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Sequential Model Example

```
seq_model = Sequential([
    Flatten(input_shape=(28, 28)),
    Dense(128, activation='relu'),
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])
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Functional API

1 — 2 — 3

Input Layers Model

Functional API

1 — 2 — 3

Input

Define input to the model

Layers

Model

Functional API

1 — 2 — 3

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Define input to the model

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Define a set of interconnected layers on the input

Defining the Model

Functional API

1 — 2 — 3

Input

Define input to the model

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Define a set of interconnected layers on the input

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Define the model using the input and output layers

Defining the Input

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from tensorflow.keras.layers import Input

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Defining the layers

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from tensorflow.keras.layers import Dense, Flatten

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 x = Flatten()(input)
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Functional API

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first_dense = tf.keras.layers.Dense(128, activation=tf.nn.relu)

first_dense(flatten_layer)
```
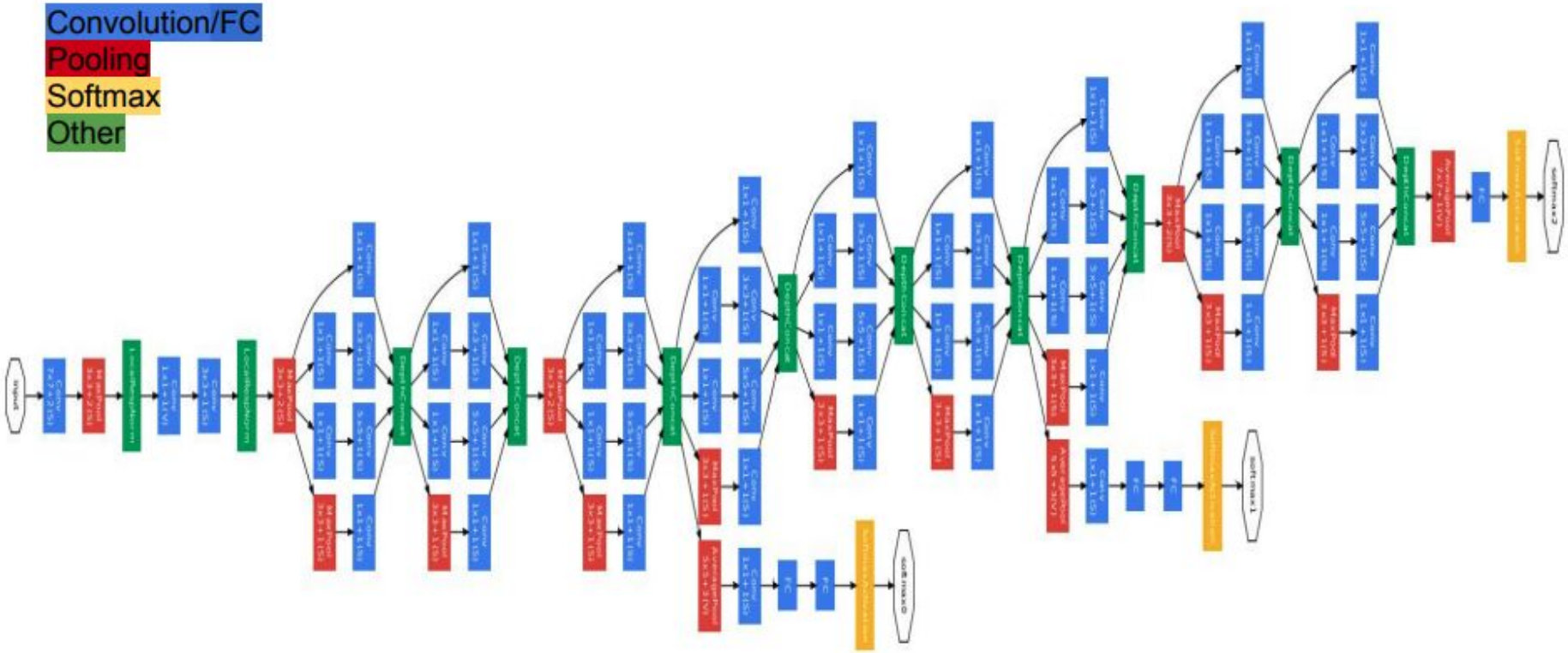
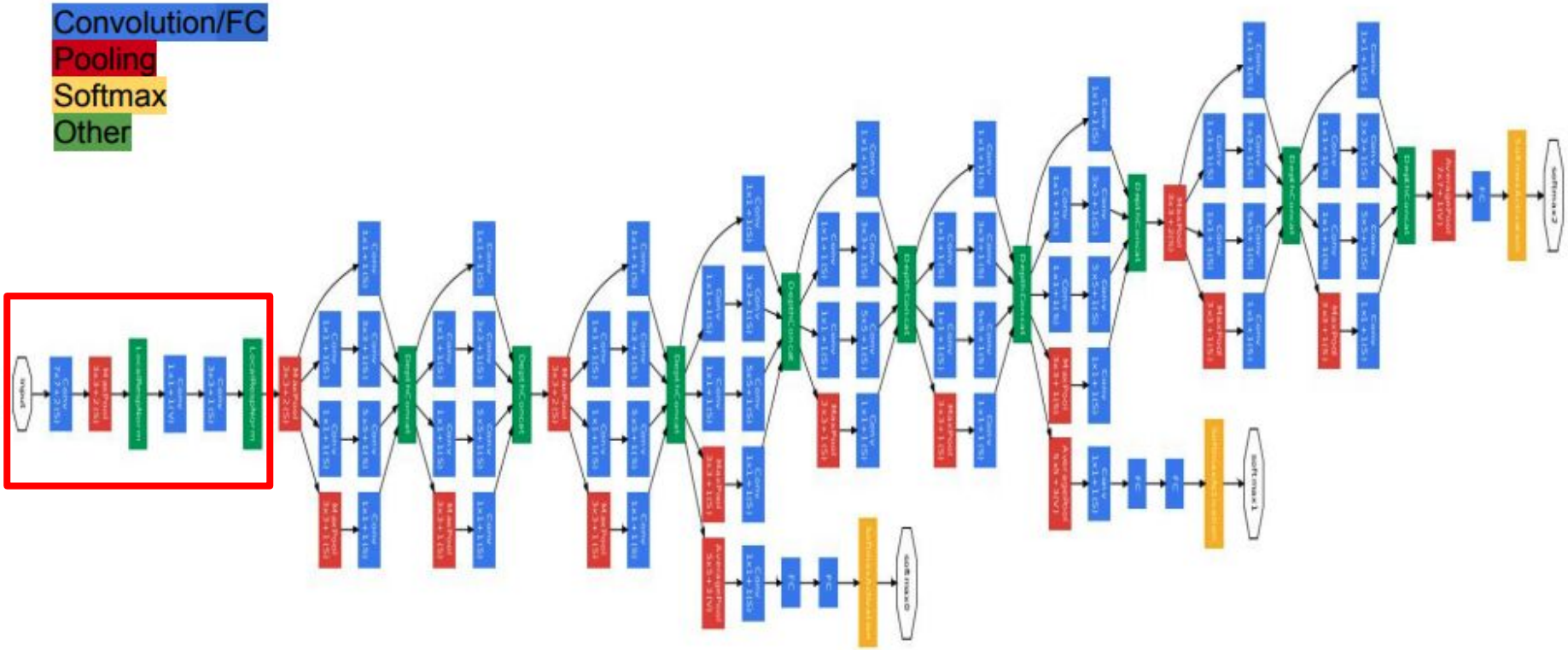


Convolution/FC
Pooling
Softmax
Other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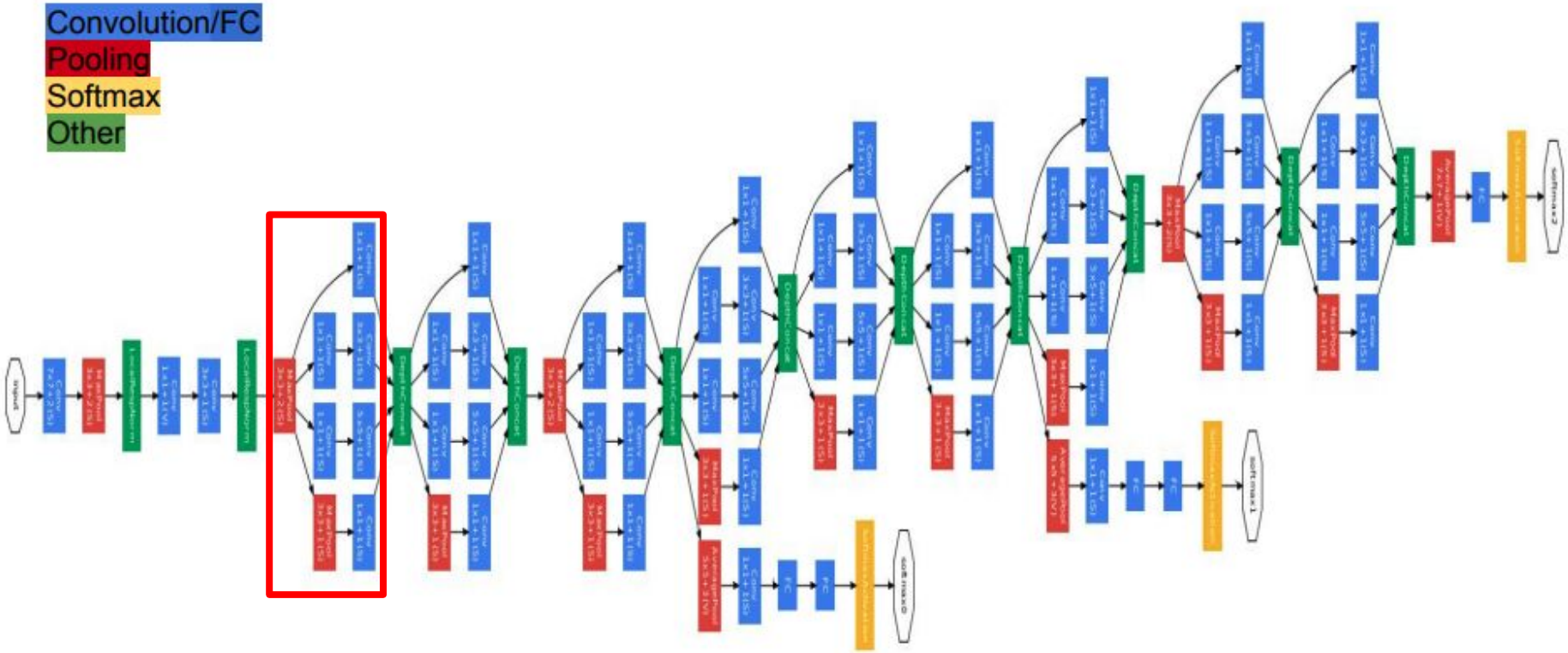
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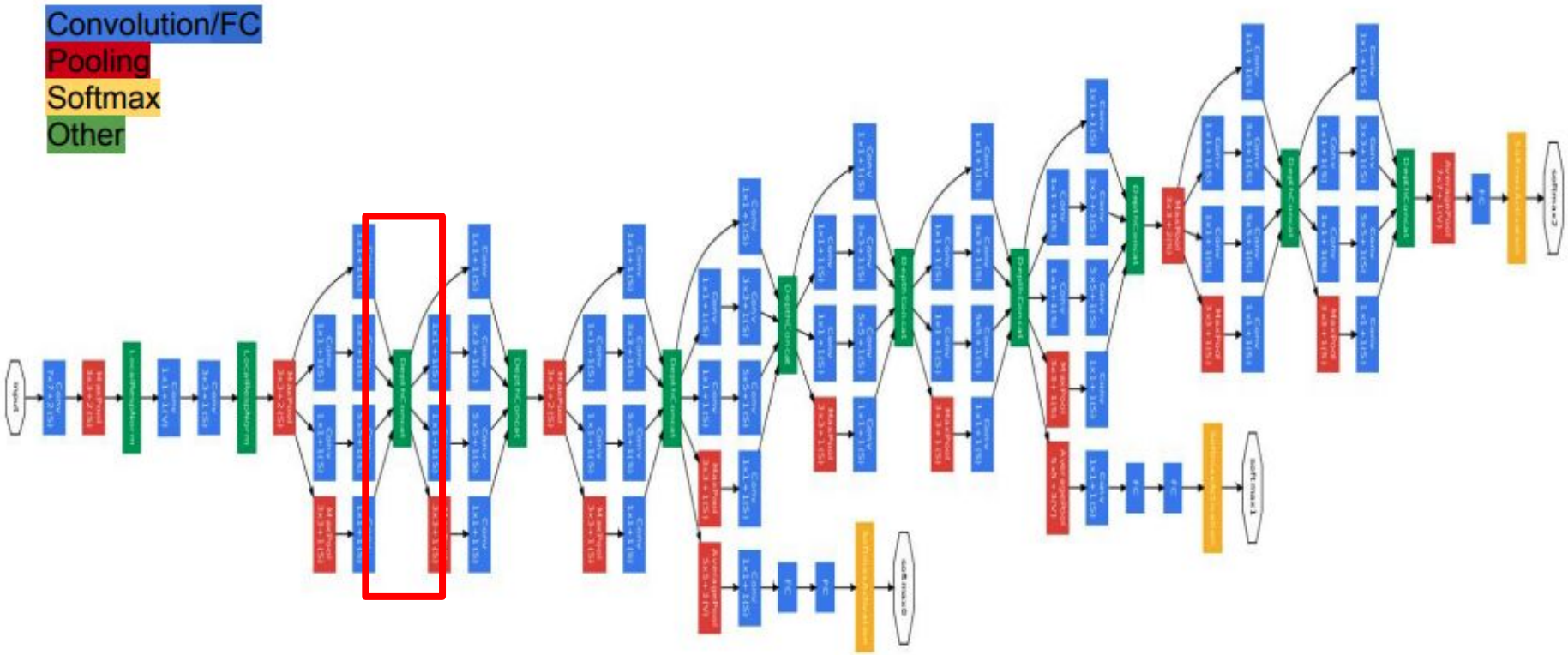
Convolution/FC
Pooling
Softmax
Other

```
layer1 = Dense(32)
layer2_1 = Dense(32)(layer1)
layer2_2 = Dense(32)(layer1)
layer2_3 = Dense(32)(layer1)
layer2_4 = Dense(32)(layer1)
merge = Concatenate([layer2_1, layer2_2, layer2_3, layer2_4])
```

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Layer 1

```
layer1 = Dense(32)
layer2_1 = Dense(32)(layer1)
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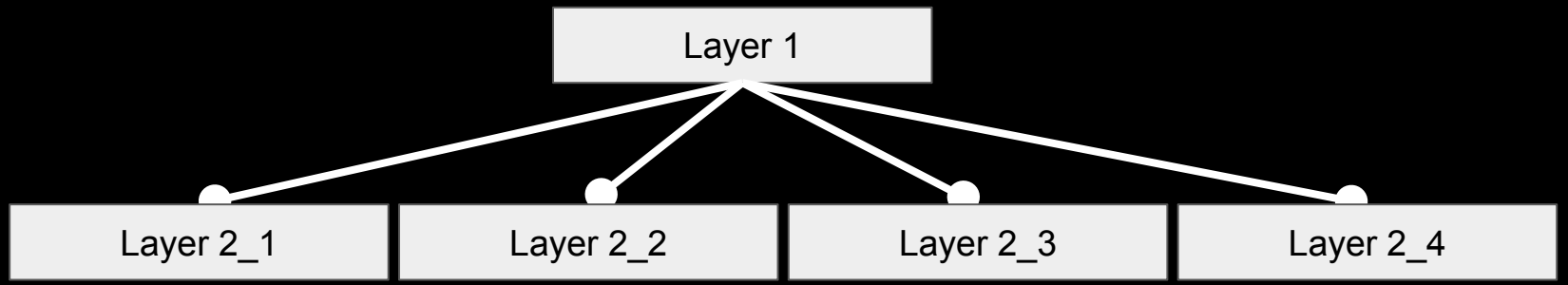

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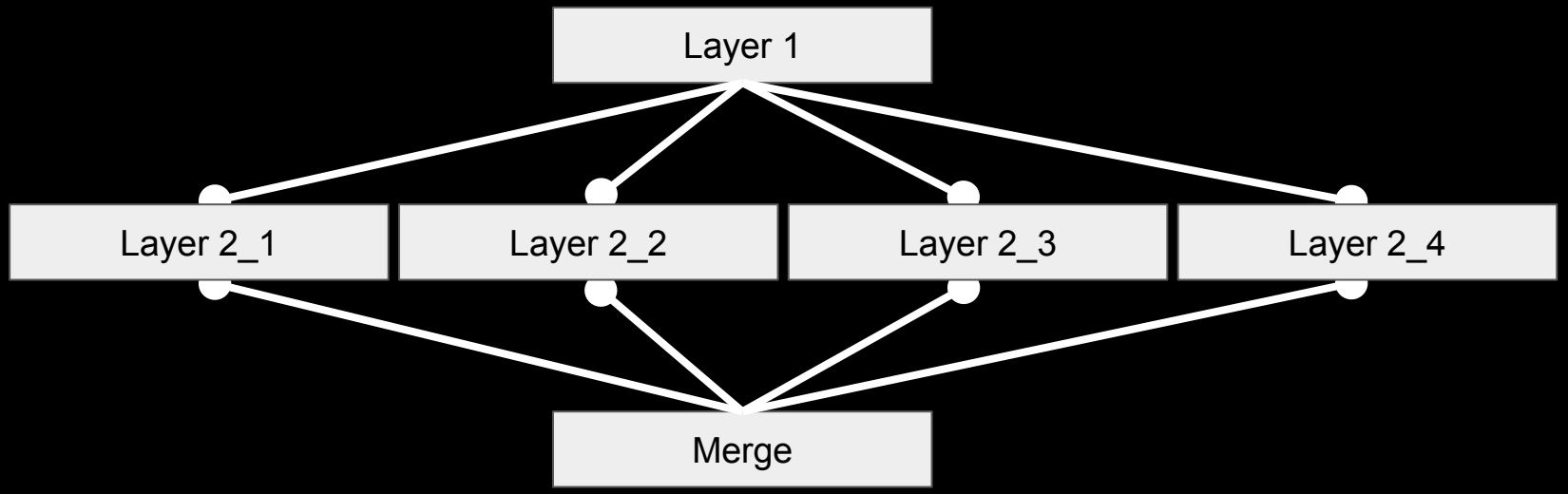

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    flatten_layer = tf.keras.layers.Flatten()(input_layer)
    first_dense = tf.keras.layers.Dense(128, activation=tf.nn.relu)(flatten_layer)
    output_layer = tf.keras.layers.Dense(10, activation=tf.nn.softmax)(first_dense)
    func_model = Model(inputs=input_layer, outputs=output_layer)
    return func_model
```

```
func_model = Model(inputs=input_layer, outputs=output_layer)
```

```
func_model = Model(inputs=[input1, input2], outputs=[output1, output2])
```

```
func_model = Model(inputs=[input1, input2], outputs=[output1, output2])
```

https://archive.ics.uci.edu/ml/datasets/Energy+efficiency

UCI

Machine Learning Repository

Center for Machine Learning and Intelligent Systems

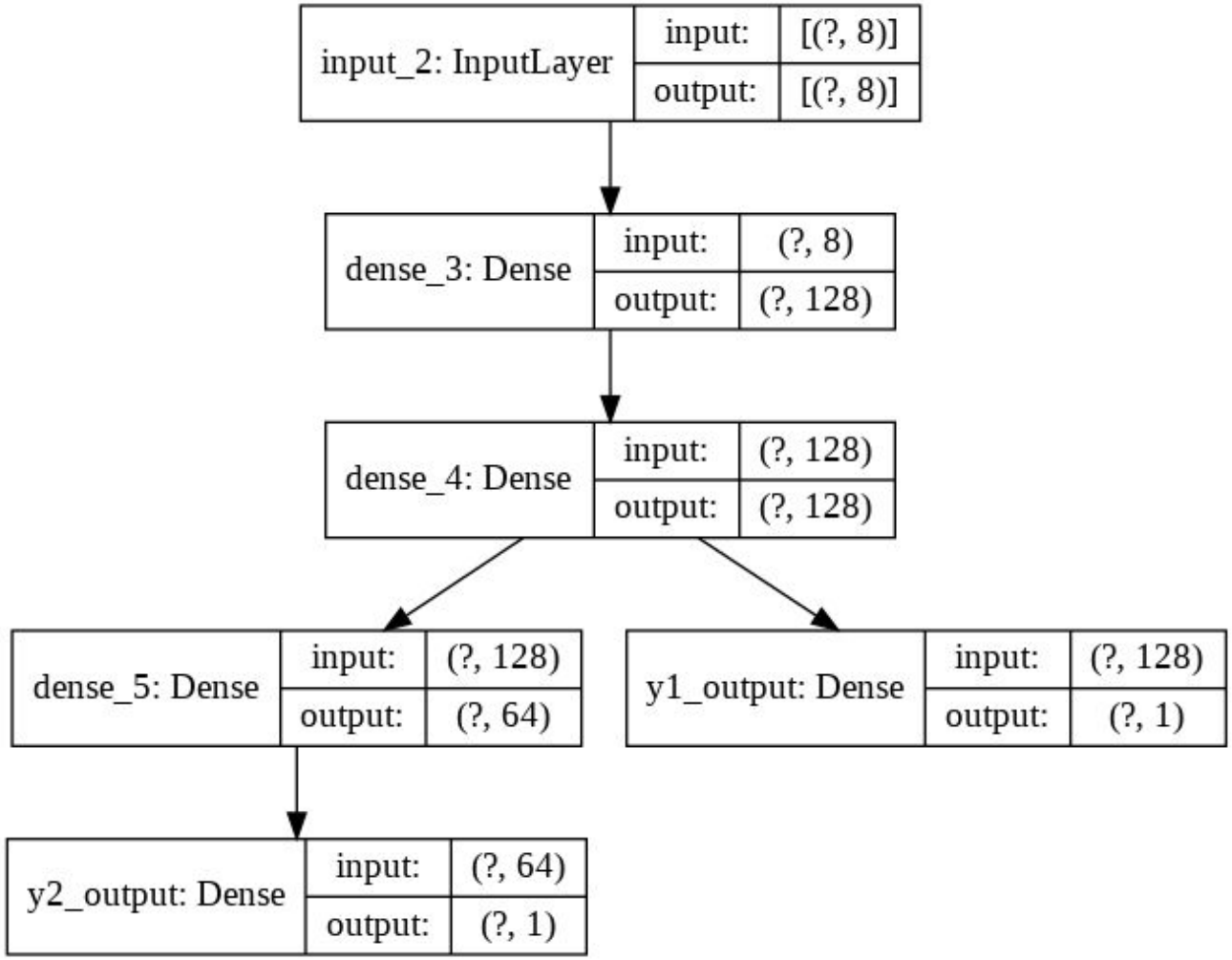
Energy efficiency Data Set

Download: Data Folder, Data Set Description

Abstract: This study looked into assessing the heating load and cooling load requirements of buildings (that is, energy efficiency) as a function of building parameters.

Data Set Characteristics:	Multivariate	**Number of Instances:**	768	**Area:**	Computer
Attribute Characteristics:	Integer, Real	**Number of Attributes:**	8	**Date Donated**	2012-11-30
Associated Tasks:	Classification, Regression	**Missing Values?**	N/A	**Number of Web Hits:**	301947

Features	Labels
X1 Relative Compactness	
X2 Surface Area	
X3 Wall Area	y1 Heating Load
X4 Roof Area	y2 Cooling Load
X5 Overall Height	
X6 Orientation	
X7 Glazing Area	
X8 Glazing Area Distribution	


input_2: InputLayer
input:
[(?, 8)]
output:
[(?, 8)]
dense_3: Dense
input:
(?, 8)
output:
(?, 128)
dense_4: Dense
input:
(?, 128)
output:
(?, 128)
dense_5: Dense
input:
(?, 128)
output:
(?, 64)
y1_output: Dense
input:
(?, 128)
output:
(?, 1)
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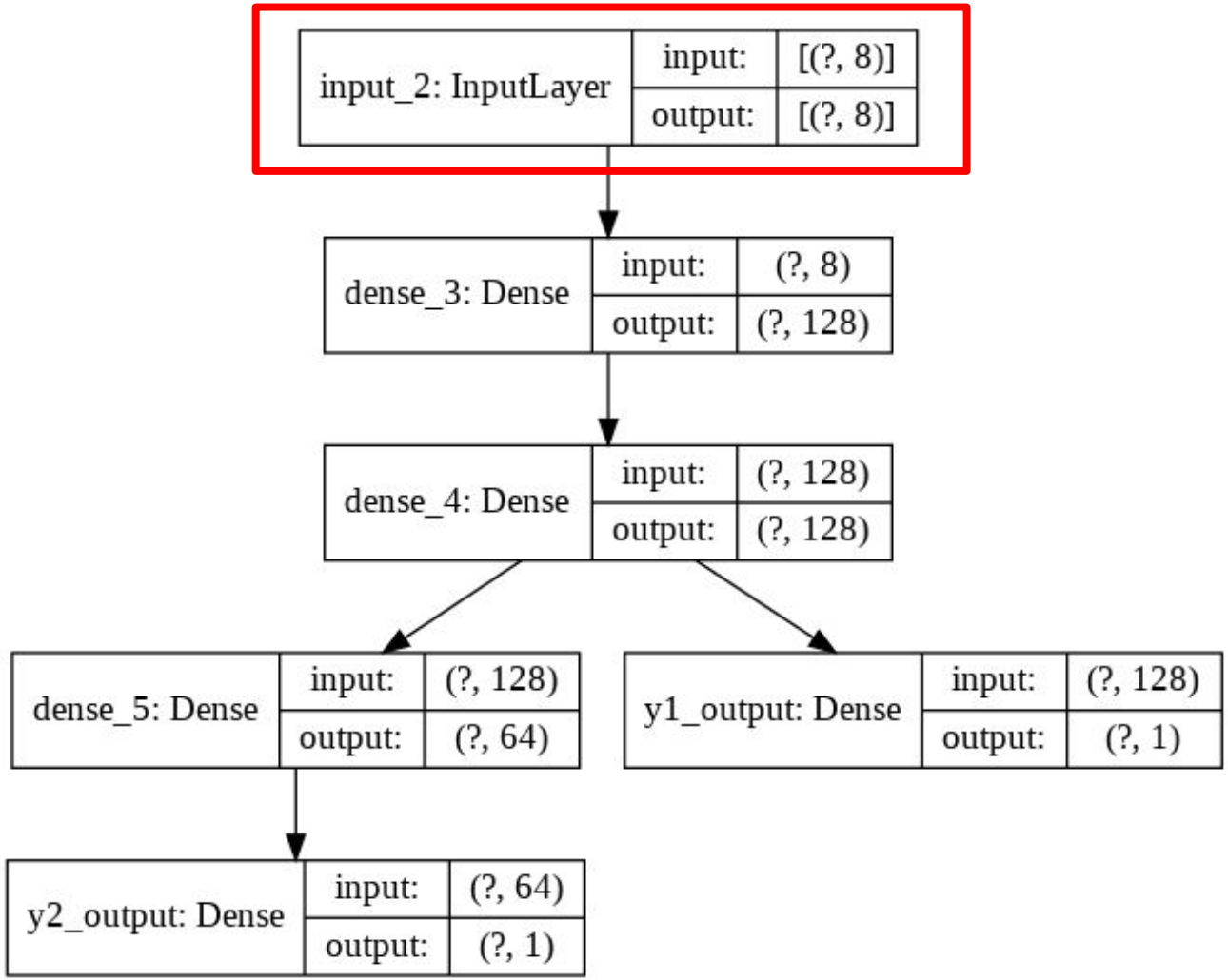
output:
(?, 1)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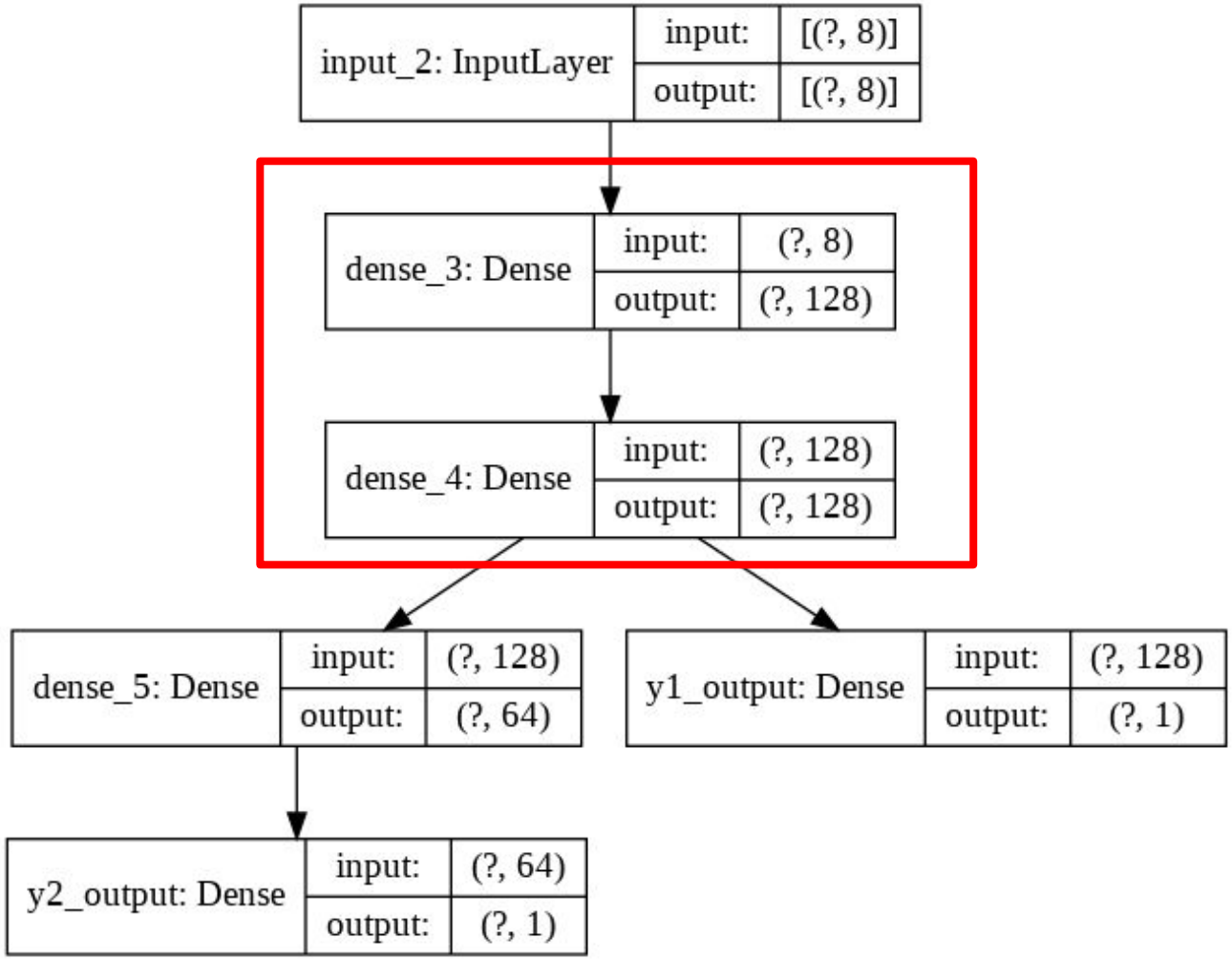
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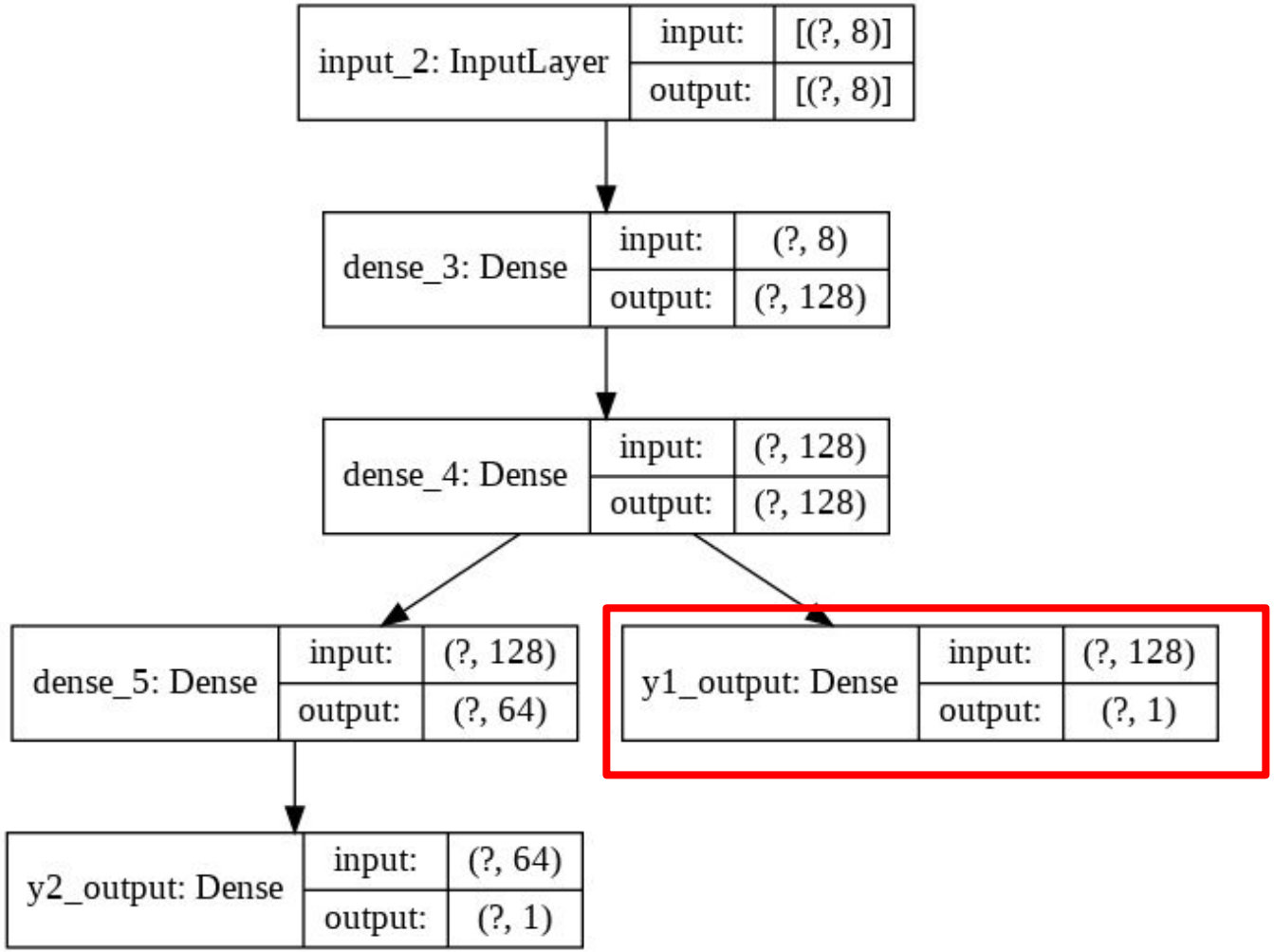
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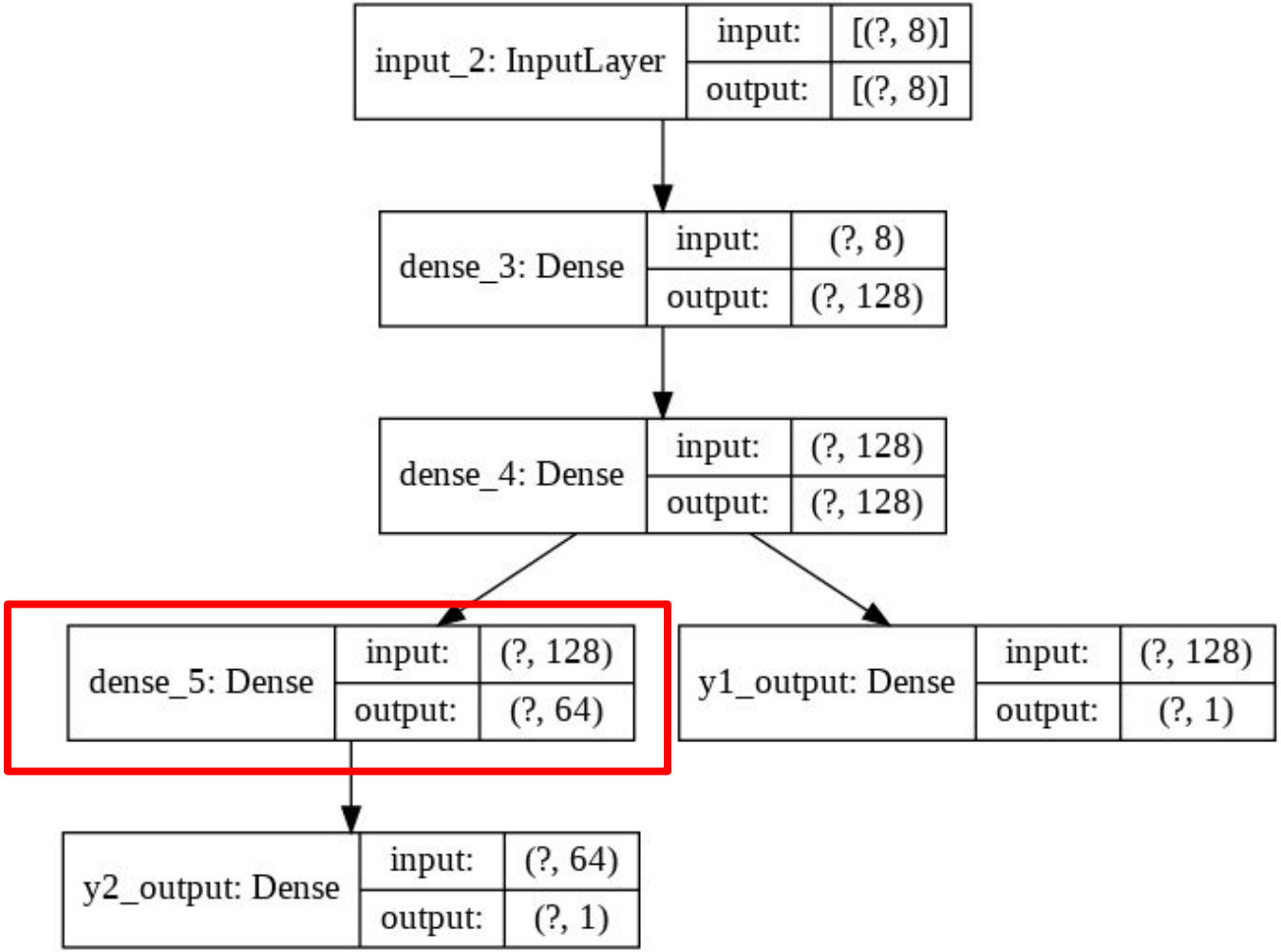
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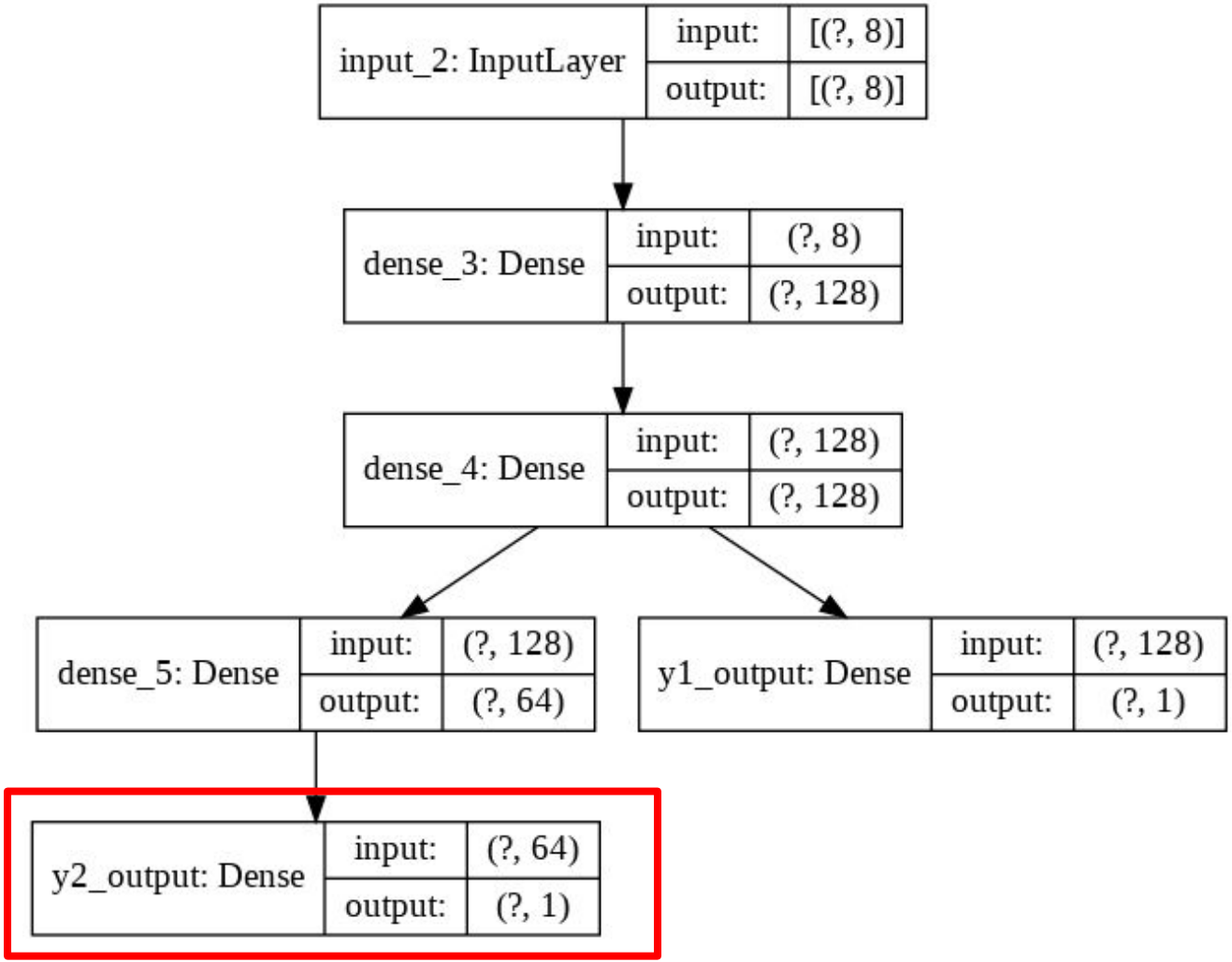
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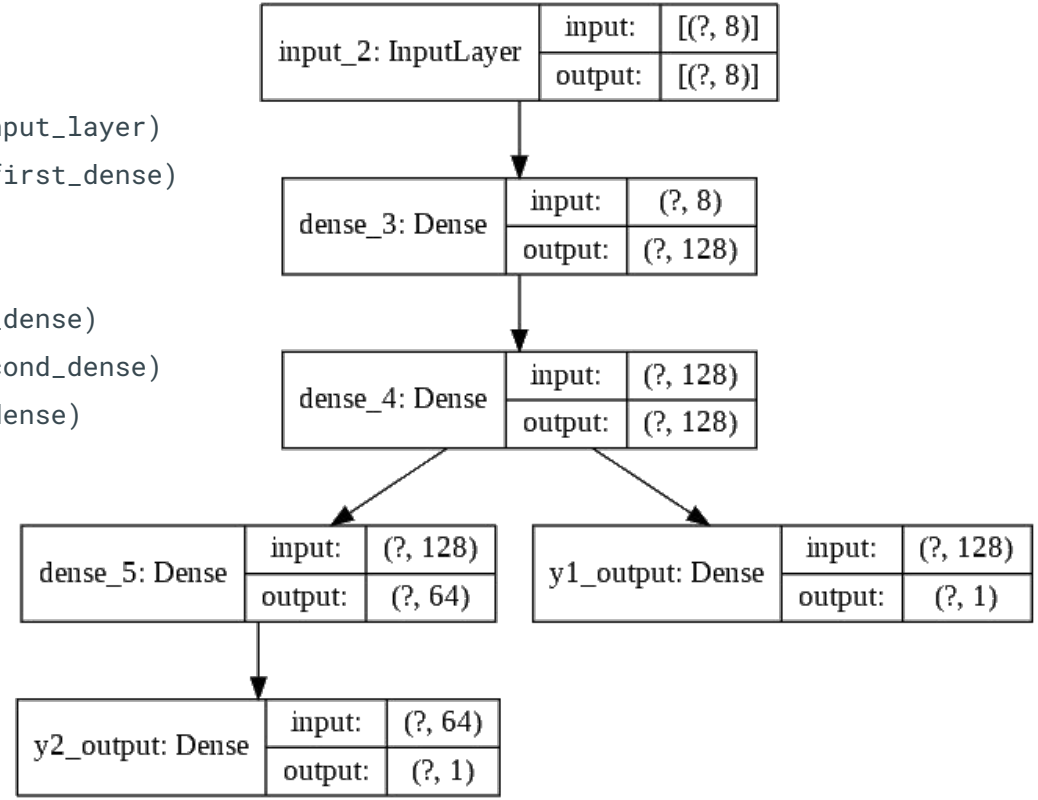
input_layer = Input(shape=(len(train .columns),))
first_dense = Dense(units='128', activation='relu')(input_layer)
second_dense = Dense(units='128', activation='relu')(first_dense)


y1_output = Dense(units='1', name='y1_output')(second_dense)
third_dense = Dense(units='64', activation='relu')(second_dense)
y2_output = Dense(units='1', name='y2_output')(third_dense)
```

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# Define the model with the input layer and a list of output layers
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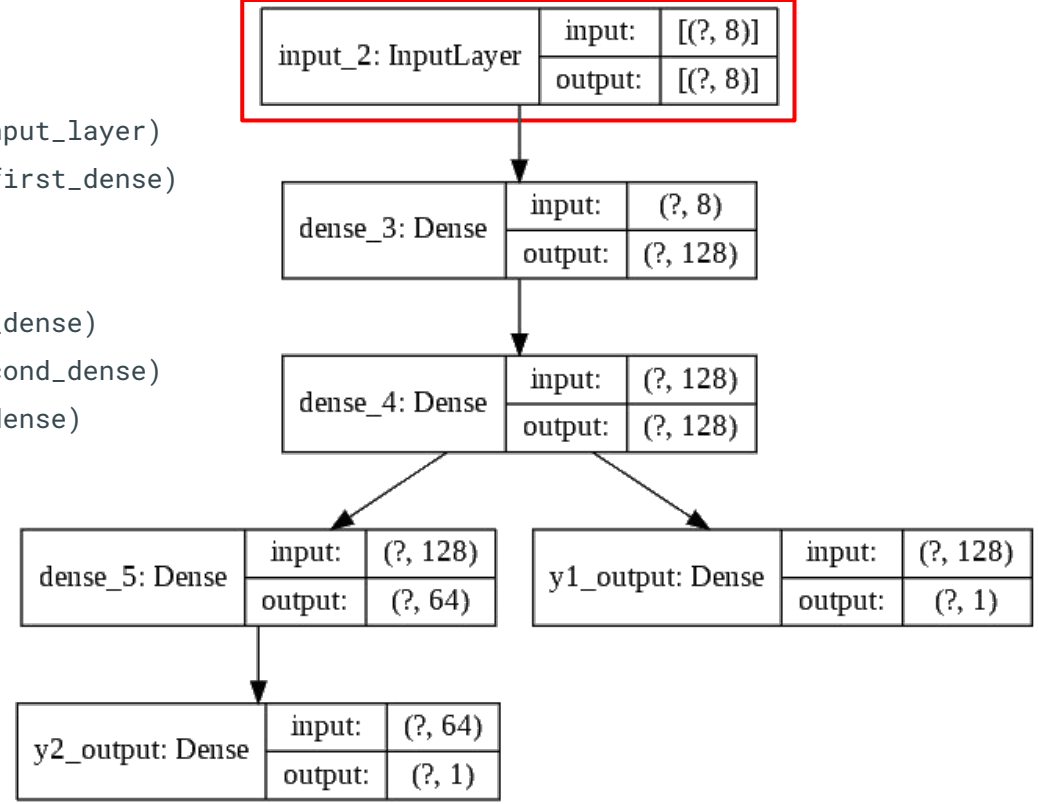


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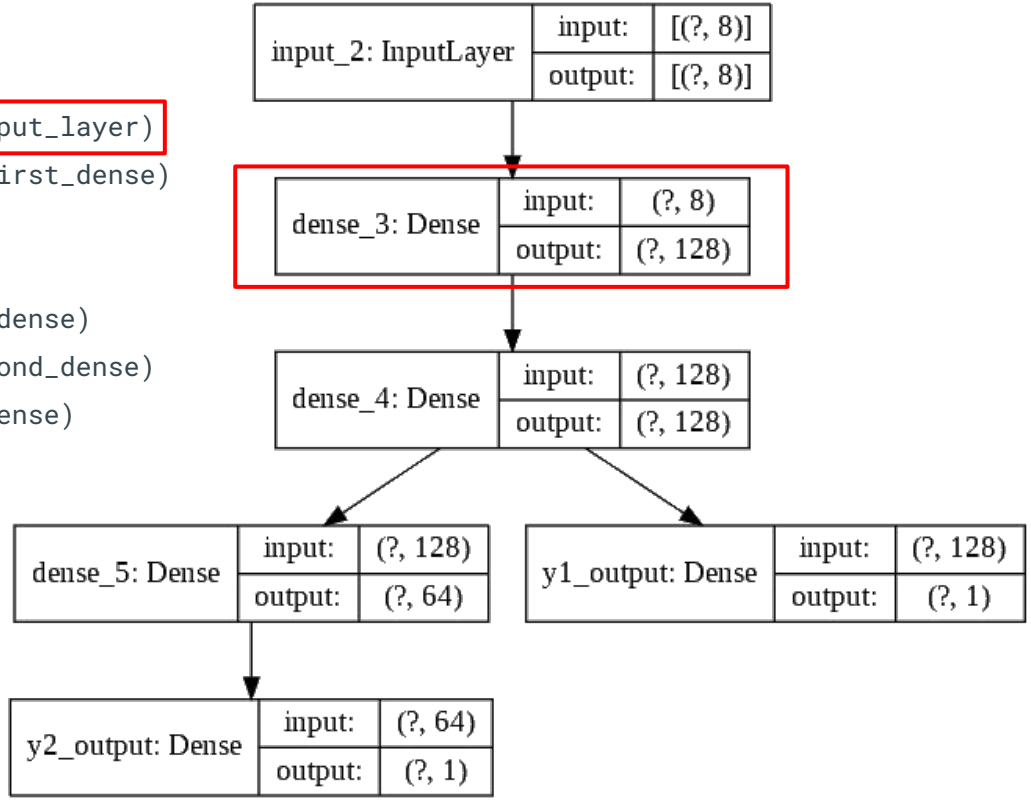


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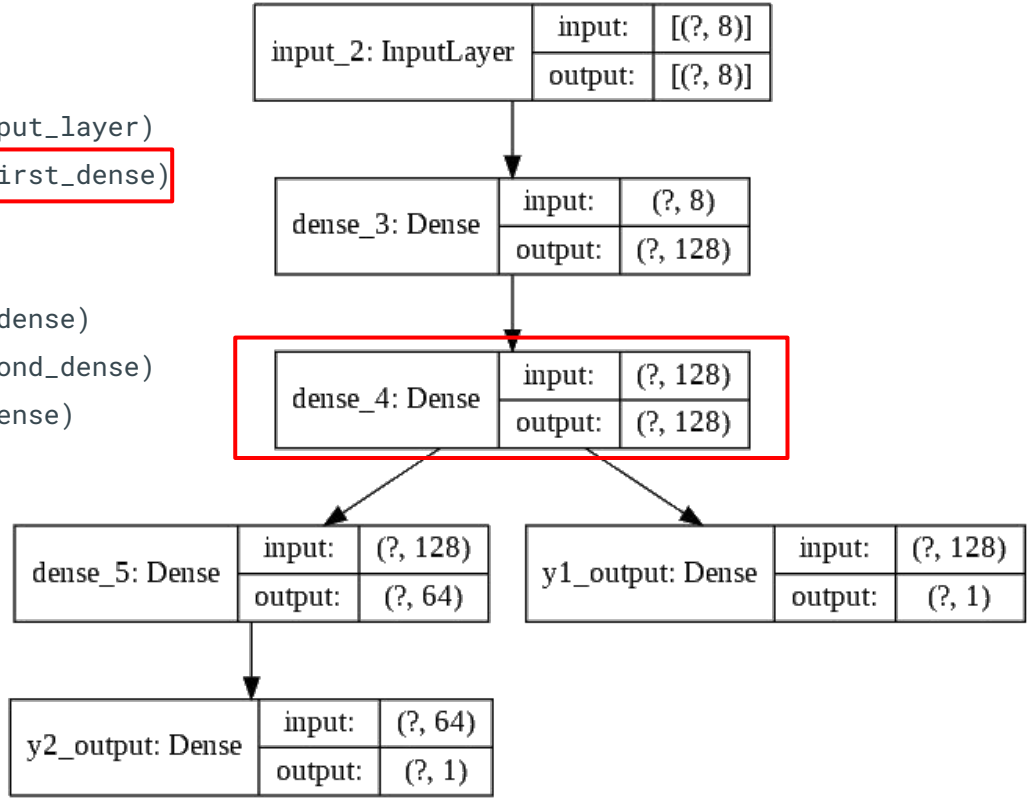


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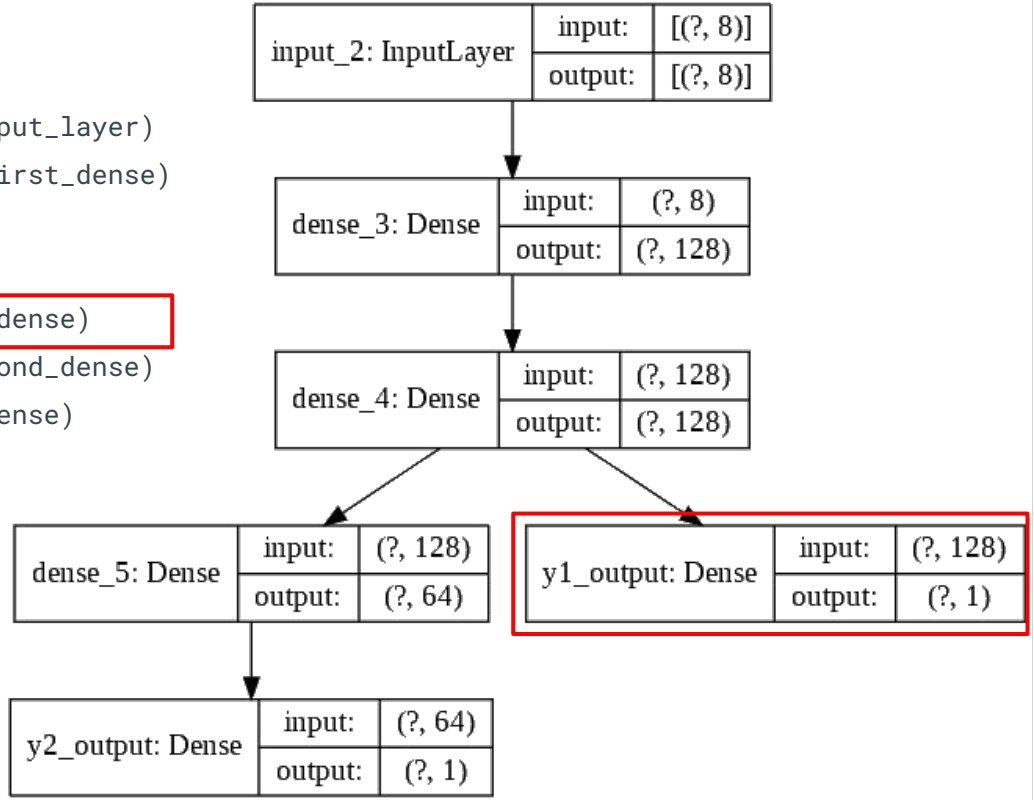


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y2_output = Dense(units='1', name='y2_output')(third_dense)
```
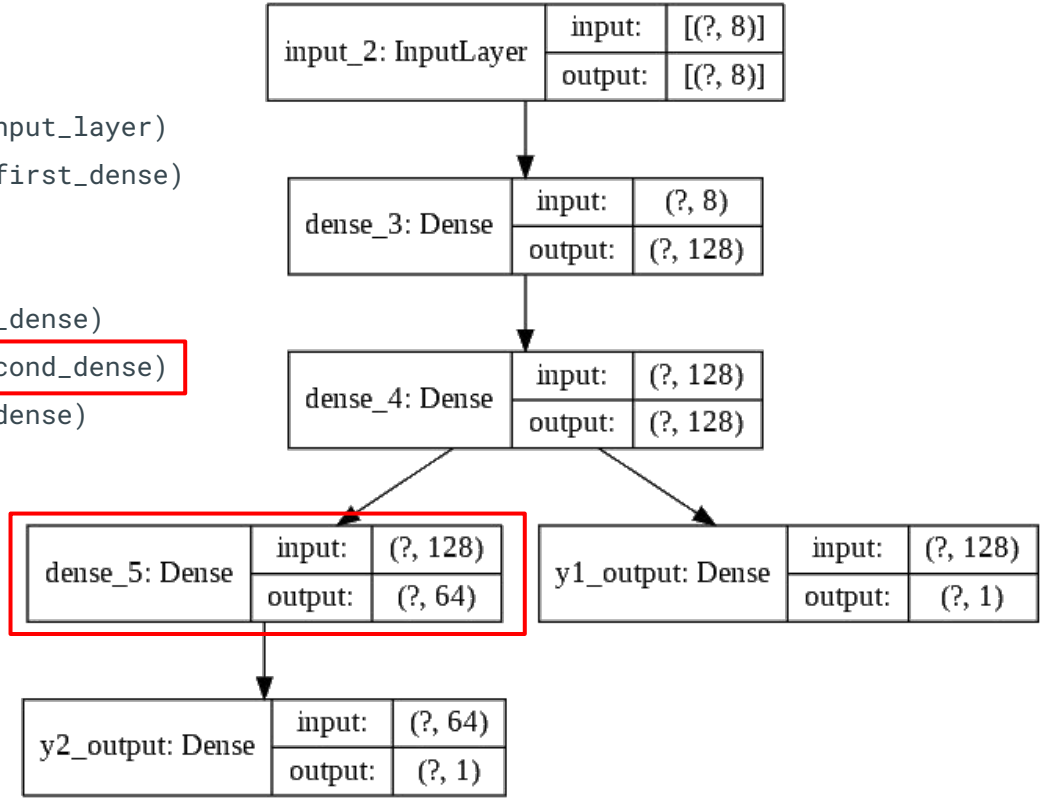
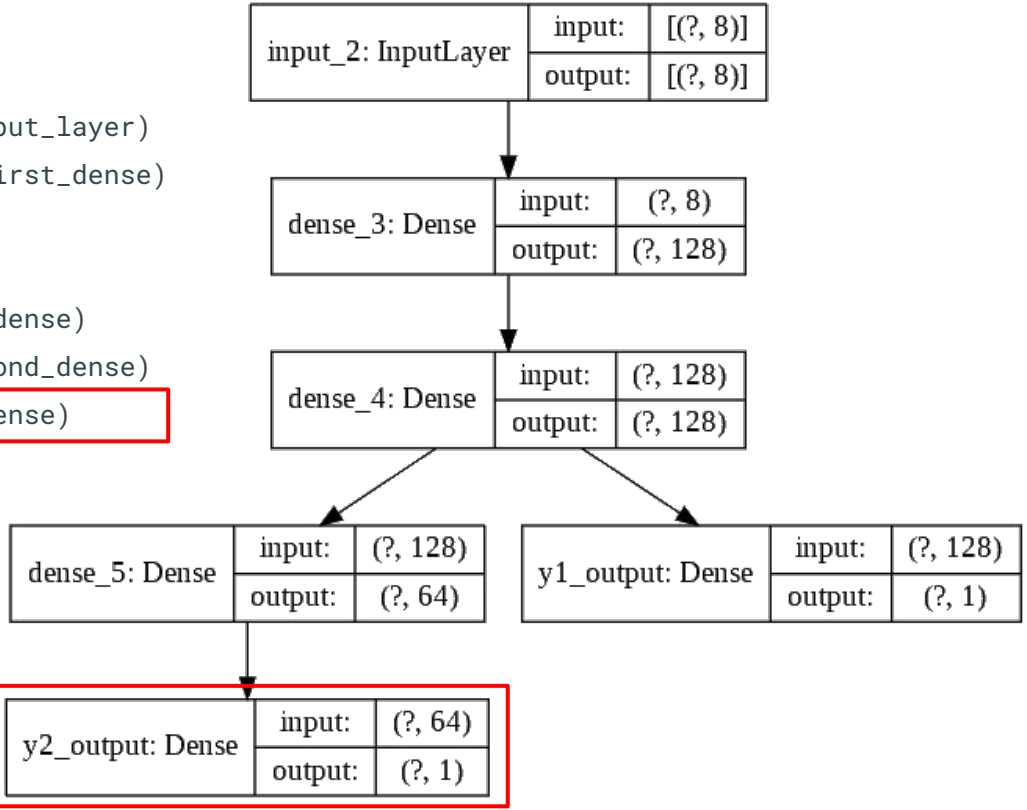



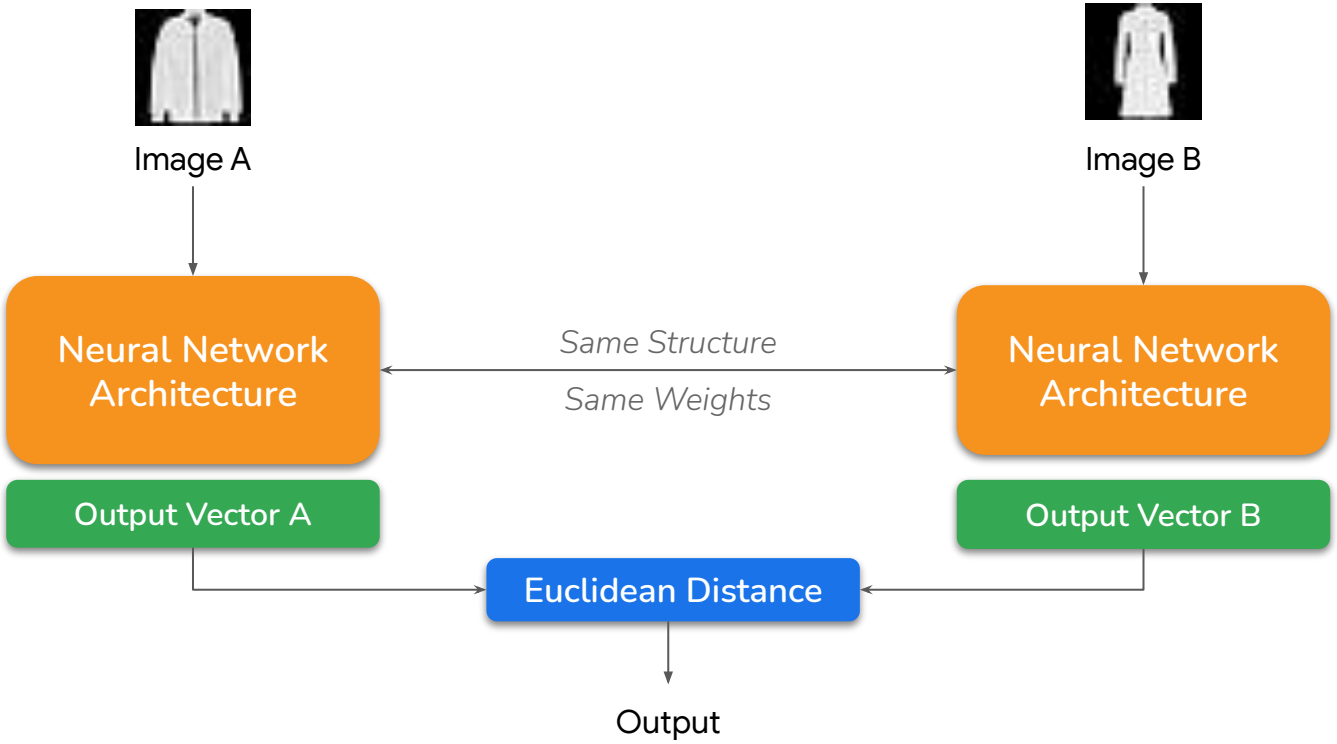

```
# Define the model with the input layer and a list of output layers
model = Model(inputs=input_layer, outputs=[y1_output, y2_output])
```

```python
input_layer = Input(shape=(len(train .columns),))
first_dense = Dense(units='128', activation='relu')(input_layer)
second_dense = Dense(units='128', activation='relu')(first_dense)


y1_output = Dense(units='1', name='y1_output')(second_dense)
third_dense = Dense(units='64', activation='relu')(second_dense)
y2_output = Dense(units='1', name='y2_output')(third_dense)
```

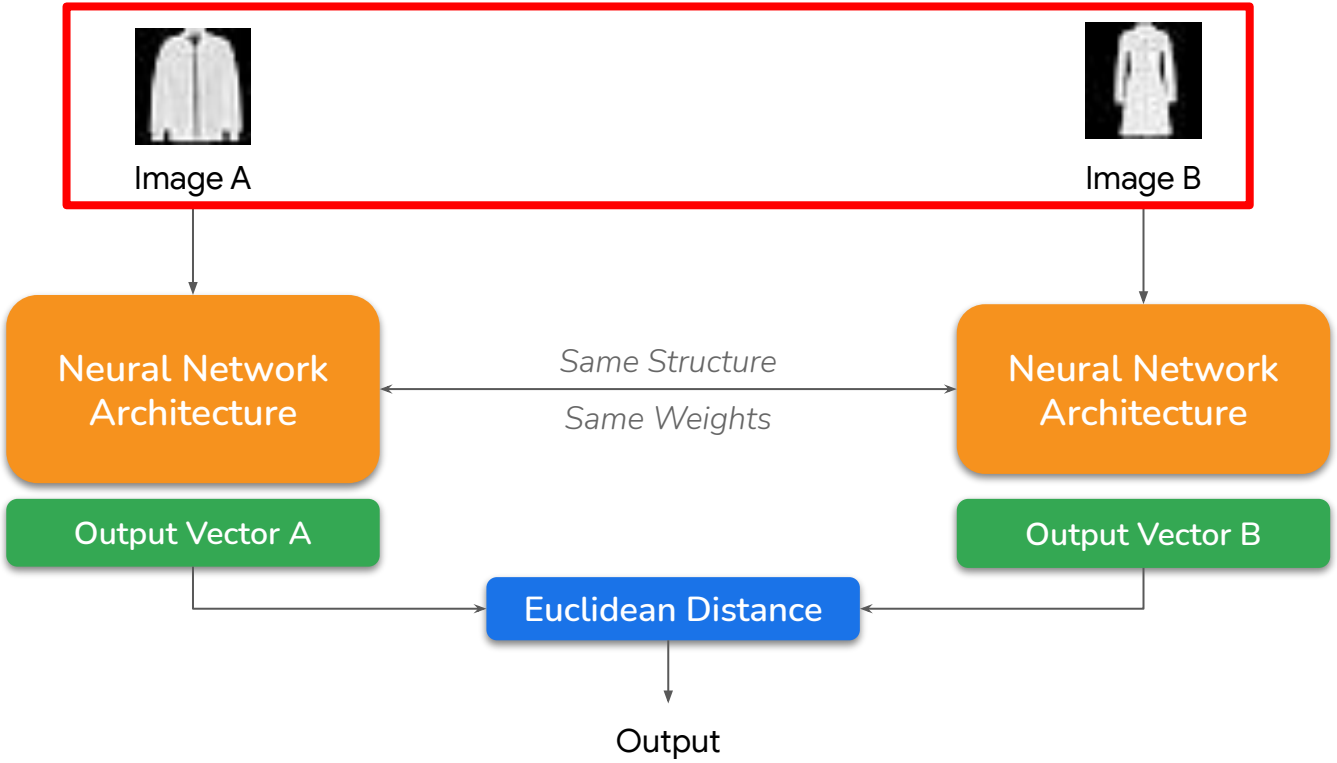



```python
# Define the model with the input layer and a list of output layers
model = Model(inputs=input_layer, outputs=[y1_output, y2_output])
```

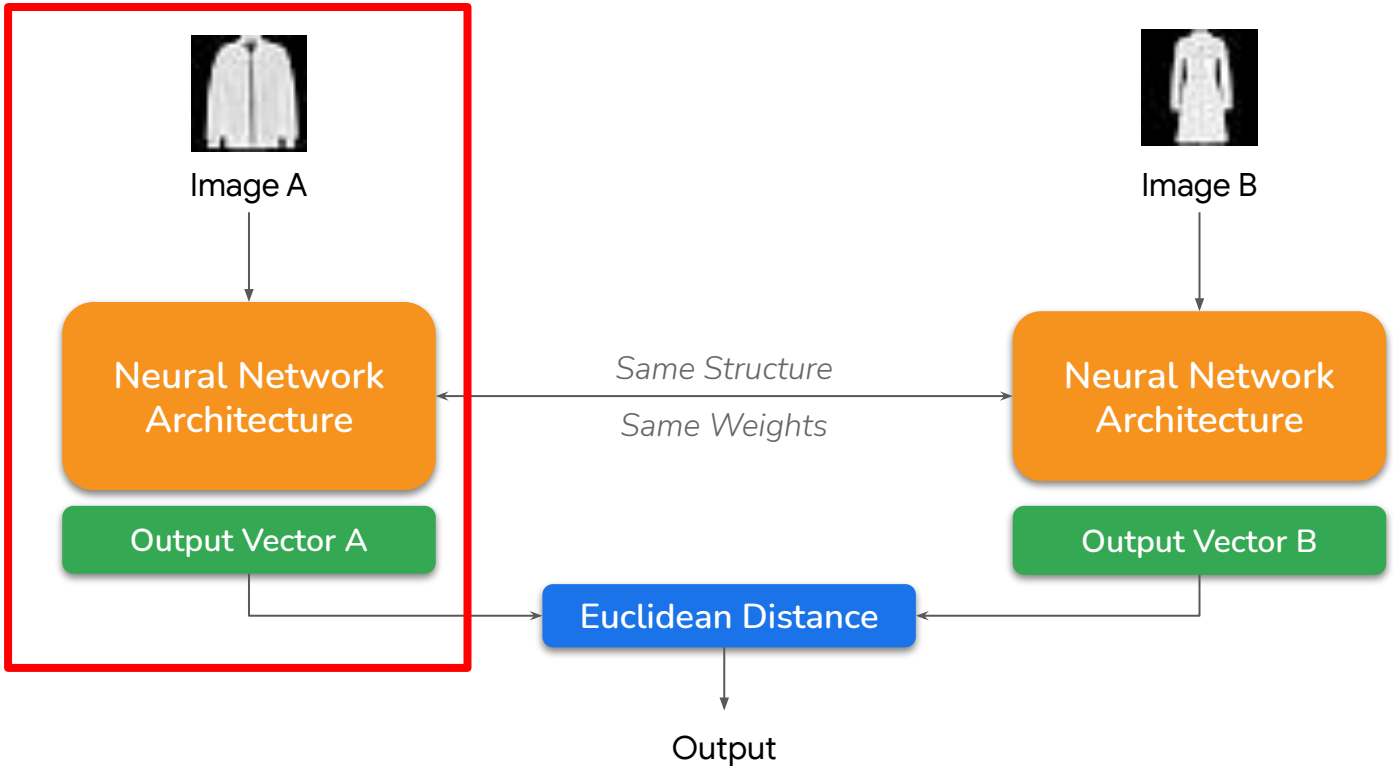
A Siamese network's architecture



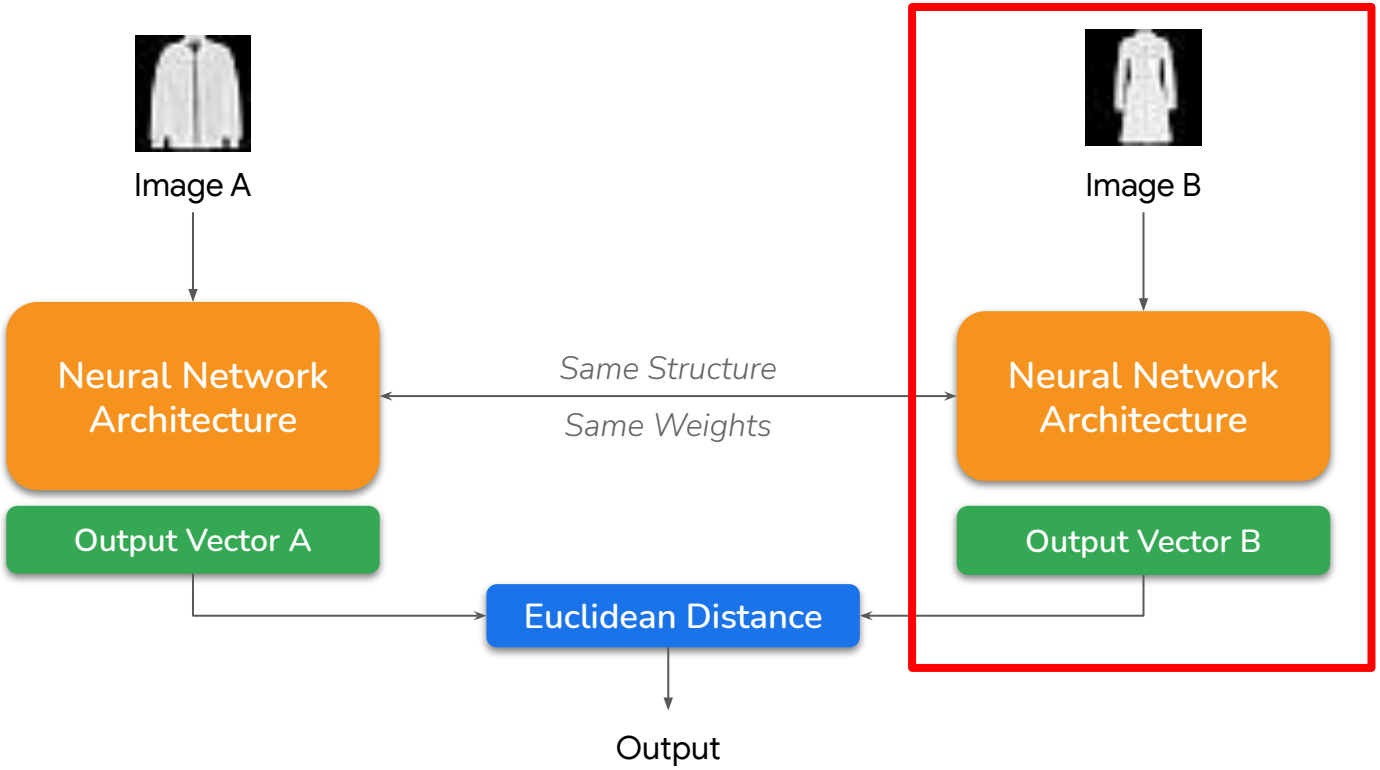
A Siamese network's architecture



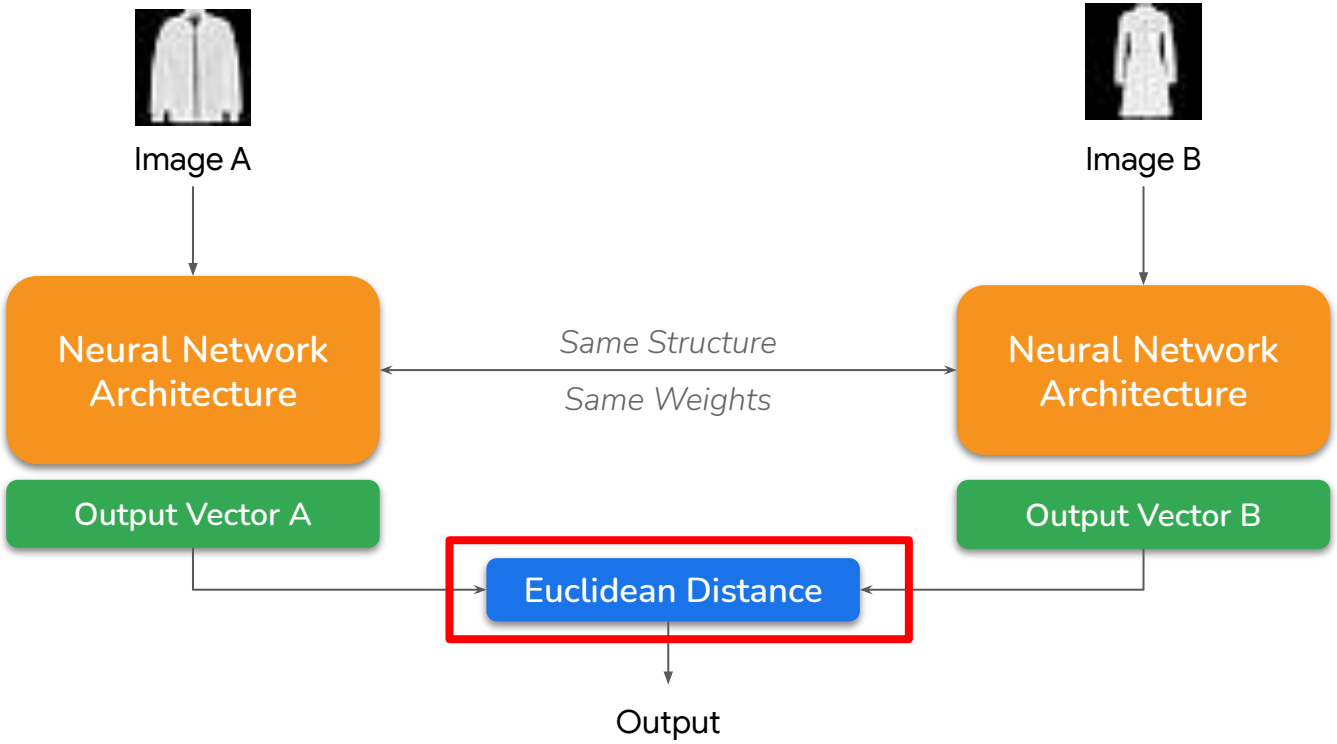
A Siamese network's architecture



A Siamese network's architecture

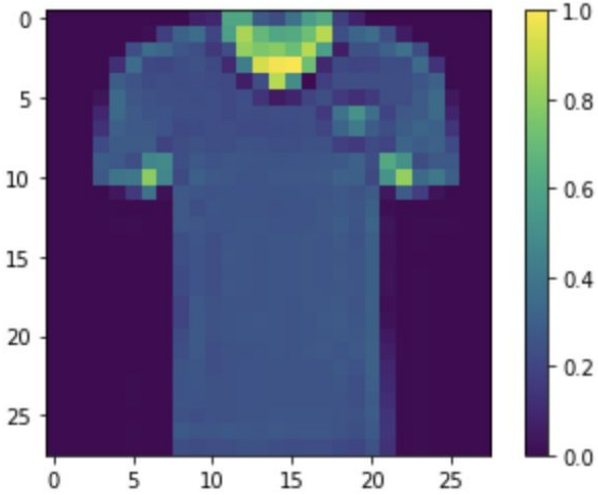


A Siamese network's architecture



References

- http://yann.lecun.com/exdb/publis/pdf/chopra-05.pdf
- http://slazebni.cs.illinois.edu/spring17/lec09_similarity.pdf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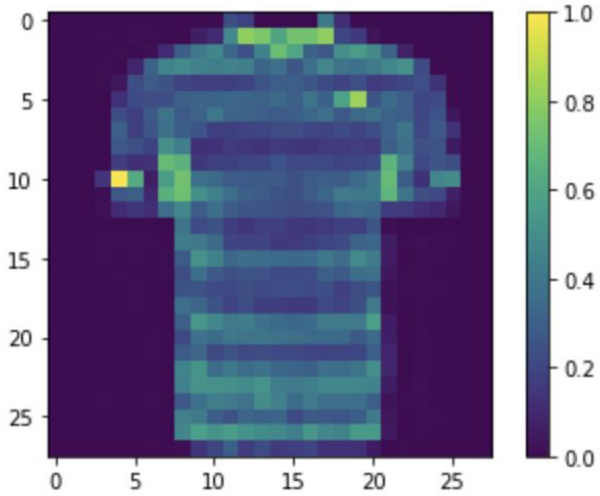
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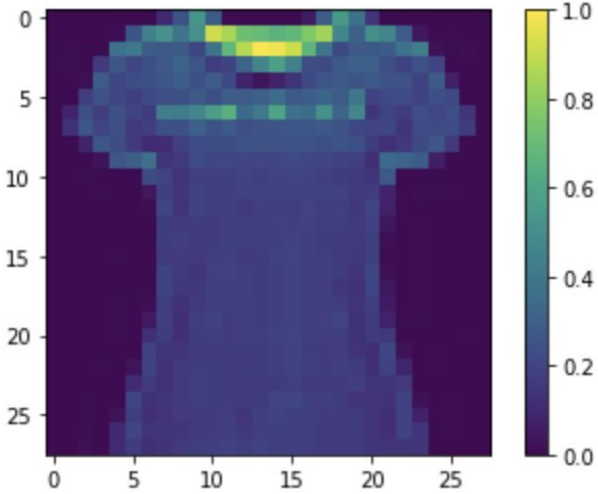
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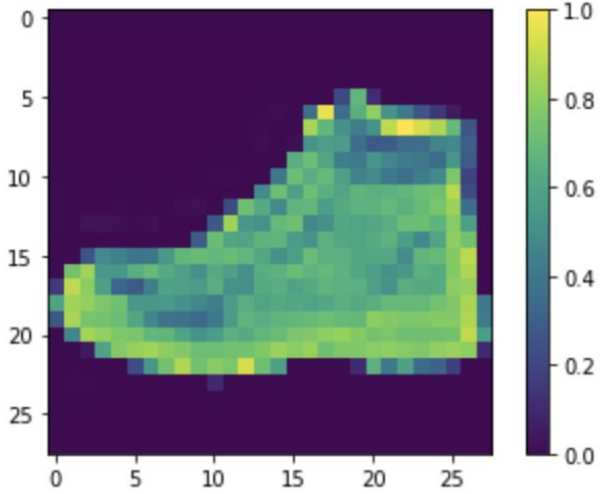
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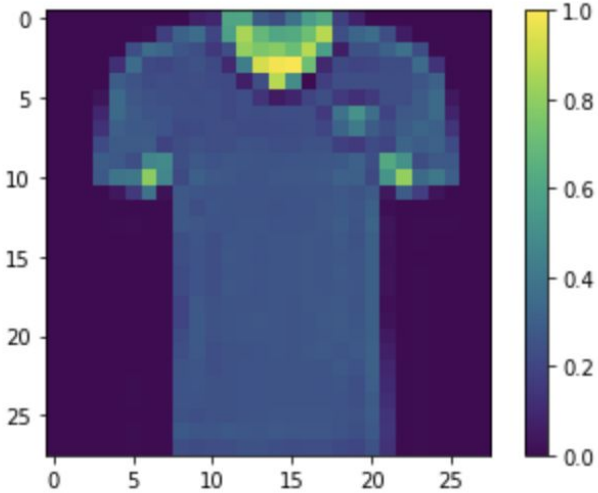
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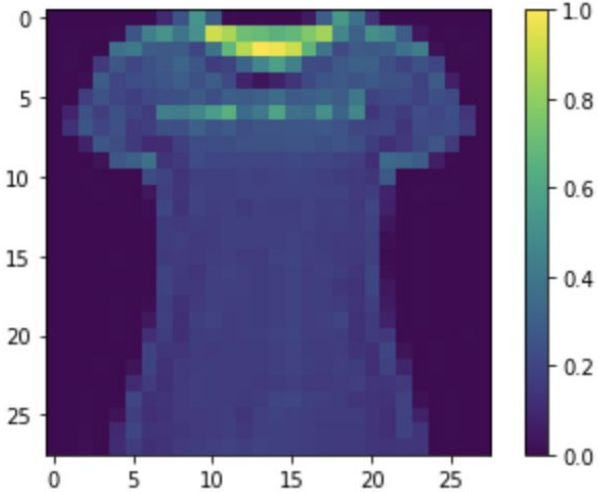
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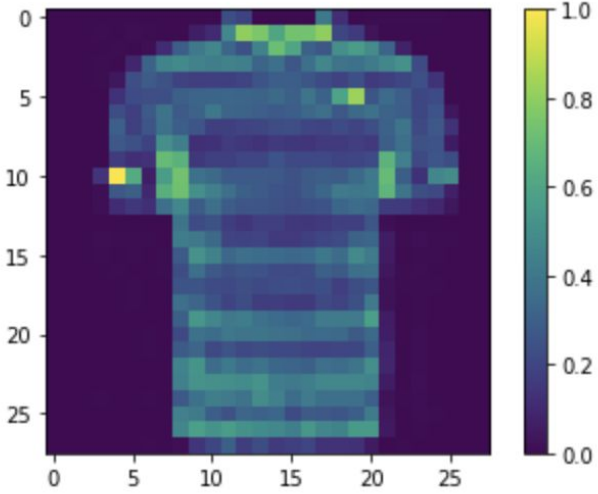
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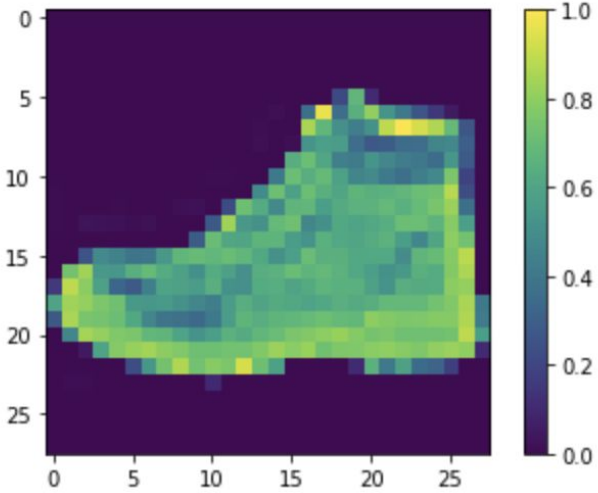
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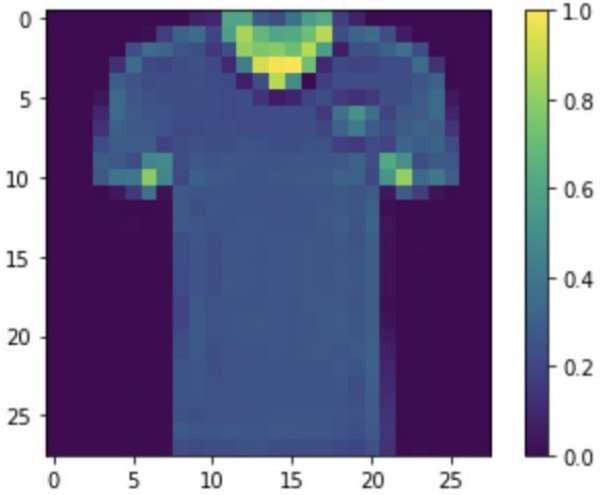
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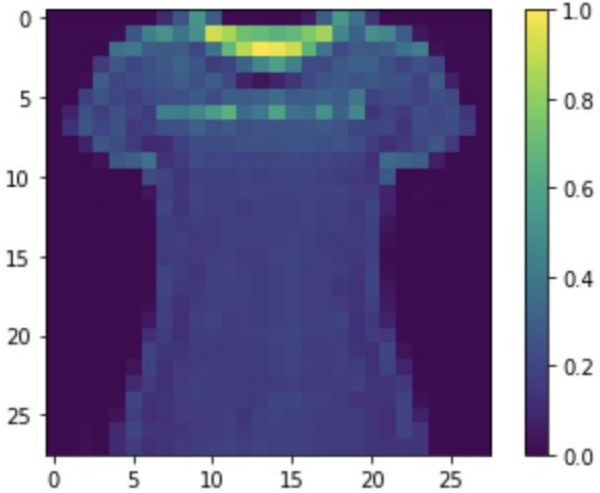
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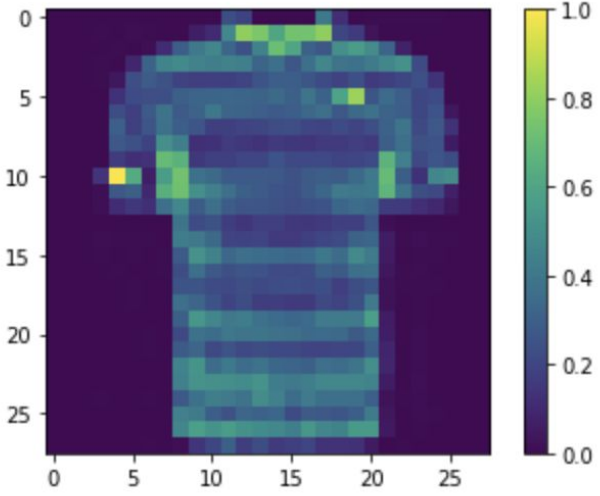
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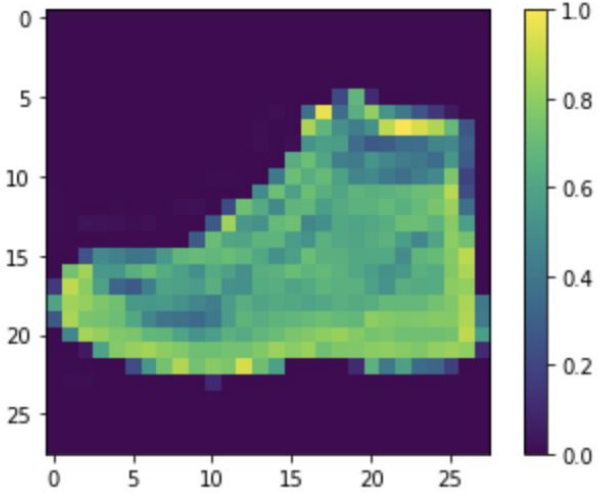
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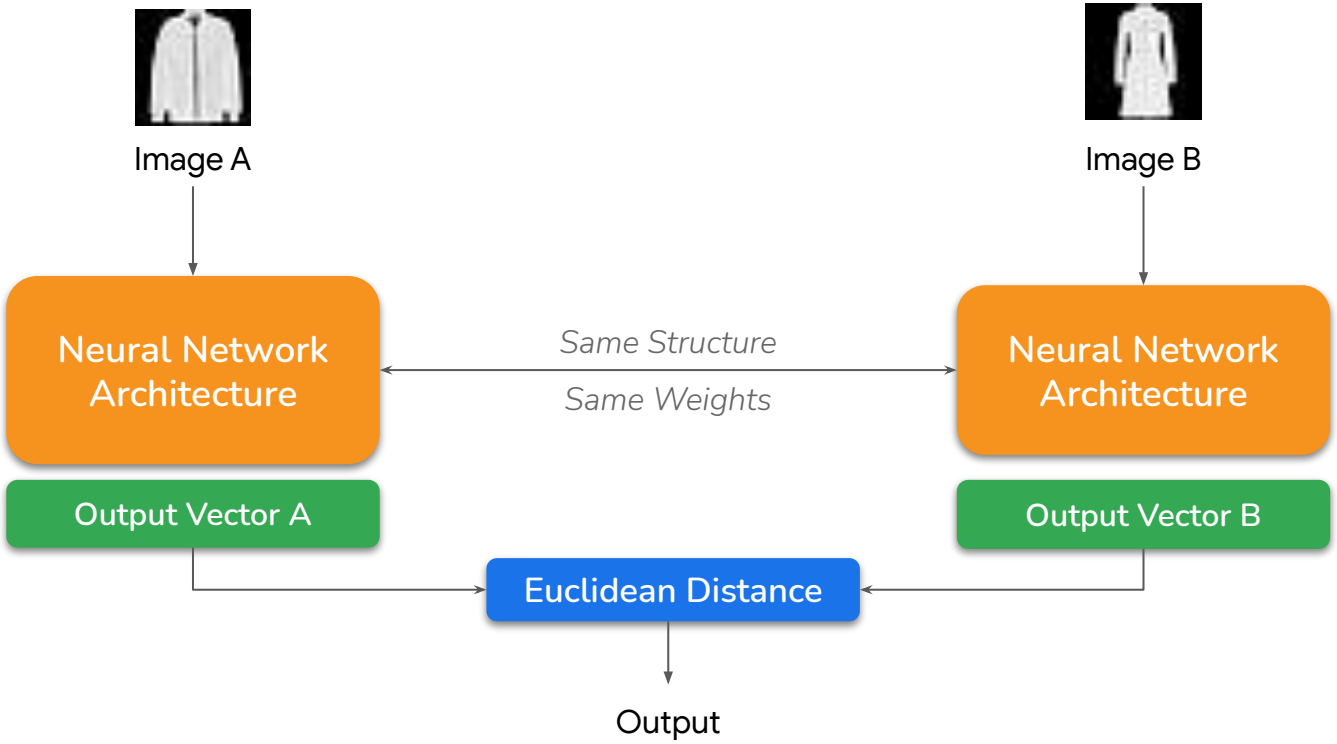
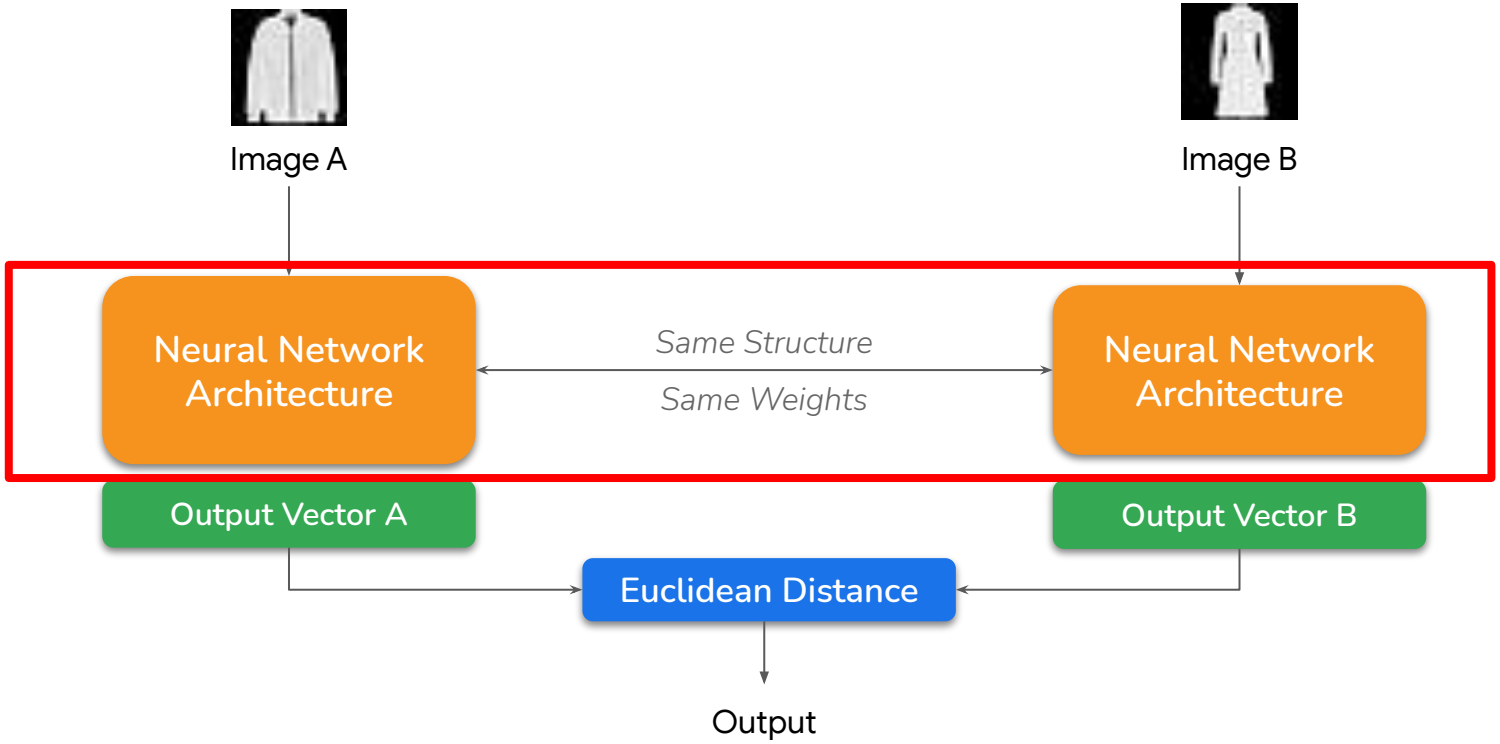
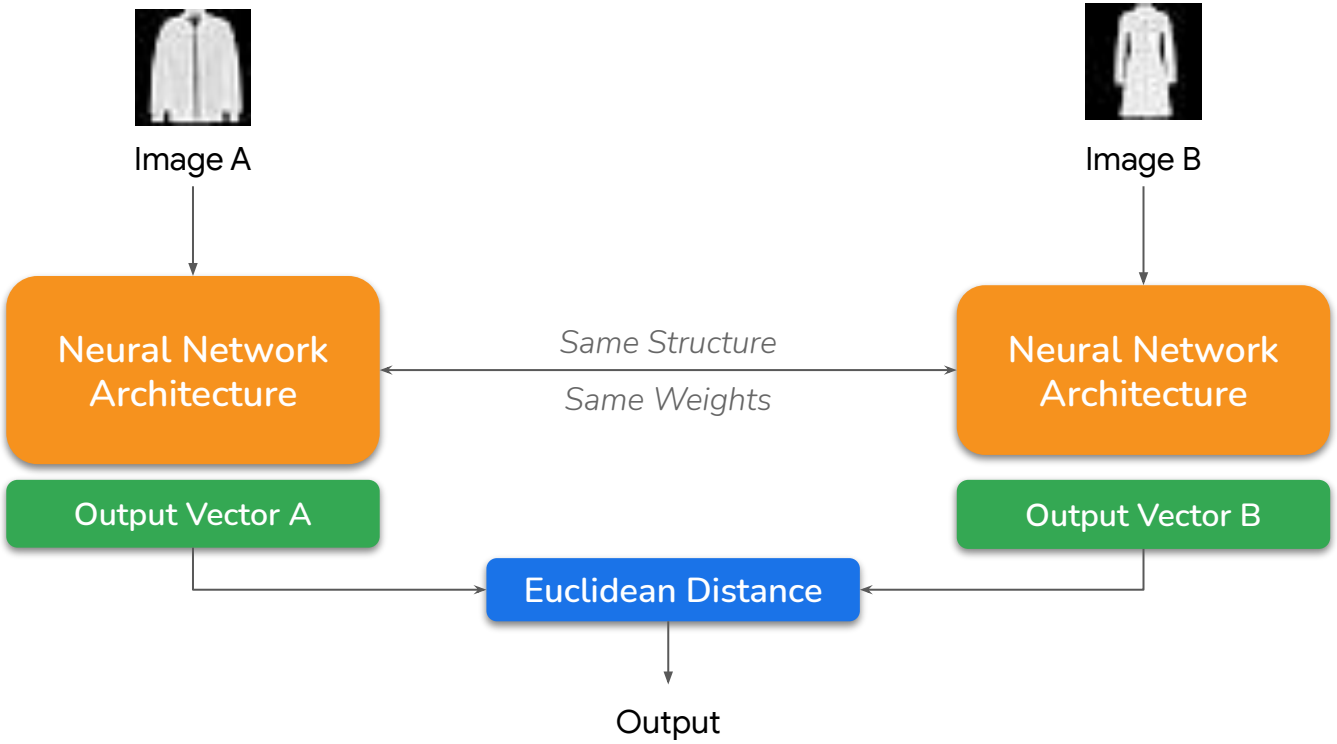
A Siamese network's architecture



A Siamese network's architecture



A Siamese network's architecture

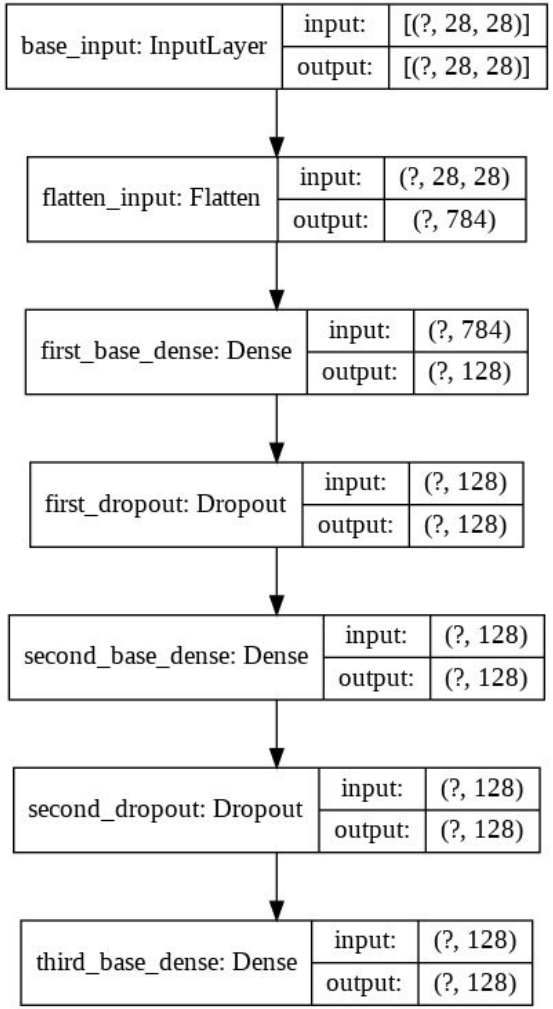


Defining the Base Network

```
def initialize_base_network():
  input = Input(shape=(28,28,))
  x = Flatten()(input)
  x = Dense(128, activation='relu')(x)
  x = Dropout(0.1)(x)
  x = Dense(128, activation='relu')(x)
  x = Dropout(0.1)(x)
  x = Dense(128, activation='relu')(x)
  return Model(inputs=input, outputs=x)
```

Defining the Base Network

```
def initialize_base_network():
  input = Input(shape=(28,28,))
  x = Flatten()(input)
  x = Dense(128, activation='relu')(x)
  x = Dropout(0.1)(x)
  x = Dense(128, activation='relu')(x)
  x = Dropout(0.1)(x)
  x = Dense(128, activation='relu')(x)
  return Model(inputs=input, outputs=x)
```


base_input: InputLayer
input: [(?, 28, 28)]
output: [(?, 28, 28)]
flatten_input: Flatten
input: (?, 28, 28)
output: (?, 784)
first_base_dense: Dense
input: (?, 784)
output: (?, 128)
first_dropout: Dropout
input: (?, 128)
output: (?, 128)
second_base_dense: Dense
input: (?, 128)
output: (?, 128)
second_dropout: Dropout
input: (?, 128)
output: (?, 128)
third_base_dense: Dense
input: (?, 128)
output: (?, 128)

Re-using the base network

```
base_network = initialize_base_network()

input_a = Input(shape=(28,28,))
input_b = Input(shape=(28,28,))

vect_output_a = base_network(input_a)
vect_output_b = base_network(input_b)
```

Re-using the base network

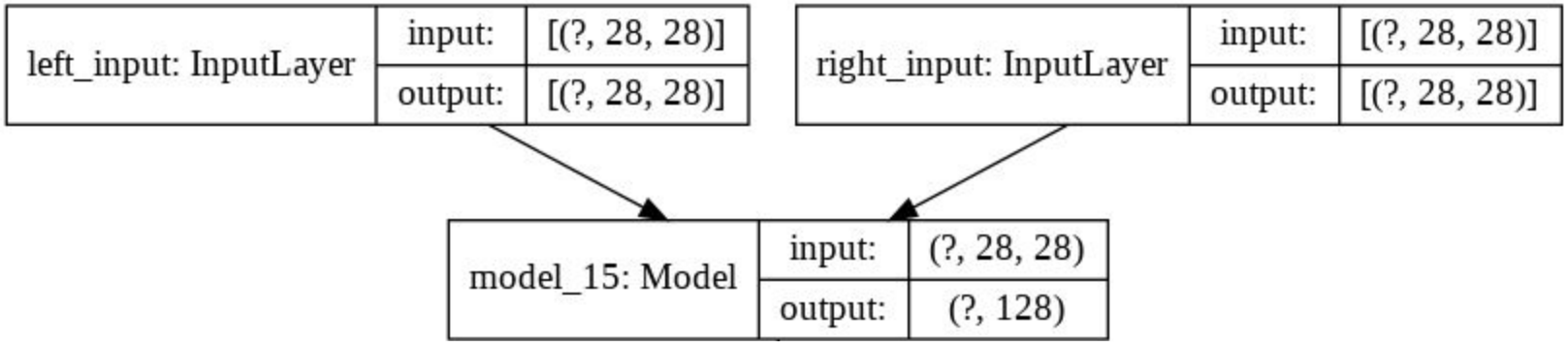
```
base_network = initialize_base_network()

input_a = Input(shape=(28,28,))
input_b = Input(shape=(28,28,))

vect_output_a = base_network(input_a)
vect_output_b = base_network(input_b)
```

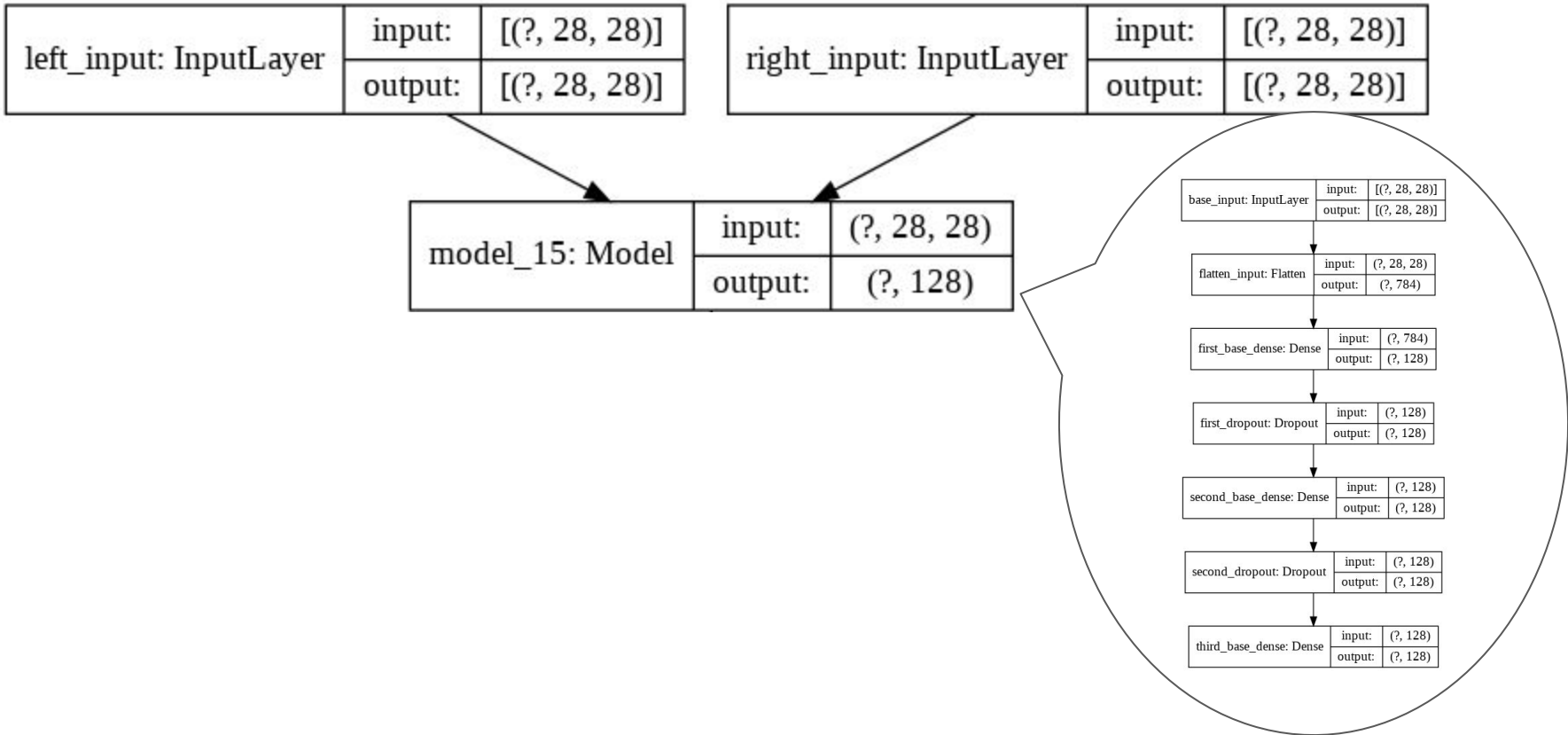
Re-using the base network

```
base_network = initialize_base_network()

input_a = Input(shape=(28,28,))
input_b = Input(shape=(28,28,))

vect_output_a = base_network(input_a)
vect_output_b = base_network(input_b)
```

Re-using the base network

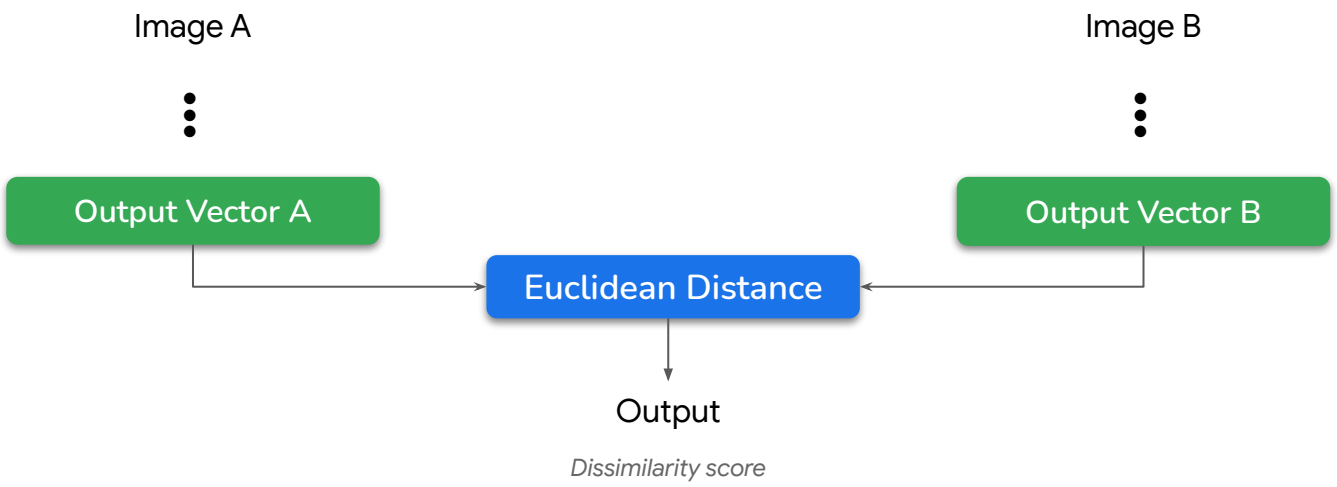
```
base_network = initialize_base_network()

input_a = Input(shape=(28,28,))
input_b = Input(shape=(28,28,))

vect_output_a = base_network(input_a)
vect_output_b = base_network(input_b)
```


left_input: InputLayer
input:
[(?, 28, 28)]
output:
[(?, 28, 28)]
right_input: InputLayer
input:
[(?, 28, 28)]
output:
[(?, 28, 28)]
model_15: Model
input:
(?, 28, 28)
output:
(?, 128)


left_input: InputLayer
input: [(?, 28, 28)]
output: [(?, 28, 28)]
right_input: InputLayer
input: [(?, 28, 28)]
output: [(?, 28, 28)]
model_15: Model
input: (?, 28, 28)
output: (?, 128)
base_input: InputLayer
input: [(?, 28, 28)]
output: [(?, 28, 28)]
flatten_input: Flatten
input: (?, 28, 28)
output: (?, 784)
first_base_dense: Dense
input: (?, 784)
output: (?, 128)
first_dropout: Dropout
input: (?, 128)
output: (?, 128)
second_base_dense: Dense
input: (?, 128)
output: (?, 128)
second_dropout: Dropout
input: (?, 128)
output: (?, 128)
third_base_dense: Dense
input: (?, 128)
output: (?, 128)

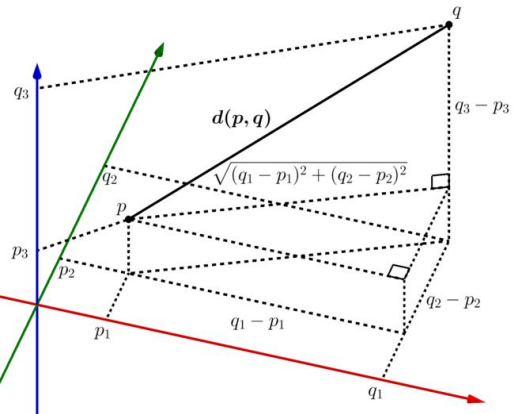
Output of the network

Similarity between two input images



http://mathonline.wikidot.com/the-distance-between-two-vectors

```python
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)
```



Output layer is euclidean distance

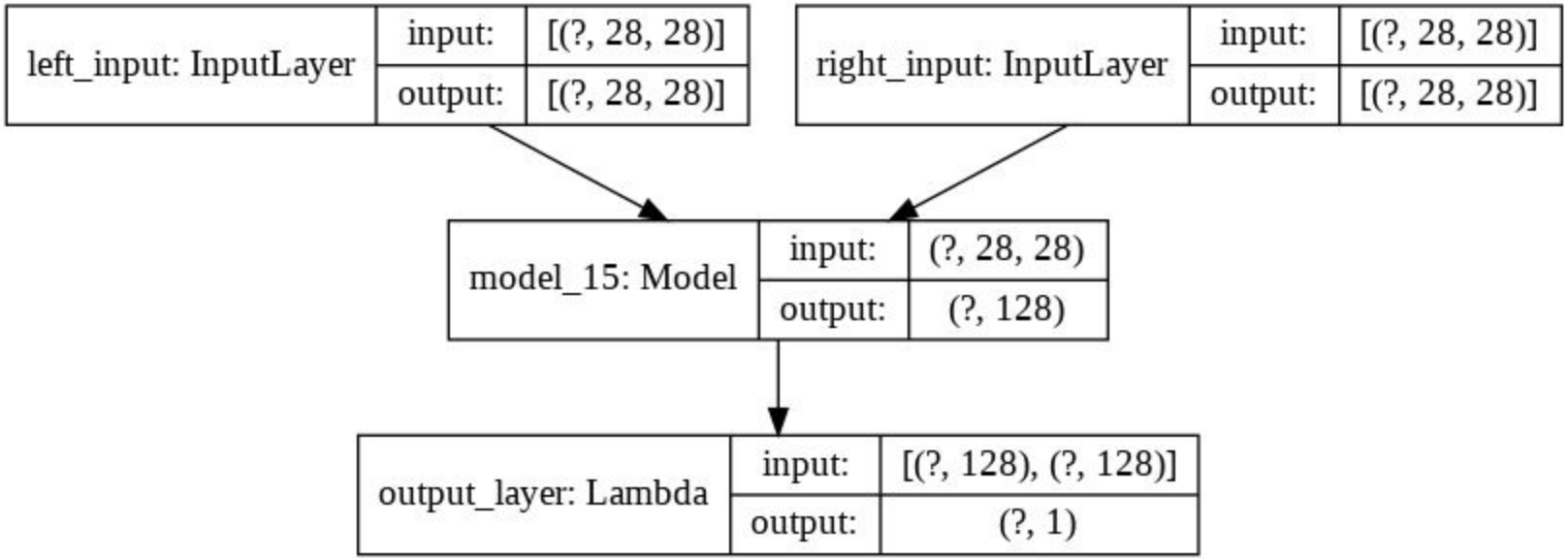
```
output = Lambda(euclidean_distance,
                output_shape=eucl_dist_output_shape)([vect_output_a, vect_output_b])
```

Output layer is euclidean distance

```
output = Lambda(euclidean_distance,
                output_shape=eucl_dist_output_shape)([vect_output_a, vect_output_b])
```

Defining the final model

```
model = Model([input_a, input_b], output)
```


left_input: InputLayer
input:
[(?, 28, 28)]
output:
[(?, 28, 28)]
right_input: InputLayer
input:
[(?, 28, 28)]
output:
[(?, 28, 28)]
model_15: Model
input:
(?, 28, 28)
output:
(?, 128)
output_layer: Lambda
input:
[(?, 128), (?, 128)]
output:
(?, 1)

Defining the final model

```
model = Model([input_a, input_b], output)

rms = RMSprop()
model.compile(loss=contrastive_loss, optimizer=rms)
```

Train the Model

```
model.fit([tr_pairs[:,0], tr_pairs[:,1]], tr_y, # Training data
          epochs=20,
          batch_size=128,
          validation_data=([ts_pairs[:,0], ts_pairs[:,1]], ts_y))
```

Train the Model

```
model.fit([tr_pairs[:,0], tr_pairs[:,1]], tr_y, # Training data
          epochs=20,
          batch_size=128,
          validation_data=([ts_pairs[:,0], ts_pairs[:,1]], ts_y))
```

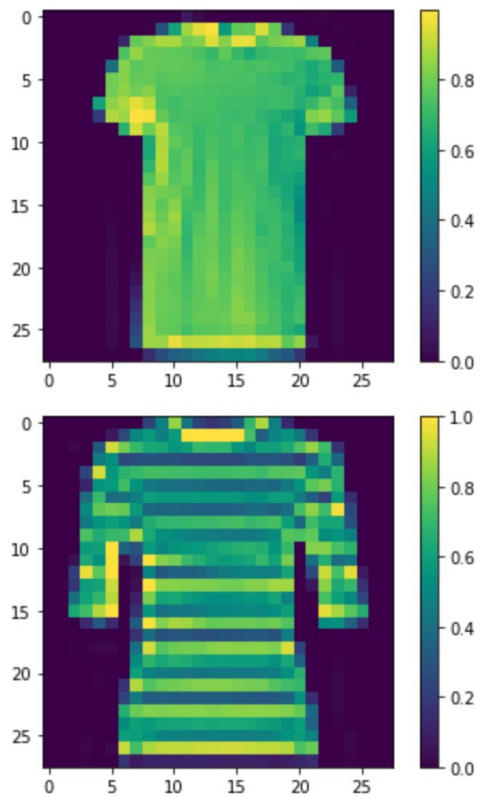
Train the Model

```
model.fit([tr_pairs[:,0], tr_pairs[:,1]], tr_y, # Training data
          epochs=20,
          batch_size=128,
          validation_data=([ts_pairs[:,0], ts_pairs[:,1]], ts_y))
```

Train the Model

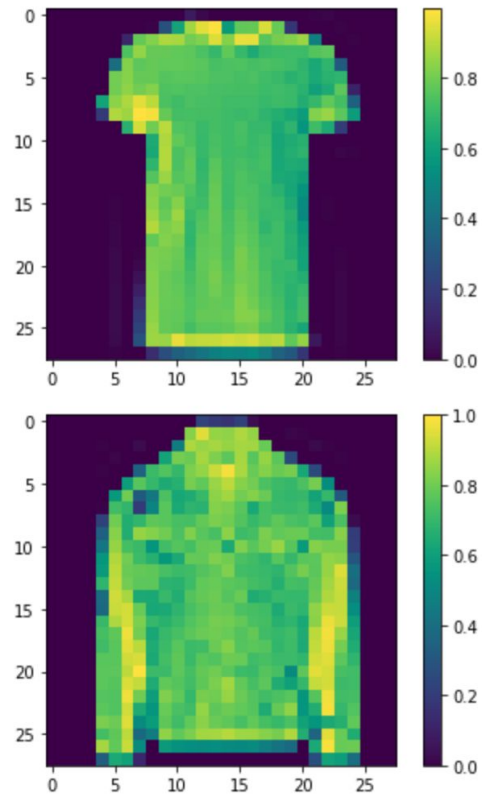
```
model.fit([tr_pairs[:,0], tr_pairs[:,1]], tr_y, # Training data
          epochs=20,
          batch_size=128,
          validation_data=([ts_pairs[:,0], ts_pairs[:,1]], ts_y))
```

```
this_pair = 8
show_image(tr_pairs[this_pair][0])
show_image(tr_pairs[this_pair][1])
print(tr_y[this_pair])
```



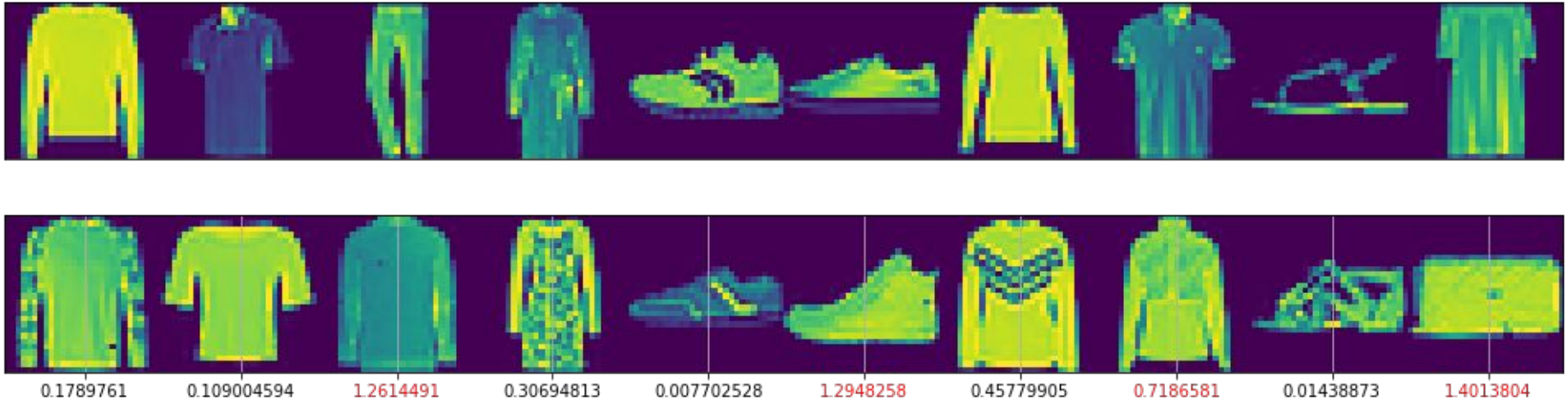
```
1.0
```

```
this_pair = 9
show_image(tr_pairs[this_pair][0])
show_image(tr_pairs[this_pair][1])
print(tr_y[this_pair])
```

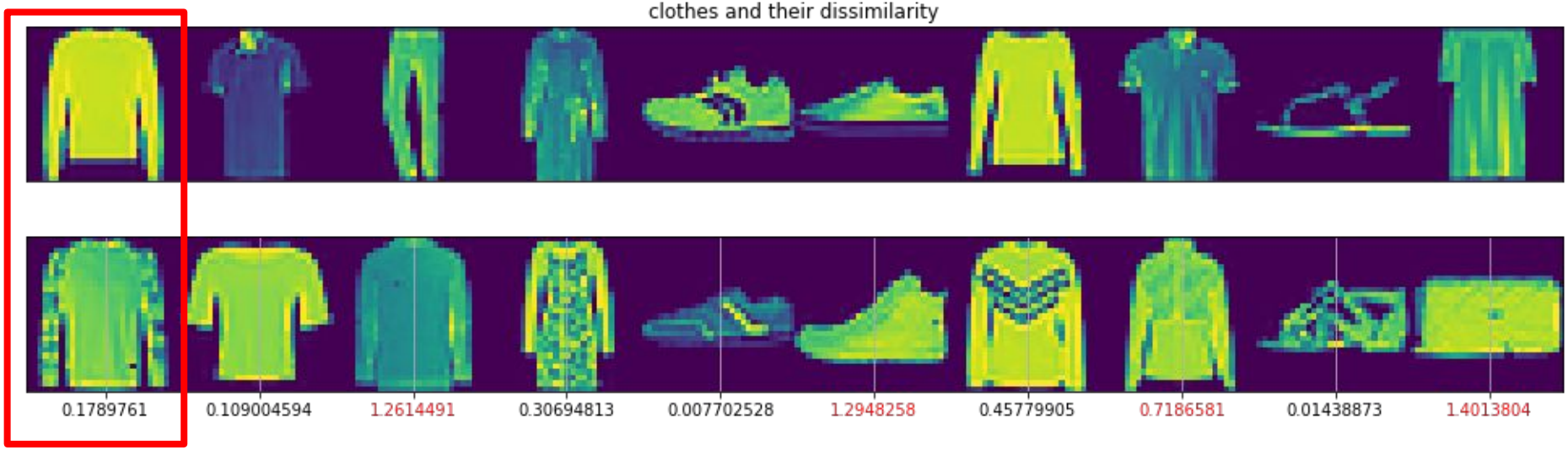


```
0.0
```

clothes and their dissimilarity



clothes and their dissimilarity



clothes and their dissimilarity