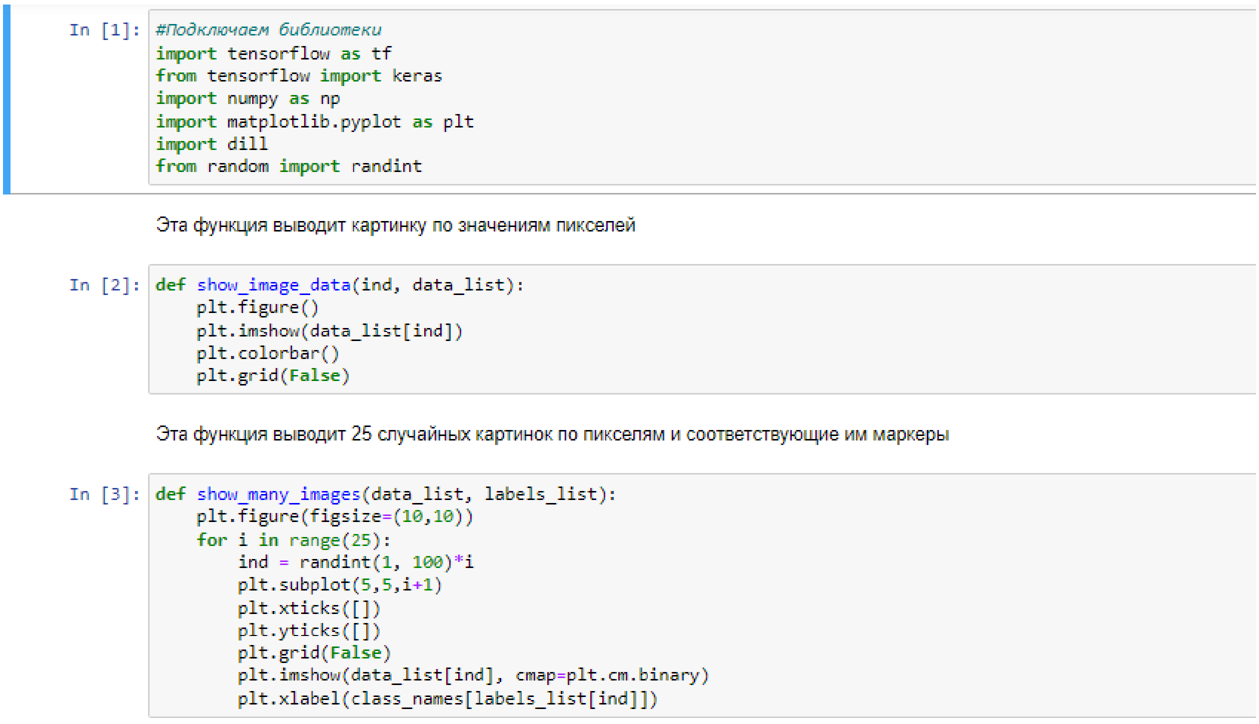


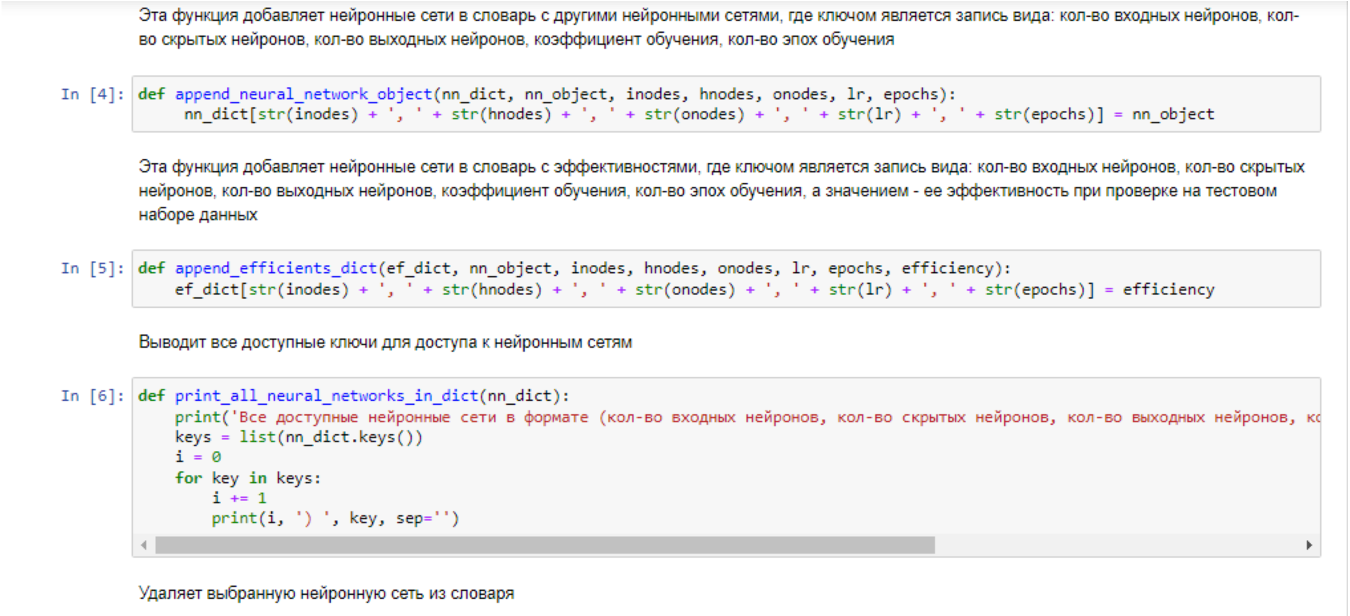
```
In [1]: #Подключаем библиотеки
        import tensorflow as tf
        from tensorflow import keras
        import numpy as np
        import matplotlib.pyplot as plt
        import dill
        from random import randint
```

Эта функция выводит картинку по значениям пикселей

```
In [2]: def show_image_data(ind, data_list):
            plt.figure()
            plt.imshow(data_list[ind])
            plt.colorbar()
            plt.grid(False)
```

Эта функция выводит 25 случайных картинок по пикселям и соответствующие им маркеры

```
In [3]: def show_many_images(data_list, labels_list):
            plt.figure(figsize=(10,10))
            for i in range(25):
                ind = randint(1, 100)*i
                plt.subplot(5,5,i+1)
                plt.xticks([])
                plt.yticks([])
                plt.grid(False)
                plt.imshow(data_list[ind], cmap=plt.cm.binary)
                plt.xlabel(class_names[labels_list[ind]])
```



Эта функция добавляет нейронные сети в словарь с другими нейронными сетями, где ключом является запись вида: кол-во входных нейронов, кол-во скрытых нейронов, кол-во выходных нейронов, коэффициент обучения, кол-во эпох обучения

```
In [4]: def append_neural_network_object(nn_dict, nn_object, inodes, hnodes, onodes, lr, epochs):
            nn_dict[str(inodes) + ', ' + str(hnodes) + ', ' + str(onodes) + ', ' + str(lr) + ', ' + str(epochs)] = nn_object
```

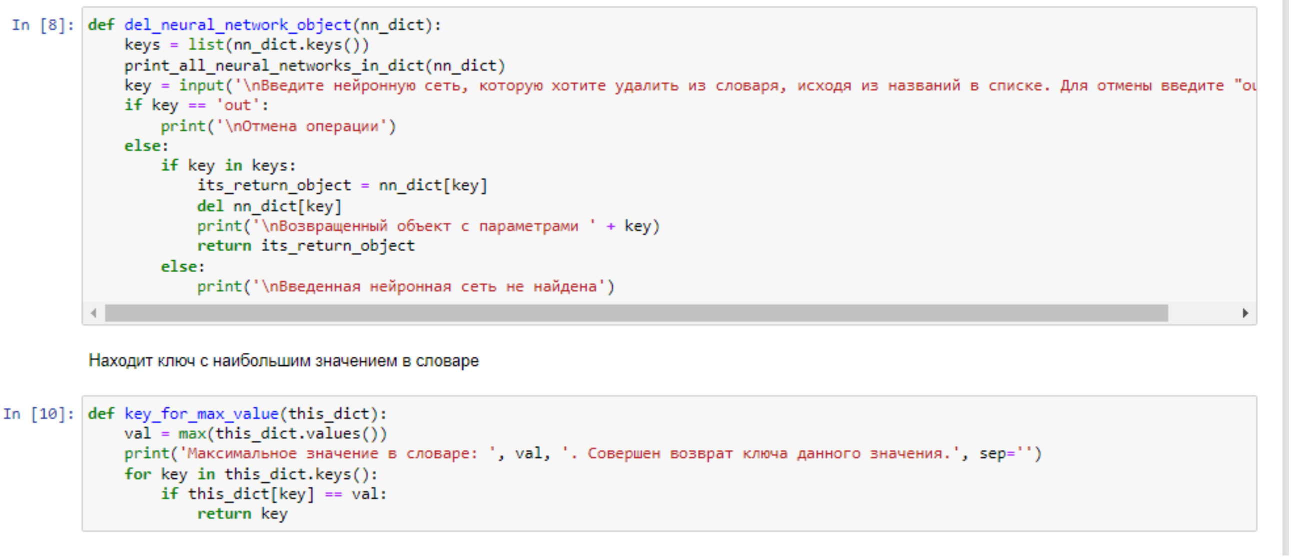
Эта функция добавляет нейронные сети в словарь с эффективностями, где ключом является запись вида: кол-во входных нейронов, кол-во скрытых нейронов, кол-во выходных нейронов, коэффициент обучения, кол-во эпох обучения, а значением - ее эффективность при проверке на тестовом наборе данных

```
In [5]: def append_efficients_dict(ef_dict, nn_object, inodes, hnodes, onodes, lr, epochs, efficiency):
            ef_dict[str(inodes) + ', ' + str(hnodes) + ', ' + str(onodes) + ', ' + str(lr) + ', ' + str(epochs)] = efficiency
```

Выводит все доступные ключи для доступа к нейронным сетям

```
In [6]: def print_all_neural_networks_in_dict(nn_dict):
            print('Все доступные нейронные сети в формате (кол-во входных нейронов, кол-во скрытых нейронов, кол-во выходных нейронов, ко
            keys = list(nn_dict.keys())
            i = 0
            for key in keys:
                i += 1
                print(i, ') ', key, sep='')
```

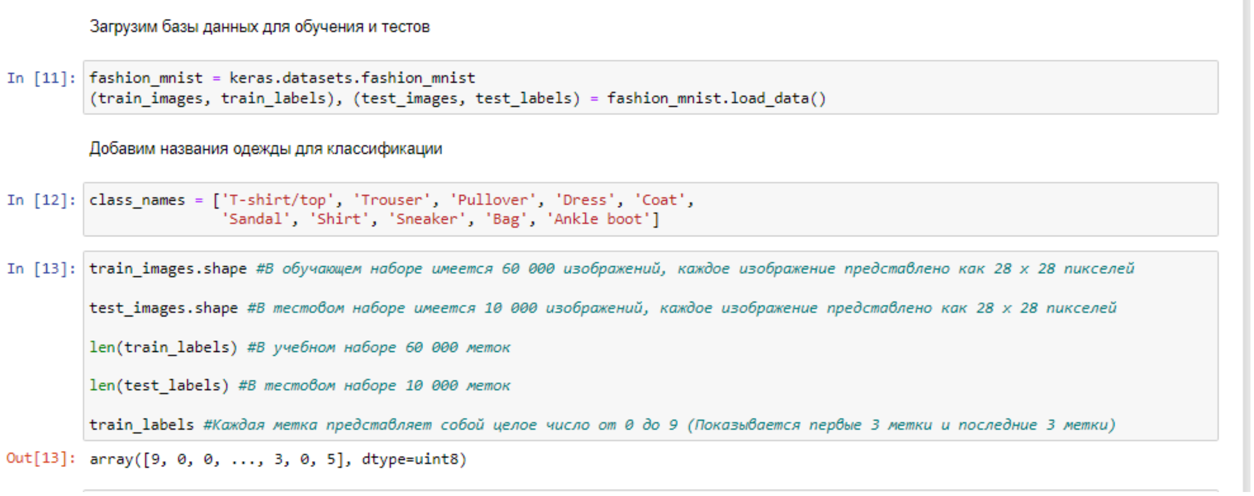
Удаляет выбранную нейронную сеть из словаря



```
In [8]: def del_neural_network_object(nn_dict):
            keys = list(nn_dict.keys())
            print_all_neural_networks_in_dict(nn_dict)
            key = input('\nВведите нейронную сеть, которую хотите удалить из словаря, исходя из названий в списке. Для отмены введите "ou
            if key == 'out':
                print('\nОтмена операции')
            else:
                if key in keys:
                    its_return_object = nn_dict[key]
                    del nn_dict[key]
                    print('\nВозвращенный объект с параметрами ' + key)
                    return its_return_object
                else:
                    print('\nВведенная нейронная сеть не найдена')
```

Находит ключ с наибольшим значением в словаре

```
In [10]: def key_for_max_value(this_dict):
             val = max(this_dict.values())
             print('Максимальное значение в словаре: ', val, '. Совершен возврат ключа данного значения.', sep='')
             for key in this_dict.keys():
                 if this_dict[key] == val:
                     return key
```



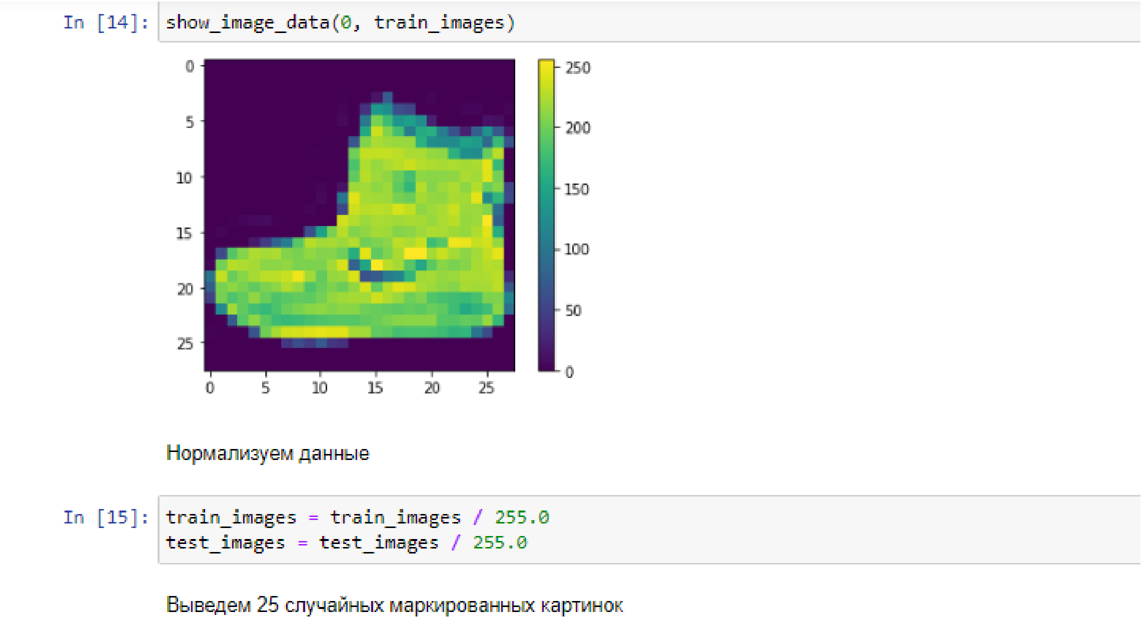
Загрузим базы данных для обучения и тестов

```
In [11]: fashion_mnist = keras.datasets.fashion_mnist
         (train_images, train_labels), (test_images, test_labels) = fashion_mnist.load_data()
```

Добавим названия одежды для классификации

```
In [12]: class_names = ['T-shirt/top', 'Trouser', 'Pullover', 'Dress', 'Coat',
                        'Sandal', 'Shirt', 'Sneaker', 'Bag', 'Ankle boot']
```

```
In [13]: train_images.shape #В обучающем наборе имеется 60 000 изображений, каждое изображение представлено как 28 x 28 пикселей

         test_images.shape #В тестовом наборе имеется 10 000 изображений, каждое изображение представлено как 28 x 28 пикселей

         len(train_labels) #В учебном наборе 60 000 меток

         len(test_labels) #В тестовом наборе 10 000 меток

         train_labels #Каждая метка представляет собой целое число от 0 до 9 (Показывается первые 3 метки и последние 3 метки)

Out[13]: array([9, 0, 0, ..., 3, 0, 5], dtype=uint8)
```

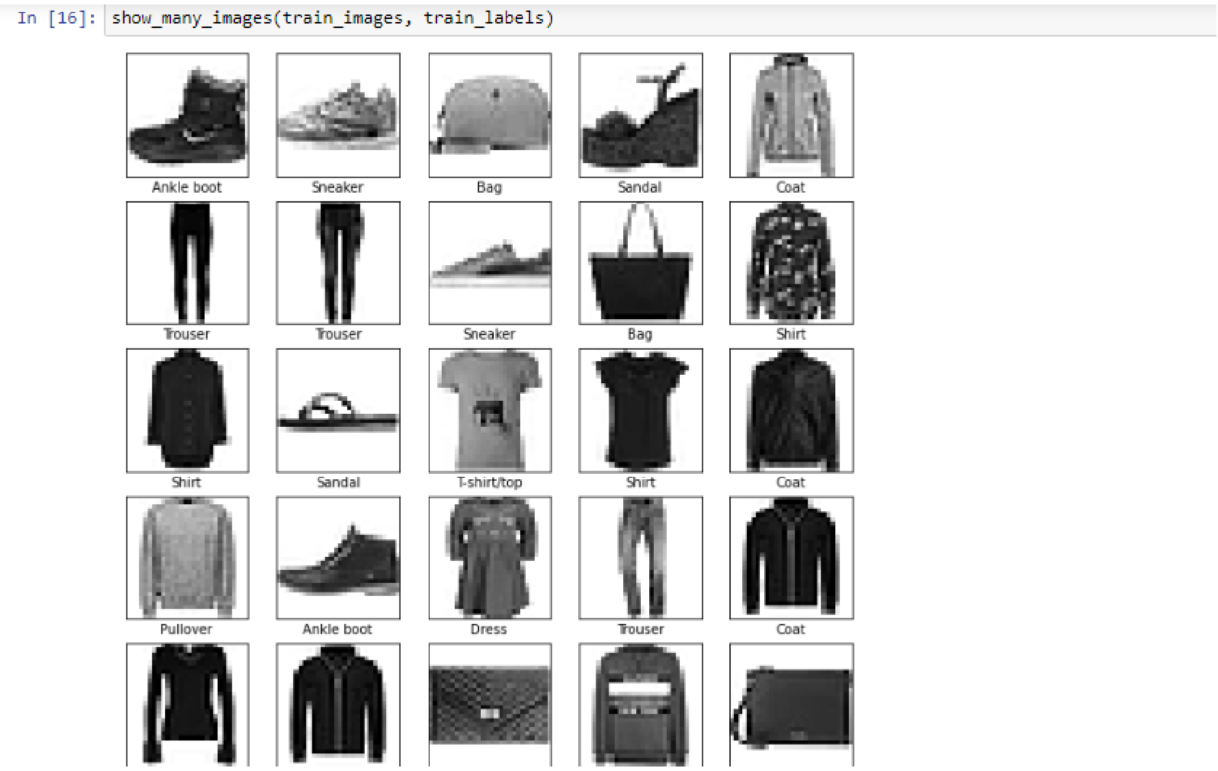


```
In [14]: show_image_data(0, train_images)
```

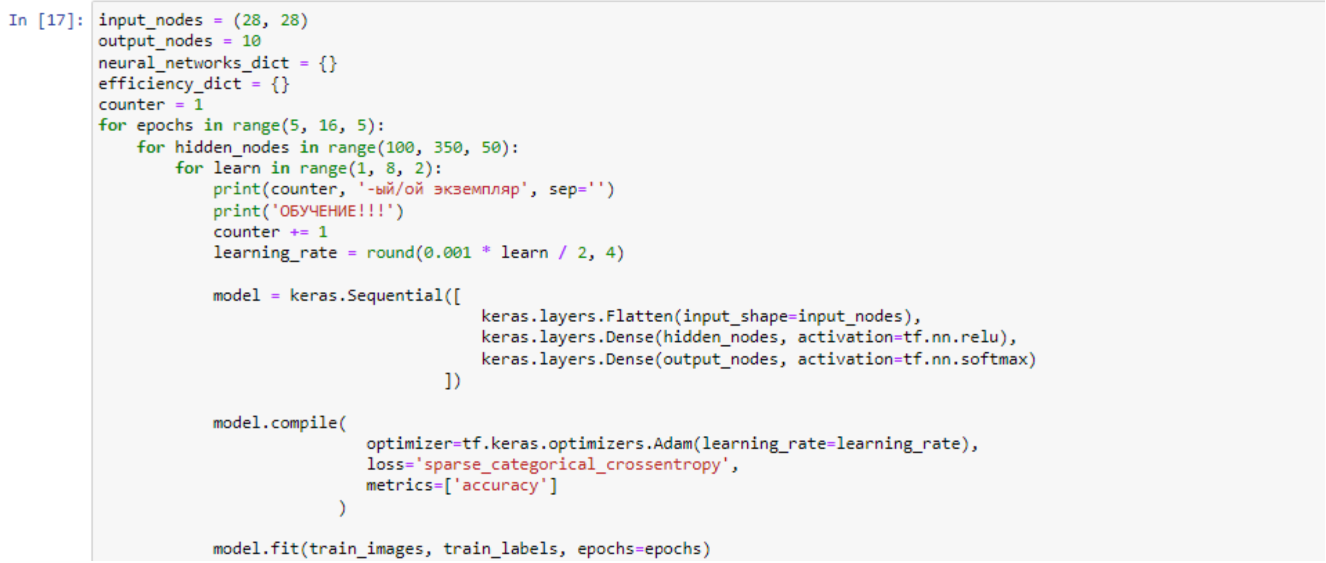
Нормализуем данные

```
In [15]: train_images = train_images / 255.0
         test_images = test_images / 255.0
```

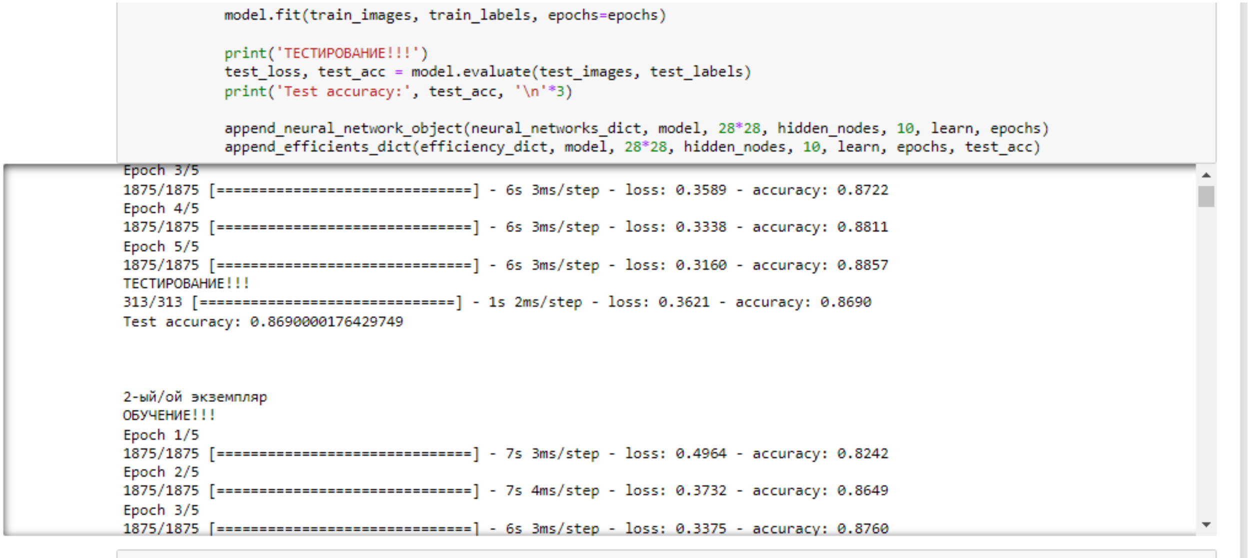
Выведем 25 случайных маркированных картинок



```
In [16]: show_many_images(train_images, train_labels)
```

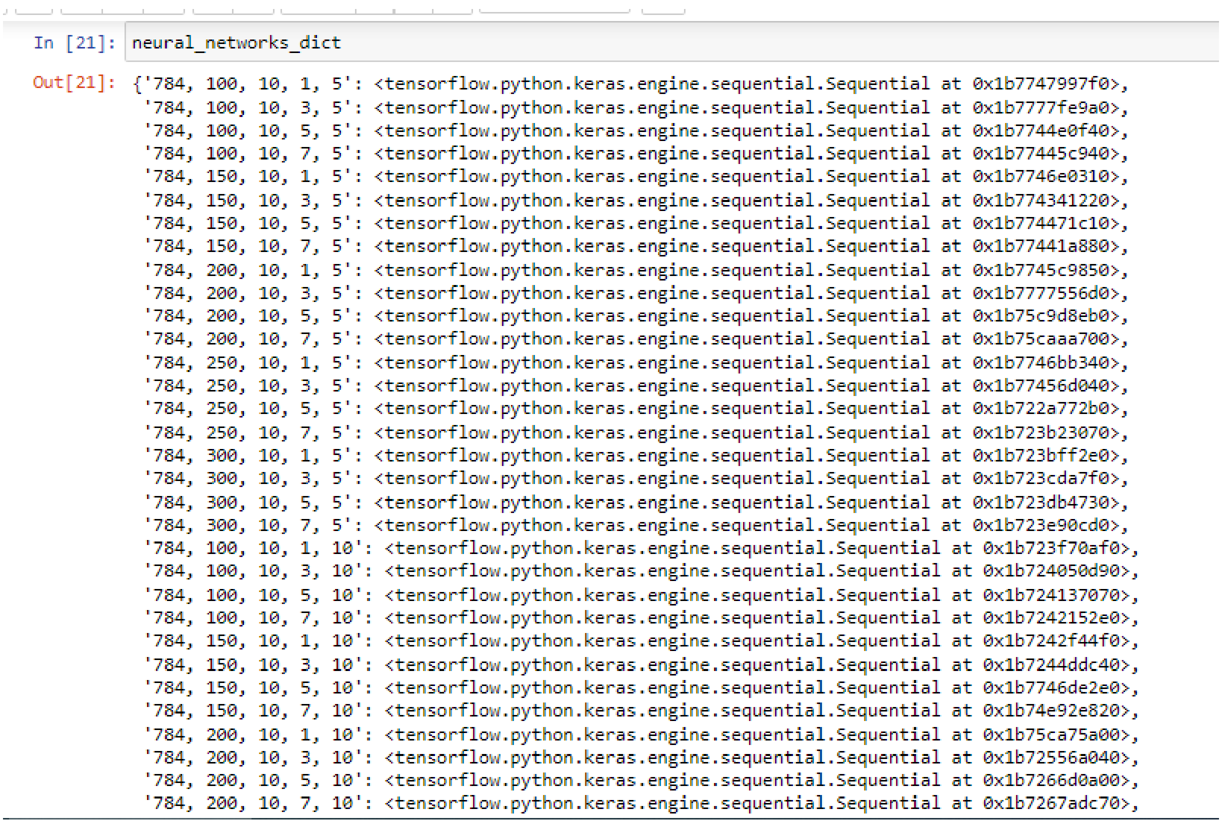


```
In [17]: input_nodes = (28, 28)
         output_nodes = 10
         neural_networks_dict = {}
         efficiency_dict = {}
         counter = 1
         for epochs in range(5, 16, 5):
             for hidden_nodes in range(100, 350, 50):
                 for learn in range(1, 8, 2):
                     print(counter, '-ый/ой экземпляр', sep='')
                     print('ОБУЧЕНИЕ!!!')
                     counter += 1
                     learning_rate = round(0.001 * learn / 2, 4)

                     model = keras.Sequential([
                                                 keras.layers.Flatten(input_shape=input_nodes),
                                                 keras.layers.Dense(hidden_nodes, activation=tf.nn.relu),
                                                 keras.layers.Dense(output_nodes, activation=tf.nn.softmax)
                                             ])

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

                     model.fit(train_images, train_labels, epochs=epochs)
```

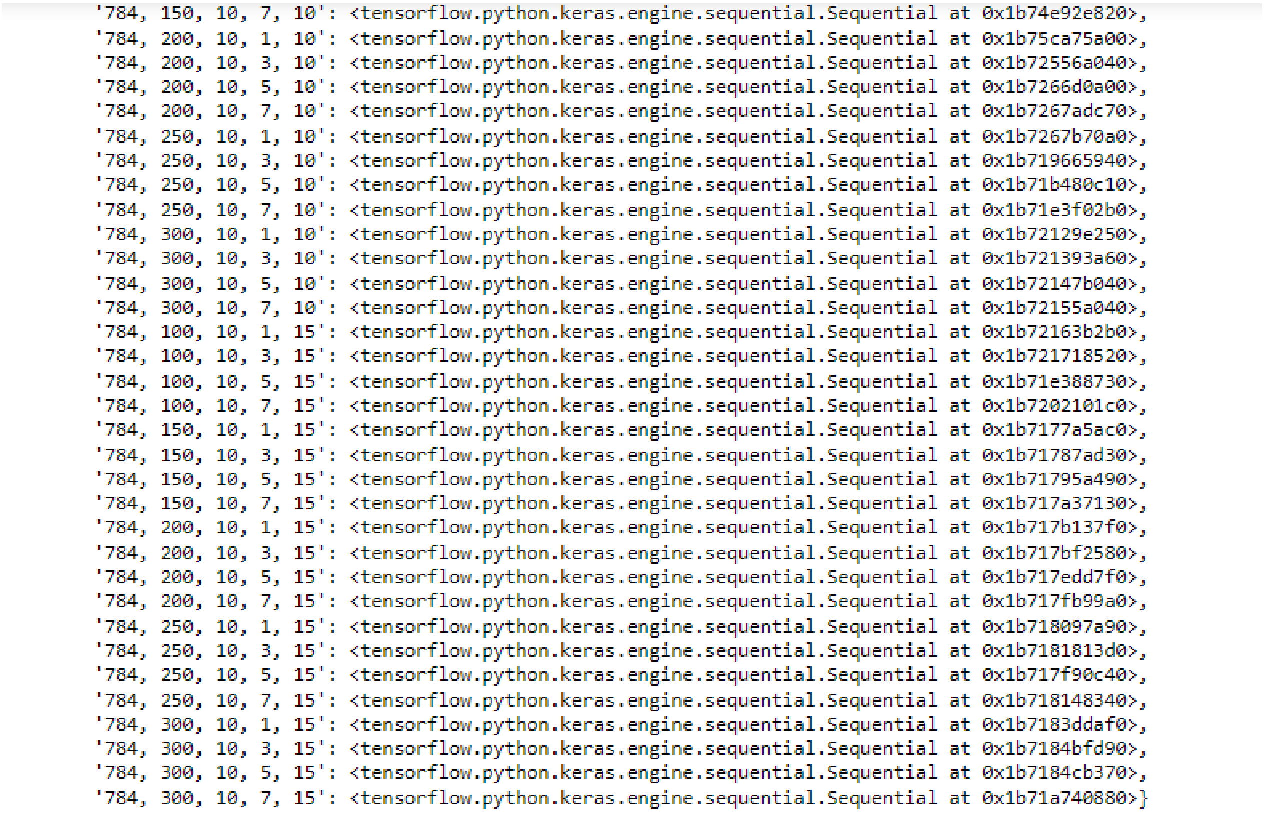


```
                     model.fit(train_images, train_labels, epochs=epochs)

                     print('ТЕСТИРОВАНИЕ!!!')
                     test_loss, test_acc = model.evaluate(test_images, test_labels)
                     print('Test accuracy:', test_acc, '\n'*3)

                     append_neural_network_object(neural_networks_dict, model, 28*28, hidden_nodes, 10, learn, epochs)
                     append_efficients_dict(efficiency_dict, model, 28*28, hidden_nodes, 10, learn, epochs, test_acc)
```

```
Epoch 3/5
1875/1875 [==============================] - 6s 3ms/step - loss: 0.3589 - accuracy: 0.8722
Epoch 4/5
1875/1875 [==============================] - 6s 3ms/step - loss: 0.3338 - accuracy: 0.8811
Epoch 5/5
1875/1875 [==============================] - 6s 3ms/step - loss: 0.3160 - accuracy: 0.8857
ТЕСТИРОВАНИЕ!!!
313/313 [==============================] - 1s 2ms/step - loss: 0.3621 - accuracy: 0.8690
Test accuracy: 0.8690000176429749



2-ый/ой экземпляр
ОБУЧЕНИЕ!!!
Epoch 1/5
1875/1875 [==============================] - 7s 3ms/step - loss: 0.4964 - accuracy: 0.8242
Epoch 2/5
1875/1875 [==============================] - 7s 4ms/step - loss: 0.3732 - accuracy: 0.8649
Epoch 3/5
1875/1875 [==============================] - 6s 3ms/step - loss: 0.3375 - accuracy: 0.8760
```



```
In [21]: neural_networks_dict

Out[21]: {'784, 100, 10, 1, 5': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7747997f0>,
          '784, 100, 10, 3, 5': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7777fe9a0>,
          '784, 100, 10, 5, 5': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7744e0f40>,
          '784, 100, 10, 7, 5': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b77445c940>,
          '784, 150, 10, 1, 5': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7746e0310>,
          '784, 150, 10, 3, 5': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b774341220>,
          '784, 150, 10, 5, 5': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b774471c10>,
          '784, 150, 10, 7, 5': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b77441a880>,
          '784, 200, 10, 1, 5': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7745c9850>,
          '784, 200, 10, 3, 5': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7777556d0>,
          '784, 200, 10, 5, 5': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b75c9d8eb0>,
          '784, 200, 10, 7, 5': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b75caaa700>,
          '784, 250, 10, 1, 5': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7746bb340>,
          '784, 250, 10, 3, 5': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b77456d040>,
          '784, 250, 10, 5, 5': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b722a772b0>,
          '784, 250, 10, 7, 5': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b723b23070>,
          '784, 300, 10, 1, 5': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b723bff2e0>,
          '784, 300, 10, 3, 5': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b723cda7f0>,
          '784, 300, 10, 5, 5': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b723db4730>,
          '784, 300, 10, 7, 5': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b723e90cd0>,
          '784, 100, 10, 1, 10': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b723f70af0>,
          '784, 100, 10, 3, 10': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b724050d90>,
          '784, 100, 10, 5, 10': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b724137070>,
          '784, 100, 10, 7, 10': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7242152e0>,
          '784, 150, 10, 1, 10': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7242f44f0>,
          '784, 150, 10, 3, 10': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7244ddc40>,
          '784, 150, 10, 5, 10': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7746de2e0>,
          '784, 150, 10, 7, 10': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b74e92e820>,
          '784, 200, 10, 1, 10': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b75ca75a00>,
          '784, 200, 10, 3, 10': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b72556a040>,
          '784, 200, 10, 5, 10': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7266d0a00>,
          '784, 200, 10, 7, 10': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7267adc70>,
```



```
 '784, 150, 10, 7, 10': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b74e92e820>,
 '784, 200, 10, 1, 10': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b75ca75a00>,
 '784, 200, 10, 3, 10': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b72556a040>,
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 '784, 200, 10, 7, 10': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7267adc70>,
```

```
 '784, 250, 10, 1, 10': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7267b70a0>,
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 '784, 300, 10, 1, 10': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b72129e250>,
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 '784, 300, 10, 5, 10': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b72147b040>,
 '784, 300, 10, 7, 10': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b72155a040>,
 '784, 100, 10, 1, 15': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b72163b2b0>,
 '784, 100, 10, 3, 15': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b721718520>,
 '784, 100, 10, 5, 15': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b71e388730>,
 '784, 100, 10, 7, 15': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7202101c0>,
 '784, 150, 10, 1, 15': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7177a5ac0>,
 '784, 150, 10, 3, 15': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b71787ad30>,
 '784, 150, 10, 5, 15': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b71795a490>,
 '784, 150, 10, 7, 15': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b717a37130>,
 '784, 200, 10, 1, 15': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b717b137f0>,
 '784, 200, 10, 3, 15': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b717bf2580>,
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 '784, 200, 10, 7, 15': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b717fb99a0>,
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 '784, 250, 10, 3, 15': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7181813d0>,
 '784, 250, 10, 5, 15': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b717f90c40>,
 '784, 250, 10, 7, 15': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b718148340>,
 '784, 300, 10, 1, 15': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7183ddaf0>,
 '784, 300, 10, 3, 15': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7184bfd90>,
 '784, 300, 10, 5, 15': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b7184cb370>,
 '784, 300, 10, 7, 15': <tensorflow.python.keras.engine.sequential.Sequential at 0x1b71a740880>}
```

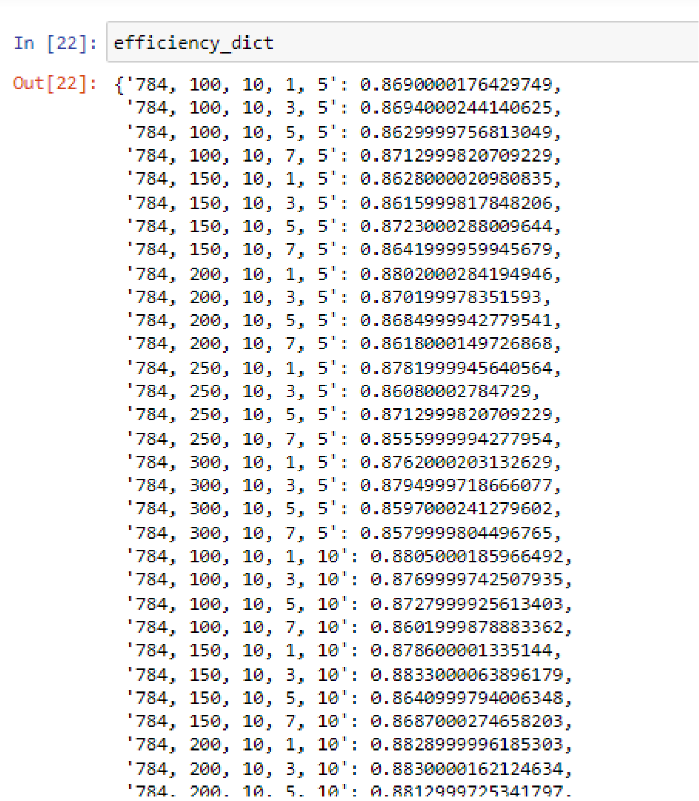

```
In [22]: efficiency_dict

Out[22]: {'784, 100, 10, 1, 5': 0.8690000176429749,
          '784, 100, 10, 3, 5': 0.8694000244140625,
          '784, 100, 10, 5, 5': 0.8629999756813049,
          '784, 100, 10, 7, 5': 0.8712999820709229,
          '784, 150, 10, 1, 5': 0.8628000020980835,
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          '784, 150, 10, 5, 5': 0.8723000288009644,
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          '784, 300, 10, 5, 5': 0.8597000241279602,
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          '784, 100, 10, 3, 10': 0.8769999742507935,
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          '784, 200, 10, 3, 10': 0.8830000162124634,
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```

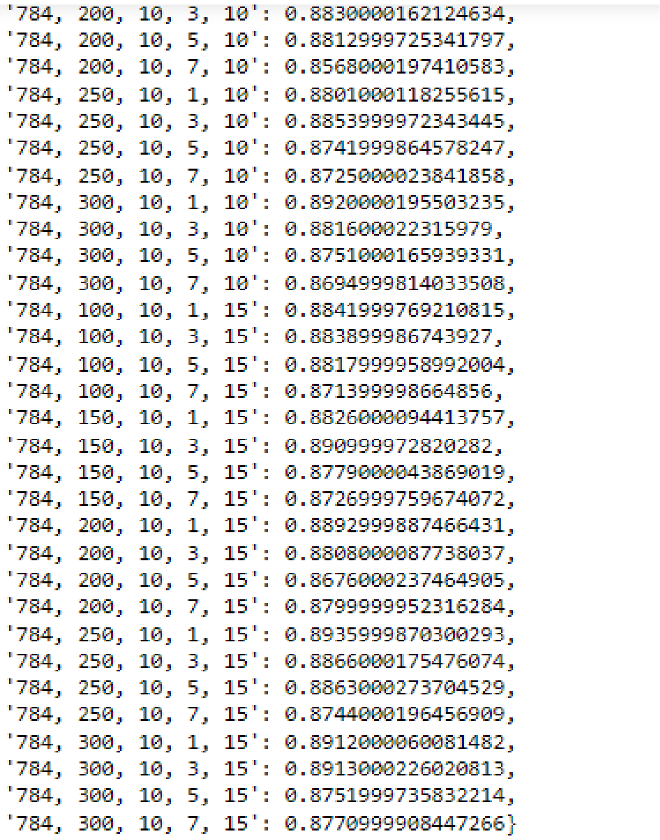

```
'784, 200, 10, 3, 10': 0.8830000162124634,
'784, 200, 10, 5, 10': 0.8812999725341797,
```

```
'784, 200, 10, 7, 10': 0.8568000197410583,
'784, 250, 10, 1, 10': 0.8801000118255615,
'784, 250, 10, 3, 10': 0.8853999972343445,
'784, 250, 10, 5, 10': 0.8741999864578247,
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'784, 300, 10, 1, 10': 0.8920000195503235,
'784, 300, 10, 3, 10': 0.881600022315979,
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'784, 300, 10, 7, 10': 0.8694999814033508,
'784, 100, 10, 1, 15': 0.8841999769210815,
'784, 100, 10, 3, 15': 0.883899986743927,
'784, 100, 10, 5, 15': 0.8817999958992004,
'784, 100, 10, 7, 15': 0.871399998664856,
'784, 150, 10, 1, 15': 0.8826000094413757,
'784, 150, 10, 3, 15': 0.890999972820282,
'784, 150, 10, 5, 15': 0.8779000043869019,
'784, 150, 10, 7, 15': 0.8726999759674072,
'784, 200, 10, 1, 15': 0.8892999887466431,
'784, 200, 10, 3, 15': 0.8808000087738037,
'784, 200, 10, 5, 15': 0.8676000237464905,
'784, 200, 10, 7, 15': 0.8799999952316284,
'784, 250, 10, 1, 15': 0.8935999870300293,
'784, 250, 10, 3, 15': 0.8866000175476074,
'784, 250, 10, 5, 15': 0.8863000273704529,
'784, 250, 10, 7, 15': 0.8744000196456909,
'784, 300, 10, 1, 15': 0.8912000060081482,
'784, 300, 10, 3, 15': 0.8913000226020813,
'784, 300, 10, 5, 15': 0.8751999735832214,
'784, 300, 10, 7, 15': 0.8770999908447266}
```
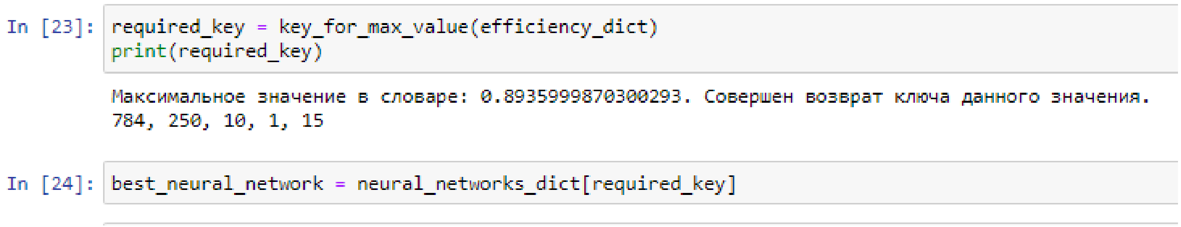
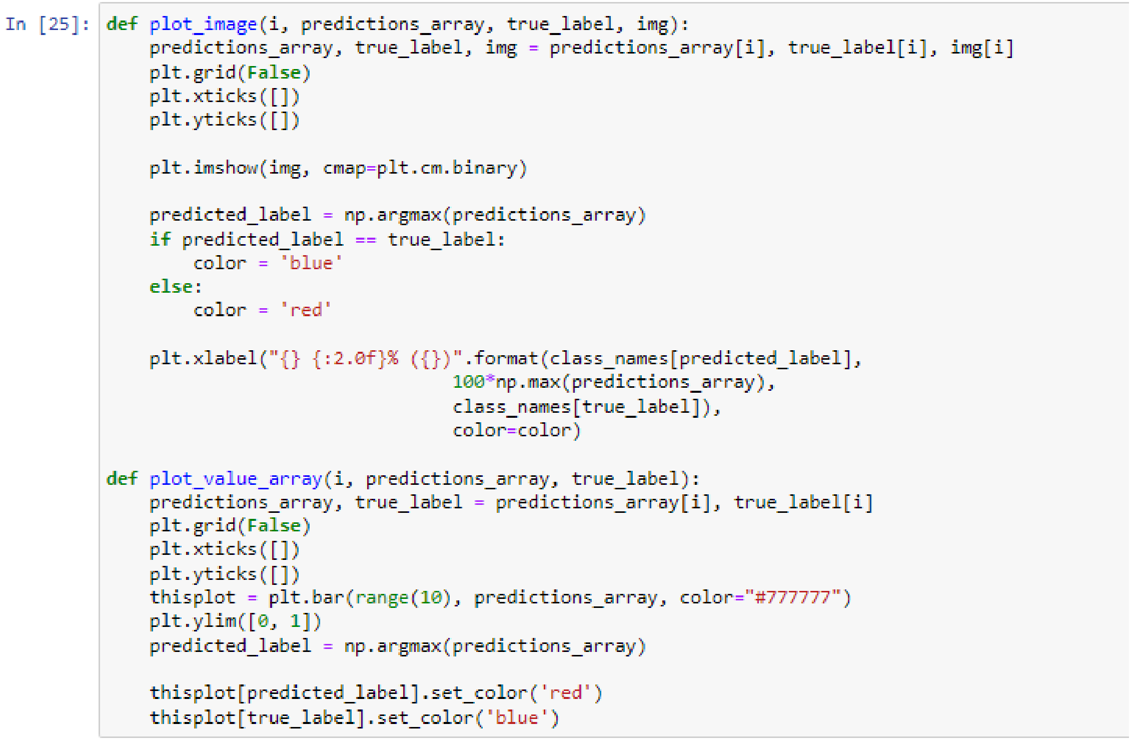
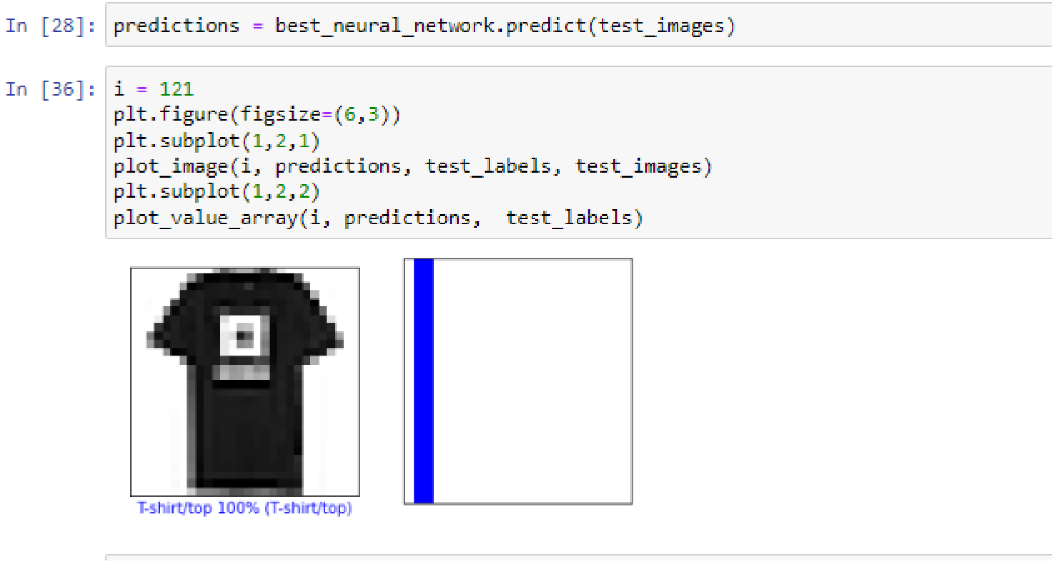



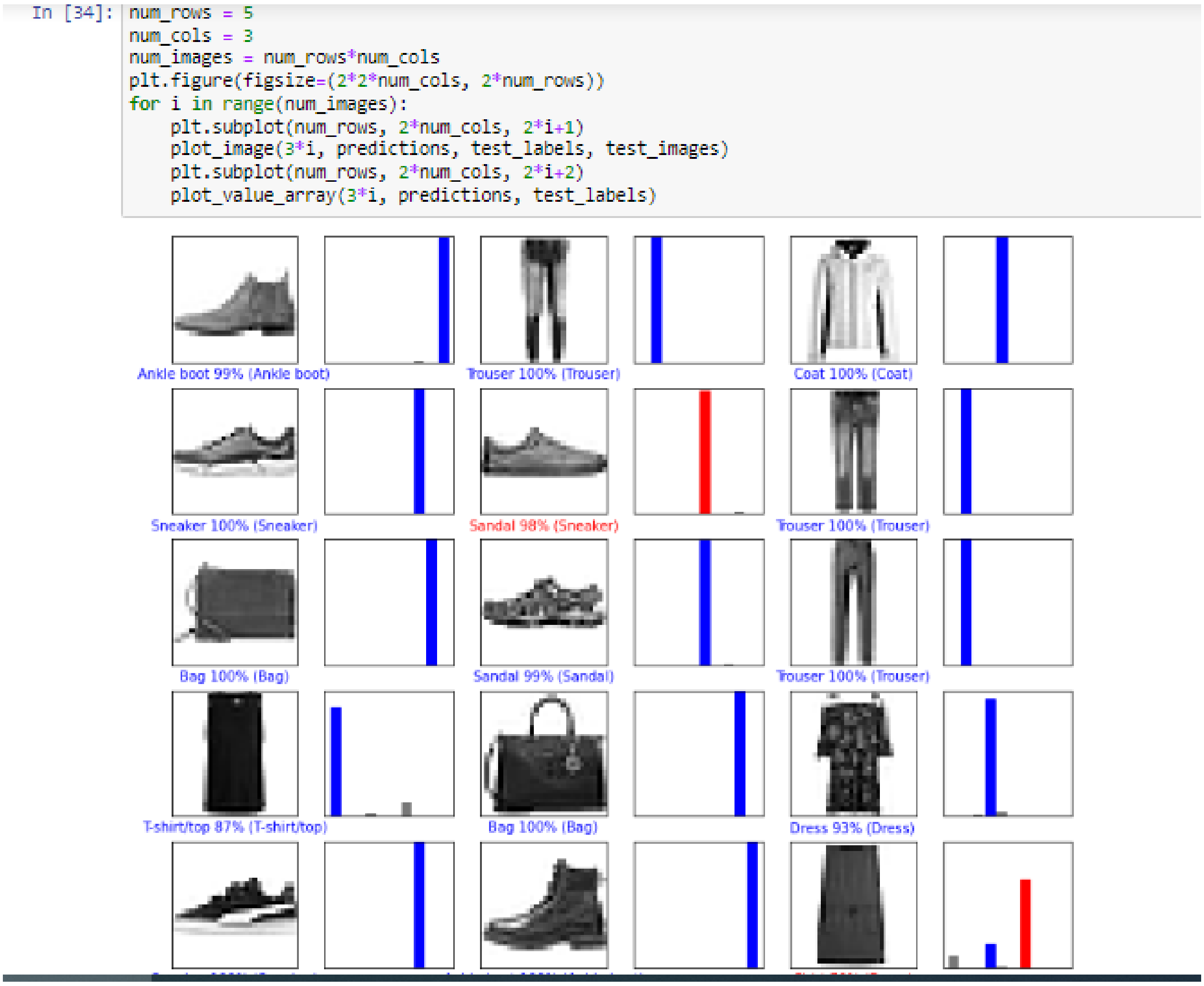
```
In [23]: required_key = key_for_max_value(efficiency_dict)
         print(required_key)

         Максимальное значение в словаре: 0.8935999870300293. Совершен возврат ключа данного значения.
         784, 250, 10, 1, 15

In [24]: best_neural_network = neural_networks_dict[required_key]
```



```
In [25]: def plot_image(i, predictions_array, true_label, img):
             predictions_array, true_label, img = predictions_array[i], true_label[i], img[i]
             plt.grid(False)
             plt.xticks([])
             plt.yticks([])

             plt.imshow(img, cmap=plt.cm.binary)

             predicted_label = np.argmax(predictions_array)
             if predicted_label == true_label:
                 color = 'blue'
             else:
                 color = 'red'

             plt.xlabel("{} {:2.0f}% ({})".format(class_names[predicted_label],
                                           100*np.max(predictions_array),
                                           class_names[true_label]),
                                           color=color)

         def plot_value_array(i, predictions_array, true_label):
             predictions_array, true_label = predictions_array[i], true_label[i]
             plt.grid(False)
             plt.xticks([])
             plt.yticks([])
             thisplot = plt.bar(range(10), predictions_array, color="#777777")
             plt.ylim([0, 1])
             predicted_label = np.argmax(predictions_array)

             thisplot[predicted_label].set_color('red')
             thisplot[true_label].set_color('blue')
```



```
In [28]: predictions = best_neural_network.predict(test_images)

In [36]: i = 121
         plt.figure(figsize=(6,3))
         plt.subplot(1,2,1)
         plot_image(i, predictions, test_labels, test_images)
         plt.subplot(1,2,2)
         plot_value_array(i, predictions,  test_labels)
```



```
In [34]: num_rows = 5
         num_cols = 3
         num_images = num_rows*num_cols
         plt.figure(figsize=(2*2*num_cols, 2*num_rows))
         for i in range(num_images):
             plt.subplot(num_rows, 2*num_cols, 2*i+1)
             plot_image(3*i, predictions, test_labels, test_images)
             plt.subplot(num_rows, 2*num_cols, 2*i+2)
             plot_value_array(3*i, predictions, test_labels)
```