Question 1

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)
```

```
<bound method Model.summary of <keras.engine.sequential.Sequential object at 0x0000019B1A72FA30>>
Epoch 1/5
1875/1875 [==============================] - 10s 5ms/step - loss: 0.2097 - accuracy: 0.9359
Epoch 2/5
1875/1875 [==============================] - 10s 5ms/step - loss: 0.0682 - accuracy: 0.9788
Epoch 3/5
1875/1875 [==============================] - 10s 5ms/step - loss: 0.0486 - accuracy: 0.9844
Epoch 4/5
1875/1875 [==============================] - 9s 5ms/step - loss: 0.0387 - accuracy: 0.9879
Epoch 5/5
1875/1875 [==============================] - 9s 5ms/step - loss: 0.0319 - accuracy: 0.9899
313/313 - 1s - loss: 0.0402 - accuracy: 0.9875 - 603ms/epoch - 2ms/step
```

Question 2

In [ ]:
```
# 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 [ ]:
```
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_logits=True),met
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 0x0000019B1A926F70>>
Epoch 1/5
1563/1563 [==============================] - 25s 15ms/step - loss: 1.5557 - accuracy: 0.4331
Epoch 2/5
1563/1563 [==============================] - 24s 15ms/step - loss: 1.1939 - accuracy: 0.5756
Epoch 3/5
```

```
1563/1563 [==============================] - 24s 15ms/step - loss: 1.0314 - accuracy: 0.6367
Epoch 4/5
1563/1563 [==============================] - 24s 16ms/step - loss: 0.9185 - accuracy: 0.6782
Epoch 5/5
1563/1563 [==============================] - 25s 16ms/step - loss: 0.8367 - accuracy: 0.7063
313/313 - 1s - loss: 0.9305 - accuracy: 0.6763 - 1s/epoch - 5ms/step
0.6762999892234802
```

Question 3

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

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 = ['accura
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 0x0000019B1A90B340>>
Epoch 1/2
1875/1875 [==============================] - 27s 14ms/step - loss: 0.1305 - accuracy: 0.9604
Epoch 2/2
1875/1875 [==============================] - 26s 14ms/step - loss: 0.0413 - accuracy: 0.9872
313/313 - 1s - loss: 0.0356 - accuracy: 0.9881 - 1s/epoch - 4ms/step
```

Question 4

In [ ]:

```
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.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 = ['accuracy
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 0x0000019B1AA8D190>>
Epoch 1/2
1875/1875 [==============================] - 27s 14ms/step - loss: 0.1310 - accuracy: 0.9605
Epoch 2/2
1875/1875 [==============================] - 26s 14ms/step - loss: 0.0426 - accuracy: 0.9869
313/313 - 1s - loss: 0.0487 - accuracy: 0.9851 - 1s/epoch - 4ms/step
WARNING:absl:Found untraced functions such as _jit_compiled_convolution_op, _jit_compiled_convolution_op, _jit_compiled_convolution_op while sav
ing (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 [ ]:

```
# 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_7"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_19 (Conv2D)          (None, 30, 30, 32)        320

 max_pooling2d_15 (MaxPoolin  (None, 15, 15, 32)       0
 g2D)

 conv2d_20 (Conv2D)          (None, 13, 13, 64)        18496

 max_pooling2d_16 (MaxPoolin  (None, 6, 6, 64)         0
 g2D)

 conv2d_21 (Conv2D)          (None, 4, 4, 64)          36928

 flatten_7 (Flatten)         (None, 1024)              0

 dense_19 (Dense)            (None, 64)                65600

 dense_20 (Dense)            (None, 10)                650

=================================================================
Total params: 121,994
Trainable params: 121,994
Non-trainable params: 0
_________________________________________________________________
None
313/313 - 1s - loss: 0.0487 - accuracy: 0.9851 - 1s/epoch - 4ms/step
```

Out[ ]:
```
[0.04871787875890732, 0.9850999712944031]
```

Question 6

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),metrics = ['accurac
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 0x0000019B1A8C3430>>
Epoch 1/3
1875/1875 - 25s - loss: 0.0678 - accuracy: 0.9812 - 25s/epoch - 13ms/step
Epoch 2/3
1875/1875 - 24s - loss: 0.0260 - accuracy: 0.9914 - 24s/epoch - 13ms/step
Epoch 3/3
1875/1875 - 25s - loss: 0.0198 - accuracy: 0.9937 - 25s/epoch - 13ms/step
313/313 - 2s - loss: 0.0308 - accuracy: 0.9907 - 2s/epoch - 5ms/step
```

Out[ ]:
```
[0.03082950785756111, 0.9907000064849854]
```

Question 7

In [ ]:
```
#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_4"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_19_input (InputLayer  [(None, 32, 32, 1)]      0
 )

 conv2d_19 (Conv2D)          (None, 30, 30, 32)        320

 max_pooling2d_15 (MaxPoolin  (None, 15, 15, 32)       0
 g2D)

 conv2d_20 (Conv2D)          (None, 13, 13, 64)        18496

 max_pooling2d_16 (MaxPoolin  (None, 6, 6, 64)         0
 g2D)

 conv2d_21 (Conv2D)          (None, 4, 4, 64)          36928

 flatten_7 (Flatten)         (None, 1024)              0

 dense_19 (Dense)            (None, 64)                65600

 dense_22 (Dense)            (None, 10)                650

=================================================================
Total params: 121,994
Trainable params: 650
Non-trainable params: 121,344
```

```
_________________________________________________________________
None
Epoch 1/3
1875/1875 - 8s - loss: 0.2144 - accuracy: 0.9524 - 8s/epoch - 5ms/step
Epoch 2/3
1875/1875 - 8s - loss: 0.0282 - accuracy: 0.9921 - 8s/epoch - 4ms/step
Epoch 3/3
1875/1875 - 8s - loss: 0.0230 - accuracy: 0.9934 - 8s/epoch - 4ms/step
313/313 - 1s - loss: 0.0295 - accuracy: 0.9905 - 1s/epoch - 5ms/step
```

Out[ ]: [0.02952304296195507, 0.9904999732971191]

Question 8

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_6"
__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================================
input_3 (InputLayer)            [(None, 224, 224, 3  0           []
                                )]

conv1_pad (ZeroPadding2D)       (None, 230, 230, 3)  0           ['input_3[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_20 (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_20[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_21 (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_21[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_22 (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_22[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_24 (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: 1.8653 - accuracy: 0.2000 - 2s/epoch - 2s/step
Epoch 2/20
1/1 - 0s - loss: 1.7368 - accuracy: 0.2000 - 202ms/epoch - 202ms/step
Epoch 3/20
1/1 - 0s - loss: 1.6405 - accuracy: 0.2000 - 200ms/epoch - 200ms/step
Epoch 4/20
1/1 - 0s - loss: 1.5762 - accuracy: 0.4000 - 215ms/epoch - 215ms/step
Epoch 5/20
1/1 - 0s - loss: 1.5326 - accuracy: 0.2000 - 233ms/epoch - 233ms/step
Epoch 6/20
1/1 - 0s - loss: 1.4988 - accuracy: 0.2000 - 219ms/epoch - 219ms/step
Epoch 7/20
1/1 - 0s - loss: 1.4707 - accuracy: 0.4000 - 208ms/epoch - 208ms/step
Epoch 8/20
1/1 - 0s - loss: 1.4466 - accuracy: 0.4000 - 206ms/epoch - 206ms/step
Epoch 9/20
1/1 - 0s - loss: 1.4241 - accuracy: 0.6000 - 208ms/epoch - 208ms/step
Epoch 10/20
1/1 - 0s - loss: 1.4004 - accuracy: 0.4000 - 211ms/epoch - 211ms/step
Epoch 11/20
1/1 - 0s - loss: 1.3736 - accuracy: 0.4000 - 210ms/epoch - 210ms/step
Epoch 12/20
1/1 - 0s - loss: 1.3434 - accuracy: 0.4000 - 210ms/epoch - 210ms/step
Epoch 13/20
1/1 - 0s - loss: 1.3109 - accuracy: 0.4000 - 210ms/epoch - 210ms/step
Epoch 14/20
1/1 - 0s - loss: 1.2774 - accuracy: 0.6000 - 207ms/epoch - 207ms/step
Epoch 15/20
1/1 - 0s - loss: 1.2446 - accuracy: 0.6000 - 209ms/epoch - 209ms/step
Epoch 16/20
1/1 - 0s - loss: 1.2134 - accuracy: 1.0000 - 201ms/epoch - 201ms/step
Epoch 17/20
1/1 - 0s - loss: 1.1843 - accuracy: 1.0000 - 232ms/epoch - 232ms/step
Epoch 18/20
1/1 - 0s - loss: 1.1571 - accuracy: 1.0000 - 206ms/epoch - 206ms/step
Epoch 19/20
1/1 - 0s - loss: 1.1316 - accuracy: 1.0000 - 196ms/epoch - 196ms/step
Epoch 20/20
1/1 - 0s - loss: 1.1071 - accuracy: 1.0000 - 199ms/epoch - 199ms/step
```

Out[ ]: <keras.callbacks.History at 0x19b19b57310>