

# C1\_W1\_Lab\_3\_siamese-network

February 18, 2021

## 1 Ungraded Lab: Implement a Siamese network

This lab will go through creating and training a multi-input model. You will build a basic Siamese Network to find the similarity or dissimilarity between items of clothing. For Week 1, you will just focus on constructing the network. You will revisit this lab in Week 2 when we talk about custom loss functions.

### 1.1 Imports

```
[1]: try:
      # %tensorflow_version only exists in Colab.
      %tensorflow_version 2.x
    except Exception:
        pass

    import tensorflow as tf
    from tensorflow.keras.models import Model
    from tensorflow.keras.layers import Input, Flatten, Dense, Dropout, Lambda
    from tensorflow.keras.optimizers import RMSprop
    from tensorflow.keras.datasets import fashion_mnist
    from tensorflow.python.keras.utils.vis_utils import plot_model
    from tensorflow.keras import backend as K

    import numpy as np
    import matplotlib.pyplot as plt
    from PIL import Image, ImageFont, ImageDraw
    import random
```

### 1.2 Prepare the Dataset

First define a few utilities for preparing and visualizing your dataset.

```
[2]: def create_pairs(x, digit_indices):
      '''Positive and negative pair creation.
      Alternates between positive and negative pairs.
```

```

'''
pairs = []
labels = []
n = min([len(digit_indices[d]) for d in range(10)]) - 1

for d in range(10):
    for i in range(n):
        z1, z2 = digit_indices[d][i], digit_indices[d][i + 1]
        pairs += [[x[z1], x[z2]]]
        inc = random.randrange(1, 10)
        dn = (d + inc) % 10
        z1, z2 = digit_indices[d][i], digit_indices[dn][i]
        pairs += [[x[z1], x[z2]]]
        labels += [1, 0]

return np.array(pairs), np.array(labels)

def create_pairs_on_set(images, labels):

    digit_indices = [np.where(labels == i)[0] for i in range(10)]
    pairs, y = create_pairs(images, digit_indices)
    y = y.astype('float32')

    return pairs, y

def show_image(image):
    plt.figure()
    plt.imshow(image)
    plt.colorbar()
    plt.grid(False)
    plt.show()

```

You can now download and prepare our train and test sets. You will also create pairs of images that will go into the multi-input model.

```

[3]: # load the dataset
(train_images, train_labels), (test_images, test_labels) = fashion_mnist.
    ↪ load_data()

# prepare train and test sets
train_images = train_images.astype('float32')
test_images = test_images.astype('float32')

# normalize values
train_images = train_images / 255.0

```

```
test_images = test_images / 255.0

# create pairs on train and test sets
tr_pairs, tr_y = create_pairs_on_set(train_images, train_labels)
ts_pairs, ts_y = create_pairs_on_set(test_images, test_labels)
```

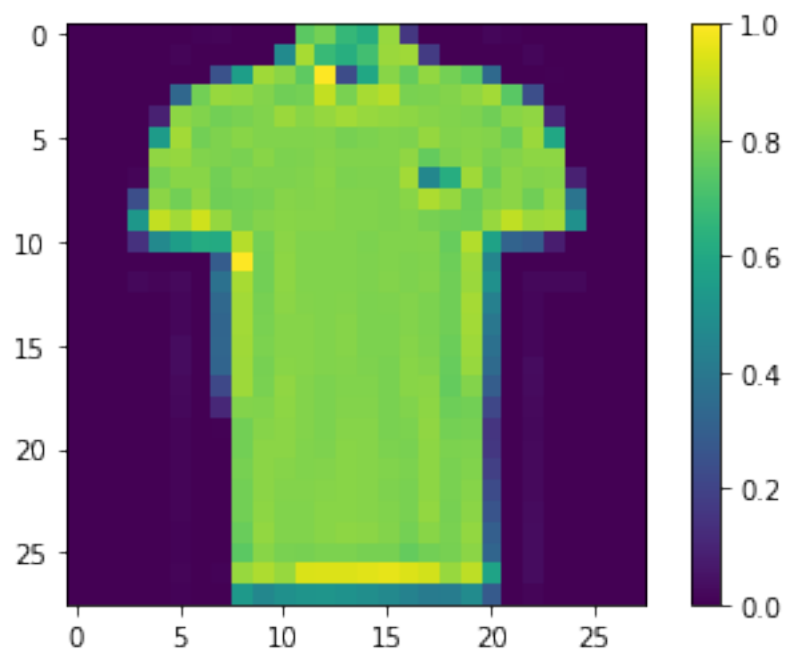
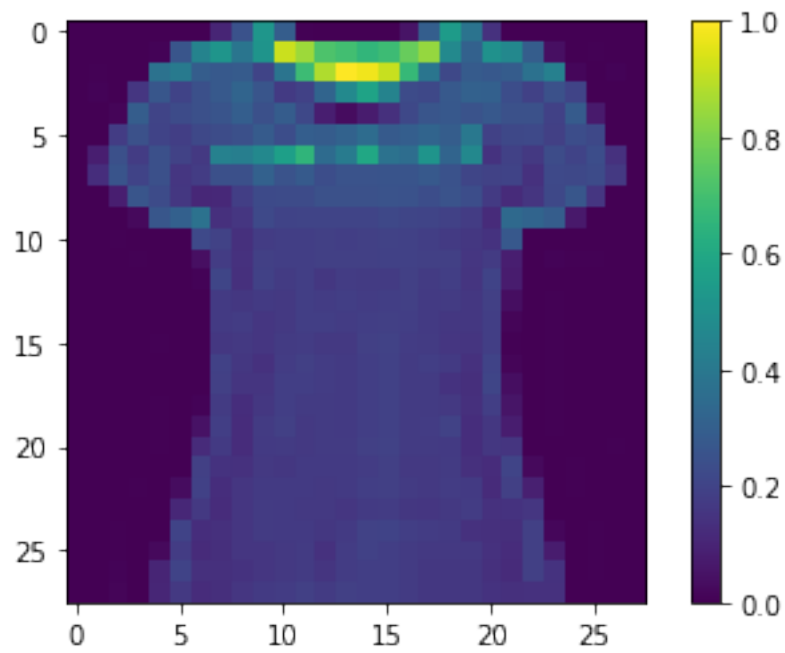
```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-
datasets/train-labels-idx1-ubyte.gz
32768/29515 [=====] - 0s 0us/step
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-
datasets/train-images-idx3-ubyte.gz
26427392/26421880 [=====] - 1s 0us/step
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-
datasets/t10k-labels-idx1-ubyte.gz
8192/5148 [=====] - 0s 0us/step
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-
datasets/t10k-images-idx3-ubyte.gz
4423680/4422102 [=====] - 0s 0us/step
```

You can see a sample pair of images below.

```
[4]: # array index
this_pair = 8

# show images at this index
show_image(ts_pairs[this_pair][0])
show_image(ts_pairs[this_pair][1])

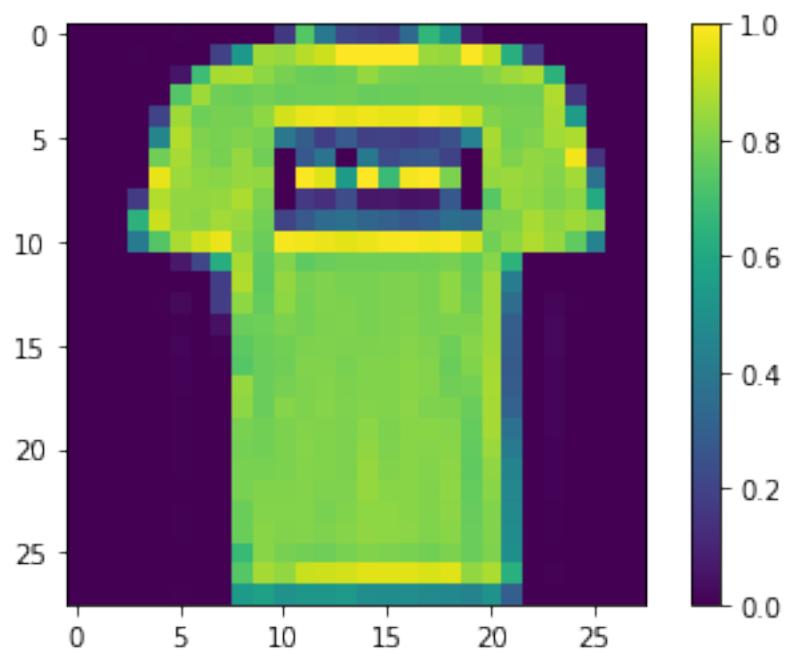
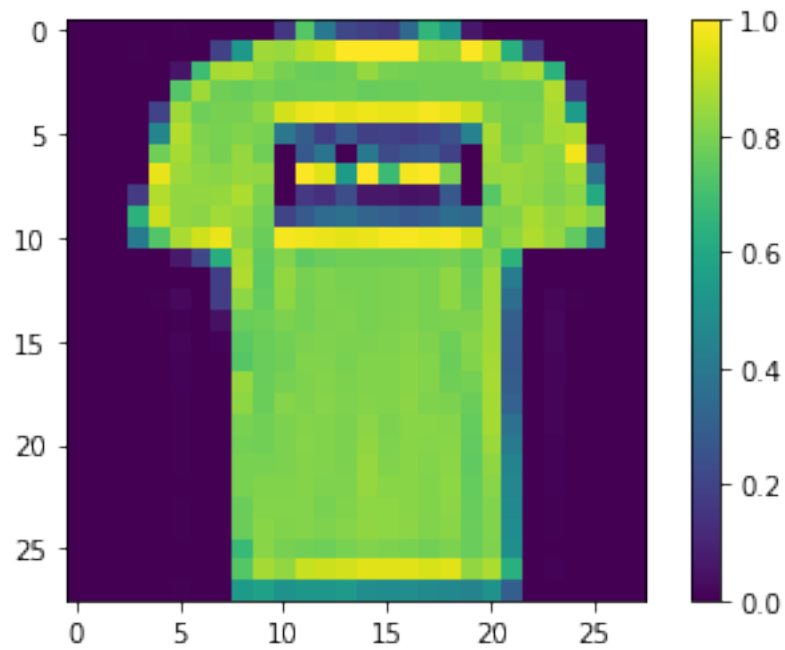
# print the label for this pair
print(tr_y[this_pair])
```

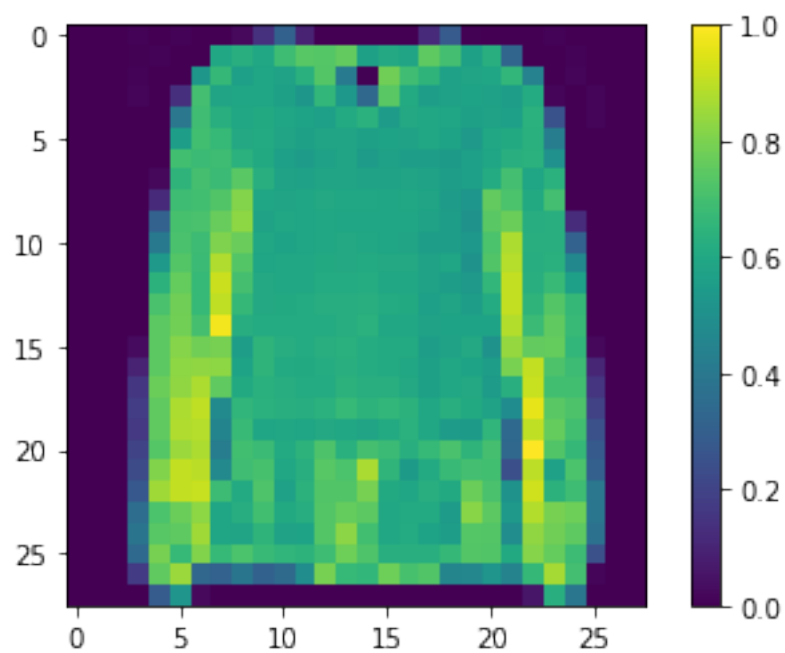
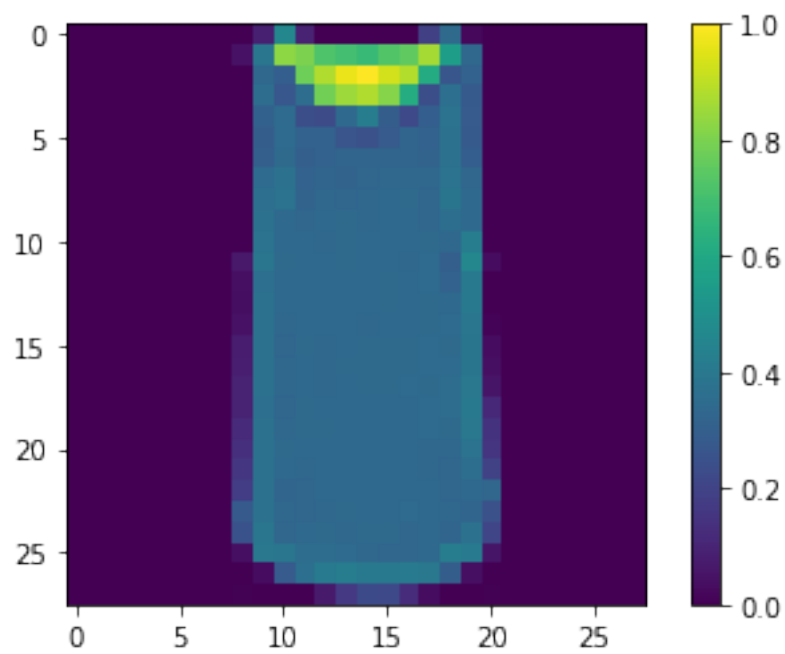


1.0

```
[5]: # print other pairs
```

```
show_image(tr_pairs[:,0][0])  
show_image(tr_pairs[:,0][1])  
  
show_image(tr_pairs[:,1][0])  
show_image(tr_pairs[:,1][1])
```





### 1.3 Build the Model

Next, you'll define some utilities for building our model.

```
[6]: def initialize_base_network():
    input = Input(shape=(28,28,), name="base_input")
    x = Flatten(name="flatten_input")(input)
    x = Dense(128, activation='relu', name="first_base_dense")(x)
    x = Dropout(0.1, name="first_dropout")(x)
    x = Dense(128, activation='relu', name="second_base_dense")(x)
    x = Dropout(0.1, name="second_dropout")(x)
    x = Dense(128, activation='relu', name="third_base_dense")(x)

    return Model(inputs=input, outputs=x)

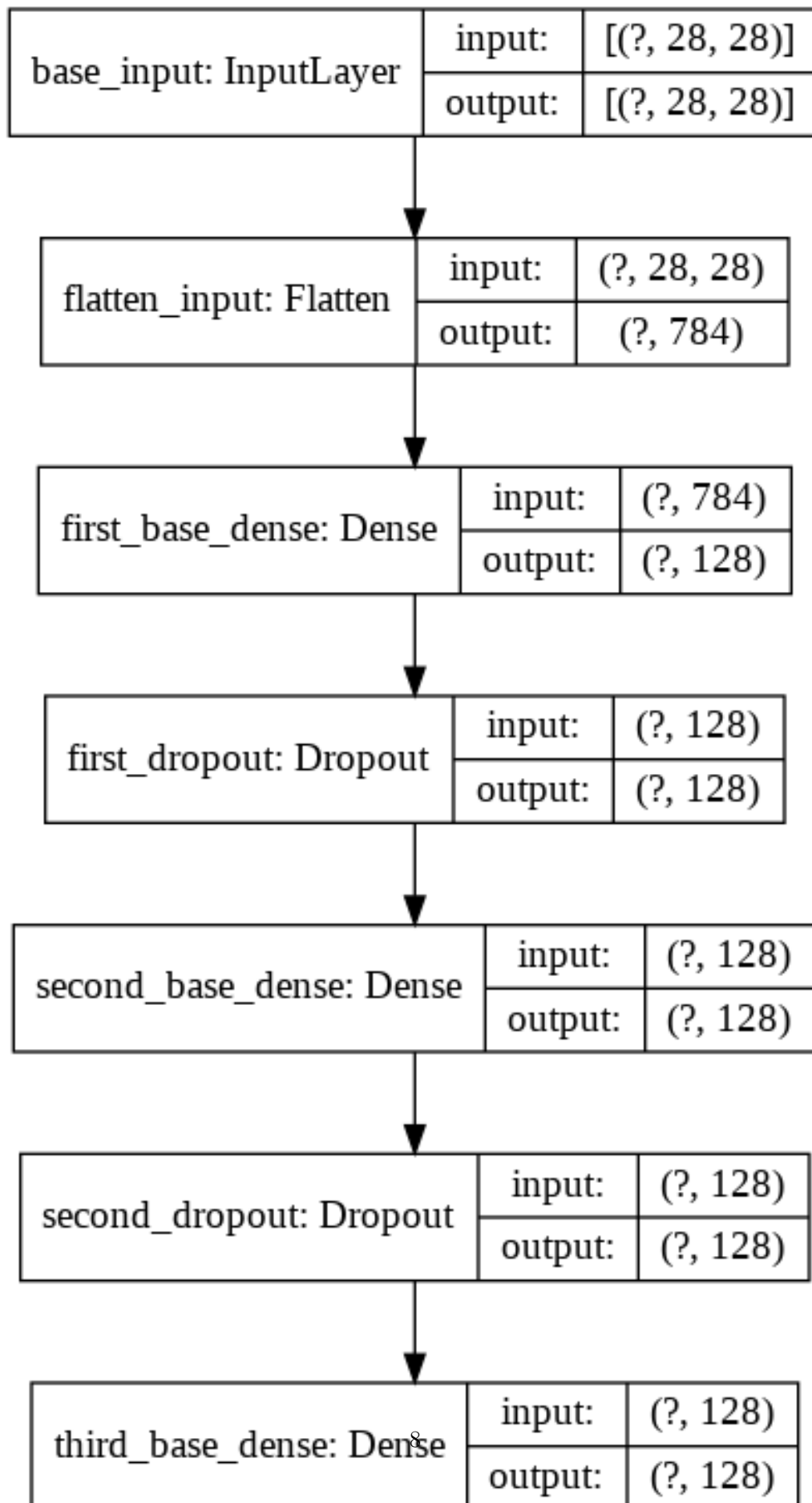
def euclidean_distance(vects):
    x, y = vects
    sum_square = K.sum(K.square(x - y), axis=1, keepdims=True)
    return K.sqrt(K.maximum(sum_square, K.epsilon()))

def eucl_dist_output_shape(shapes):
    shape1, shape2 = shapes
    return (shape1[0], 1)
```

Let's see how our base network looks. This is where the two inputs will pass through to generate an output vector.

```
[7]: base_network = initialize_base_network()
plot_model(base_network, show_shapes=True, show_layer_names=True,
           to_file='base-model.png')
```

[7]:





Let's now build the Siamese network. The plot will show two inputs going to the base network.

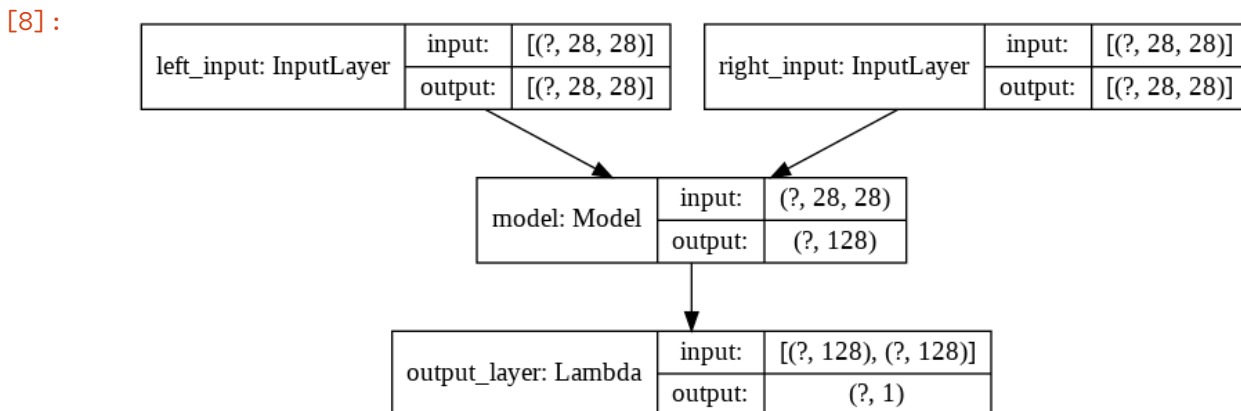
```
[8]: # create the left input and point to the base network
input_a = Input(shape=(28,28,), name="left_input")
vect_output_a = base_network(input_a)

# create the right input and point to the base network
input_b = Input(shape=(28,28,), name="right_input")
vect_output_b = base_network(input_b)

# measure the similarity of the two vector outputs
output = Lambda(euclidean_distance, name="output_layer",
    ↳output_shape=eucl_dist_output_shape)([vect_output_a, vect_output_b])

# specify the inputs and output of the model
model = Model([input_a, input_b], output)

# plot model graph
plot_model(model, show_shapes=True, show_layer_names=True, to_file='outer-model.
    ↳png')
```



## 1.4 Train the Model

You can now define the custom loss for our network and start training. Don't worry about why it's written as a nested function just yet. You will revisit this in Week 2.

```
[9]: def contrastive_loss_with_margin(margin):
    def contrastive_loss(y_true, y_pred):
```

```

'''Contrastive loss from Hadsell-et-al.'06
http://yann.lecun.com/exdb/publis/pdf/hadsell-chopra-lecun-06.pdf
'''

square_pred = K.square(y_pred)
margin_square = K.square(K.maximum(margin - y_pred, 0))
return K.mean(y_true * square_pred + (1 - y_true) * margin_square)

return contrastive_loss

```

```

[10]: rms = RMSprop()
model.compile(loss=contrastive_loss_with_margin(margin=1), optimizer=rms)
history = model.fit([tr_pairs[:,0], tr_pairs[:,1]], tr_y, epochs=20,
    ↳ batch_size=128, validation_data=([ts_pairs[:,0], ts_pairs[:,1]], ts_y))

```

Train on 119980 samples, validate on 19980 samples

Epoch 1/20

119980/119980 [=====] - 8s 65us/sample - loss: 0.1100 -  
val\_loss: 0.0842

Epoch 2/20

119980/119980 [=====] - 7s 60us/sample - loss: 0.0785 -  
val\_loss: 0.0757

Epoch 3/20

119980/119980 [=====] - 7s 60us/sample - loss: 0.0708 -  
val\_loss: 0.0704

Epoch 4/20

119980/119980 [=====] - 7s 60us/sample - loss: 0.0658 -  
val\_loss: 0.0710

Epoch 5/20

119980/119980 [=====] - 7s 60us/sample - loss: 0.0630 -  
val\_loss: 0.0664

Epoch 6/20

119980/119980 [=====] - 7s 62us/sample - loss: 0.0606 -  
val\_loss: 0.0660

Epoch 7/20

119980/119980 [=====] - 7s 62us/sample - loss: 0.0592 -  
val\_loss: 0.0642

Epoch 8/20

119980/119980 [=====] - 7s 62us/sample - loss: 0.0580 -  
val\_loss: 0.0639

Epoch 9/20

119980/119980 [=====] - 7s 61us/sample - loss: 0.0571 -  
val\_loss: 0.0644

Epoch 10/20

119980/119980 [=====] - 7s 60us/sample - loss: 0.0560 -  
val\_loss: 0.0661

Epoch 11/20

119980/119980 [=====] - 7s 59us/sample - loss: 0.0554 -  
val\_loss: 0.0646

```

Epoch 12/20
119980/119980 [=====] - 7s 61us/sample - loss: 0.0545 -
val_loss: 0.0644
Epoch 13/20
119980/119980 [=====] - 7s 61us/sample - loss: 0.0542 -
val_loss: 0.0639
Epoch 14/20
119980/119980 [=====] - 7s 60us/sample - loss: 0.0532 -
val_loss: 0.0642
Epoch 15/20
119980/119980 [=====] - 7s 59us/sample - loss: 0.0527 -
val_loss: 0.0642
Epoch 16/20
119980/119980 [=====] - 7s 60us/sample - loss: 0.0519 -
val_loss: 0.0634
Epoch 17/20
119980/119980 [=====] - 7s 60us/sample - loss: 0.0520 -
val_loss: 0.0623
Epoch 18/20
119980/119980 [=====] - 7s 61us/sample - loss: 0.0510 -
val_loss: 0.0635
Epoch 19/20
119980/119980 [=====] - 7s 60us/sample - loss: 0.0512 -
val_loss: 0.0632
Epoch 20/20
119980/119980 [=====] - 7s 59us/sample - loss: 0.0506 -
val_loss: 0.0643

```

## 1.5 Model Evaluation

As usual, you can evaluate our model by computing the accuracy and observing the metrics during training.

```

[11]: def compute_accuracy(y_true, y_pred):
        '''Compute classification accuracy with a fixed threshold on distances.'''
        pred = y_pred.ravel() > 0.5
        return np.mean(pred == y_true)

```

```

[12]: loss = model.evaluate(x=[ts_pairs[:,0],ts_pairs[:,1]], y=ts_y)

y_pred_train = model.predict([tr_pairs[:,0], tr_pairs[:,1]])
train_accuracy = compute_accuracy(tr_y, y_pred_train)

y_pred_test = model.predict([ts_pairs[:,0], ts_pairs[:,1]])
test_accuracy = compute_accuracy(ts_y, y_pred_test)

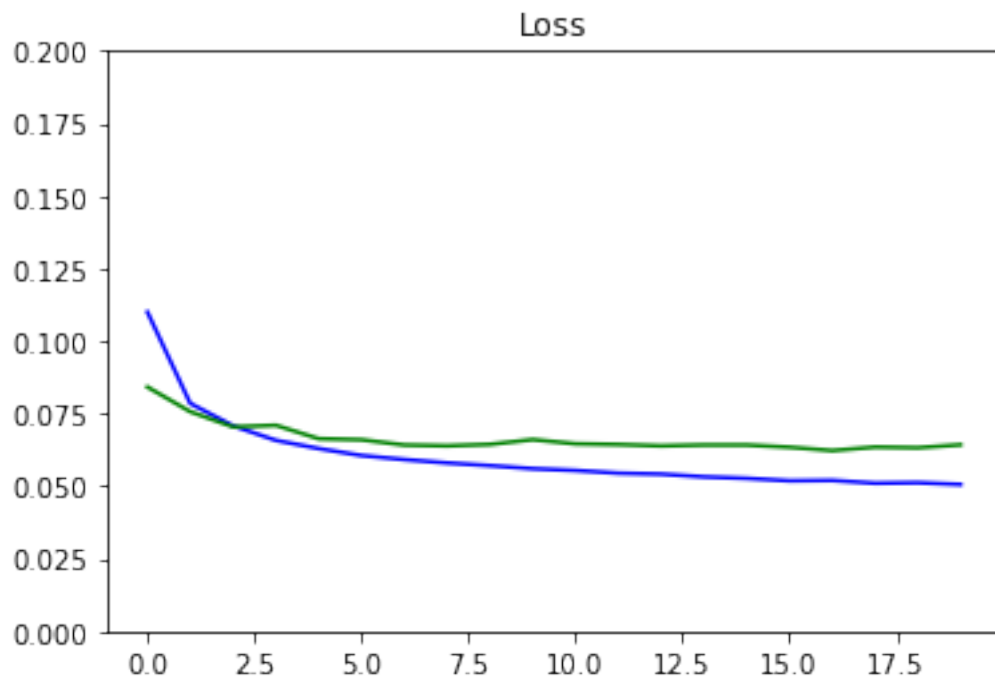
```

```
print("Loss = {}, Train Accuracy = {} Test Accuracy = {}".format(loss,
    ↪train_accuracy, test_accuracy))
```

19980/19980 [=====] - 1s 30us/sample - loss: 0.0643  
 Loss = 0.06426353676997879, Train Accuracy = 0.0606434405734289 Test Accuracy = 0.08618618618618619

```
[13]: def plot_metrics(metric_name, title, ylim=5):
    plt.title(title)
    plt.ylim(0,ylim)
    plt.plot(history.history[metric_name],color='blue',label=metric_name)
    plt.plot(history.history['val_' + metric_name],color='green',label='val_' +
    ↪metric_name)

plot_metrics(metric_name='loss', title="Loss", ylim=0.2)
```



```
[14]: # Matplotlib config
def visualize_images():
    plt.rc('image', cmap='gray_r')
    plt.rc('grid', linewidth=0)
    plt.rc('xtick', top=False, bottom=False, labelsizes='large')
    plt.rc('ytick', left=False, right=False, labelsizes='large')
    plt.rc('axes', facecolor='F8F8F8', titlesize="large", edgecolor='white')
```

```

plt.rc('text', color='a8151a')
plt.rc('figure', facecolor='F0F0F0')# Matplotlib fonts

# utility to display a row of digits with their predictions
def display_images(left, right, predictions, labels, title, n):
    plt.figure(figsize=(17,3))
    plt.title(title)
    plt.yticks([])
    plt.xticks([])
    plt.grid(None)
    left = np.reshape(left, [n, 28, 28])
    left = np.swapaxes(left, 0, 1)
    left = np.reshape(left, [28, 28*n])
    plt.imshow(left)
    plt.figure(figsize=(17,3))
    plt.yticks([])
    plt.xticks([28*x+14 for x in range(n)], predictions)
    for i,t in enumerate(plt.gca().xaxis.get_ticklabels()):
        if predictions[i] > 0.5: t.set_color('red') # bad predictions in red
    plt.grid(None)
    right = np.reshape(right, [n, 28, 28])
    right = np.swapaxes(right, 0, 1)
    right = np.reshape(right, [28, 28*n])
    plt.imshow(right)

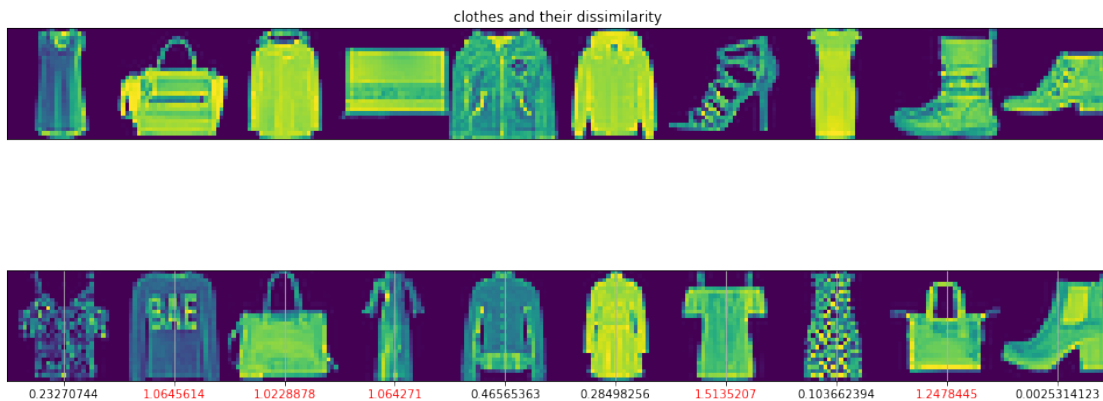
```

You can see sample results for 10 pairs of items below.

```

[15]: y_pred_train = np.squeeze(y_pred_train)
indexes = np.random.choice(len(y_pred_train), size=10)
display_images(tr_pairs[:, 0][indexes], tr_pairs[:, 1][indexes],
→y_pred_train[indexes], tr_y[indexes], "clothes and their dissimilarity", 10)

```



[ ]: