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Index: 190162F

Question 1

In [1]:

```
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 [2]:

```
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)
```

```
<bound method Model.summary of <keras.engine.sequential.Sequential object at 0x000001EB56AFFEB0>>
Epoch 1/5
1875/1875 [==============================] - 15s 8ms/step - loss: 0.2124 - accuracy: 0.9366
Epoch 2/5
1875/1875 [==============================] - 14s 8ms/step - loss: 0.0708 - accuracy: 0.9780
Epoch 3/5
1875/1875 [==============================] - 14s 7ms/step - loss: 0.0507 - accuracy: 0.9843
Epoch 4/5
1875/1875 [==============================] - 14s 7ms/step - loss: 0.0387 - accuracy: 0.9881
Epoch 5/5
1875/1875 [==============================] - 14s 7ms/step - loss: 0.0314 - accuracy: 0.9905
313/313 - 1s - loss: 0.0317 - accuracy: 0.9899 - 1s/epoch - 3ms/step
```

Question 2

In [3]:

```
# for CIFAR10
import tensorflow as tf
from tensorflow import keras
import matplotlib.pyplot as plt
from tensorflow.keras.datasets import cifar10, mnist
import tensorflow as tf
import matplotlib.pyplot as plt
(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']
```

In [4]:

```
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_logi
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)
```

```
<bound method Model.summary of <keras.engine.sequential.Sequential object at 0x000001EB56D08F40>>
Epoch 1/5
1563/1563 [==============================] - 34s 22ms/step - loss: 1.5462 - accuracy: 0.4356
Epoch 2/5
1563/1563 [==============================] - 34s 22ms/step - loss: 1.1877 - accuracy: 0.5804
Epoch 3/5
1563/1563 [==============================] - 37s 24ms/step - loss: 1.0237 - accuracy: 0.6393
Epoch 4/5
1563/1563 [==============================] - 54s 34ms/step - loss: 0.9236 - accuracy: 0.6772
Epoch 5/5
1563/1563 [==============================] - 34s 22ms/step - loss: 0.8415 - accuracy: 0.7057
313/313 - 2s - loss: 0.9032 - accuracy: 0.6870 - 2s/epoch - 6ms/step
0.6869999766349792
```

Question 3

In [5]:

```
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

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),metrics
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,)
<bound method Model.summary of <keras.engine.sequential.Sequential object at 0x000001EB575297F0>>
Epoch 1/2
1875/1875 [==============================] - 33s 17ms/step - loss: 0.1273 - accuracy: 0.9598
Epoch 2/2
1875/1875 [==============================] - 33s 17ms/step - loss: 0.0407 - accuracy: 0.9875
313/313 - 2s - loss: 0.0434 - accuracy: 0.9857 - 2s/epoch - 5ms/step
```

Question 4

In [7]:
```
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/')
```

```
<bound method Model.summary of <keras.engine.sequential.Sequential object at 0x000001EB5956C430>>
Epoch 1/2
1875/1875 [==============================] - 33s 17ms/step - loss: 0.1316 - accuracy: 0.9592
Epoch 2/2
1875/1875 [==============================] - 33s 18ms/step - loss: 0.0432 - accuracy: 0.9866
313/313 - 2s - loss: 0.0358 - accuracy: 0.9884 - 2s/epoch - 5ms/step
WARNING:absl:Found untraced functions such as _jit_compiled_convolution_op, _jit_compiled_convolution_op, _jit_compiled_convolution_
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
```

Question 5

In [8]:
```
# loading the model
model_ld = keras.models.load_model('saved_model/')
print(model_ld.summary())
model_ld.evaluate(test_images,test_labels, verbose=2)
```

```
Model: "sequential_4"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_11 (Conv2D)          (None, 30, 30, 32)        320

 max_pooling2d_7 (MaxPooling  (None, 15, 15, 32)       0
 2D)

 conv2d_12 (Conv2D)          (None, 13, 13, 64)        18496

 max_pooling2d_8 (MaxPooling  (None, 6, 6, 64)         0
 2D)

 conv2d_13 (Conv2D)          (None, 4, 4, 64)          36928

 flatten_4 (Flatten)         (None, 1024)              0

 dense_9 (Dense)             (None, 64)                65600

 dense_10 (Dense)            (None, 10)                650

=================================================================
Total params: 121,994
Trainable params: 121,994
Non-trainable params: 0
_________________________________________________________________
None
313/313 - 2s - loss: 0.0358 - accuracy: 0.9884 - 2s/epoch - 6ms/step
```

Out[8]:
```
[0.035840511322021484, 0.9883999824523926]
```

Question 6

In [9]:
```
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),metrics
print(new_model.summary)

new_model.fit(train_images,train_labels,epochs = 3,verbose = 2)
new_model.evaluate(test_images, test_labels, verbose=2)
```

```
<bound method Model.summary of <keras.engine.functional.Functional object at 0x000001EB59AB3DC0>>
Epoch 1/3
1875/1875 - 31s - loss: 0.0827 - accuracy: 0.9778 - 31s/epoch - 17ms/step
Epoch 2/3
```

```
1875/1875 - 31s - loss: 0.0255 - accuracy: 0.9916 - 31s/epoch - 16ms/step
Epoch 3/3
1875/1875 - 32s - loss: 0.0204 - accuracy: 0.9934 - 32s/epoch - 17ms/step
313/313 - 2s - loss: 0.0313 - accuracy: 0.9909 - 2s/epoch - 6ms/step
```
Out[9]:
```
[0.03133460134267807, 0.9908999800682068]
```

Question 7

In [10]:
```
#transfer learning
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_11_input (InputLayer  [(None, 32, 32, 1)]      0
 )

 conv2d_11 (Conv2D)          (None, 30, 30, 32)        320

 max_pooling2d_7 (MaxPooling  (None, 15, 15, 32)       0
 2D)

 conv2d_12 (Conv2D)          (None, 13, 13, 64)        18496

 max_pooling2d_8 (MaxPooling  (None, 6, 6, 64)         0
 2D)

 conv2d_13 (Conv2D)          (None, 4, 4, 64)          36928

 flatten_4 (Flatten)         (None, 1024)              0

 dense_9 (Dense)             (None, 64)                65600

 dense_12 (Dense)            (None, 10)                650

=================================================================
Total params: 121,994
Trainable params: 650
Non-trainable params: 121,344
_________________________________________________________________
None
Epoch 1/3
1875/1875 - 14s - loss: 0.2449 - accuracy: 0.9530 - 14s/epoch - 7ms/step
Epoch 2/3
1875/1875 - 22s - loss: 0.0258 - accuracy: 0.9924 - 22s/epoch - 12ms/step
Epoch 3/3
1875/1875 - 12s - loss: 0.0212 - accuracy: 0.9937 - 12s/epoch - 7ms/step
313/313 - 2s - loss: 0.0296 - accuracy: 0.9913 - 2s/epoch - 6ms/step
```
Out[10]:
```
[0.029627874493598938, 0.9912999868392944]
```

Question 8

In [11]:
```
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())
```

```
A local file was found, but it seems to be incomplete or outdated because the auto file hash does not match the original value of 3e
```

```
f43a0b657b3be2300d5770ece849e0 so we will re-download the data.
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/resnet/resnet50v2_weights_tf_dim_ordering_tf_kern
els.h5
102869336/102869336 [==============================] - 791s 8us/step
Model: "model_2"
__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================================
 input_1 (InputLayer)           [(None, 224, 224, 3  0           []
                                )]

 conv1_pad (ZeroPadding2D)      (None, 230, 230, 3)  0           ['input_1[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 (BatchN  (None, 56, 56, 64)  256         ['pool1_pool[0][0]']
 ormalization)

 conv2_block1_preact_relu (Acti  (None, 56, 56, 64)  0           ['conv2_block1_preact_bn[0][0]']
 vation)

 conv2_block1_1_conv (Conv2D)   (None, 56, 56, 64)   4096        ['conv2_block1_preact_relu[0][0]'
                                                                 ]

 conv2_block1_1_bn (BatchNormal  (None, 56, 56, 64)  256         ['conv2_block1_1_conv[0][0]']
 ization)

 conv2_block1_1_relu (Activatio  (None, 56, 56, 64)  0           ['conv2_block1_1_bn[0][0]']
 n)

 conv2_block1_2_pad (ZeroPaddin  (None, 58, 58, 64)  0           ['conv2_block1_1_relu[0][0]']
 g2D)

 conv2_block1_2_conv (Conv2D)   (None, 56, 56, 64)   36864       ['conv2_block1_2_pad[0][0]']

 conv2_block1_2_bn (BatchNormal  (None, 56, 56, 64)  256         ['conv2_block1_2_conv[0][0]']
 ization)

 conv2_block1_2_relu (Activatio  (None, 56, 56, 64)  0           ['conv2_block1_2_bn[0][0]']
 n)

 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_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_13 (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 [12]:

```
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: 1.9159 - accuracy: 0.2000 - 2s/epoch - 2s/step
Epoch 2/20
1/1 - 0s - loss: 1.7722 - accuracy: 0.2000 - 301ms/epoch - 301ms/step
Epoch 3/20
1/1 - 0s - loss: 1.6626 - accuracy: 0.2000 - 287ms/epoch - 287ms/step
Epoch 4/20
1/1 - 0s - loss: 1.5818 - accuracy: 0.2000 - 297ms/epoch - 297ms/step
Epoch 5/20
1/1 - 0s - loss: 1.5270 - accuracy: 0.4000 - 302ms/epoch - 302ms/step
Epoch 6/20
1/1 - 0s - loss: 1.4932 - accuracy: 0.6000 - 298ms/epoch - 298ms/step
Epoch 7/20
1/1 - 0s - loss: 1.4721 - accuracy: 0.4000 - 300ms/epoch - 300ms/step
Epoch 8/20
1/1 - 0s - loss: 1.4560 - accuracy: 0.4000 - 286ms/epoch - 286ms/step
Epoch 9/20
1/1 - 0s - loss: 1.4399 - accuracy: 0.6000 - 298ms/epoch - 298ms/step
Epoch 10/20
1/1 - 0s - loss: 1.4212 - accuracy: 0.6000 - 301ms/epoch - 301ms/step
Epoch 11/20
1/1 - 0s - loss: 1.3990 - accuracy: 0.6000 - 299ms/epoch - 299ms/step
Epoch 12/20
1/1 - 0s - loss: 1.3736 - accuracy: 0.8000 - 301ms/epoch - 301ms/step
Epoch 13/20
1/1 - 0s - loss: 1.3458 - accuracy: 0.8000 - 323ms/epoch - 323ms/step
Epoch 14/20
1/1 - 0s - loss: 1.3165 - accuracy: 0.8000 - 274ms/epoch - 274ms/step
Epoch 15/20
1/1 - 0s - loss: 1.2861 - accuracy: 0.8000 - 301ms/epoch - 301ms/step
Epoch 16/20
1/1 - 0s - loss: 1.2551 - accuracy: 0.8000 - 290ms/epoch - 290ms/step
Epoch 17/20
1/1 - 0s - loss: 1.2242 - accuracy: 0.8000 - 304ms/epoch - 304ms/step
Epoch 18/20
1/1 - 0s - loss: 1.1942 - accuracy: 0.8000 - 296ms/epoch - 296ms/step
Epoch 19/20
1/1 - 0s - loss: 1.1662 - accuracy: 0.8000 - 305ms/epoch - 305ms/step
Epoch 20/20
1/1 - 0s - loss: 1.1407 - accuracy: 1.0000 - 316ms/epoch - 316ms/step
```

Out[12]:

```
<keras.callbacks.History at 0x1eb5960b6d0>
```

In [ ]: