EX11_190095C

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Index No - 190095C

GitHub repository - https://github.com/Pasindu-Manodara/Image-Processing-Home-Work-Exercise.git

Question 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,)
```

[ ]:
```
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
0x000001E07693BBB0>>
Epoch 1/5
1875/1875 [==============================] - 17s 9ms/step - loss: 0.2034 -
accuracy: 0.9386
Epoch 2/5
1875/1875 [==============================] - 16s 9ms/step - loss: 0.0691 -
accuracy: 0.9786
Epoch 3/5
1875/1875 [==============================] - 10s 5ms/step - loss: 0.0491 -
accuracy: 0.9850
Epoch 4/5
1875/1875 [==============================] - 9s 5ms/step - loss: 0.0386 -
accuracy: 0.9874
Epoch 5/5
1875/1875 [==============================] - 9s 5ms/step - loss: 0.0316 -
accuracy: 0.9906
313/313 - 1s - loss: 0.0443 - accuracy: 0.9859 - 530ms/epoch - 2ms/step
```

Question 2

[ ]:
```
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']
```

[ ]:
```
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),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)
print(test_accuracy)
```

```
<bound method Model.summary of <keras.engine.sequential.Sequential object at
0x000001E076D7C970>>
Epoch 1/5
1563/1563 [==============================] - 29s 18ms/step - loss: 1.5739 -
accuracy: 0.4225
Epoch 2/5
1563/1563 [==============================] - 52s 33ms/step - loss: 1.1936 -
accuracy: 0.5775
Epoch 3/5
1563/1563 [==============================] - 32s 21ms/step - loss: 1.0255 -
accuracy: 0.6394
Epoch 4/5
1563/1563 [==============================] - 27s 17ms/step - loss: 0.9066 -
accuracy: 0.6808
Epoch 5/5
1563/1563 [==============================] - 34s 22ms/step - loss: 0.8286 -
accuracy: 0.7109
313/313 - 2s - loss: 0.9206 - accuracy: 0.6799 - 2s/epoch - 6ms/step
0.6798999905586243
```

Question 3

[ ]:
```
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 = ['accuracy'])
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 [==============================] - 44s 23ms/step - loss: 0.1397 -
accuracy: 0.9561
Epoch 2/2
1875/1875 [==============================] - 31s 17ms/step - loss: 0.0423 -
accuracy: 0.9872
313/313 - 1s - loss: 0.0402 - accuracy: 0.9862 - 1s/epoch - 4ms/step
```

Question 4

[ ]:
```
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 = ['accuracy'])
print(model_lw.summary())

model_lw.load_weights('saved_weights/')

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 [==============================] - 33s 18ms/step - loss: 0.0302 -
accuracy: 0.9905
```

```
Epoch 2/2
1875/1875 [==============================] - 32s 17ms/step - loss: 0.0221 -
accuracy: 0.9927
313/313 - 1s - loss: 0.0351 - accuracy: 0.9889 - 1s/epoch - 4ms/step
INFO:tensorflow:Assets written to: saved_model/assets
```

Question 5

[ ]:
```
# 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_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 - 1s - loss: 0.0351 - accuracy: 0.9889 - 1s/epoch - 5ms/step
```

[ ]:
```
[0.03505805879831314, 0.9889000058174133]
```

Question 6

[ ]:
```
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 = ['accuracy'])
print(new_model.summary())

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

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

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

 max_pooling2d_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 - 28s - loss: 0.0636 - accuracy: 0.9822 - 28s/epoch - 15ms/step
Epoch 2/3
1875/1875 - 27s - loss: 0.0176 - accuracy: 0.9944 - 27s/epoch - 14ms/step
Epoch 3/3
```

```
1875/1875 - 41s - loss: 0.0140 - accuracy: 0.9957 - 41s/epoch - 22ms/step
313/313 - 2s - loss: 0.0275 - accuracy: 0.9927 - 2s/epoch - 7ms/step
```

[ ]:
```
[0.02746218629181385, 0.9926999807357788]
```

Question 7

[ ]:
```
#transfer learning
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),metrics = ['accuracy'])

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

```
Epoch 1/3
1875/1875 - 12s - loss: 0.2941 - accuracy: 0.9417 - 12s/epoch - 6ms/step
Epoch 2/3
1875/1875 - 12s - loss: 0.0159 - accuracy: 0.9958 - 12s/epoch - 6ms/step
Epoch 3/3
1875/1875 - 12s - loss: 0.0111 - accuracy: 0.9968 - 12s/epoch - 7ms/step
313/313 - 2s - loss: 0.0242 - accuracy: 0.9927 - 2s/epoch - 7ms/step
```

[ ]:
```
[0.024224577471613884, 0.9926999807357788]
```

Question 8

[ ]:
```
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())
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-
applications/resnet/resnet50v2_weights_tf_dim_ordering_tf_kernels.h5
102875136/102869336 [==============================] - 12s 0us/step
102883328/102869336 [==============================] - 12s 0us/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_7 (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_7[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_8 (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_8[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_9 (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_9[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_11 (Dense)               (None, 5)            10245
['avg_pool[0][0]']

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

[ ]:
```
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=18,verbose=2)
```

```
Epoch 1/18
1/1 - 0s - loss: 1.6276 - accuracy: 0.2000 - 265ms/epoch - 265ms/step
```

```
Epoch 2/18
1/1 - 0s - loss: 1.6275 - accuracy: 0.4000 - 242ms/epoch - 242ms/step
Epoch 3/18
1/1 - 0s - loss: 1.6222 - accuracy: 0.4000 - 265ms/epoch - 265ms/step
Epoch 4/18
1/1 - 0s - loss: 1.6126 - accuracy: 0.4000 - 275ms/epoch - 275ms/step
Epoch 5/18
1/1 - 0s - loss: 1.5997 - accuracy: 0.4000 - 257ms/epoch - 257ms/step
Epoch 6/18
1/1 - 0s - loss: 1.5845 - accuracy: 0.6000 - 235ms/epoch - 235ms/step
Epoch 7/18
1/1 - 0s - loss: 1.5677 - accuracy: 0.6000 - 243ms/epoch - 243ms/step
Epoch 8/18
1/1 - 0s - loss: 1.5500 - accuracy: 0.6000 - 232ms/epoch - 232ms/step
Epoch 9/18
1/1 - 0s - loss: 1.5318 - accuracy: 0.4000 - 231ms/epoch - 231ms/step
Epoch 10/18
1/1 - 0s - loss: 1.5135 - accuracy: 0.4000 - 236ms/epoch - 236ms/step
Epoch 11/18
1/1 - 0s - loss: 1.4951 - accuracy: 0.4000 - 241ms/epoch - 241ms/step
Epoch 12/18
1/1 - 0s - loss: 1.4765 - accuracy: 0.6000 - 236ms/epoch - 236ms/step
Epoch 13/18
1/1 - 0s - loss: 1.4576 - accuracy: 0.6000 - 227ms/epoch - 227ms/step
Epoch 14/18
1/1 - 0s - loss: 1.4382 - accuracy: 0.6000 - 238ms/epoch - 238ms/step
Epoch 15/18
1/1 - 0s - loss: 1.4184 - accuracy: 0.6000 - 243ms/epoch - 243ms/step
Epoch 16/18
1/1 - 0s - loss: 1.3980 - accuracy: 0.6000 - 235ms/epoch - 235ms/step
Epoch 17/18
1/1 - 0s - loss: 1.3772 - accuracy: 0.8000 - 234ms/epoch - 234ms/step
Epoch 18/18
1/1 - 0s - loss: 1.3562 - accuracy: 0.8000 - 235ms/epoch - 235ms/step
```

[ ]: <keras.callbacks.History at 0x1e0093fe620>