```
print("Student Name: Simon")
print("Student ID: 1930026144")
```

```
Student Name: Simon
Student ID: 1930026144
```

```
import keras
keras.__version__
```

```
'2.8.0'
```

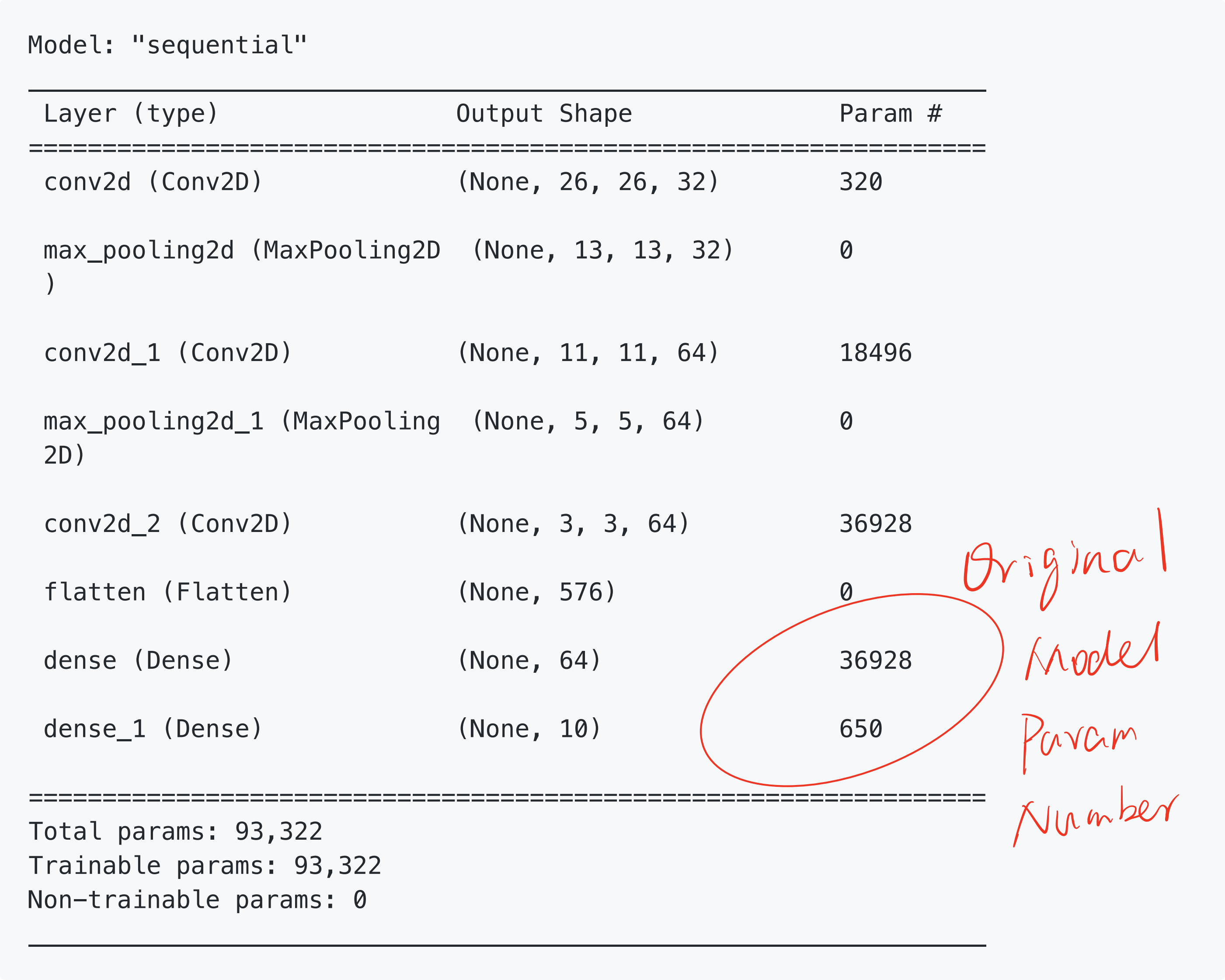
```
from keras import layers
from keras import models

model = models.Sequential()
model.add(layers.Conv2D(32, (3, 3), activation='relu', input_shape=(28, 28, 1)))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(64, (3, 3), activation='relu'))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(64, (3, 3), activation='relu'))
```

```
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 26, 26, 32)        320

 max_pooling2d (MaxPooling2D  (None, 13, 13, 32)       0
 )

 conv2d_1 (Conv2D)           (None, 11, 11, 64)        18496

 max_pooling2d_1 (MaxPooling  (None, 5, 5, 64)         0
 2D)

 conv2d_2 (Conv2D)           (None, 3, 3, 64)          36928

=================================================================
Total params: 55,744
Trainable params: 55,744
Non-trainable params: 0
_________________________________________________________________
```

```python
model.add(layers.Flatten())
model.add(layers.Dense(64, activation='relu'))
model.add(layers.Dense(10, activation='softmax'))
```

```python
model.summary()
```



```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 conv2d (Conv2D)             (None, 26, 26, 32)        320       
                                                                 
 max_pooling2d (MaxPooling2D  (None, 13, 13, 32)       0         
 )                                                               
                                                                 
 conv2d_1 (Conv2D)           (None, 11, 11, 64)        18496     
                                                                 
 max_pooling2d_1 (MaxPooling  (None, 5, 5, 64)         0         
 2D)                                                             
                                                                 
 conv2d_2 (Conv2D)           (None, 3, 3, 64)          36928     
                                                                 
 flatten (Flatten)           (None, 576)               0         
                                                                 
 dense (Dense)               (None, 64)                36928     
                                                                 
 dense_1 (Dense)             (None, 10)                650       
                                                                 
=================================================================
Total params: 93,322
Trainable params: 93,322
Non-trainable params: 0
_________________________________________________________________
```

Original
Model
Param
Number

```
import numpy as np
import os
import gzip
def load_data(data_folder):
    files = [
        'train-labels-idx1-ubyte.gz', 'train-images-idx3-ubyte.gz',
        't10k-labels-idx1-ubyte.gz', 't10k-images-idx3-ubyte.gz'
]
    paths = []
    for fname in files:
        paths.append(os.path.join(data_folder, fname))
    print("Opening y_train path", paths[0])
    with gzip.open(paths[0], 'rb') as lbpath:
        y_train = np.frombuffer(lbpath.read(), np.uint8, offset=8)
    print("Opening x_train path", paths[1])
    with gzip.open(paths[1], 'rb') as imgpath:
        x_train = np.frombuffer(imgpath.read(), np.uint8,
offset=16).reshape(len(y_train), 28, 28)
    print("Opening y_test path", paths[2])
    with gzip.open(paths[2], 'rb') as lbpath:
        y_test = np.frombuffer(lbpath.read(), np.uint8, offset=8)
    print("Opening x_test path", paths[3])
    with gzip.open(paths[3], 'rb') as imgpath:
        x_test = np.frombuffer(imgpath.read(), np.uint8,
offset=16).reshape(len(y_test), 28, 28)
    return (x_train, y_train), (x_test, y_test)
```

```
local_folder = "mnist_dataset"
(train_images, train_labels), (test_images, test_labels) =
load_data(local_folder)
```

```
Opening y_train path mnist_dataset/train-labels-idx1-ubyte.gz
Opening x_train path mnist_dataset/train-images-idx3-ubyte.gz
Opening y_test path mnist_dataset/t10k-labels-idx1-ubyte.gz
Opening x_test path mnist_dataset/t10k-images-idx3-ubyte.gz
```

```
# from keras.datasets import mnist
from tensorflow.keras.utils import to_categorical
import requests

# (train_images, train_labels), (test_images, test_labels) = mnist.load_data()

train_images = train_images.reshape((60000, 28, 28, 1))
train_images = train_images.astype('float32') / 255

test_images = test_images.reshape((10000, 28, 28, 1))
test_images = test_images.astype('float32') / 255

train_labels = to_categorical(train_labels)
test_labels = to_categorical(test_labels)
```

```
model.compile(optimizer='rmsprop',
              loss='categorical_crossentropy',
              metrics=['accuracy'])
model.fit(train_images, train_labels, epochs=5, batch_size=1)
```

```
Epoch 1/5


2022-11-05 21:14:22.369766: W tensorflow/core/platform/profile_utils/cpu_utils.cc


60000/60000 [==============================] - 67s 1ms/step - loss: 0.2044 - accu
Epoch 2/5
60000/60000 [==============================] - 64s 1ms/step - loss: 0.2509 - accu
Epoch 3/5
60000/60000 [==============================] - 64s 1ms/step - loss: 0.2675 - accu
Epoch 4/5
60000/60000 [==============================] - 64s 1ms/step - loss: 0.2844 - accu
Epoch 5/5
60000/60000 [==============================] - 64s 1ms/step - loss: 0.3045 - accu





<keras.callbacks.History at 0x14894cf10>
```

Let's evaluate the model on the test data:

```
test_loss, test_acc = model.evaluate(test_images, test_labels)
```

```
313/313 [==============================] - 1s 2ms/step - loss: 0.2841 - accuracy:
```

```
test_acc
```

```
0.982200026512146
```

Accuracy