Coding Tutorial

November 3, 2020

```
In [1]: import tensorflow as tf
        print(tf.__version__)
```

```
2.0.0
```

1 The Sequential model API

## Coding tutorials #### Section **??** #### Section **??** #### Section **??** #### Section **??** #### Section **??**

## Building a Sequential model

```
In [2]: from tensorflow.keras.models import Sequential
        from tensorflow.keras.layers import Dense, Flatten, Softmax
```

Build a feedforward neural network model

```
In [3]: # Build the Sequential feedforward neural network model
        model = Sequential()
        model.add(Flatten(input_shape = (28, 28)))
        model.add(Dense(units = 16, activation = 'relu'))
        model.add(Dense(units = 16, activation = 'relu'))
        model.add(Dense(units = 10, activation = 'softmax'))
```

```
In [4]: # Print the model summary
        model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
flatten (Flatten)            (None, 784)               0
_________________________________________________________________
dense (Dense)                (None, 16)                12560
_________________________________________________________________
dense_1 (Dense)              (None, 16)                272
```

```
_________________________________________________________________
dense_2 (Dense)              (None, 10)                170
=================================================================
Total params: 13,002
Trainable params: 13,002
Non-trainable params: 0
_________________________________________________________________
```

## Convolutional and pooling layers

```
In [5]: from tensorflow.keras.models import Sequential
        from tensorflow.keras.layers import Dense, Flatten, Conv2D, MaxPooling2D
```

#### Build a convolutional neural network model

```
In [6]: # Build the Sequential convolutional neural network model
        model = Sequential([
            Conv2D(filters = 16, kernel_size = (3, 3), padding = 'SAME', strides = 2,
                          activation = 'relu', input_shape = (28, 28, 1)),
            MaxPooling2D(pool_size = (3, 3)),
            Flatten(),
            Dense(units = 10, activation = 'softmax')
        ])
```

```
In [7]: # Print the model summary
        model.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 14, 14, 16)        160
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 4, 4, 16)          0
_________________________________________________________________
flatten_1 (Flatten)          (None, 256)               0
_________________________________________________________________
dense_3 (Dense)              (None, 10)                2570
=================================================================
Total params: 2,730
Trainable params: 2,730
Non-trainable params: 0
_________________________________________________________________
```

## The compile method

Compile the model

```
In [8]: # Define the model optimizer, loss function and metrics
        opt = tf.keras.optimizers.Adam(learning_rate = 0.005)
        loss = tf.keras.losses.SparseCategoricalCrossentropy()
        acc = tf.keras.metrics.SparseCategoricalAccuracy()
        mae = tf.keras.metrics.MeanAbsoluteError()

        model.compile(optimizer = opt,
                      loss = loss,
                      metrics = [acc, mae])
```

```
In [9]: # Print the resulting model attributes
        print(model.optimizer)
        print(model.loss)
        print(model.metrics)
```

```
<tensorflow.python.keras.optimizer_v2.adam.Adam object at 0x7f3c3c50dbe0>
<tensorflow.python.keras.losses.SparseCategoricalCrossentropy object at 0x7f3c3c50dda0>
[<tensorflow.python.keras.metrics.SparseCategoricalAccuracy object at 0x7f3c3c50db00>, <tensor
```

## The fit method

```
In [10]: from tensorflow.keras.preprocessing import image
         import matplotlib.pyplot as plt
         import numpy as np
         import pandas as pd
```

Load the data

```
In [11]: # Load the Fashion-MNIST dataset

         fashion_mnist_data = tf.keras.datasets.fashion_mnist
         (train_images, train_labels), (test_images, test_labels) = fashion_mnist_data.load_da
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/train-labels-
32768/29515 [=================================] - 0s 0us/step
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/train-images-
26427392/26421880 [==============================] - 0s 0us/step
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/t10k-labels-i
8192/5148 [===============================================] - 0s 0us/step
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/t10k-images-i
4423680/4422102 [==============================] - 0s 0us/step
```

```
In [12]: # Print the shape of the training data
         train_images.shape
```

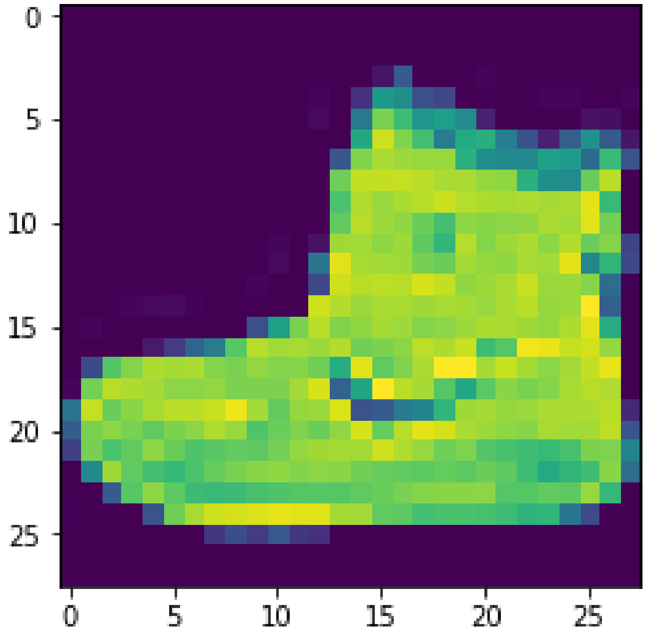
```
Out[12]: (60000, 28, 28)
```

```
In [13]: # Define the labels

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

```
In [14]: # Rescale the image values so that they lie in between 0 and 1.
         train_images = train_images/255.
         test_images = test_images/255.
```

```
In [15]: # Display one of the images
         i = 0
         img = train_images[i, :, :]
         plt.imshow(img)
         plt.show()
         print('Label: ', labels[train_labels[i]])
```



```
Label:  Ankle boot
```

Fit the model

```
In [16]: # Fit the model
         history = model.fit(train_images[..., np.newaxis], train_labels, epochs = 10, batch_s
```

```
Train on 60000 samples
Epoch 1/10
60000/60000 [==============================] - 19s 319us/sample - loss: 0.7897 - sparse_catego
Epoch 2/10
60000/60000 [==============================] - 18s 293us/sample - loss: 0.4845 - sparse_catego
Epoch 3/10
60000/60000 [==============================] - 18s 298us/sample - loss: 0.4369 - sparse_catego
Epoch 4/10
60000/60000 [==============================] - 18s 300us/sample - loss: 0.4159 - sparse_catego
Epoch 5/10
60000/60000 [==============================] - 18s 302us/sample - loss: 0.4037 - sparse_catego
Epoch 6/10
60000/60000 [==============================] - 18s 305us/sample - loss: 0.3949 - sparse_catego
Epoch 7/10
60000/60000 [==============================] - 18s 307us/sample - loss: 0.3909 - sparse_catego
Epoch 8/10
60000/60000 [==============================] - 18s 302us/sample - loss: 0.3821 - sparse_catego
Epoch 9/10
60000/60000 [==============================] - 18s 303us/sample - loss: 0.3787 - sparse_catego
Epoch 10/10
60000/60000 [==============================] - 19s 308us/sample - loss: 0.3759 - sparse_catego
```

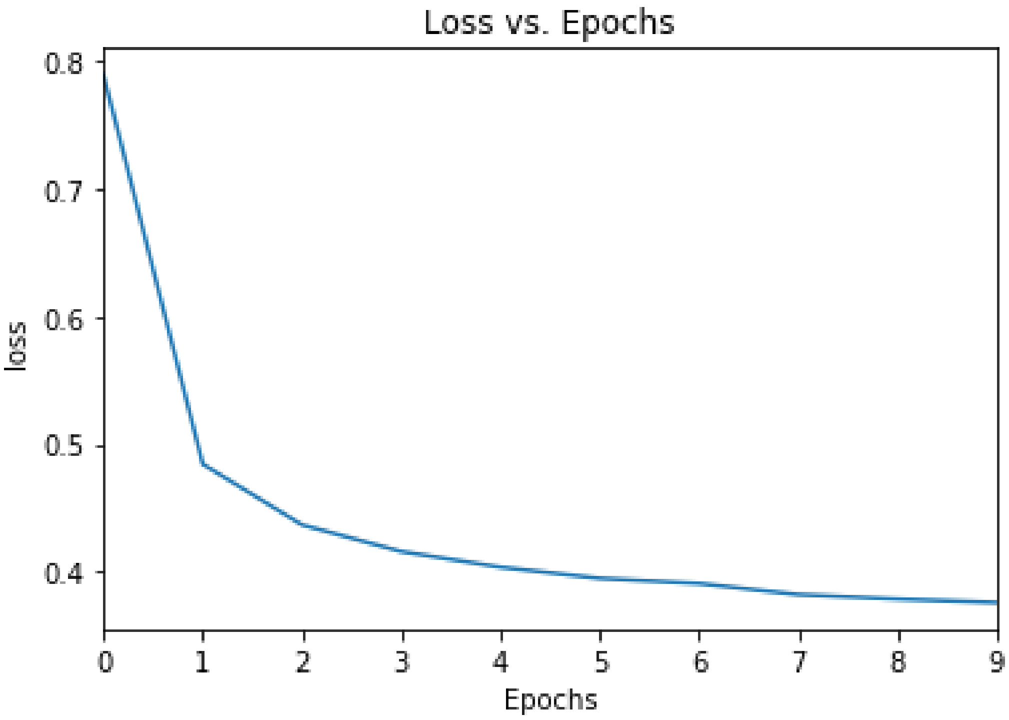
Plot training history

```
In [17]: # Load the history into a pandas Dataframe
         df = pd.DataFrame(history.history)
         df
```

```
Out[17]:        loss  sparse_categorical_accuracy  mean_absolute_error
         0  0.789680                     0.722767             4.420000
         1  0.484538                     0.827783             4.420001
         2  0.436880                     0.845500             4.420000
         3  0.415931                     0.851583             4.420001
         4  0.403653                     0.855500             4.420001
         5  0.394873                     0.857217             4.419999
         6  0.390850                     0.858650             4.420001
         7  0.382136                     0.862050             4.420000
         8  0.378665                     0.862717             4.420000
         9  0.375889                     0.864350             4.420000
```

```
In [18]: # Make a plot for the loss
         loss_plot = df.plot(y = 'loss', title = 'Loss vs. Epochs', legend = False)
         loss_plot.set(xlabel = 'Epochs', ylabel = 'loss')

Out[18]: [Text(0, 0.5, 'loss'), Text(0.5, 0, 'Epochs')]
```



```
In [27]: #Make accuracy

In [28]: # Make a plot for the accuracy

In [29]: # Make a plot for the additional metric
```

## The evaluate and predict methods

```
In [30]: import matplotlib.pyplot as plt
         import numpy as np
```

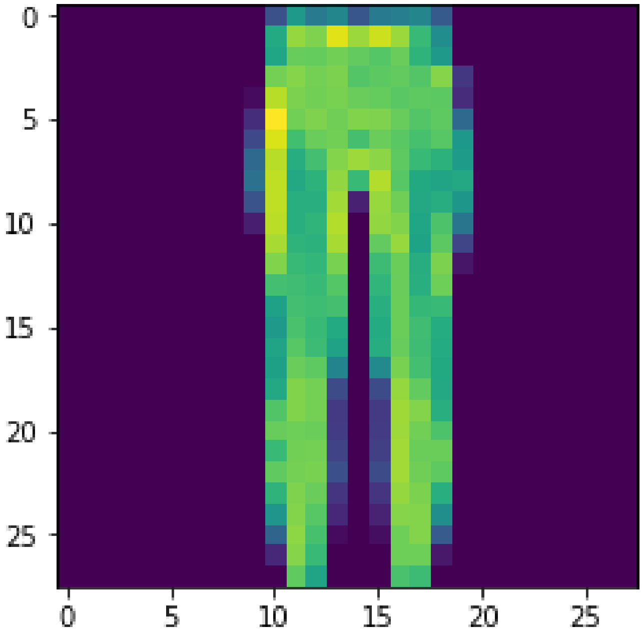
Evaluate the model on the test set

```
In [33]: # Evaluate the model
         test_loss, accuracy, mea = model.evaluate(test_images[..., np.newaxis], test_labels, v

10000/1 - 2s - loss: 0.3682 - sparse_categorical_accuracy: 0.8383 - mean_absolute_error: 4.420
```

Make predictions from the model

```
In [34]: # Choose a random test image
         random_idx = np.random.choice(test_images.shape[0])
         test_img = test_images[random_idx]
         plt.imshow(test_img)
         plt.show()
         print('Label: ', labels[test_labels[random_idx]])
```



```
Label:  Trouser
```

```
In [36]: # Get the model predictions
         predictions = model.predict(test_img[np.newaxis, ..., np.newaxis])
```

```
In [37]: print('Model prediction: ', labels[np.argmax(predictions)], ' | Probability = ', 100*r
```

```
Model prediction:  Trouser  | Probability =  99.97922778129578
```