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➢ MNIST

1. convolution layer * 2、pooling * 2、flatten *1、dense *2

```
Model: "sequential_1"
```

Layer (type)	Output Shape	Param #
conv2d_2 (Conv2D)	(None, 28, 28, 32)	320
max_pooling2d_2 (MaxPooling 2D)	(None, 14, 14, 32)	0
conv2d_3 (Conv2D)	(None, 14, 14, 64)	18496
max_pooling2d_3 (MaxPooling 2D)	(None, 7, 7, 64)	0
flatten_1 (Flatten)	(None, 3136)	0
dense_2 (Dense)	(None, 49)	153713
dense_3 (Dense)	(None, 10)	500

```
Total params: 173,029
Trainable params: 173,029
Non-trainable params: 0
```

詳細資訊

```
Epoch 1/10
1875/1875 [==============================] - 12s 6ms/step - loss: 0.1414 - accuracy: 0.9570
Epoch 2/10
1875/1875 [==============================] - 11s 6ms/step - loss: 0.0463 - accuracy: 0.9858
Epoch 3/10
1875/1875 [==============================] - 11s 6ms/step - loss: 0.0324 - accuracy: 0.9897
Epoch 4/10
1875/1875 [==============================] - 11s 6ms/step - loss: 0.0241 - accuracy: 0.9925
Epoch 5/10
1875/1875 [==============================] - 11s 6ms/step - loss: 0.0187 - accuracy: 0.9938
Epoch 6/10
1875/1875 [==============================] - 11s 6ms/step - loss: 0.0143 - accuracy: 0.9957
Epoch 7/10
1875/1875 [==============================] - 11s 6ms/step - loss: 0.0122 - accuracy: 0.9960
Epoch 8/10
1875/1875 [==============================] - 11s 6ms/step - loss: 0.0094 - accuracy: 0.9969
Epoch 9/10
1875/1875 [==============================] - 11s 6ms/step - loss: 0.0083 - accuracy: 0.9973
Epoch 10/10
1875/1875 [==============================] - 11s 6ms/step - loss: 0.0073 - accuracy: 0.9973
<keras.callbacks.History at 0x7fdfda4e0e90>
```

Training

```
313/313 [==============================] - 1s 4ms/step - loss: 0.0400 - accuracy: 0.9901
[0.040005773305892944, 0.9901000261306763]
```

Testing

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2. convolution layer *3、pooling *2、flatten *1、dense *3、dropout * 2

```
Model: "sequential_2"
_________________________________________________________________
 Layer (type)                 Output Shape              Param #
=================================================================
 conv2d_3 (Conv2D)            (None, 28, 28, 64)        3200

 max_pooling2d_2 (MaxPooling  (None, 14, 14, 64)        0
 2D)

 conv2d_4 (Conv2D)            (None, 14, 14, 128)       73856

 conv2d_5 (Conv2D)            (None, 14, 14, 128)       147584

 max_pooling2d_3 (MaxPooling  (None, 7, 7, 128)         0
 2D)

 flatten_2 (Flatten)          (None, 6272)              0

 dense_5 (Dense)              (None, 128)               802944

 dropout_2 (Dropout)          (None, 128)               0

 dense_6 (Dense)              (None, 64)                8256

 dropout_3 (Dropout)          (None, 64)                0

 dense_7 (Dense)              (None, 10)                650

=================================================================
Total params: 1,036,490
Trainable params: 1,036,490
Non-trainable params: 0
```

詳細資訊

```
Epoch 1/10
1875/1875 [==============================] - 29s 15ms/step - loss: 0.3667 - accuracy: 0.8880
Epoch 2/10
1875/1875 [==============================] - 29s 15ms/step - loss: 0.1271 - accuracy: 0.9680
Epoch 3/10
1875/1875 [==============================] - 29s 15ms/step - loss: 0.0883 - accuracy: 0.9781
Epoch 4/10
1875/1875 [==============================] - 28s 15ms/step - loss: 0.0759 - accuracy: 0.9819
Epoch 5/10
1875/1875 [==============================] - 28s 15ms/step - loss: 0.0626 - accuracy: 0.9845
Epoch 6/10
1875/1875 [==============================] - 28s 15ms/step - loss: 0.0563 - accuracy: 0.9863
Epoch 7/10
1875/1875 [==============================] - 27s 14ms/step - loss: 0.0500 - accuracy: 0.9872
Epoch 8/10
1875/1875 [==============================] - 27s 14ms/step - loss: 0.0432 - accuracy: 0.9899
Epoch 9/10
1875/1875 [==============================] - 27s 14ms/step - loss: 0.0402 - accuracy: 0.9902
Epoch 10/10
1875/1875 [==============================] - 27s 14ms/step - loss: 0.0383 - accuracy: 0.9906
```

Training

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```
313/313 [==============================] - 2s 7ms/step - loss: 0.0292 - accuracy: 0.9931
[0.02923295833170414, 0.9930999875068665]
```

Testing

3. convolution *1、pooling *1、flatten *1、dense *2

```
Model: "sequential_5"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_10 (Conv2D)          (None, 26, 26, 32)        320

 max_pooling2d_10 (MaxPoolin  (None, 13, 13, 32)       0
 g2D)

 flatten_5 (Flatten)         (None, 5408)              0

 dense_10 (Dense)            (None, 64)                346176

 dense_11 (Dense)            (None, 10)                650

=================================================================
Total params: 347,146
Trainable params: 347,146
Non-trainable params: 0
```

詳細資訊

```
Epoch 1/10
1875/1875 [==============================] - 33s 18ms/step - loss: 0.1648 - accuracy: 0.9522
Epoch 2/10
1875/1875 [==============================] - 33s 17ms/step - loss: 0.0587 - accuracy: 0.9821
Epoch 3/10
1875/1875 [==============================] - 33s 17ms/step - loss: 0.0387 - accuracy: 0.9883
Epoch 4/10
1875/1875 [==============================] - 32s 17ms/step - loss: 0.0277 - accuracy: 0.9912
Epoch 5/10
1875/1875 [==============================] - 32s 17ms/step - loss: 0.0204 - accuracy: 0.9937
Epoch 6/10
1875/1875 [==============================] - 32s 17ms/step - loss: 0.0143 - accuracy: 0.9952
Epoch 7/10
1875/1875 [==============================] - 34s 18ms/step - loss: 0.0114 - accuracy: 0.9962
Epoch 8/10
1875/1875 [==============================] - 34s 18ms/step - loss: 0.0081 - accuracy: 0.9974
Epoch 9/10
1875/1875 [==============================] - 33s 18ms/step - loss: 0.0067 - accuracy: 0.9980
Epoch 10/10
1875/1875 [==============================] - 33s 17ms/step - loss: 0.0059 - accuracy: 0.9983
```

Training

```
313/313 [==============================] - 2s 7ms/step - loss: 0.0676 - accuracy: 0.9843
[0.06756725162267685, 0.9843000173568726]
```

Testing

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- 結論與比較

由以上三種測試進行比較：

Training accuracy :3 > 1 > 2

Testing accuracy : 2 > 1 > 3

參數數量 : 2 > 3 > 1

結論 ： 較多層 layer 的 model 在測試時擁有較高的精確度

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➢ Fashion MNIST

1. convolution layer *3、pooling *2、flatten *1、dense *3、dropout * 2

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                 Output Shape              Param #
=================================================================
 conv2d (Conv2D)              (None, 28, 28, 64)        3200

 max_pooling2d (MaxPooling2D  (None, 14, 14, 64)        0
 )

 conv2d_1 (Conv2D)            (None, 14, 14, 128)       73856

 conv2d_2 (Conv2D)            (None, 14, 14, 128)       147584

 max_pooling2d_1 (MaxPooling  (None, 7, 7, 128)         0
 2D)

 flatten (Flatten)            (None, 6272)              0

 dense (Dense)                (None, 128)               802944

 dropout (Dropout)            (None, 128)               0

 dense_1 (Dense)              (None, 64)                8256

 dropout_1 (Dropout)          (None, 64)                0

 dense_2 (Dense)              (None, 10)                650

=================================================================
Total params: 1,036,490
Trainable params: 1,036,490
Non-trainable params: 0
```

詳細資訊

```
Epoch 1/10
1875/1875 [==============================] - 38s 15ms/step - loss: 0.6588 - accuracy: 0.7677
Epoch 2/10
1875/1875 [==============================] - 27s 15ms/step - loss: 0.4140 - accuracy: 0.8585
Epoch 3/10
1875/1875 [==============================] - 27s 15ms/step - loss: 0.3577 - accuracy: 0.8784
Epoch 4/10
1875/1875 [==============================] - 27s 14ms/step - loss: 0.3239 - accuracy: 0.8884
Epoch 5/10
1875/1875 [==============================] - 27s 14ms/step - loss: 0.2996 - accuracy: 0.8963
Epoch 6/10
1875/1875 [==============================] - 27s 14ms/step - loss: 0.2784 - accuracy: 0.9045
Epoch 7/10
1875/1875 [==============================] - 27s 14ms/step - loss: 0.2636 - accuracy: 0.9098
Epoch 8/10
1875/1875 [==============================] - 27s 14ms/step - loss: 0.2510 - accuracy: 0.9131
Epoch 9/10
1875/1875 [==============================] - 27s 14ms/step - loss: 0.2384 - accuracy: 0.9157
Epoch 10/10
1875/1875 [==============================] - 27s 14ms/step - loss: 0.2257 - accuracy: 0.9208
```

Training

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```
313/313 [==============================] - 2s 7ms/step - loss: 0.2543 - accuracy: 0.9167
[0.2543412744998932, 0.916700005531311]
```

Testing

2. convolution layer *3、pooling *2、flatten *1、dense *3、dropout * 2
(嘗試調整 convolution 的 filter 數量與大小)

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 28, 28, 128)       1280

 max_pooling2d (MaxPooling2D  (None, 14, 14, 128)      0
 )

 conv2d_1 (Conv2D)           (None, 14, 14, 64)        204864

 conv2d_2 (Conv2D)           (None, 14, 14, 32)        100384

 max_pooling2d_1 (MaxPooling  (None, 7, 7, 32)         0
 2D)

 flatten (Flatten)           (None, 1568)              0

 dense (Dense)               (None, 128)               200832

 dropout (Dropout)           (None, 128)               0

 dense_1 (Dense)             (None, 64)                8256

 dropout_1 (Dropout)         (None, 64)                0

 dense_2 (Dense)             (None, 10)                650

=================================================================
Total params: 516,266
Trainable params: 516,266
Non-trainable params: 0
```

詳細資訊

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108321018 資工三 王俊貴

```
Epoch 1/10
1875/1875 [==============================] - 35s 13ms/step - loss: 0.6428 - accuracy: 0.7736
Epoch 2/10
1875/1875 [==============================] - 25s 13ms/step - loss: 0.3771 - accuracy: 0.8708
Epoch 3/10
1875/1875 [==============================] - 25s 13ms/step - loss: 0.3185 - accuracy: 0.8933
Epoch 4/10
1875/1875 [==============================] - 25s 13ms/step - loss: 0.2776 - accuracy: 0.9054
Epoch 5/10
1875/1875 [==============================] - 25s 13ms/step - loss: 0.2523 - accuracy: 0.9146
Epoch 6/10
1875/1875 [==============================] - 25s 13ms/step - loss: 0.2354 - accuracy: 0.9197
Epoch 7/10
1875/1875 [==============================] - 25s 13ms/step - loss: 0.2188 - accuracy: 0.9243
Epoch 8/10
1875/1875 [==============================] - 25s 13ms/step - loss: 0.2073 - accuracy: 0.9306
Epoch 9/10
1875/1875 [==============================] - 25s 13ms/step - loss: 0.1923 - accuracy: 0.9344
Epoch 10/10
1875/1875 [==============================] - 25s 13ms/step - loss: 0.1826 - accuracy: 0.9360
<keras.callbacks.History at 0x7f24003e41d0>
```

Training

```
313/313 [==============================] - 2s 8ms/step - loss: 0.2910 - accuracy: 0.9059
[0.2910033166408539, 0.9059000015258789]
```

Testing

3. convolution layer *2、pooling *2、flatten *1、dense *3

```
Model: "sequential_6"
```

Layer (type)	Output Shape	Param #
conv2d_17 (Conv2D)	(None, 28, 28, 32)	320
max_pooling2d_17 (MaxPooling2D)	(None, 14, 14, 32)	0
conv2d_18 (Conv2D)	(None, 14, 14, 64)	18496
max_pooling2d_18 (MaxPooling2D)	(None, 7, 7, 64)	0
flatten_6 (Flatten)	(None, 3136)	0
dense_19 (Dense)	(None, 300)	941100
dense_20 (Dense)	(None, 49)	14749
dense_21 (Dense)	(None, 10)	500

```
Total params: 975,165
Trainable params: 975,165
Non-trainable params: 0
```

詳細資訊

107321011 資工四 楊博丞
108321006 資工三 王奇立
108321018 資工三 王俊貴

```
Epoch 1/10
1875/1875 [==============================] - 14s 7ms/step - loss: 0.4137 - accuracy: 0.8500
Epoch 2/10
1875/1875 [==============================] - 14s 7ms/step - loss: 0.2647 - accuracy: 0.9033
Epoch 3/10
1875/1875 [==============================] - 14s 7ms/step - loss: 0.2191 - accuracy: 0.9190
Epoch 4/10
1875/1875 [==============================] - 14s 8ms/step - loss: 0.1830 - accuracy: 0.9312
Epoch 5/10
1875/1875 [==============================] - 14s 7ms/step - loss: 0.1563 - accuracy: 0.9420
Epoch 6/10
1875/1875 [==============================] - 14s 7ms/step - loss: 0.1307 - accuracy: 0.9515
Epoch 7/10
1875/1875 [==============================] - 14s 7ms/step - loss: 0.1082 - accuracy: 0.9603
Epoch 8/10
1875/1875 [==============================] - 14s 7ms/step - loss: 0.0909 - accuracy: 0.9661
Epoch 9/10
1875/1875 [==============================] - 14s 7ms/step - loss: 0.0742 - accuracy: 0.9723
Epoch 10/10
1875/1875 [==============================] - 14s 7ms/step - loss: 0.0616 - accuracy: 0.9778
<keras.callbacks.History at 0x7f913ead6e50>
```

Training

```
313/313 [==============================] - 2s 5ms/step - loss: 0.3378 - accuracy: 0.9208
[0.33779269456863403, 0.920799970626831]
```

Testing

➢ 結論與比較

由以上三種測試進行比較：

Training accuracy : 3 > 2 > 1

Testing accuracy : 3 > 1 > 2

參數數量 : 1 > 3 > 2

結論 : 將 filter 大小及數量依序遞減，並沒有得到比較好的結果，

反而是較少的 layer 擁有較好的結果。