2_preact_bn[0][0]']
vation)

conv2_block2_1_conv (Conv2D)   (None, 56, 56, 64)   16384       ['conv2_block2_preact_relu[0][0]'
                                                                ]

conv2_block2_1_bn (BatchNormal  (None, 56, 56, 64)  256        ['conv2_block2_1_conv[0][0]']
ization)

conv2_block2_1_relu (Activatio  (None, 56, 56, 64)  0          ['conv2_block2_1_bn[0][0]']
n)

conv2_block2_2_pad (ZeroPaddin  (None, 58, 58, 64)  0          ['conv2_block2_1_relu[0][0]']
g2D)

conv2_block2_2_conv (Conv2D)   (None, 56, 56, 64)   36864       ['conv2_block2_2_pad[0][0]']

conv2_block2_2_bn (BatchNormal  (None, 56, 56, 64)  256        ['conv2_block2_2_conv[0][0]']
ization)

conv2_block2_2_relu (Activatio  (None, 56, 56, 64)  0          ['conv2_block2_2_bn[0][0]']
n)

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 (BatchN  (None, 56, 56, 256)  1024      ['conv2_block2_out[0][0]']
ormalization)

conv2_block3_preact_relu (Acti  (None, 56, 56, 256)  0         ['conv2_block3_preact_bn[0][0]']
vation)

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_16 (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_16[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_17 (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_17[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_18 (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_18[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_14 (Dense)               (None, 5)            10245       ['avg_pool[0][0]']

==================================================================================================
Total params: 23,575,045
```

```
Trainable params: 10,245
Non-trainable params: 23,564,800
_________________________________________________________________
None
Epoch 1/18
1/1 - 3s - loss: 2.3055 - accuracy: 0.2000 - 3s/epoch - 3s/step
Epoch 2/18
1/1 - 0s - loss: 2.0851 - accuracy: 0.2000 - 271ms/epoch - 271ms/step
Epoch 3/18
1/1 - 0s - loss: 1.8969 - accuracy: 0.2000 - 280ms/epoch - 280ms/step
Epoch 4/18
1/1 - 0s - loss: 1.7455 - accuracy: 0.2000 - 264ms/epoch - 264ms/step
Epoch 5/18
1/1 - 0s - loss: 1.6341 - accuracy: 0.2000 - 265ms/epoch - 265ms/step
Epoch 6/18
1/1 - 0s - loss: 1.5587 - accuracy: 0.2000 - 277ms/epoch - 277ms/step
Epoch 7/18
1/1 - 0s - loss: 1.5096 - accuracy: 0.2000 - 266ms/epoch - 266ms/step
Epoch 8/18
1/1 - 0s - loss: 1.4765 - accuracy: 0.4000 - 251ms/epoch - 251ms/step
Epoch 9/18
1/1 - 0s - loss: 1.4526 - accuracy: 0.6000 - 265ms/epoch - 265ms/step
Epoch 10/18
1/1 - 0s - loss: 1.4339 - accuracy: 0.6000 - 282ms/epoch - 282ms/step
Epoch 11/18
1/1 - 0s - loss: 1.4185 - accuracy: 0.6000 - 270ms/epoch - 270ms/step
Epoch 12/18
1/1 - 0s - loss: 1.4054 - accuracy: 0.6000 - 258ms/epoch - 258ms/step
Epoch 13/18
1/1 - 0s - loss: 1.3935 - accuracy: 0.6000 - 272ms/epoch - 272ms/step
Epoch 14/18
1/1 - 0s - loss: 1.3811 - accuracy: 0.8000 - 272ms/epoch - 272ms/step
Epoch 15/18
1/1 - 0s - loss: 1.3661 - accuracy: 0.6000 - 280ms/epoch - 280ms/step
Epoch 16/18
1/1 - 0s - loss: 1.3471 - accuracy: 0.4000 - 271ms/epoch - 271ms/step
Epoch 17/18
1/1 - 0s - loss: 1.3237 - accuracy: 0.6000 - 271ms/epoch - 271ms/step
Epoch 18/18
1/1 - 0s - loss: 1.2962 - accuracy: 0.6000 - 279ms/epoch - 279ms/step
```

Out[ ]:
```
<keras.callbacks.History at 0x28056c7bc10>
```