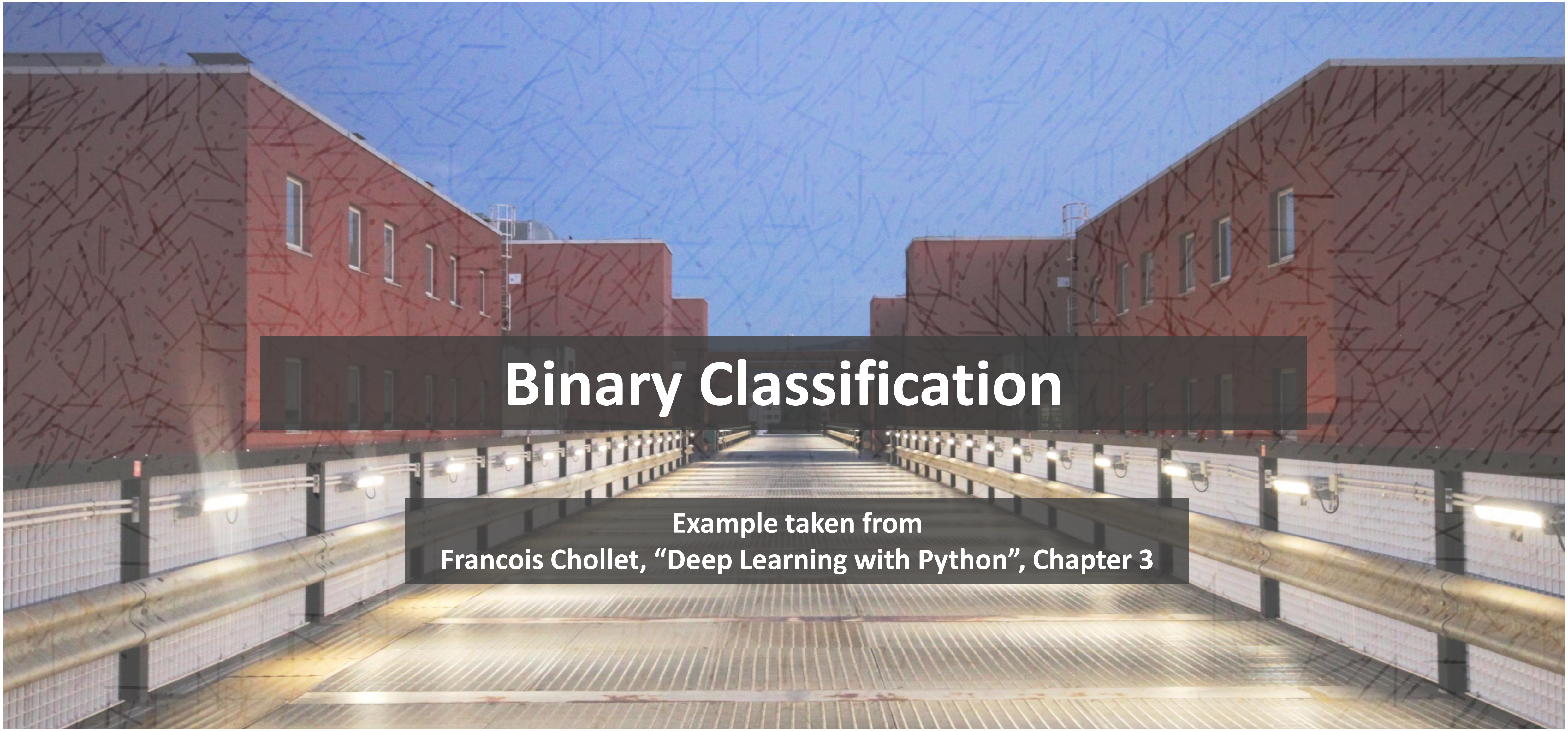
UNIVERSITÀ DELLA CALABRIA



Binary Classification

Example taken from
Francois Chollet, “Deep Learning with Python”, Chapter 3

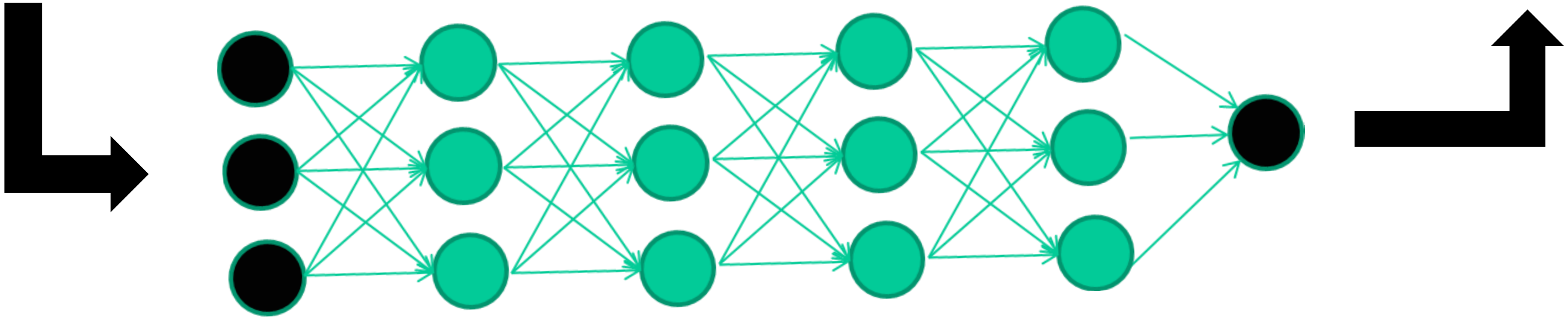
IMDb Dataset

- 50.000 higly polarized reviews from the Internet Movie Database
  - 50% positive and 50% negative
- 25.000 used for traning, and 25.000 used for testing
  - again, 50% positive and 50% negative
- The dataset comes packaged with Keras
  - Each review (sequence of words) is turned into a sequence of integers
  - Each integer stands for a specific word in a dictionary
- Goal
  - Build a classifier predicting whether the review is positive or negative

Loading the Dataset

```
from keras.datasets import imdb

(train_data, train_labels), (test_data, test_labels) = imdb.load_data(num_words=10000)
```

```
train_data[0]     [1, 14, 22, 16, … ]          train_labels[0]   1  #positive
```



Preprocessing

- Input

```
import numpy as np

def vectorize_sequences(sequences, dimension=10000):
    # Create an all-zero matrix of shape (len(sequences), dimension)
    results = np.zeros((len(sequences), dimension))
    for i, sequence in enumerate(sequences):
        results[i, sequence] = 1.  # set specific indices of results[i] to 1s
    return results

# Our vectorized training data
x_train = vectorize_sequences(train_data)
# Our vectorized test data
x_test = vectorize_sequences(test_data)
```

- Output

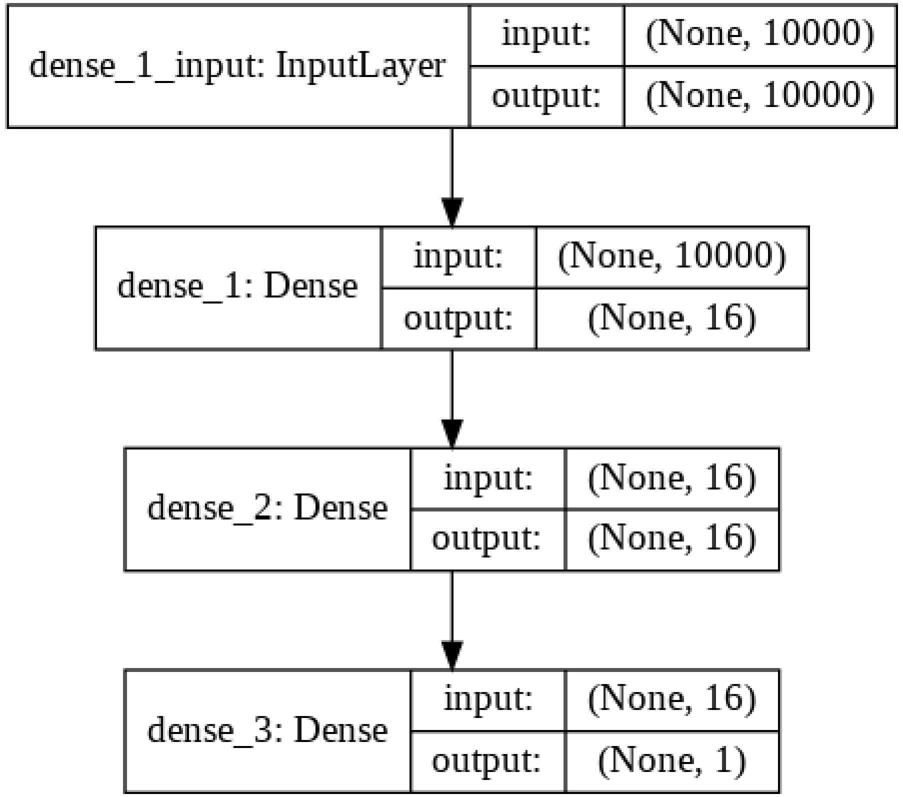
```
# Our vectorized labels
y_train = np.asarray(train_labels).astype('float32')
y_test = np.asarray(test_labels).astype('float32')
```

Define the Network

```
from keras import models
from keras import layers

model = models.Sequential()
model.add(layers.Dense(16, activation='relu', input_shape=(10000,)))
model.add(layers.Dense(16, activation='relu'))
model.add(layers.Dense(1, activation='sigmoid'))


model.compile(optimizer='rmsprop',
              loss='binary_crossentropy',
              metrics=['accuracy'])
```

Plot the Model

```python
from keras.utils.vis_utils import plot_model
plot_model(model, show_shapes=True, show_layer_names=True)
```



dense_1_input: InputLayer | input: (None, 10000) | output: (None, 10000)

dense_1: Dense | input: (None, 10000) | output: (None, 16)

dense_2: Dense | input: (None, 16) | output: (None, 16)

dense_3: Dense | input: (None, 16) | output: (None, 1)

Parameters

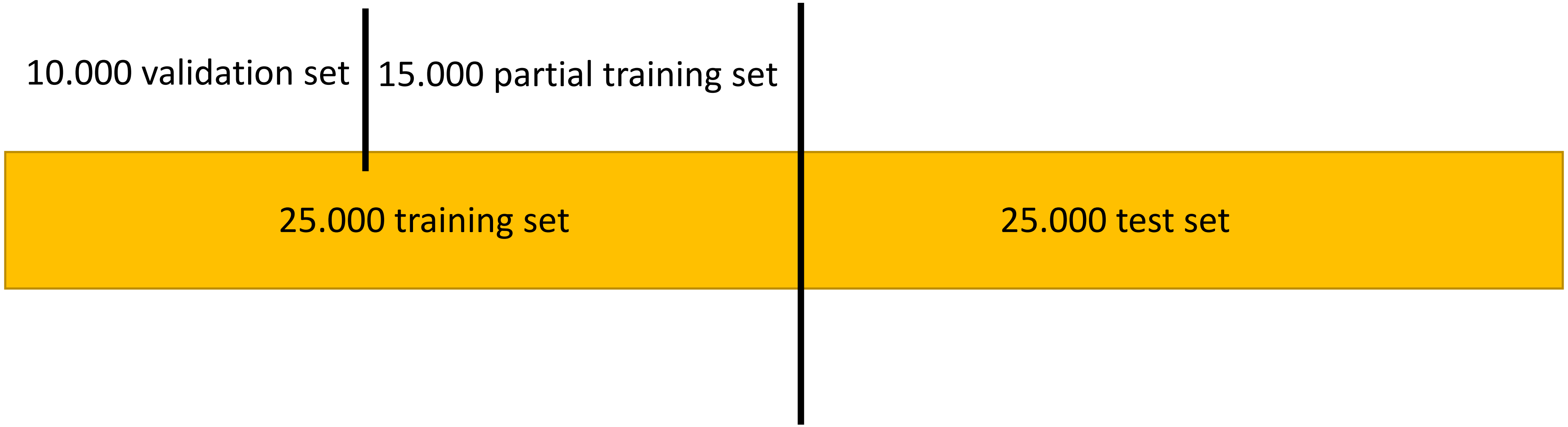
```
model.compile(optimizer='rmsprop',
              loss='binary_crossentropy',
              metrics=['accuracy'])
```

```
from keras import optimizers
from keras import losses
from keras import metrics

model.compile(optimizer=optimizers.RMSprop(lr=0.001),
              loss=losses.binary_crossentropy,
              metrics=[metrics.binary_accuracy])
```

Validation Set

- It is needed to monitor the performances of the network

```
x_val = x_train[:10000]
partial_x_train = x_train[10000:]

y_val = y_train[:10000]
partial_y_train = y_train[10000:]
```

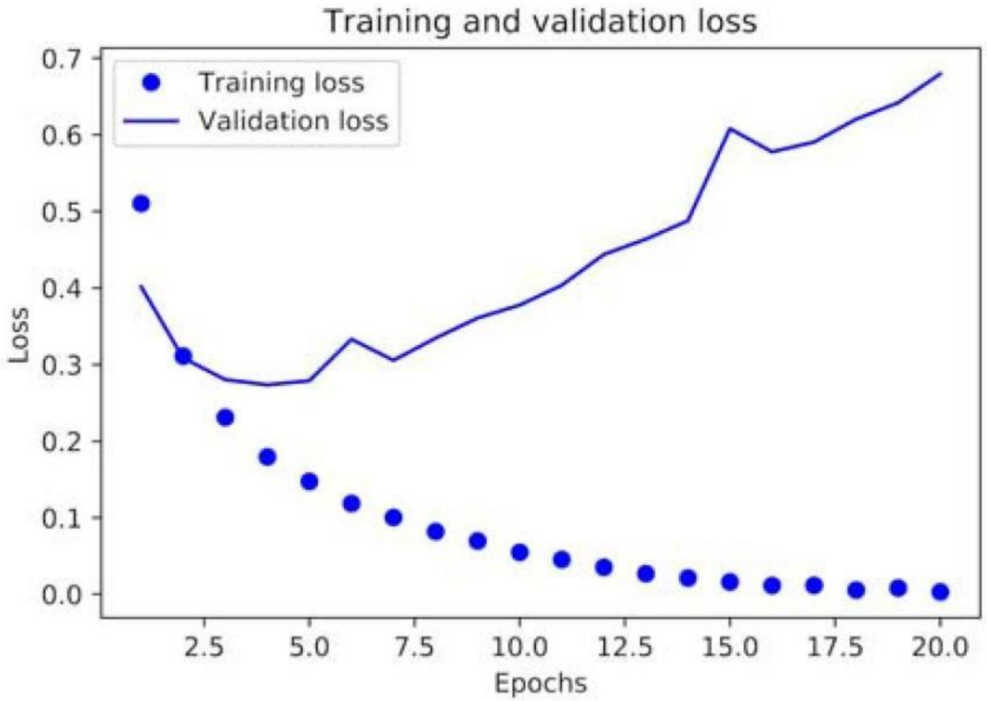


Training

```
history = model.fit(partial_x_train,
                    partial_y_train,
                    epochs=20,
                    batch_size=512,
                    validation_data=(x_val, y_val))
```

Traning and Validation Loss

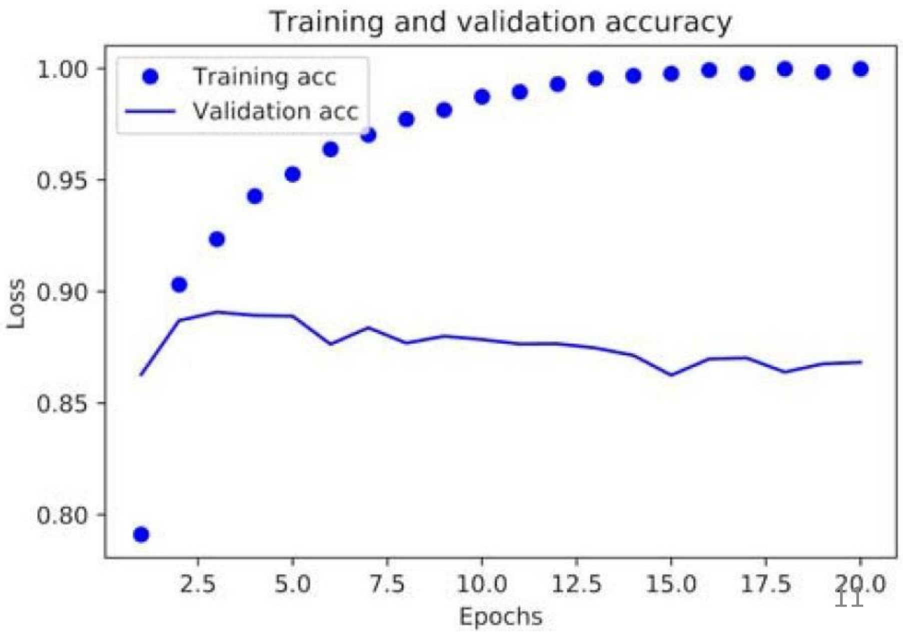
```
import matplotlib.pyplot as plt
loss = history.history['loss']
val_loss = history.history['val_loss']
epochs = range(1, len(loss) + 1)
# "bo" is for "blue dot"
plt.plot(epochs, loss, 'bo', label='Training loss')
# b is for "solid blue line"
plt.plot(epochs, val_loss, 'b', label='Validation loss')
plt.title('Training and validation loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.show()
```



Training and Validation Accuracy

```
plt.clf()   # clear figure
acc = history_dict['binary_accuracy']
val_acc = history_dict['val_binary_accuracy']

plt.plot(epochs, acc, 'bo', label='Training acc')
plt.plot(epochs, val_acc, 'b', label='Validation acc')
plt.title('Training and validation accuracy')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()

plt.show()
```

Overfitting



Early Stopping

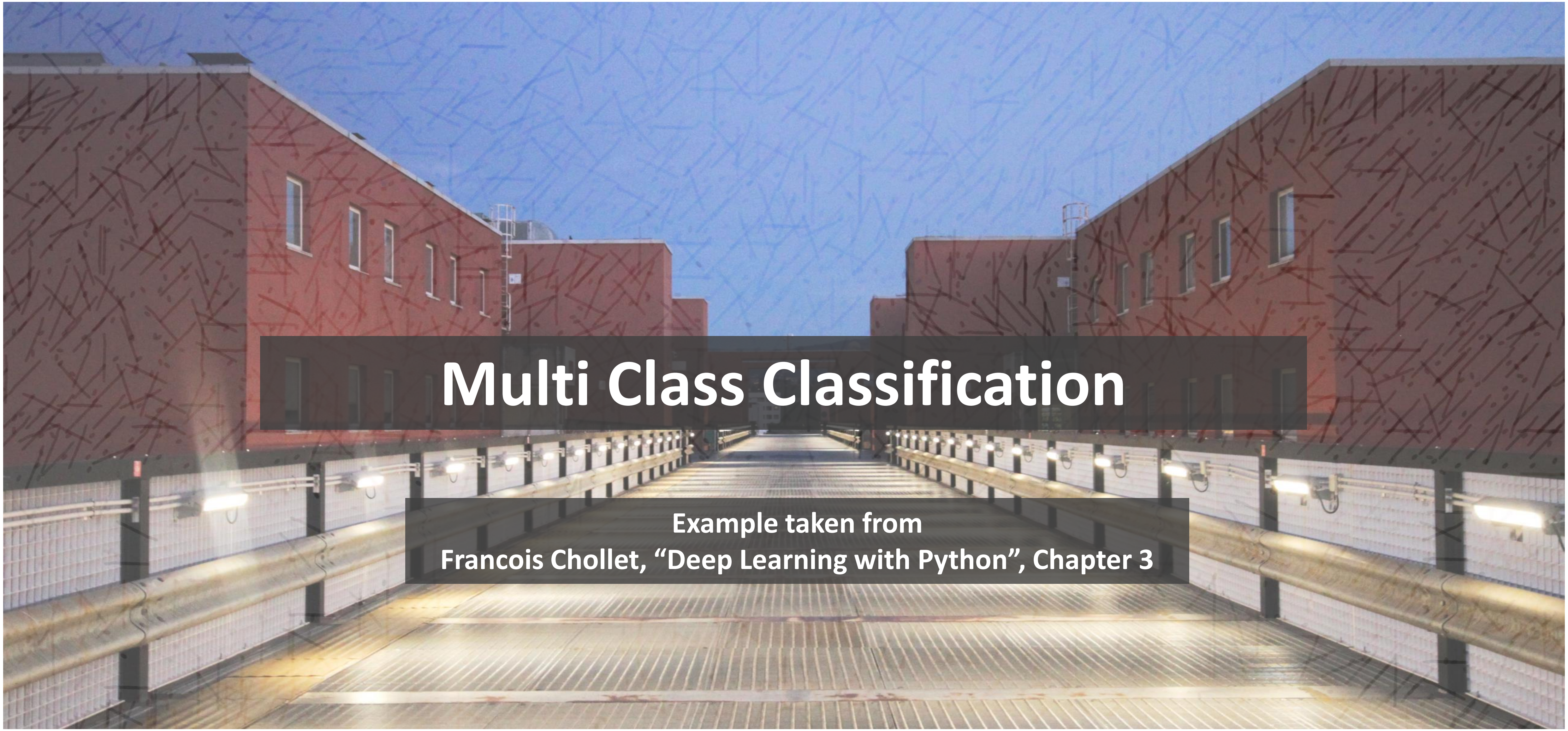
```
model = models.Sequential()
model.add(layers.Dense(16, activation='relu', input_shape=(10000,)))
model.add(layers.Dense(16, activation='relu'))
model.add(layers.Dense(1, activation='sigmoid'))

model.compile(optimizer='rmsprop',
              loss='binary_crossentropy',
              metrics=['accuracy'])

model.fit(x_train, y_train, epochs=4, batch_size=512)
results = model.evaluate(x_test, y_test)
```

```
[0.29184698499679568, 0.88495999999999997]
```

Prediction

```
model.predict(x_test)
```

```
array([[ 0.91966152], [ 0.86563045], [ 0.99936908], ..., [ 0.45731062], [
0.0038014 ], [ 0.79525089]], dtype=float32
```



Multi Class Classification

Example taken from
Francois Chollet, “Deep Learning with Python”, Chapter 3

Reuters Dataset

- A set of short newswires and their topics, published by Reuters in 1986
- It's a very simple, widely used toy dataset for text classification
- There are 46 different topics; some topics are more represented than others, but each topic has at least 10 examples in the training set

Loading the Dataset

```
from keras.datasets import reuters

(train_data, train_labels),(test_data, test_labels)=reuters.load_data(num_words=10000)
```

Preprocessing: Input

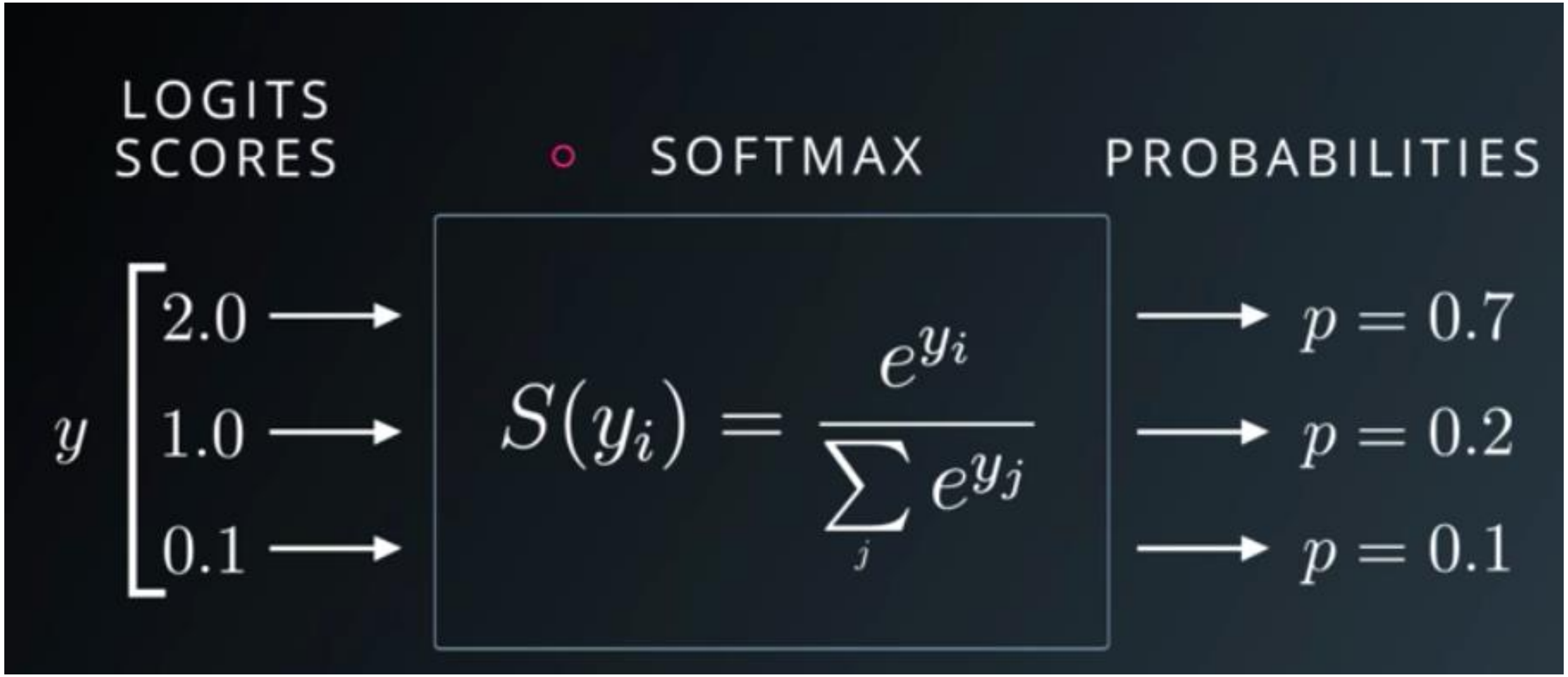
```
import numpy as np

def vectorize_sequences(sequences, dimension=10000):
    results = np.zeros((len(sequences), dimension))
    for i, sequence in enumerate(sequences):
        results[i, sequence] = 1.
    return results

# Our vectorized training data
x_train = vectorize_sequences(train_data)
# Our vectorized test data
x_test = vectorize_sequences(test_data)
```

Preprocessing: Output

```
def to_one_hot(labels, dimension=46):
    results = np.zeros((len(labels), dimension))
    for i, label in enumerate(labels):
        results[i, label] = 1.
    return results

# Our vectorized training labels
one_hot_train_labels = to_one_hot(train_labels)
# Our vectorized test labels
one_hot_test_labels = to_one_hot(test_labels)
```

```
from keras.utils.np_utils import to_categorical

one_hot_train_labels = to_categorical(train_labels)
one_hot_test_labels = to_categorical(test_labels)
```

Softmax Activation



Define the Network

```
from keras import models
from keras import layers

model = models.Sequential()
model.add(layers.Dense(64, activation='relu', input_shape=(10000,)))
model.add(layers.Dense(64, activation='relu'))
model.add(layers.Dense(46, activation='softmax'))
```

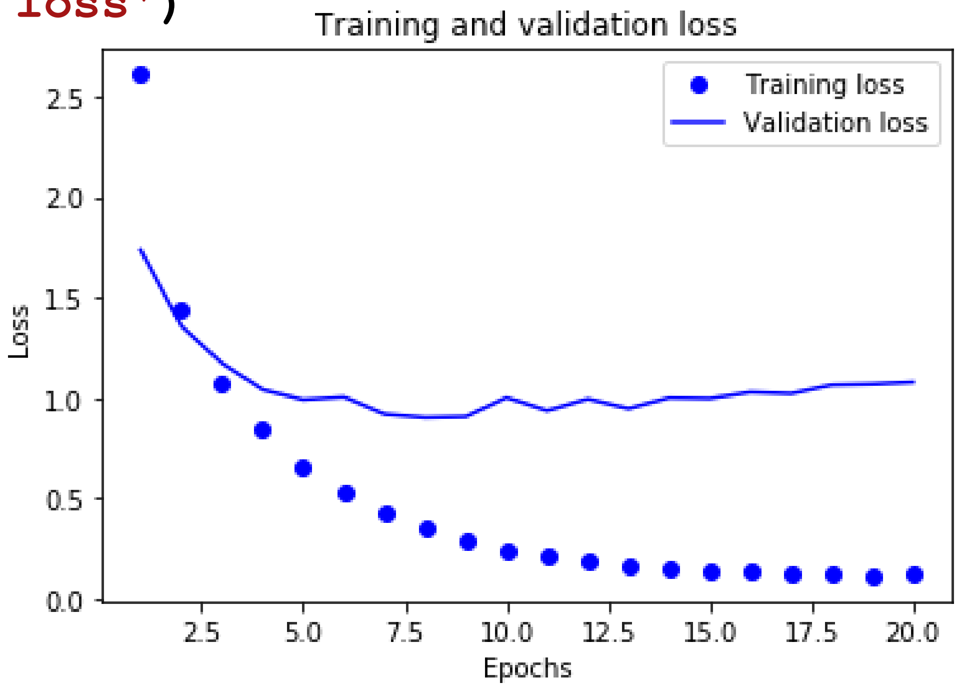
```
model.compile(optimizer='rmsprop',
              loss='categorical_crossentropy',
              metrics=['accuracy'])
```

Validation Set and Training

```
x_val = x_train[:1000]
partial_x_train = x_train[1000:]

y_val = one_hot_train_labels[:1000]
partial_y_train = one_hot_train_labels[1000:]



history = model.fit(partial_x_train,
                    partial_y_train,
                    epochs=20,
                    batch_size=512,
                    validation_data=(x_val, y_val))
```

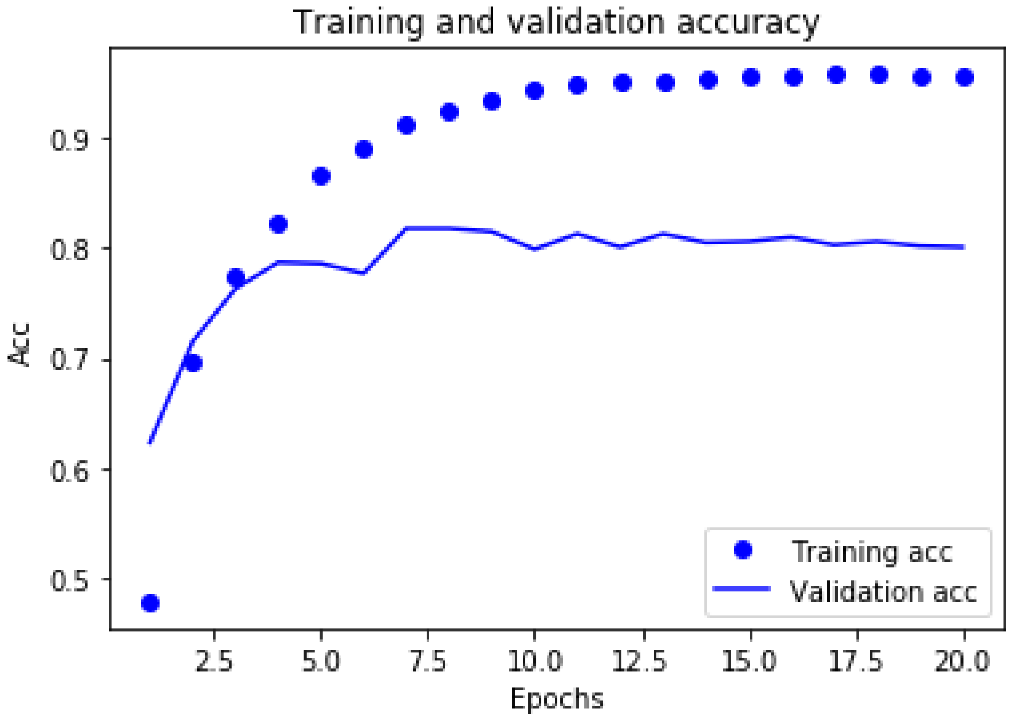
Loss Function

```
import matplotlib.pyplot as plt

loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(1, len(loss) + 1)

plt.plot(epochs, loss, 'bo', label='Training loss')
plt.plot(epochs, val_loss, 'b', label='Validation loss')
plt.title('Training and validation loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()

plt.show()
```



Accuracy

```
plt.clf()   # clear figure

acc = history.history['acc']
val_acc = history.history['val_acc']

plt.plot(epochs, acc, 'bo', label='Training acc')
plt.plot(epochs, val_acc, 'b', label='Validation acc')
plt.title('Training and validation accuracy')
plt.xlabel('Epochs')
plt.ylabel('Acc')
plt.legend()

plt.show()
```



Dealing with Overfitting

```
model = models.Sequential()
model.add(layers.Dense(64, activation='relu', input_shape=(10000,)))
model.add(layers.Dense(64, activation='relu'))
model.add(layers.Dense(46, activation='softmax'))

model.compile(optimizer='rmsprop',
              loss='categorical_crossentropy',
              metrics=['accuracy'])
model.fit(partial_x_train,
          partial_y_train,
          epochs=8,
          batch_size=512,
          validation_data=(x_val, y_val))
results = model.evaluate(x_test, one_hot_test_labels)
```

Different Encoding Approaches

- Use integer labels

```
y_train = np.array(train_labels)
y_test = np.array(test_labels)
```

- Select the loss function (sparse_categorical_crossentropy)

```
model.compile(optimizer='rmsprop’ ,
              loss='sparse_categorical_crossentropy’ ,
              metrics=['acc'])
```