Deep Learning

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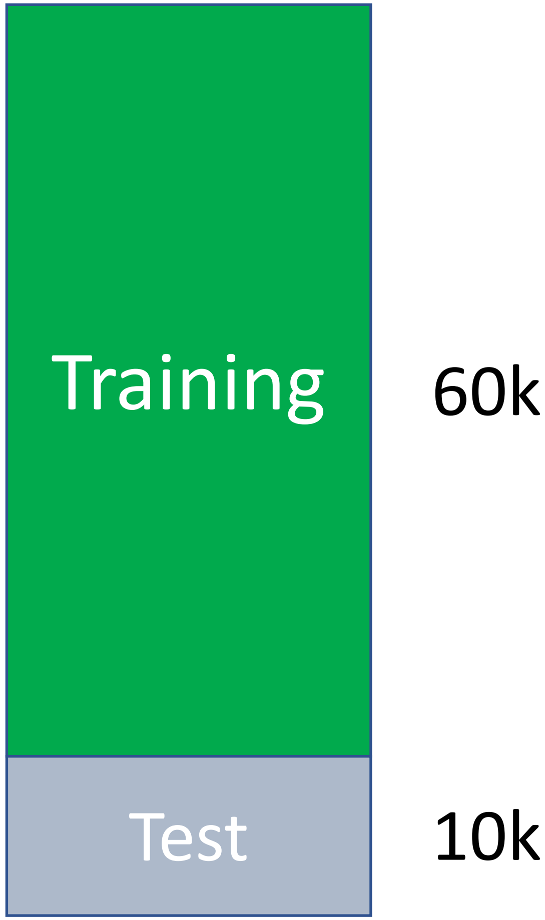
THE MNIST DATABASE of handwritten digits



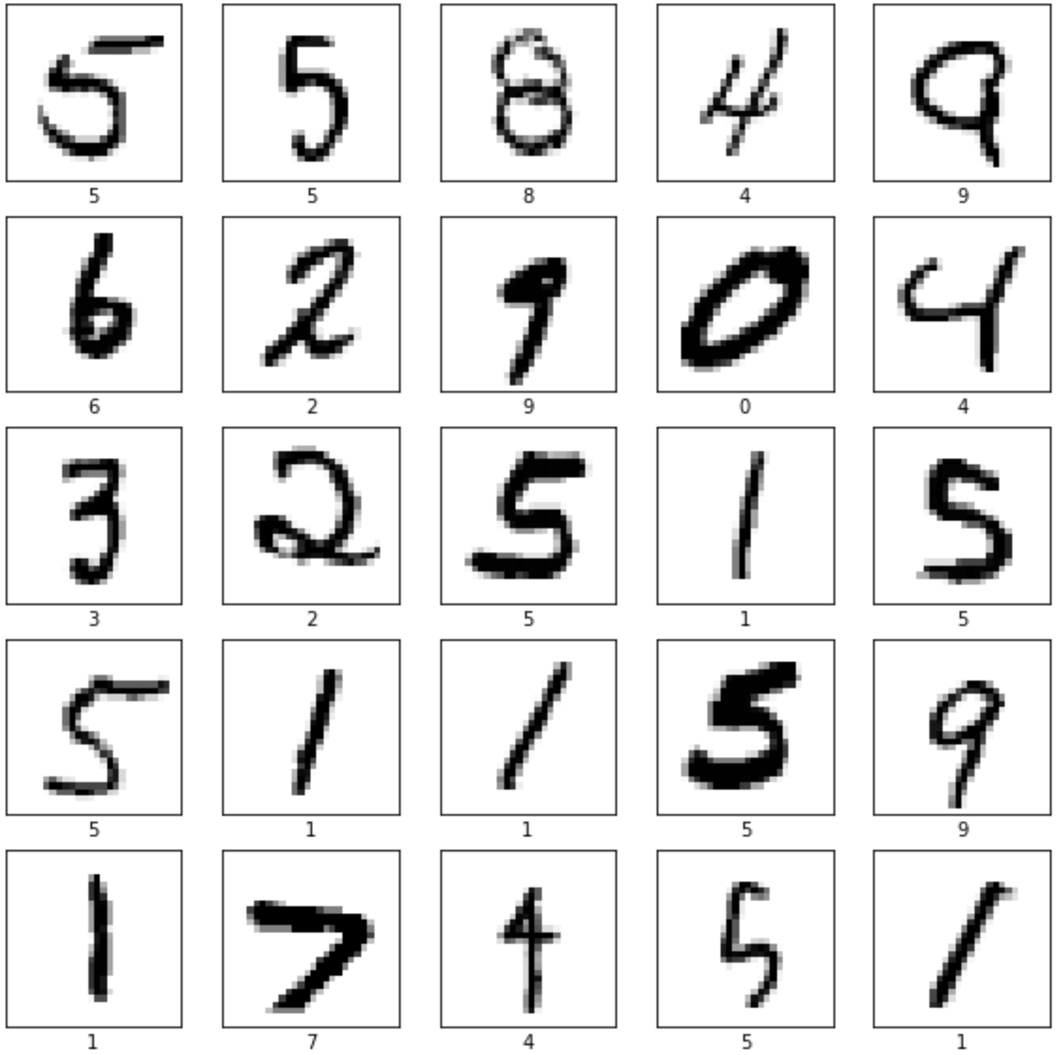
Training

60k

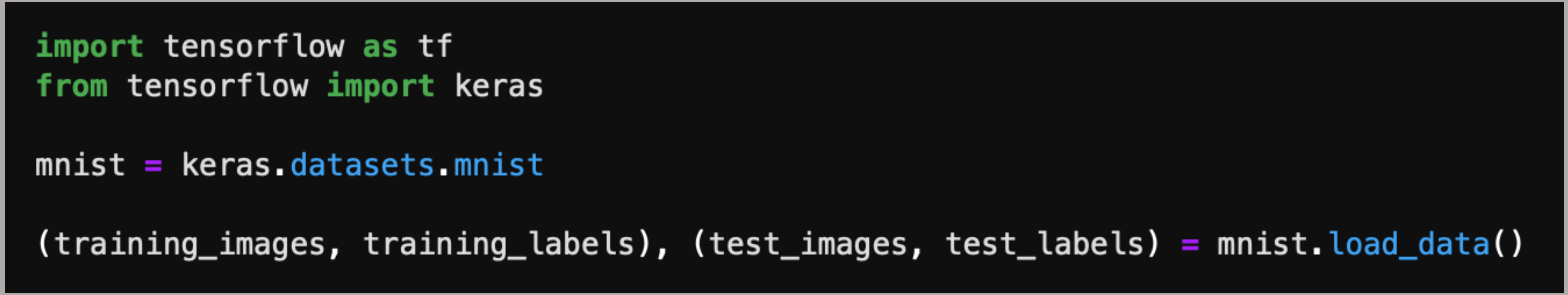
Test

10k

- 70k 张图片
- 10个分类
- 图片28X28

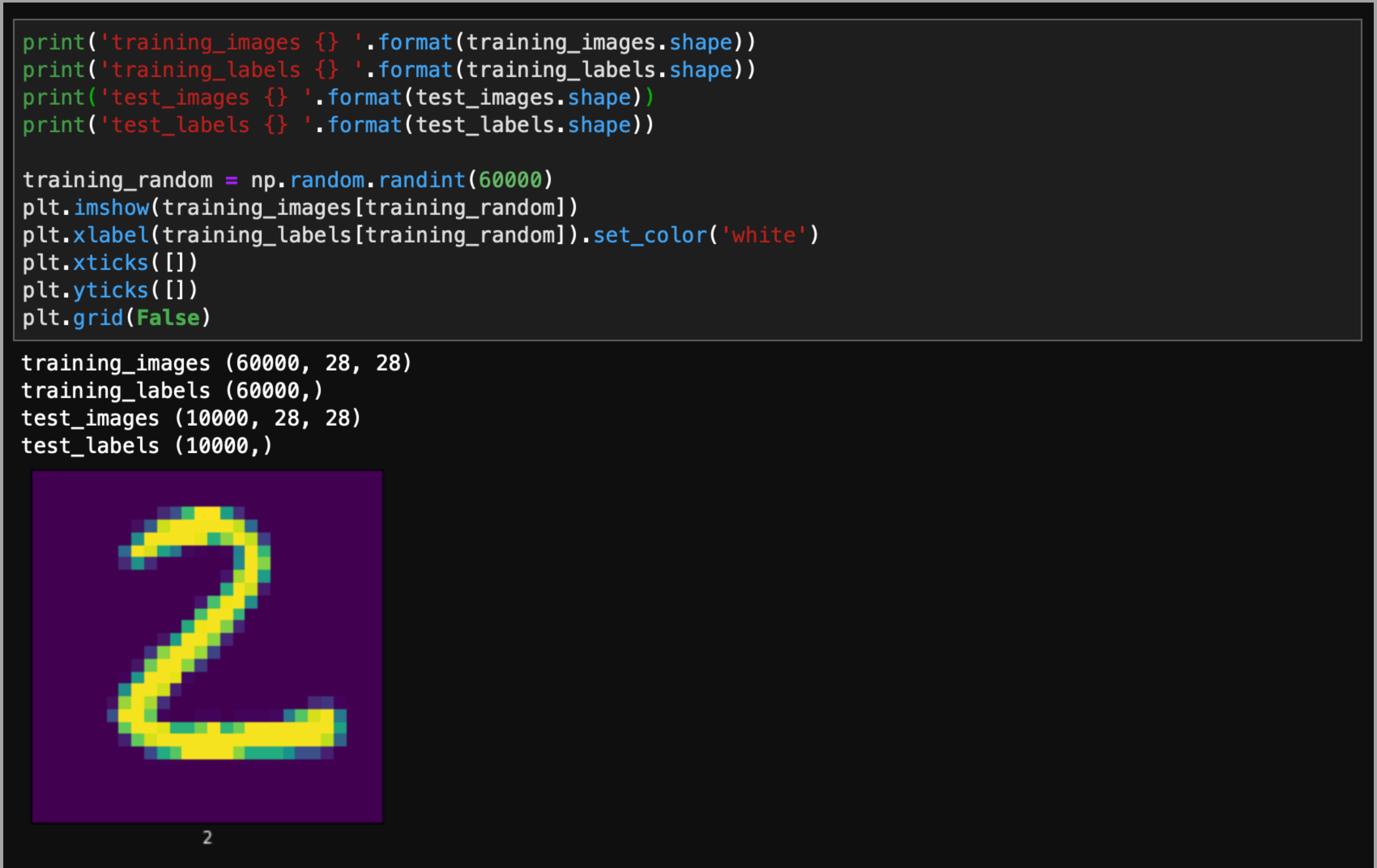


THE MNIST DATABASE of handwritten digits



```
import tensorflow as tf
from tensorflow import keras

mnist = keras.datasets.mnist

(training_images, training_labels), (test_images, test_labels) = mnist.load_data()
```

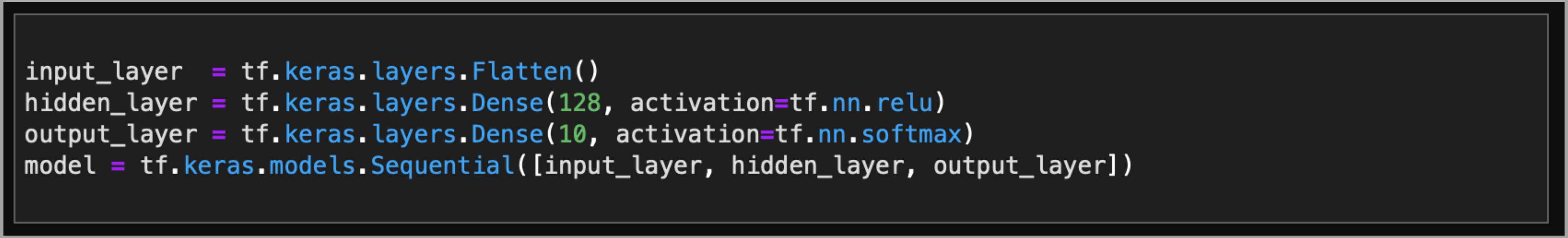
THE MNIST DATABASE of handwritten digits



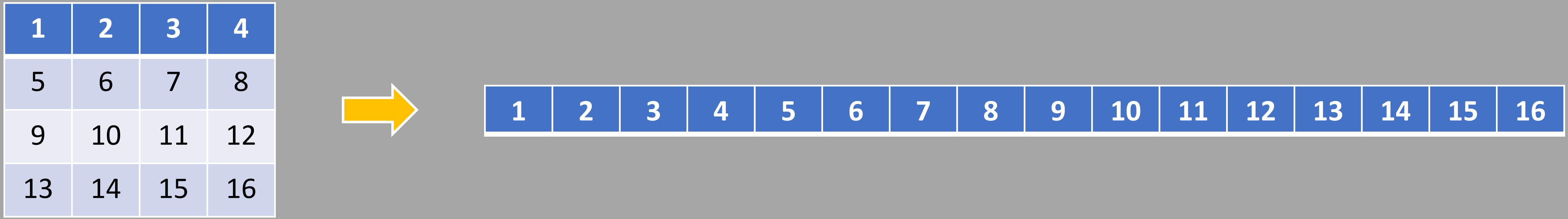
```
print('training_images {} '.format(training_images.shape))
print('training_labels {} '.format(training_labels.shape))
print('test_images {} '.format(test_images.shape))
print('test_labels {} '.format(test_labels.shape))

training_random = np.random.randint(60000)
plt.imshow(training_images[training_random])
plt.xlabel(training_labels[training_random]).set_color('white')
plt.xticks([])
plt.yticks([])
plt.grid(False)
```

```
training_images (60000, 28, 28)
training_labels (60000,)
test_images (10000, 28, 28)
test_labels (10000,)
```

THE MNIST DATABASE of handwritten digits



```
input_layer  = tf.keras.layers.Flatten()
hidden_layer = tf.keras.layers.Dense(128, activation=tf.nn.relu)
output_layer = tf.keras.layers.Dense(10, activation=tf.nn.softmax)
model = tf.keras.models.Sequential([input_layer, hidden_layer, output_layer])
```



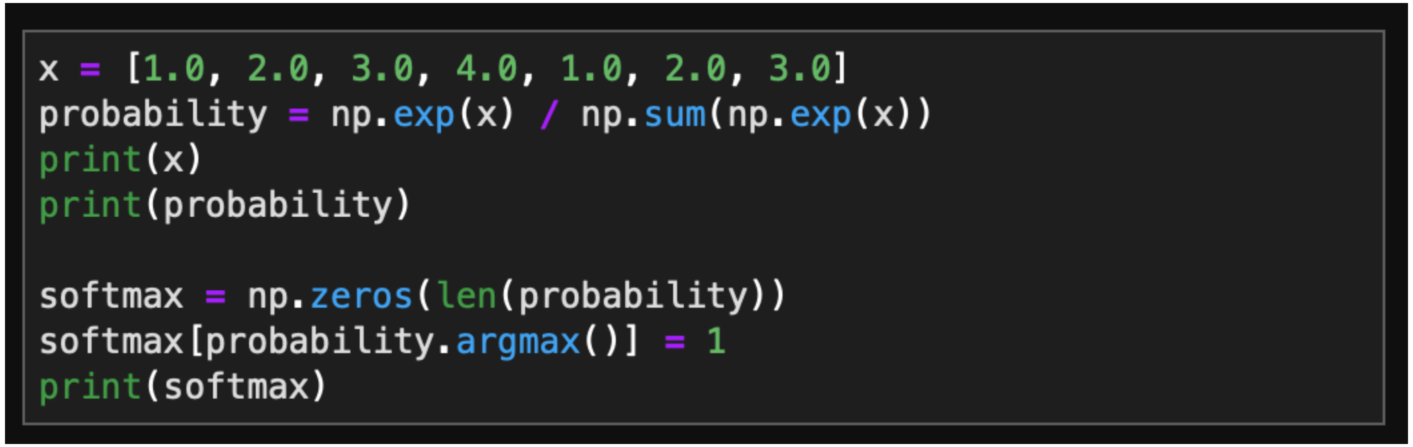
1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

THE MNIST DATABASE of handwritten digits

softmax

$$\sigma(x)_i = \frac{e^{x_i}}{\sum_{j=1}^{n} e^{x_j}}$$

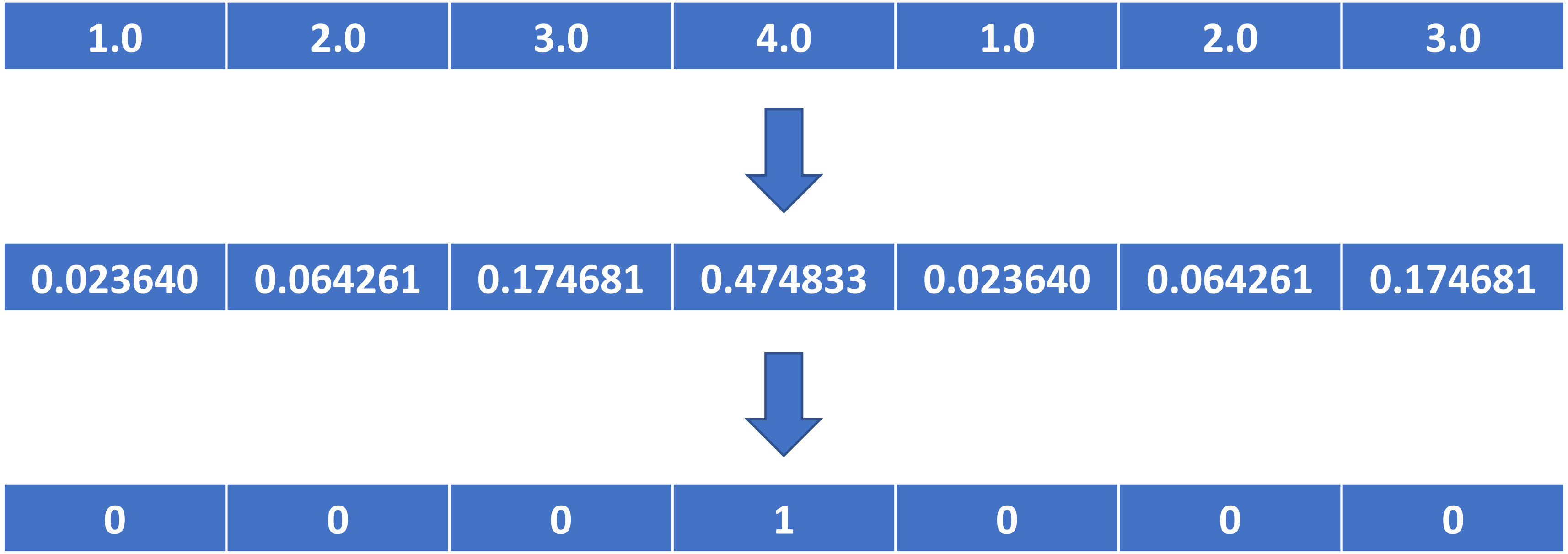


```
x = [1.0, 2.0, 3.0, 4.0, 1.0, 2.0, 3.0]
probability = np.exp(x) / np.sum(np.exp(x))
print(x)
print(probability)

softmax = np.zeros(len(probability))
softmax[probability.argmax()] = 1
print(softmax)
```

THE MNIST DATABASE of handwritten digits

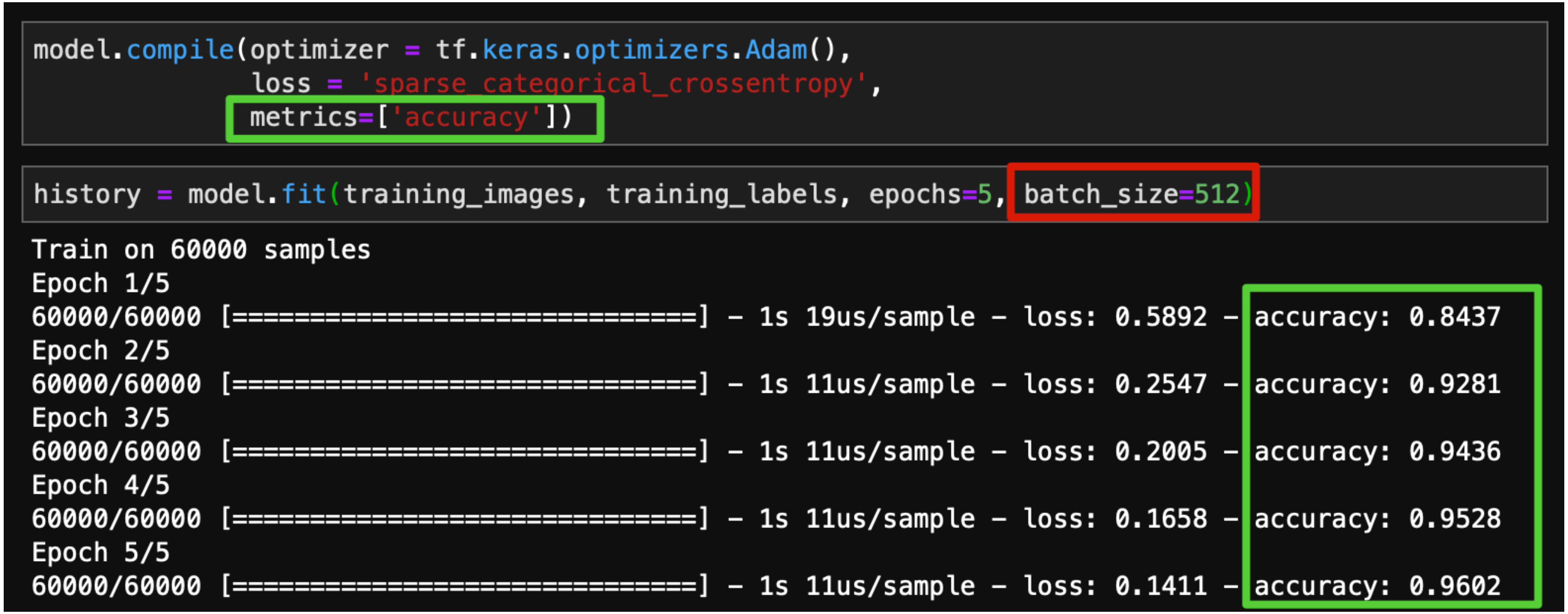
softmax

$$\sigma(x)_i = \frac{e^{x_i}}{\sum_{j=1}^{n} e^{x_j}}$$



1.0	2.0	3.0	4.0	1.0	2.0	3.0
0.023640	0.064261	0.174681	0.474833	0.023640	0.064261	0.174681
0	0	0	1	0	0	0

THE MNIST DATABASE of handwritten digits

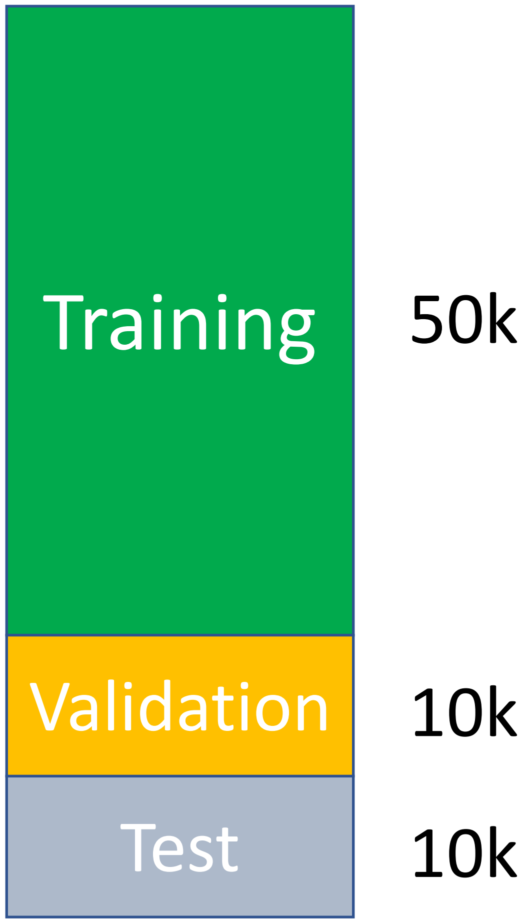


```
model.compile(optimizer = tf.keras.optimizers.Adam(),
              loss = 'sparse_categorical_crossentropy',
              metrics=['accuracy'])
```

```
history = model.fit(training_images, training_labels, epochs=5, batch_size=512)
```

```
Train on 60000 samples
Epoch 1/5
60000/60000 [==============================] - 1s 19us/sample - loss: 0.5892 - accuracy: 0.8437
Epoch 2/5
60000/60000 [==============================] - 1s 11us/sample - loss: 0.2547 - accuracy: 0.9281
Epoch 3/5
60000/60000 [==============================] - 1s 11us/sample - loss: 0.2005 - accuracy: 0.9436
Epoch 4/5
60000/60000 [==============================] - 1s 11us/sample - loss: 0.1658 - accuracy: 0.9528
Epoch 5/5
60000/60000 [==============================] - 1s 11us/sample - loss: 0.1411 - accuracy: 0.9602
```

THE MNIST DATABASE of handwritten digits 过拟合



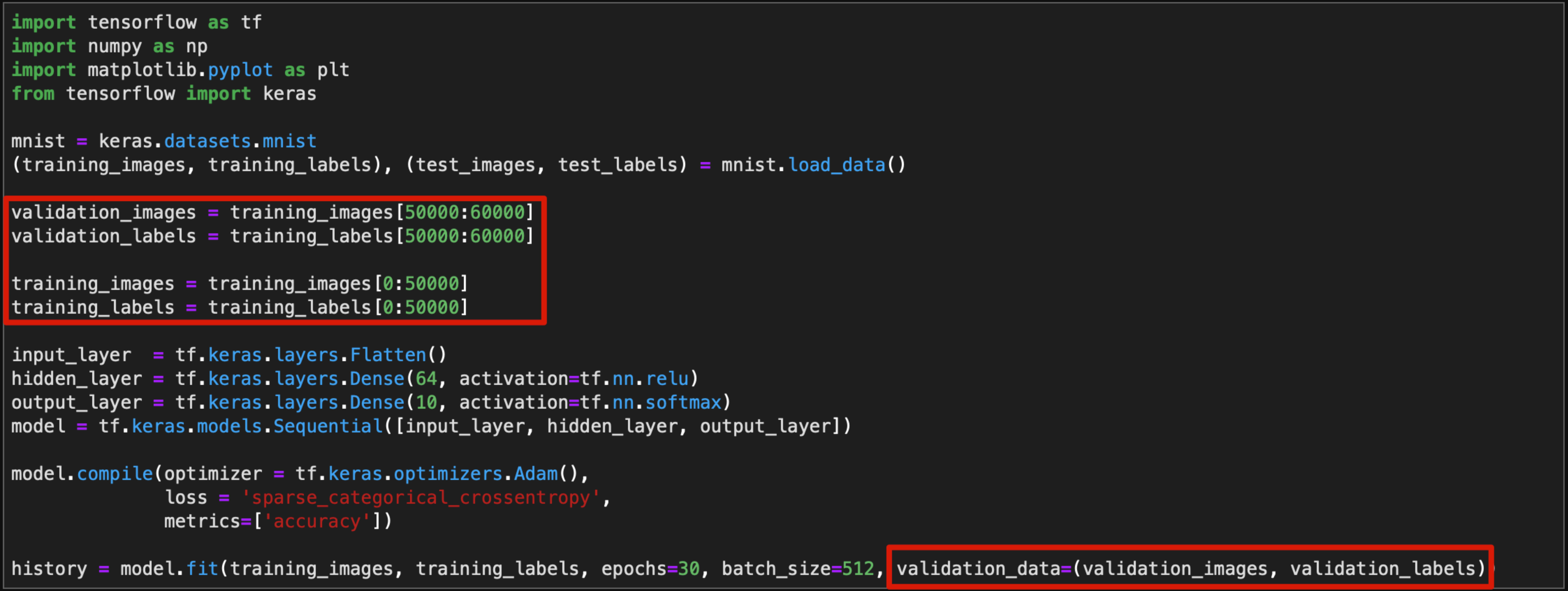
Training 50k

Validation 10k

Test 10k

THE MNIST DATABASE of handwritten digits

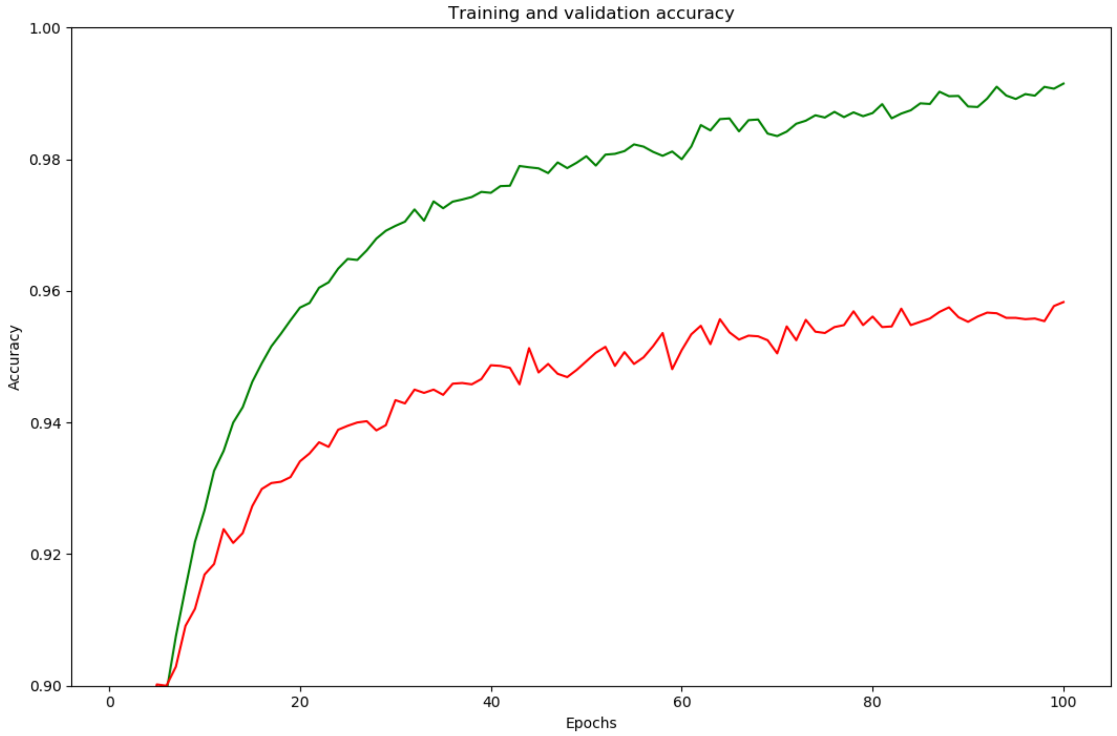
过拟合



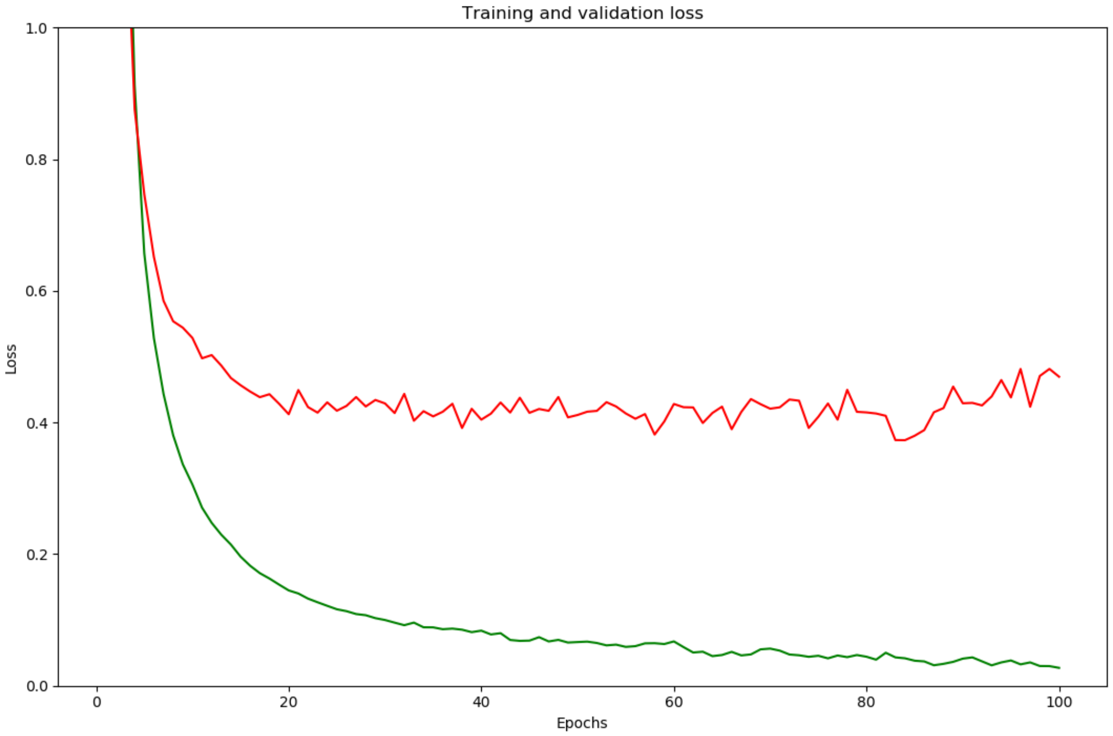
```
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
from tensorflow import keras

mnist = keras.datasets.mnist
(training_images, training_labels), (test_images, test_labels) = mnist.load_data()

validation_images = training_images[50000:60000]
validation_labels = training_labels[50000:60000]

training_images = training_images[0:50000]
training_labels = training_labels[0:50000]

input_layer  = tf.keras.layers.Flatten()
hidden_layer = tf.keras.layers.Dense(64, activation=tf.nn.relu)
output_layer = tf.keras.layers.Dense(10, activation=tf.nn.softmax)
model = tf.keras.models.Sequential([input_layer, hidden_layer, output_layer])

model.compile(optimizer = tf.keras.optimizers.Adam(),
              loss = 'sparse_categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(training_images, training_labels, epochs=30, batch_size=512, validation_data=(validation_images, validation_labels))
```

THE MNIST DATABASE of handwritten digits

过拟合



Training and validation accuracy



Training and validation loss

THE MNIST DATABASE of handwritten digits

过拟合

解决办法：

- 改进神经网络结构
- 使用数据增强，增加更多的数据
- drop-out方法，在训练的时候随机暂停某些神经元的训练
- 其它方法

END

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