Fashion MNIST image classification with Tensorflow

- Fashion-MNIST is a dataset of Zalando's article images consisting of 60,000 training examples and 10,000 test examples. Each example is a 28x28 grayscale image, associated with a label from 10 classes.
- There are 10 classes in Fashion-MNIST: T-shirt/top, Trouser, Pullover, Dress, Coat, Sandal, Shirt, Sneaker, Bag, and Ankle boot.
- Sequential model in tensorflow is created with 5 layers, in which 3 layers are hidden layers for the classification of images with the output of probability distribution over the 10 classes.

tensorflow_datasets

In [1]:
```
!pip install -U tensorflow_datasets
```

```
Requirement already satisfied: tensorflow_datasets in /opt/conda/lib/python3.10/site-packages (4.9.2)
Requirement already satisfied: absl-py in /opt/conda/lib/python3.10/site-packages (from tensorflow_datasets) (1.4.0)
Requirement already satisfied: array-record in /opt/conda/lib/python3.10/site-packages (from tensorflow_datasets) (0.2.0)
Requirement already satisfied: click in /opt/conda/lib/python3.10/site-packages (from tensorflow_datasets) (8.1.3)
Requirement already satisfied: dm-tree in /opt/conda/lib/python3.10/site-packages (from tensorflow_datasets) (0.1.8)
Requirement already satisfied: etils[enp,epath]>=0.9.0 in /opt/conda/lib/python3.10/site-packages (from tensorflow_datasets) (1.2.0)
Requirement already satisfied: numpy in /opt/conda/lib/python3.10/site-packages (from tensorflow_datasets) (1.23.5)
Requirement already satisfied: promise in /opt/conda/lib/python3.10/site-packages (from tensorflow_datasets) (2.3)
Requirement already satisfied: protobuf>=3.20 in /opt/conda/lib/python3.10/site-packages (from tensorflow_datasets) (3.20.3)
Requirement already satisfied: psutil in /opt/conda/lib/python3.10/site-packages (from tensorflow_datasets) (5.9.3)
Requirement already satisfied: requests>=2.19.0 in /opt/conda/lib/python3.10/site-packages (from tensorflow_datasets) (2.28.2)
Requirement already satisfied: tensorflow-metadata in /opt/conda/lib/python3.10/site-packages (from tensorflow_datasets) (0.14.0)
Requirement already satisfied: termcolor in /opt/conda/lib/python3.10/site-packages (from tensorflow_datasets) (2.3.0)
Requirement already satisfied: toml in /opt/conda/lib/python3.10/site-packages (from tensorflow_datasets) (0.10.2)
Requirement already satisfied: tqdm in /opt/conda/lib/python3.10/site-packages (from tensorflow_datasets) (4.64.1)
Requirement already satisfied: wrapt in /opt/conda/lib/python3.10/site-packages (from tensorflow_datasets) (1.14.1)
Requirement already satisfied: importlib_resources in /opt/conda/lib/python3.10/site-packages (from etils[enp,epath]>=0.9.0->tensorflow_datasets) (5.12.0)
Requirement already satisfied: typing_extensions in /opt/conda/lib/python3.10/site-packages (from etils[enp,epath]>=0.9.0->tensorflow_datasets) (4.5.0)
Requirement already satisfied: zipp in /opt/conda/lib/python3.10/site-packages (from etils[enp,epath]>=0.9.0->tensorflow_datasets) (3.15.0)
Requirement already satisfied: charset-normalizer<4,>=2 in /opt/conda/lib/python3.10/site-packages (from requests>=2.19.0->tensorflow_datasets) (2.1.1)
Requirement already satisfied: idna<4,>=2.5 in /opt/conda/lib/python3.10/site-packages (from requests>=2.19.0->tensorflow_datasets) (3.4)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in /opt/conda/lib/python3.10/site-packages (from requests>=2.19.0->tensorflow_datasets) (1.26.15)
Requirement already satisfied: certifi>=2017.4.17 in /opt/conda/lib/python3.10/site-packages (from requests>=2.19.0->tensorflow_datasets) (2023.5.7)
Requirement already satisfied: six in /opt/conda/lib/python3.10/site-packages (from promise->tensorflow_datasets) (1.16.0)
Requirement already satisfied: googleapis-common-protos in /opt/conda/lib/python3.10/site-packages (from tensorflow-metadata->tensorflow_datasets) (1.57.1)
WARNING: Running pip as the 'root' user can result in broken permissions and conflicting behaviour with the system package manager. It is recommended to use a virtual environment instead: https://pip.pypa.io/warnings/venv
```

In [2]:
```
from __future__ import absolute_import, division, print_function

import tensorflow as tf
import tensorflow_datasets as tfds
import logging
logger = tf.get_logger()
logger.setLevel(logging.ERROR)
```

```
/opt/conda/lib/python3.10/site-packages/tensorflow_io/python/ops/__init__.py:98: UserWarning: unable to load libtensorflow_io_plugins.so: unable to open file: libtensorflow_io_plugins.so, from paths: ['/opt/conda/lib/python3.10/site-packages/tensorflow_io/python/ops/libtensorflow_io_plugins.so']
caused by: ['/opt/conda/lib/python3.10/site-packages/tensorflow_io/python/ops/libtensorflow_io_plugins.so: undefined symbol: _ZN3tsl6StatusC1EN10tensorflow5error4CodeESt17basic_string_viewIcSt11char_traitsIcEENS_14SourceLocationE']
  warnings.warn(f"unable to load libtensorflow_io_plugins.so: {e}")
/opt/conda/lib/python3.10/site-packages/tensorflow_io/python/ops/__init__.py:104: UserWarning: file system plugins are not loaded: unable to open file: libtensorflow_io.so, from paths: ['/opt/conda/lib/python3.10/site-packages/tensorflow_io/python/ops/libtensorflow_io.so']
caused by: ['/opt/conda/lib/python3.10/site-packages/tensorflow_io/python/ops/libtensorflow_io.so: undefined symbol: _ZTVN10tensorflow13GcsFileSystemE']
  warnings.warn(f"file system plugins are not loaded: {e}")
```

In [3]:
```
import math
import numpy as np
import matplotlib.pyplot as plt

import tqdm
import tqdm.auto
tqdm.tqdm = tqdm.auto.tqdm
```

In [4]:
```
dataset, metadata = tfds.load('fashion_mnist', as_supervised = True, with_info = True)
train_dataset, test_dataset = dataset['train'], dataset['test']
```

Downloading and preparing dataset 29.45 MiB (download: 29.45 MiB, generated: 36.42 MiB, total: 65.87 MiB) to /root/tensorflow_datasets/fashion_mnist/3.0.1...

Dl Completed...: 100% 4/4 [00:00<00:00, 13.61 url/s]

Dl Size...: 100% 29/29 [00:00<00:00, 70.47 MiB/s]

Extraction completed...: 100% 4/4 [00:00<00:00, 5.23 file/s]

Dataset fashion_mnist downloaded and prepared to /root/tensorflow_datasets/fashion_mnist/3.0.1. Subsequent calls will reuse this data.

In [5]:
```
class_names = metadata.features['label'].names
print("Class names: {}".format(class_names))
```

```
Class names: ['T-shirt/top', 'Trouser', 'Pullover', 'Dress', 'Coat', 'Sandal', 'Shirt', 'Sneaker', 'Bag', 'Ankle boot']
```

In [6]:
```
num_train_examples = metadata.splits['train'].num_examples
num_test_examples = metadata.splits['test'].num_examples
print("Number of training examples: ",num_train_examples)
print("Number of testing examples: ",num_test_examples)
```

```
Number of training examples:  60000
Number of testing examples:  10000
```

Helper function for normalization of image

In [7]:
```
def normalize(images,labels):
  images = tf.cast(images, tf.float32)
  images /= 255
  return images,labels
```

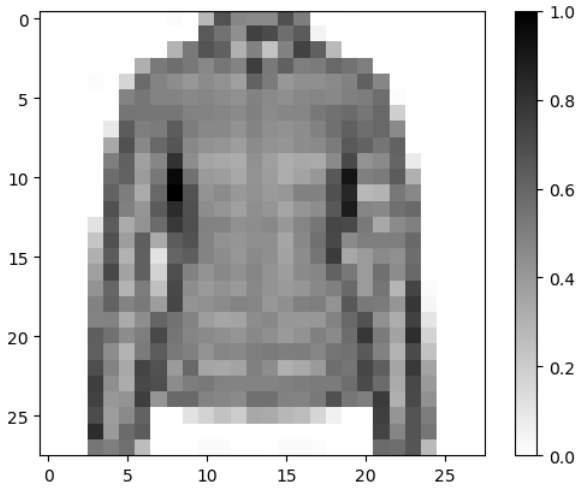
In [8]:
```
train_dataset = train_dataset.map(normalize)
test_dataset = test_dataset.map(normalize)
```

First image of test dataset

- Take a single image and remove the color dimension by reshaping

In [9]:
```
for image,label in test_dataset.take(1):
  break
image = image.numpy().reshape((28,28))
```

In [10]:
```
plt.figure()
plt.imshow(image, cmap = plt.cm.binary)
plt.colorbar()
plt.grid(False)
plt.show()
```



Let's plot first 25 images of test dataset

In [11]:
```
plt.figure(figsize = (10,10))
i =  0
for image,label in test_dataset.take(30):
  image = image.numpy().reshape(28,28)
  plt.subplot(6,5,i+1)
  plt.xticks([])
  plt.yticks([])
  plt.imshow(image, cmap = plt.cm.binary)
  plt.grid(False)
  plt.xlabel(class_names[label])
  i+=1

plt.show()
```

Building model with one input layer, 3 hidden layers, and one output layer

In [12]:
```
model = tf.keras.Sequential([tf.keras.layers.Flatten(input_shape = (28,28,1)),
                             tf.keras.layers.Dense(units = 512, activation = tf.nn.relu),
                             tf.keras.layers.Dense(units = 256, activation = tf.nn.relu),
                             tf.keras.layers.Dense(units = 128, activation = tf.nn.relu),
                             tf.keras.layers.Dense(units = 10, activation = tf.nn.softmax)])
```

Model compilation

In [13]:
```
model.compile(optimizer = 'adam', loss = 'sparse_categorical_crossentropy', metrics = ['accuracy'])
```

Batch division

In [14]:
```
BATCH_SIZE = 32
train_dataset = train_dataset.repeat().shuffle(num_train_examples).batch(BATCH_SIZE)
```

```
test_dataset = test_dataset.batch(BATCH_SIZE)
```

Fitting the model

In [15]:
```
model.fit(train_dataset, epochs = 10, steps_per_epoch = math.ceil(num_train_examples/BATCH_SIZE))
```

```
Epoch 1/10
1875/1875 [==============================] - 15s 6ms/step - loss: 0.4699 - accuracy: 0.8259
Epoch 2/10
1875/1875 [==============================] - 11s 6ms/step - loss: 0.3593 - accuracy: 0.8680
Epoch 3/10
1875/1875 [==============================] - 11s 6ms/step - loss: 0.3213 - accuracy: 0.8804
Epoch 4/10
1875/1875 [==============================] - 11s 6ms/step - loss: 0.3038 - accuracy: 0.8875
Epoch 5/10
1875/1875 [==============================] - 11s 6ms/step - loss: 0.2764 - accuracy: 0.8967
Epoch 6/10
1875/1875 [==============================] - 11s 6ms/step - loss: 0.2680 - accuracy: 0.8992
Epoch 7/10
1875/1875 [==============================] - 11s 6ms/step - loss: 0.2543 - accuracy: 0.9035
Epoch 8/10
1875/1875 [==============================] - 11s 6ms/step - loss: 0.2431 - accuracy: 0.9073
Epoch 9/10
1875/1875 [==============================] - 11s 6ms/step - loss: 0.2387 - accuracy: 0.9101
Epoch 10/10
1875/1875 [==============================] - 11s 6ms/step - loss: 0.2255 - accuracy: 0.9154
```

Out[15]:
```
<keras.callbacks.History at 0x79c47e22de40>
```

- Training accuracy - 91.4%

Test Accuracy

In [16]:
```
test_loss, test_accuracy = model.evaluate(test_dataset, steps = math.ceil(num_test_examples/BATCH_SIZE))
print(f"Test Loss = {test_loss}, Test Accuracy = {test_accuracy}")
```

```
313/313 [==============================] - 1s 2ms/step - loss: 0.3389 - accuracy: 0.8864
Test Loss = 0.33890867233276367, Test Accuracy = 0.8863999843597412
```

- Test accuracy - 89%

Helper function for plotting images and probability distributions

In [17]:
```
def plot_images(i,predictions_array,true_labels,images):
  predictions_array, true_label, img = predictions_array[i], true_labels[i], images[i]
  plt.grid(False)
  plt.xticks([])
  plt.yticks([])
  plt.imshow(img[...,0], cmap = plt.cm.binary)

  predicted_label = np.argmax(predictions_array)
  if predicted_label == true_label:
    color = 'blue'
  else:
    color = 'red'
  plt.xlabel(f"{class_names[predicted_label]} {100*np.max(predictions_array):2.0f}% ({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')
```

Helper function for predicting batchwise test images

In [18]:
```
!pip install simple_colors
```

```
Collecting simple_colors
  Downloading simple_colors-0.1.5-py3-none-any.whl (2.8 kB)
Installing collected packages: simple_colors
Successfully installed simple_colors-0.1.5
WARNING: Running pip as the 'root' user can result in broken permissions and conflicting behaviour with the system package manager. It is recommended to use a virtual environment instead: https://pip.pypa.io/warnings/venv
```

In [19]:
```
from simple_colors import *
```

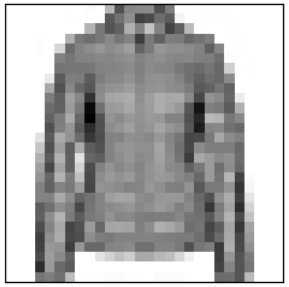
In [20]:
```
def Batch_test_images(i):
    if i <= 312:
        for test_images, test_labels in test_dataset.take(i):
            test_images = test_images.numpy()
            test_labels = test_labels.numpy()
            predictions = model.predict(test_images)

        print(f"\n\nThe prediction array: {predictions[0]}\n\n")
        print(f"Using argmax, the class label should be :{np.argmax(predictions[0])}\n\n")
        print(f"Test label in the test dataset: {test_labels[0]}\n\n")
        print(magenta(f"The class name {test_labels[0]} is {class_names[test_labels[0]]}\n\n",'bold'))

        print(green(f"Plotting the first image of the batch {i}\n",'underlined'))
        plt.figure(figsize = (6,3))
        plot_images(0,predictions, test_labels, test_images)
        plt.show()

        print(green("Plotting the probability distribution of the image\n",'underlined'))
        img = test_images[0]
        img = np.array([img])
        plt.figure()
        predictions_single = model.predict(img)
        plot_value_array(0,predictions_single, test_labels)
        plt.xticks(range(10),class_names, rotation = 45)
        plt.show()
        print(magenta(f"Class label: {np.argmax(predictions_single[0])}\n\n",'bold'))

        print(green("Images in this batch:",'underlined'))
        num_rows = 8
        num_cols = 4

        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_images(i,predictions, test_labels, test_images)
            plt.subplot(num_rows, 2*num_cols, 2*i+2)
            plot_value_array(i,predictions, test_labels)

    elif i == 313:
        print(blue("The total number of batches in the test dataset are 313,\nout of which only 312 batches have batch size of 32 images, and batch no. 313 have 16 images\n\n",'bold'))
        for test_images, test_labels in test_dataset.take(i):
            test_images = test_images.numpy()
            test_labels = test_labels.numpy()
            predictions = model.predict(test_images)

        print(f"\n\nThe prediction array: {predictions[0]}\n\n")
        print(f"Using argmax, the class label should be :{np.argmax(predictions[0])}\n\n")
        print(f"Test label in the test dataset: {test_labels[0]}\n\n")
```

```
        print(magenta(f"The class name {test_labels[0]} is {class_names[test_labels[0]]}\n\n",'bold'))

        print(green(f"Plotting the first image of the batch {i}\n",'underlined'))
        plt.figure(figsize = (6,3))
        plot_images(0,predictions, test_labels, test_images)
        plt.show()

        print(green("Plotting the probability distribution of the image\n",'underlined'))
        img = test_images[0]
        img = np.array([img])
        plt.figure()
        predictions_single = model.predict(img)
        plot_value_array(0,predictions_single, test_labels)
        plt.xticks(range(10),class_names, rotation = 45)
        plt.show()
        print(magenta(f"Class label: {np.argmax(predictions_single[0])}\n\n",'bold'))

        print(green("Images in this batch:",'underlined'))
        num_rows = 4
        num_cols = 4

        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_images(i,predictions, test_labels, test_images)
            plt.subplot(num_rows, 2*num_cols, 2*i+2)
            plot_value_array(i,predictions, test_labels)

    else:
        print(red("Batch number not available in the test dataset!",['bold','underlined']))
```

Let's visualize first batch

In [21]:
```
Batch_test_images(1)
```

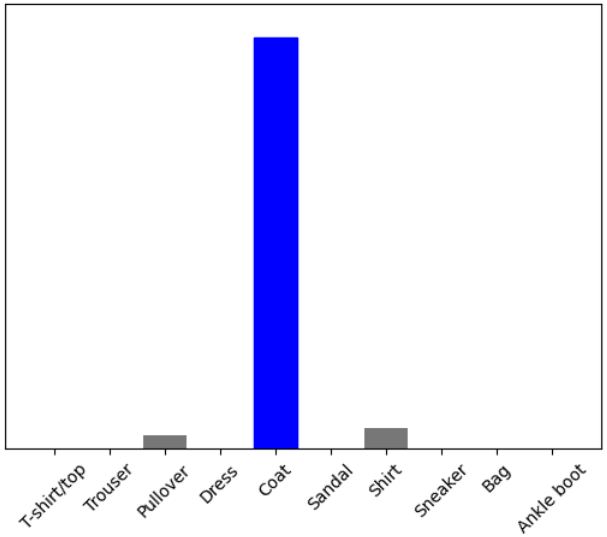
```
1/1 [==============================] - 0s 97ms/step


The prediction array: [6.7695455e-06 1.6986764e-08 2.8431309e-02 1.2104877e-06 9.2561787e-01
 2.5978336e-10 4.5941804e-02 1.0161884e-09 1.1758699e-07 1.0382424e-06]


Using argmax, the class label should be :4


Test label in the test dataset: 4


The class name 4 is Coat


Plotting the first image of the batch 1
```



Coat 93% (Coat)

Plotting the probability distribution of the image

```
1/1 [==============================] - 0s 64ms/step
```




```
Class label: 4
```

Images in this batch:


Coat 93% (Coat)
Coat 95% (Coat)
Ankle boot 85% (Ankle boot)
Sneaker 98% (Sneaker)
Sandal 100% (Sandal)
Trouser 100% (Trouser)
T-shirt/top 100% (T-shirt/top)
Sandal 100% (Sandal)
neaker 100% (Sneaker)
Coat 99% (Coat)
T-shirt/top 98% (T-shirt/top)
Bag 100% (Bag)
ullover 99% (Pullover)
Dress 93% (Dress)
Ankle boot 100% (Ankle boot)
T-shirt/top 81% (T-shirt/top)
neaker 98% (Sneaker)
Sneaker 100% (Sneaker)
Pullover 95% (Pullover)
Pullover 99% (Pullover)
hirt/top 86% (T-shirt/top)
Coat 99% (Coat)
Coat 97% (Coat)
Coat 70% (Coat)
shirt/top 88% (Pullover)
Sneaker 100% (Sneaker)
Sneaker 98% (Sneaker)
Coat 91% (Coat)

12th batch

In [22]:
```
Batch_test_images(12)
```

```
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 25ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
```

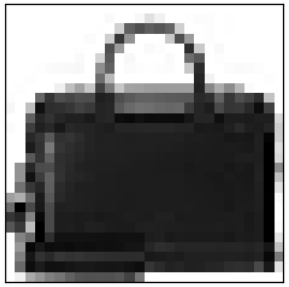
```
The prediction array: [5.9447488e-16 4.3578938e-22 2.8100479e-18 1.4206168e-19 5.1729344e-15
 2.7168468e-18 8.4245470e-14 2.1218092e-16 9.9999994e-01 7.1193508e-18]
```

```
Using argmax, the class label should be :8
```

```
Test label in the test dataset: 8
```

The class name 8 is Bag

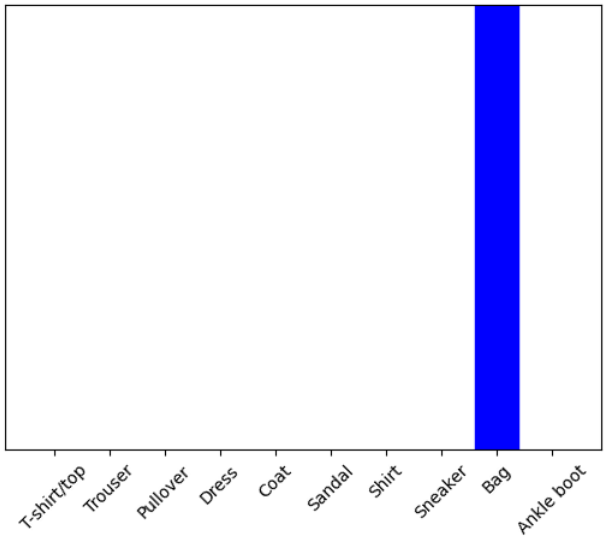
Plotting the first image of the batch 12



Bag 100% (Bag)

Plotting the probability distribution of the image

```
1/1 [==============================] - 0s 21ms/step
```




```
Class label: 8
```

Images in this batch:


Bag 100% (Bag)
Dress 98% (Dress)
T-shirt/top 99% (T-shirt/top)
Trouser 100% (Trouser)
ullover 83% (Pullover)
Dress 99% (Dress)
Bag 100% (Bag)
Sandal 96% (Sandal)
neaker 92% (Sneaker)
Bag 90% (Shirt)
Bag 100% (Bag)
Pullover 83% (Pullover)
e boot 100% (Ankle boot)
Trouser 100% (Trouser)
Coat 54% (Shirt)
Pullover 97% (Pullover)
rouser 100% (Trouser)
Dress 100% (Dress)
Ankle boot 100% (Ankle boot)
Sandal 100% (Sandal)
Coat 95% (Coat)
Coat 65% (Pullover)
Coat 93% (Coat)
Sneaker 100% (Sneaker)
Shirt 88% (T-shirt/top)
Sneaker 100% (Sneaker)
T-shirt/top 100% (T-shirt/top)
Dress 97% (Dress)

313th batch

In [23]:
```
Batch_test_images(313)
```

The total number of batches in the test dataset are 313,
out of which only 312 batches have batch size of 32 images, and batch no. 313 have 16 images

```
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 15ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 15ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 15ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
```

```
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 15ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 15ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 18ms/step
```

```
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 15ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 15ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 16ms/step
```

```
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 18ms/step
```

```
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 15ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 19ms/step
1/1 [==============================] - 0s 16ms/step
1/1 [==============================] - 0s 17ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 23ms/step
1/1 [==============================] - 0s 22ms/step
1/1 [==============================] - 0s 21ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 18ms/step
1/1 [==============================] - 0s 20ms/step
1/1 [==============================] - 0s 20ms/step
```

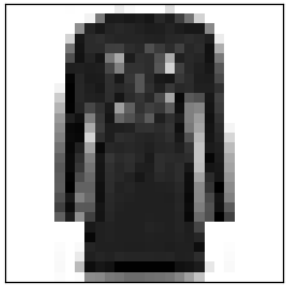
```
The prediction array: [2.55992659e-03 1.08937085e-04 2.35956572e-02 6.67338133e-01
 2.03605831e-01 4.54306837e-06 1.02473870e-01 1.80504105e-06
 3.08661984e-04 2.66289385e-06]
```

```
Using argmax, the class label should be :3
```

```
Test label in the test dataset: 3
```

The class name 3 is Dress

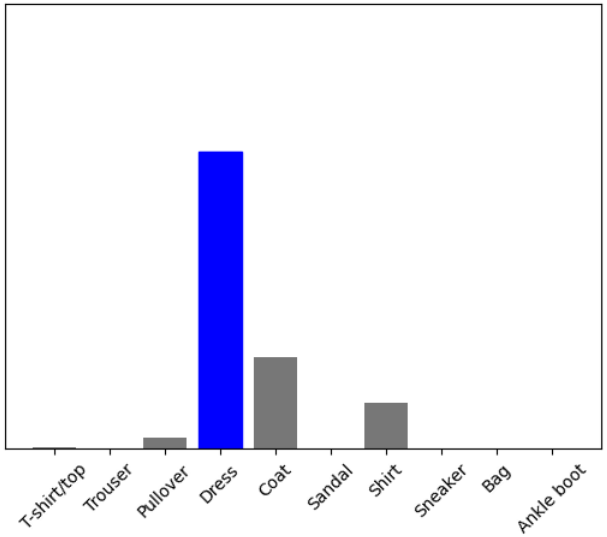
Plotting the first image of the batch 313



Dress 67% (Dress)

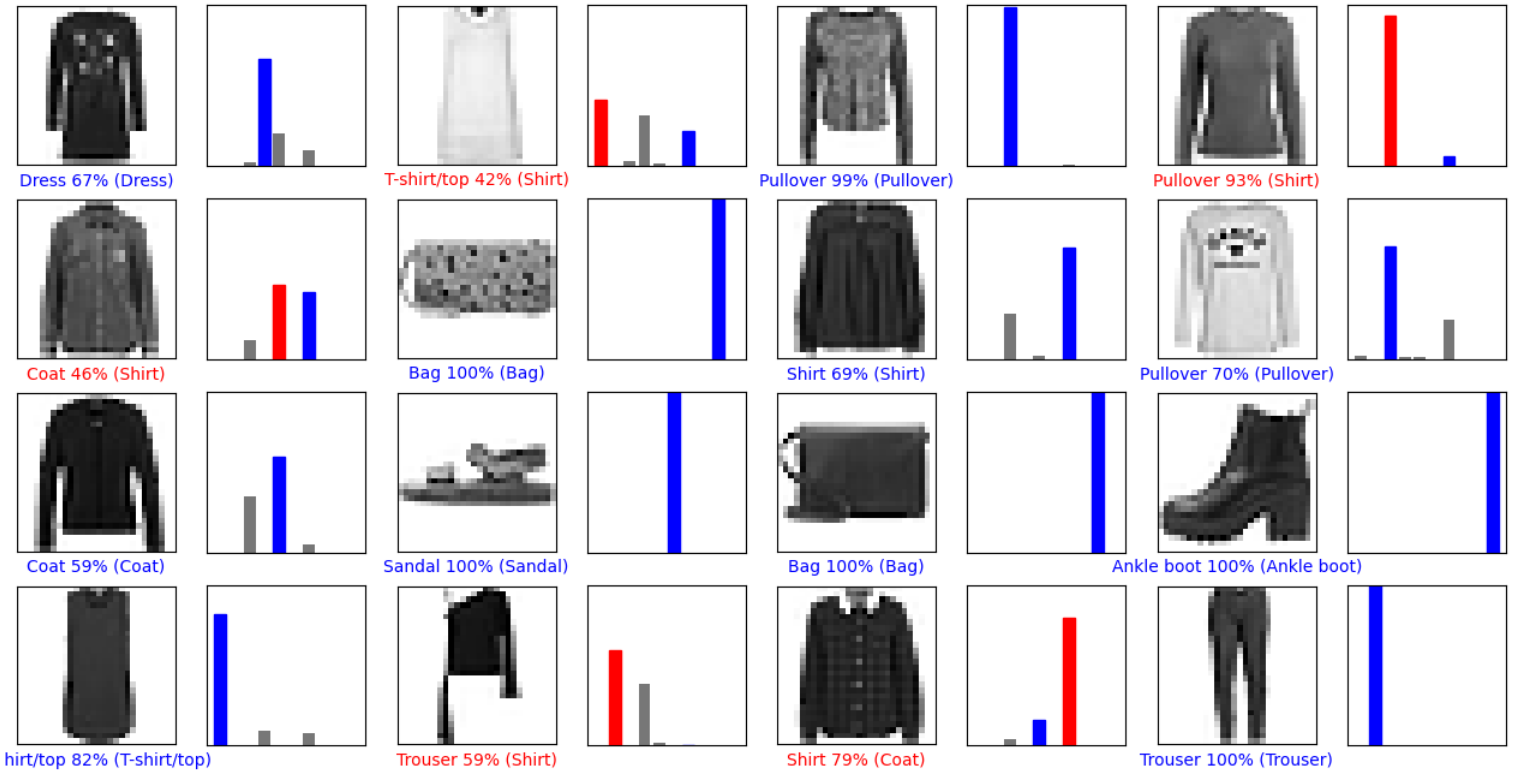
Plotting the probability distribution of the image

```
1/1 [==============================] - 0s 21ms/step
```



Class label: 3

Images in this batch:



315th batch

In [24]:
```
Batch_test_images(315)
```

```
Batch number not available in the test dataset!
```

Conclusion:

- We were able to classify test dataset from the model trained on train dataset with train accuracy 91.4% and test accuracy 89%.
- There were 313 batches in the test dataset, as total number of examples in the test dataset were 10,000. The batch size was 32, and only 312 batches were able to take 32 batch size. While, 313th batch took 16 batch size.