```
Python 3.7.4 (default, Aug  9 2019, 18:34:13) [MSC v.1915 64 bit (AMD64)]
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IPython 7.8.0 -- An enhanced Interactive Python.
```

In [**1**]:   *'C:/Data/SGN-41007 PR and ML/exercises/Ex5/EX5_3.py'*   =*'C:/Data/
SGN-41007 PR and ML/exercises/Ex5'*

```
x_train shape: (60000, 28, 28, 1)
60000 train samples
10000 test samples
Model: "sequential"

_____
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 26, 26, 32)        320
_____
conv2d_1 (Conv2D)            (None, 24, 24, 64)        18496
_____
max_pooling2d (MaxPooling2D) (None, 12, 12, 64)        0
_____
dropout (Dropout)            (None, 12, 12, 64)        0
_____
flatten (Flatten)            (None, 9216)              0
_____
dense (Dense)                (None, 128)               1179776
_____
dropout_1 (Dropout)          (None, 128)               0
_____
dense_1 (Dense)              (None, 10)                1290
=================================================================
Total params: 1,199,882
Trainable params: 1,199,882
Non-trainable params: 0
_____
Train on 60000 samples, validate on 10000 samples
Epoch 1/12
60000/60000 [==============================] - 42s 699us/sample - loss: 2.2758 - accuracy:
0.1551 - val_loss: 2.2342 - val_accuracy: 0.3381
Epoch 2/12
60000/60000 [==============================] - 37s 624us/sample - loss: 2.2136 - accuracy:
0.2777 - val_loss: 2.1592 - val_accuracy: 0.5767
Epoch 3/12
60000/60000 [==============================] - 37s 622us/sample - loss: 2.1342 - accuracy:
0.3896 - val_loss: 2.0588 - val_accuracy: 0.6586
Epoch 4/12
60000/60000 [==============================] - 37s 621us/sample - loss: 2.0284 - accuracy:
0.4726 - val_loss: 1.9228 - val_accuracy: 0.7026
Epoch 5/12
60000/60000 [==============================] - 37s 622us/sample - loss: 1.8926 - accuracy:
0.5298 - val_loss: 1.7477 - val_accuracy: 0.7319
Epoch 6/12
60000/60000 [==============================] - 37s 623us/sample - loss: 1.7246 - accuracy:
0.5723 - val_loss: 1.5416 - val_accuracy: 0.7555
Epoch 7/12
60000/60000 [==============================] - 49s 811us/sample - loss: 1.5496 - accuracy:
0.6033 - val_loss: 1.3342 - val_accuracy: 0.7679
Epoch 8/12
60000/60000 [==============================] - 37s 624us/sample - loss: 1.3864 - accuracy:
0.6298 - val_loss: 1.1513 - val_accuracy: 0.7823
```

```
Epoch 9/12
60000/60000 [==============================] - 37s 623us/sample - loss: 1.2454 - accuracy:
0.6526 - val_loss: 1.0031 - val_accuracy: 0.7969
Epoch 10/12
60000/60000 [==============================] - 37s 623us/sample - loss: 1.1360 - accuracy:
0.6746 - val_loss: 0.8880 - val_accuracy: 0.8127
Epoch 11/12
60000/60000 [==============================] - 37s 623us/sample - loss: 1.0454 - accuracy:
0.6944 - val_loss: 0.7994 - val_accuracy: 0.8247
Epoch 12/12
60000/60000 [==============================] - 37s 623us/sample - loss: 0.9747 - accuracy:
0.7083 - val_loss: 0.7305 - val_accuracy: 0.8338
Test loss: 0.7305269384384155
Test accuracy: 0.8338
```

In [2]:   'C:/Data/SGN-41007 PR and ML/exercises/Ex5/EX5_4.py'   ='C:/Data/
SGN-41007 PR and ML/exercises/Ex5'
Reloaded modules: tmpo5d9h6va
Model: "model"

Layer (type)	Output Shape	Param #
input_1 (InputLayer)	[(None, 128, 128, 3)]	0
conv1_pad (ZeroPadding2D)	(None, 129, 129, 3)	0
conv1 (Conv2D)	(None, 64, 64, 8)	216
conv1_bn (BatchNormalization	(None, 64, 64, 8)	32
conv1_relu (ReLU)	(None, 64, 64, 8)	0
conv_dw_1 (DepthwiseConv2D)	(None, 64, 64, 8)	72
conv_dw_1_bn (BatchNormaliza	(None, 64, 64, 8)	32
conv_dw_1_relu (ReLU)	(None, 64, 64, 8)	0
conv_pw_1 (Conv2D)	(None, 64, 64, 16)	128
conv_pw_1_bn (BatchNormaliza	(None, 64, 64, 16)	64
conv_pw_1_relu (ReLU)	(None, 64, 64, 16)	0
conv_pad_2 (ZeroPadding2D)	(None, 65, 65, 16)	0
conv_dw_2 (DepthwiseConv2D)	(None, 32, 32, 16)	144
conv_dw_2_bn (BatchNormaliza	(None, 32, 32, 16)	64
conv_dw_2_relu (ReLU)	(None, 32, 32, 16)	0
conv_pw_2 (Conv2D)	(None, 32, 32, 32)	512
conv_pw_2_bn (BatchNormaliza	(None, 32, 32, 32)	128
conv_pw_2_relu (ReLU)	(None, 32, 32, 32)	0
conv_dw_3 (DepthwiseConv2D)	(None, 32, 32, 32)	288

conv_dw_3_bn (BatchNormaliza	(None, 32, 32, 32)	128
conv_dw_3_relu (ReLU)	(None, 32, 32, 32)	0
conv_pw_3 (Conv2D)	(None, 32, 32, 32)	1024
conv_pw_3_bn (BatchNormaliza	(None, 32, 32, 32)	128
conv_pw_3_relu (ReLU)	(None, 32, 32, 32)	0
conv_pad_4 (ZeroPadding2D)	(None, 33, 33, 32)	0
conv_dw_4 (DepthwiseConv2D)	(None, 16, 16, 32)	288
conv_dw_4_bn (BatchNormaliza	(None, 16, 16, 32)	128
conv_dw_4_relu (ReLU)	(None, 16, 16, 32)	0
conv_pw_4 (Conv2D)	(None, 16, 16, 64)	2048
conv_pw_4_bn (BatchNormaliza	(None, 16, 16, 64)	256
conv_pw_4_relu (ReLU)	(None, 16, 16, 64)	0
conv_dw_5 (DepthwiseConv2D)	(None, 16, 16, 64)	576
conv_dw_5_bn (BatchNormaliza	(None, 16, 16, 64)	256
conv_dw_5_relu (ReLU)	(None, 16, 16, 64)	0
conv_pw_5 (Conv2D)	(None, 16, 16, 64)	4096
conv_pw_5_bn (BatchNormaliza	(None, 16, 16, 64)	256
conv_pw_5_relu (ReLU)	(None, 16, 16, 64)	0
conv_pad_6 (ZeroPadding2D)	(None, 17, 17, 64)	0
conv_dw_6 (DepthwiseConv2D)	(None, 8, 8, 64)	576
conv_dw_6_bn (BatchNormaliza	(None, 8, 8, 64)	256
conv_dw_6_relu (ReLU)	(None, 8, 8, 64)	0
conv_pw_6 (Conv2D)	(None, 8, 8, 128)	8192
conv_pw_6_bn (BatchNormaliza	(None, 8, 8, 128)	512
conv_pw_6_relu (ReLU)	(None, 8, 8, 128)	0
conv_dw_7 (DepthwiseConv2D)	(None, 8, 8, 128)	1152
conv_dw_7_bn (BatchNormaliza	(None, 8, 8, 128)	512
conv_dw_7_relu (ReLU)	(None, 8, 8, 128)	0
conv_pw_7 (Conv2D)	(None, 8, 8, 128)	16384

```
conv_pw_7_bn (BatchNormaliza  (None, 8, 8, 128)       512
_____
conv_pw_7_relu (ReLU)         (None, 8, 8, 128)       0
_____
conv_dw_8 (DepthwiseConv2D)   (None, 8, 8, 128)       1152
_____
conv_dw_8_bn (BatchNormaliza  (None, 8, 8, 128)       512
_____
conv_dw_8_relu (ReLU)         (None, 8, 8, 128)       0
_____
conv_pw_8 (Conv2D)            (None, 8, 8, 128)       16384
_____
conv_pw_8_bn (BatchNormaliza  (None, 8, 8, 128)       512
_____
conv_pw_8_relu (ReLU)         (None, 8, 8, 128)       0
_____
conv_dw_9 (DepthwiseConv2D)   (None, 8, 8, 128)       1152
_____
conv_dw_9_bn (BatchNormaliza  (None, 8, 8, 128)       512
_____
conv_dw_9_relu (ReLU)         (None, 8, 8, 128)       0
_____
conv_pw_9 (Conv2D)            (None, 8, 8, 128)       16384
_____
conv_pw_9_bn (BatchNormaliza  (None, 8, 8, 128)       512
_____
conv_pw_9_relu (ReLU)         (None, 8, 8, 128)       0
_____
conv_dw_10 (DepthwiseConv2D)  (None, 8, 8, 128)       1152
_____
conv_dw_10_bn (BatchNormaliz  (None, 8, 8, 128)       512
_____
conv_dw_10_relu (ReLU)        (None, 8, 8, 128)       0
_____
conv_pw_10 (Conv2D)           (None, 8, 8, 128)       16384
_____
conv_pw_10_bn (BatchNormaliz  (None, 8, 8, 128)       512
_____
conv_pw_10_relu (ReLU)        (None, 8, 8, 128)       0
_____
conv_dw_11 (DepthwiseConv2D)  (None, 8, 8, 128)       1152
_____
conv_dw_11_bn (BatchNormaliz  (None, 8, 8, 128)       512
_____
conv_dw_11_relu (ReLU)        (None, 8, 8, 128)       0
_____
conv_pw_11 (Conv2D)           (None, 8, 8, 128)       16384
_____
conv_pw_11_bn (BatchNormaliz  (None, 8, 8, 128)       512
_____
conv_pw_11_relu (ReLU)        (None, 8, 8, 128)       0
_____
conv_pad_12 (ZeroPadding2D)   (None, 9, 9, 128)       0
_____
conv_dw_12 (DepthwiseConv2D)  (None, 4, 4, 128)       1152
_____
conv_dw_12_bn (BatchNormaliz  (None, 4, 4, 128)       512
_____
conv_dw_12_relu (ReLU)        (None, 4, 4, 128)       0
```

```
_____
conv_pw_12 (Conv2D)           (None, 4, 4, 256)      32768
_____
conv_pw_12_bn (BatchNormaliz  (None, 4, 4, 256)      1024
_____
conv_pw_12_relu (ReLU)        (None, 4, 4, 256)      0
_____
conv_dw_13 (DepthwiseConv2D)  (None, 4, 4, 256)      2304
_____
conv_dw_13_bn (BatchNormaliz  (None, 4, 4, 256)      1024
_____
conv_dw_13_relu (ReLU)        (None, 4, 4, 256)      0
_____
conv_pw_13 (Conv2D)           (None, 4, 4, 256)      65536
_____
conv_pw_13_bn (BatchNormaliz  (None, 4, 4, 256)      1024
_____
conv_pw_13_relu (ReLU)        (None, 4, 4, 256)      0
_____
flatten_1 (Flatten)           (None, 4096)           0
_____
dense_2 (Dense)               (None, 100)            409700
_____
dense_3 (Dense)               (None, 2)              202
================================================================
Total params: 628,446
Trainable params: 622,974
Non-trainable params: 5,472
_____
```

In [3]:   'C:/Data/SGN-41007 PR and ML/exercises/Ex5/EX5_5.py'   ='C:/Data/
SGN-41007 PR and ML/exercises/Ex5'
x_train shape: (60000, 128, 128, 3)
60000 train samples
10000 test samples
Model: "mobilenet_0.25_128"

```
_____
Layer (type)                  Output Shape          Param #
================================================================
input_2 (InputLayer)          [(None, 128, 128, 3)]  0
_____
conv1_pad (ZeroPadding2D)     (None, 129, 129, 3)    0
_____
conv1 (Conv2D)                (None, 64, 64, 8)      216
_____
conv1_bn (BatchNormalization  (None, 64, 64, 8)      32
_____
conv1_relu (ReLU)             (None, 64, 64, 8)      0
_____
conv_dw_1 (DepthwiseConv2D)   (None, 64, 64, 8)      72
_____
conv_dw_1_bn (BatchNormaliza  (None, 64, 64, 8)      32
_____
conv_dw_1_relu (ReLU)         (None, 64, 64, 8)      0
_____
conv_pw_1 (Conv2D)            (None, 64, 64, 16)     128
_____
conv_pw_1_bn (BatchNormaliza  (None, 64, 64, 16)     64
_____
```

conv_pw_1_relu (ReLU)	(None, 64, 64, 16)	0
conv_pad_2 (ZeroPadding2D)	(None, 65, 65, 16)	0
conv_dw_2 (DepthwiseConv2D)	(None, 32, 32, 16)	144
conv_dw_2_bn (BatchNormaliza	(None, 32, 32, 16)	64
conv_dw_2_relu (ReLU)	(None, 32, 32, 16)	0
conv_pw_2 (Conv2D)	(None, 32, 32, 32)	512
conv_pw_2_bn (BatchNormaliza	(None, 32, 32, 32)	128
conv_pw_2_relu (ReLU)	(None, 32, 32, 32)	0
conv_dw_3 (DepthwiseConv2D)	(None, 32, 32, 32)	288
conv_dw_3_bn (BatchNormaliza	(None, 32, 32, 32)	128
conv_dw_3_relu (ReLU)	(None, 32, 32, 32)	0
conv_pw_3 (Conv2D)	(None, 32, 32, 32)	1024
conv_pw_3_bn (BatchNormaliza	(None, 32, 32, 32)	128
conv_pw_3_relu (ReLU)	(None, 32, 32, 32)	0
conv_pad_4 (ZeroPadding2D)	(None, 33, 33, 32)	0
conv_dw_4 (DepthwiseConv2D)	(None, 16, 16, 32)	288
conv_dw_4_bn (BatchNormaliza	(None, 16, 16, 32)	128
conv_dw_4_relu (ReLU)	(None, 16, 16, 32)	0
conv_pw_4 (Conv2D)	(None, 16, 16, 64)	2048
conv_pw_4_bn (BatchNormaliza	(None, 16, 16, 64)	256
conv_pw_4_relu (ReLU)	(None, 16, 16, 64)	0
conv_dw_5 (DepthwiseConv2D)	(None, 16, 16, 64)	576
conv_dw_5_bn (BatchNormaliza	(None, 16, 16, 64)	256
conv_dw_5_relu (ReLU)	(None, 16, 16, 64)	0
conv_pw_5 (Conv2D)	(None, 16, 16, 64)	4096
conv_pw_5_bn (BatchNormaliza	(None, 16, 16, 64)	256
conv_pw_5_relu (ReLU)	(None, 16, 16, 64)	0
conv_pad_6 (ZeroPadding2D)	(None, 17, 17, 64)	0
conv_dw_6 (DepthwiseConv2D)	(None, 8, 8, 64)	576
conv_dw_6_bn (BatchNormaliza	(None, 8, 8, 64)	256

conv_dw_6_relu (ReLU)	(None, 8, 8, 64)	0
conv_pw_6 (Conv2D)	(None, 8, 8, 128)	8192
conv_pw_6_bn (BatchNormaliza	(None, 8, 8, 128)	512
conv_pw_6_relu (ReLU)	(None, 8, 8, 128)	0
conv_dw_7 (DepthwiseConv2D)	(None, 8, 8, 128)	1152
conv_dw_7_bn (BatchNormaliza	(None, 8, 8, 128)	512
conv_dw_7_relu (ReLU)	(None, 8, 8, 128)	0
conv_pw_7 (Conv2D)	(None, 8, 8, 128)	16384
conv_pw_7_bn (BatchNormaliza	(None, 8, 8, 128)	512
conv_pw_7_relu (ReLU)	(None, 8, 8, 128)	0
conv_dw_8 (DepthwiseConv2D)	(None, 8, 8, 128)	1152
conv_dw_8_bn (BatchNormaliza	(None, 8, 8, 128)	512
conv_dw_8_relu (ReLU)	(None, 8, 8, 128)	0
conv_pw_8 (Conv2D)	(None, 8, 8, 128)	16384
conv_pw_8_bn (BatchNormaliza	(None, 8, 8, 128)	512
conv_pw_8_relu (ReLU)	(None, 8, 8, 128)	0
conv_dw_9 (DepthwiseConv2D)	(None, 8, 8, 128)	1152
conv_dw_9_bn (BatchNormaliza	(None, 8, 8, 128)	512
conv_dw_9_relu (ReLU)	(None, 8, 8, 128)	0
conv_pw_9 (Conv2D)	(None, 8, 8, 128)	16384
conv_pw_9_bn (BatchNormaliza	(None, 8, 8, 128)	512
conv_pw_9_relu (ReLU)	(None, 8, 8, 128)	0
conv_dw_10 (DepthwiseConv2D)	(None, 8, 8, 128)	1152
conv_dw_10_bn (BatchNormaliz	(None, 8, 8, 128)	512
conv_dw_10_relu (ReLU)	(None, 8, 8, 128)	0
conv_pw_10 (Conv2D)	(None, 8, 8, 128)	16384
conv_pw_10_bn (BatchNormaliz	(None, 8, 8, 128)	512
conv_pw_10_relu (ReLU)	(None, 8, 8, 128)	0
conv_dw_11 (DepthwiseConv2D)	(None, 8, 8, 128)	1152

```
conv_dw_11_bn (BatchNormaliz (None, 8, 8, 128)       512
_____
conv_dw_11_relu (ReLU)       (None, 8, 8, 128)       0
_____
conv_pw_11 (Conv2D)          (None, 8, 8, 128)       16384
_____
conv_pw_11_bn (BatchNormaliz (None, 8, 8, 128)       512
_____
conv_pw_11_relu (ReLU)       (None, 8, 8, 128)       0
_____
conv_pad_12 (ZeroPadding2D)  (None, 9, 9, 128)       0
_____
conv_dw_12 (DepthwiseConv2D) (None, 4, 4, 128)       1152
_____
conv_dw_12_bn (BatchNormaliz (None, 4, 4, 128)       512
_____
conv_dw_12_relu (ReLU)       (None, 4, 4, 128)       0
_____
conv_pw_12 (Conv2D)          (None, 4, 4, 256)       32768
_____
conv_pw_12_bn (BatchNormaliz (None, 4, 4, 256)       1024
_____
conv_pw_12_relu (ReLU)       (None, 4, 4, 256)       0
_____
conv_dw_13 (DepthwiseConv2D) (None, 4, 4, 256)       2304
_____
conv_dw_13_bn (BatchNormaliz (None, 4, 4, 256)       1024
_____
conv_dw_13_relu (ReLU)       (None, 4, 4, 256)       0
_____
conv_pw_13 (Conv2D)          (None, 4, 4, 256)       65536
_____
conv_pw_13_bn (BatchNormaliz (None, 4, 4, 256)       1024
_____
conv_pw_13_relu (ReLU)       (None, 4, 4, 256)       0
=================================================================
Total params: 218,544
Trainable params: 213,072
Non-trainable params: 5,472
_____
Model: "sequential_1"
_____
Layer (type)                 Output Shape            Param #
=================================================================
mobilenet_0.25_128 (Model)   (None, 4, 4, 256)       218544
_____
flatten_3 (Flatten)          (None, 4096)            0
_____
dense_6 (Dense)              (None, 100)             409700
_____
dense_7 (Dense)              (None, 10)              1010
=================================================================
Total params: 629,254
Trainable params: 623,782
Non-trainable params: 5,472
_____
Train on 60000 samples, validate on 10000 samples
Epoch 1/12
WARNING:tensorflow:Entity <function
```

```
Function._initialize_uninitialized_variables.<locals>.initialize_variables at
0x000001C1AD5F0CA8> could not be transformed and will be executed as-is. Please report this
to the AutoGraph team. When filing the bug, set the verbosity to 10 (on Linux, `export
AUTOGRAPH_VERBOSITY=10`) and attach the full output. Cause:
WARNING: Entity <function
Function._initialize_uninitialized_variables.<locals>.initialize_variables at
0x000001C1AD5F0CA8> could not be transformed and will be executed as-is. Please report this
to the AutoGraph team. When filing the bug, set the verbosity to 10 (on Linux, `export
AUTOGRAPH_VERBOSITY=10`) and attach the full output. Cause:
60000/60000 [==============================] - 262s 4ms/sample - loss: 6.9221 - accuracy:
0.1857 - val_loss: 6.4549 - val_accuracy: 0.1908
Epoch 2/12
60000/60000 [==============================] - 254s 4ms/sample - loss: 6.0317 - accuracy:
0.2101 - val_loss: 5.6742 - val_accuracy: 0.2136
Epoch 3/12
60000/60000 [==============================] - 253s 4ms/sample - loss: 5.2482 - accuracy:
0.2393 - val_loss: 4.9173 - val_accuracy: 0.2522
Epoch 4/12
60000/60000 [==============================] - 253s 4ms/sample - loss: 4.6854 - accuracy:
0.2693 - val_loss: 4.3916 - val_accuracy: 0.2835
Epoch 5/12
60000/60000 [==============================] - 254s 4ms/sample - loss: 4.0912 - accuracy:
0.2981 - val_loss: 3.7501 - val_accuracy: 0.3175
Epoch 6/12
60000/60000 [==============================] - 255s 4ms/sample - loss: 3.3837 - accuracy:
0.3376 - val_loss: 3.0608 - val_accuracy: 0.3568
Epoch 7/12
60000/60000 [==============================] - 254s 4ms/sample - loss: 2.8424 - accuracy:
0.3740 - val_loss: 2.6334 - val_accuracy: 0.3903
Epoch 8/12
60000/60000 [==============================] - 254s 4ms/sample - loss: 2.4586 - accuracy:
0.4067 - val_loss: 2.2902 - val_accuracy: 0.4277
Epoch 9/12
60000/60000 [==============================] - 254s 4ms/sample - loss: 2.1604 - accuracy:
0.4442 - val_loss: 2.0185 - val_accuracy: 0.4694
Epoch 10/12
60000/60000 [==============================] - 254s 4ms/sample - loss: 1.9453 - accuracy:
0.4858 - val_loss: 1.8321 - val_accuracy: 0.5077
Epoch 11/12
60000/60000 [==============================] - 253s 4ms/sample - loss: 1.8016 - accuracy:
0.5215 - val_loss: 1.6999 - val_accuracy: 0.5504
Epoch 12/12
60000/60000 [==============================] - 253s 4ms/sample - loss: 1.6651 - accuracy:
0.5653 - val_loss: 1.5628 - val_accuracy: 0.5976
Test loss: 1.5627559288024901
Test accuracy: 0.5976
```

In [4]: