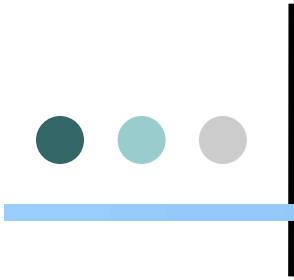
Chapter 3:

Neural networks



Outlines

1. Anatomy of neural networks
2. Introduction to Keras
3. Keras in practice

Keras in practice

3. Keras environment setting
   - It's highly recommended to run deep-learning code on a modern NVIDIA GPU.
     - ✓ Some applications will be excruciatingly slow on a CPU, even a fast multicore CPU.
     - ✓ Speed increases by a factor of 5 or 10 by using a modern GPU compared to using a CPU.
   - If you don't want to install a GPU on your machine, you can run your experiments on Google Cloud Platform.
   - In order to use Keras, it is necessary to install TensorFlow, CNTK, Theano, or all of those.

Keras in practice

3. Keras environment setting
   - Google Colab.

https://colab.research.google.com/#

   - Jupyter notebooks.

https://jupyter.org/

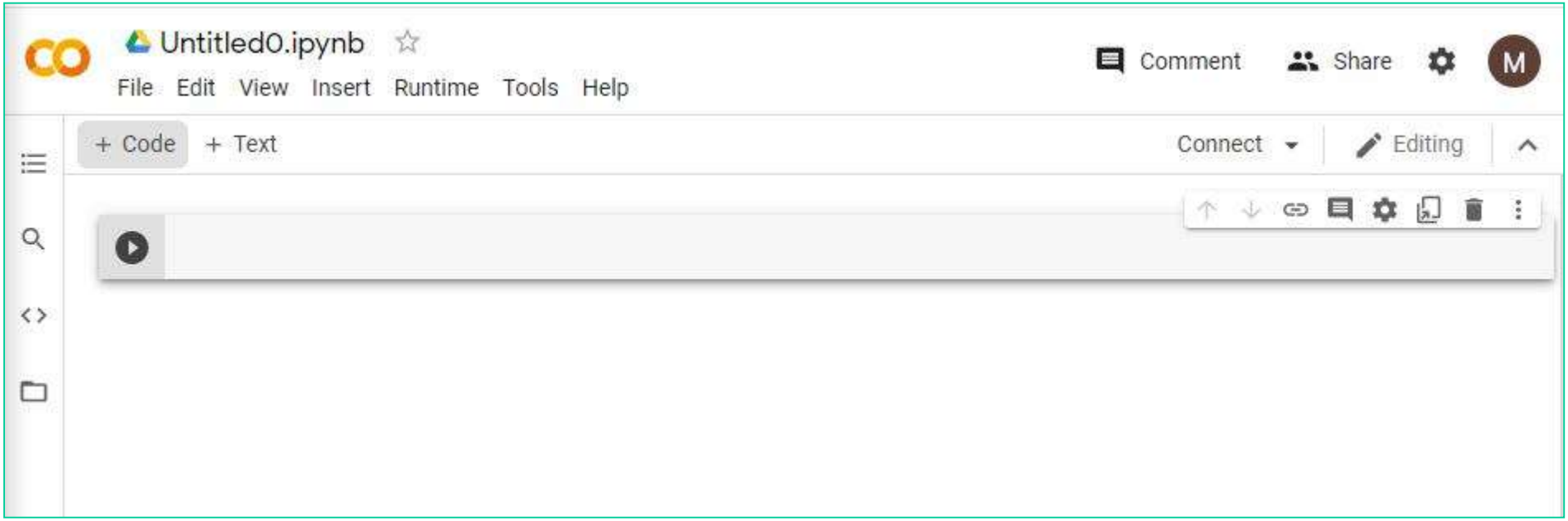
   - Server
   - Worstaion
   - Personal computer

Keras in practice

- Google colab:
  - Google colab is a google utility, a cloud service, free.
  - Colab doesn't require complex setup. The notebooks we create can be edited simultaneously by team members - much like you would edit a document in Google Docs.
  - The biggest advantage is that Colab supports most popular machine learning libraries and can be simple when installing a new library.

Keras in practice

- Google colab:



Keras in practice

- Google colab:
  - Connect Colab to Google Drive

```
[ ]  from google.colab import drive
     drive.mount('/content/gdrive')

     Go to this URL in a browser: https://accounts.google.com/o/

     Enter your authorization code:
     ··········
     Mounted at /content/gdrive
```

Keras in practice

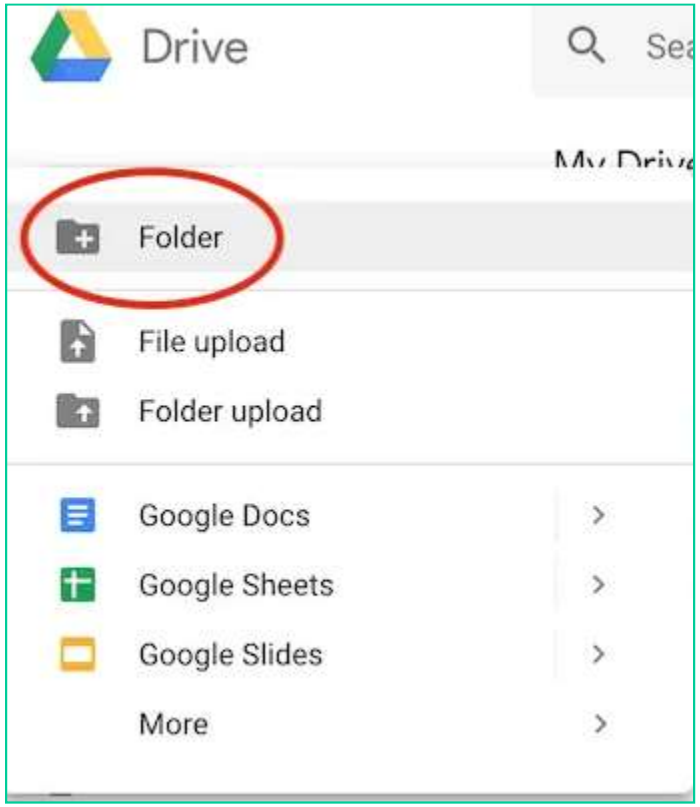
- Google colab:
  - Write and execute code in Python
  - Create/Upload/Share notebook files
  - Import/save notebooks to Google Drive
  - Import notebooks from GitHub
  - PyTorch, TensorFlow, Keras, OpenCV built-in
  - Free cloud service with free GPUs, GPU upgradeable using paid GPUs.

Keras in practice

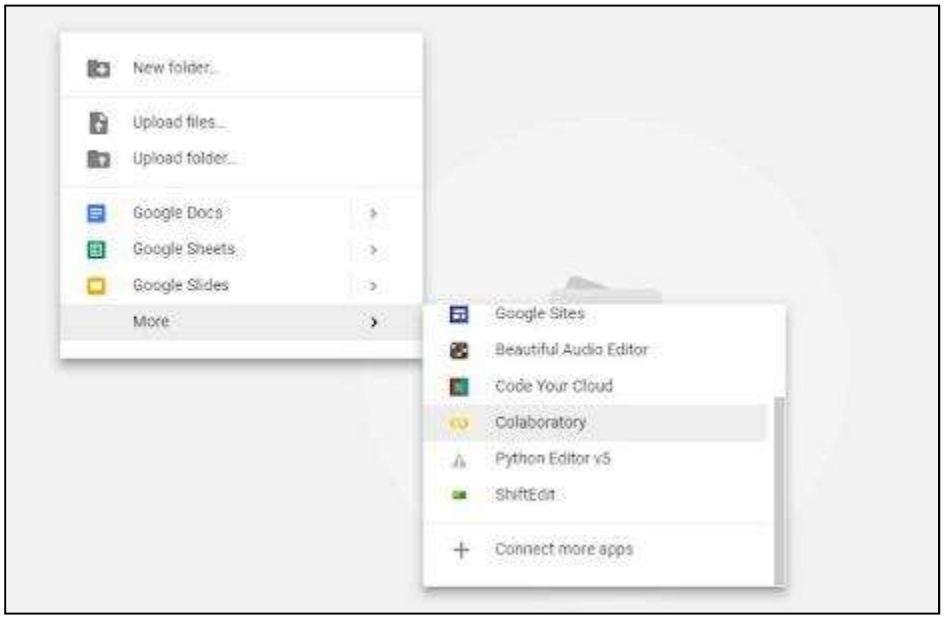
- Google colab:
  - To use Colaboratory, you must have a Google account and then access Colaboratory with that account. Otherwise, most of Colaboratory's features will not work.
  - To create a google colab file, first we access the folder on google drive where we want to create the colab file, then right-click and select the "Colaboratory" option.

Keras in practice

- Google colab:



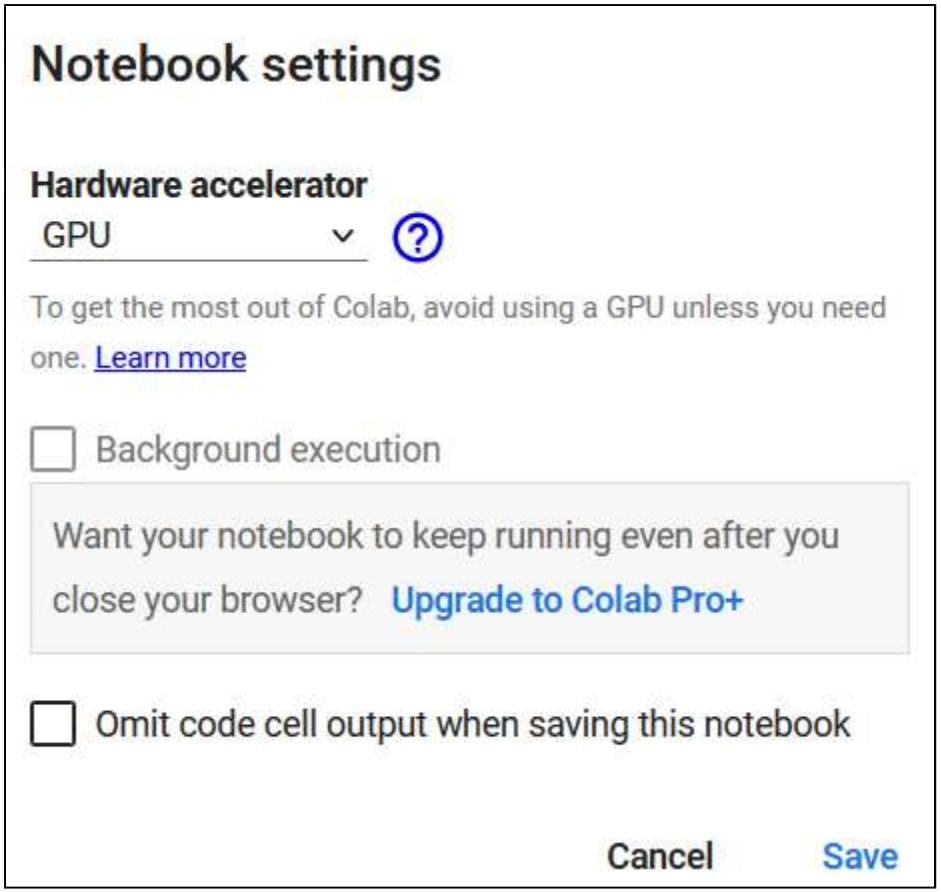
Create a folder on Google Drive



Tạo Notebook trên Colab

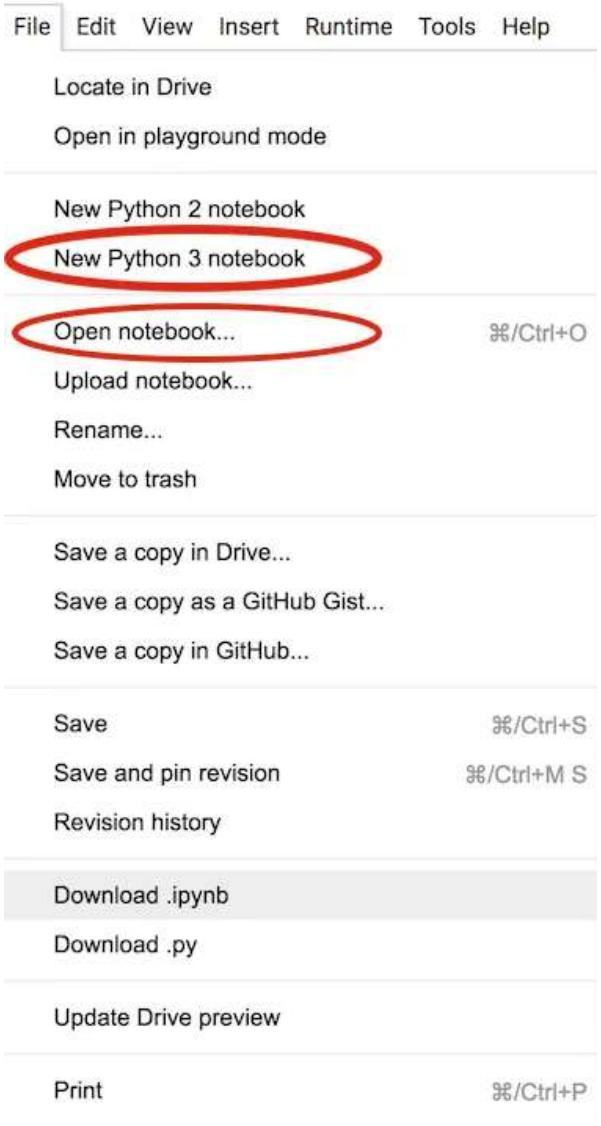
Keras in practice

- Google colab:
  - Select GPU:
  - ✓ Select “runtime”.
  - ✓ Select “change runtime type”.
  - ✓ Select “GPU” from “hardware accelerator”



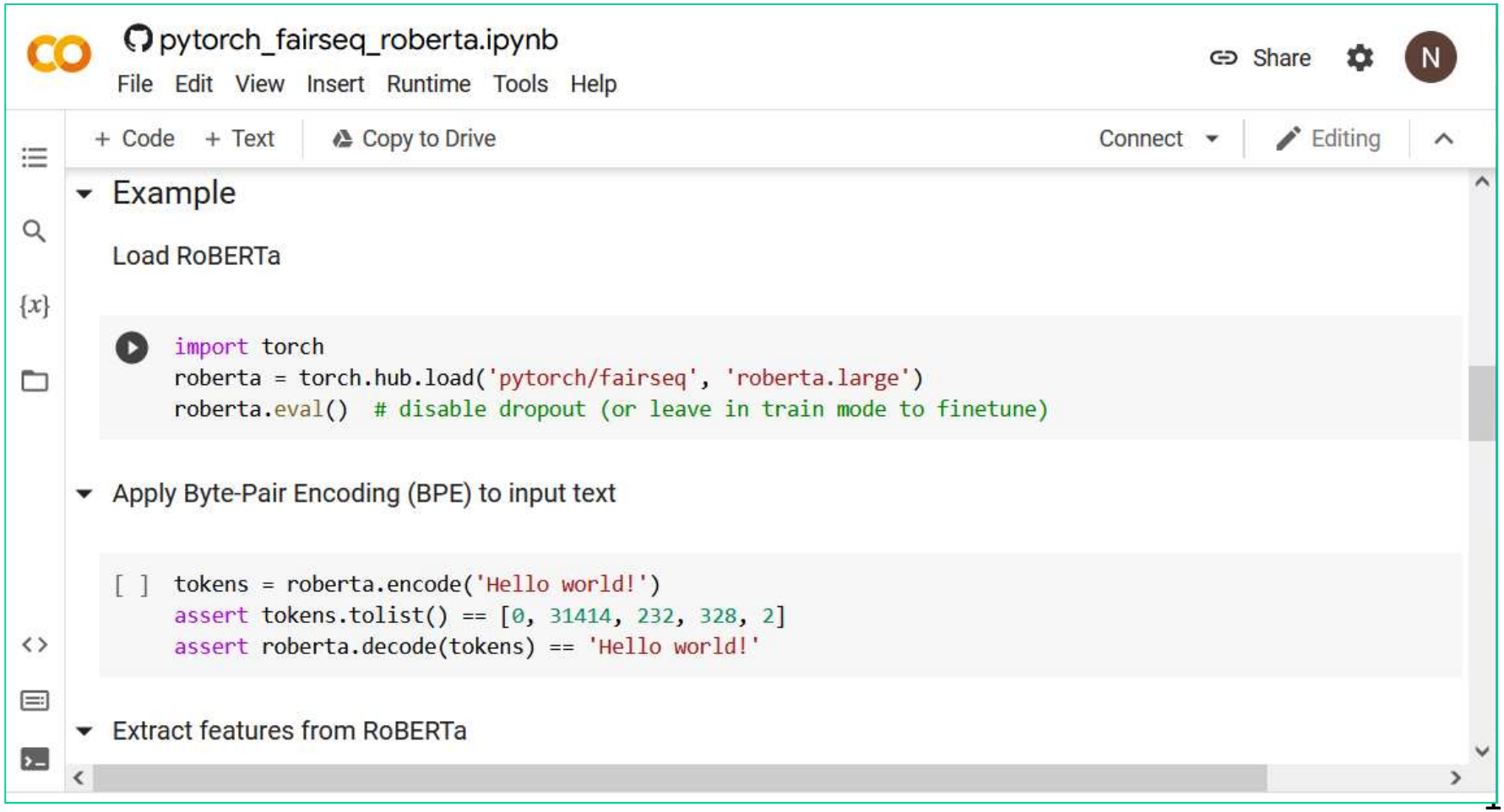
Keras in practice

- Google colab:
  - Reopen or create a new notebook.



Keras in practice

- Google colab:

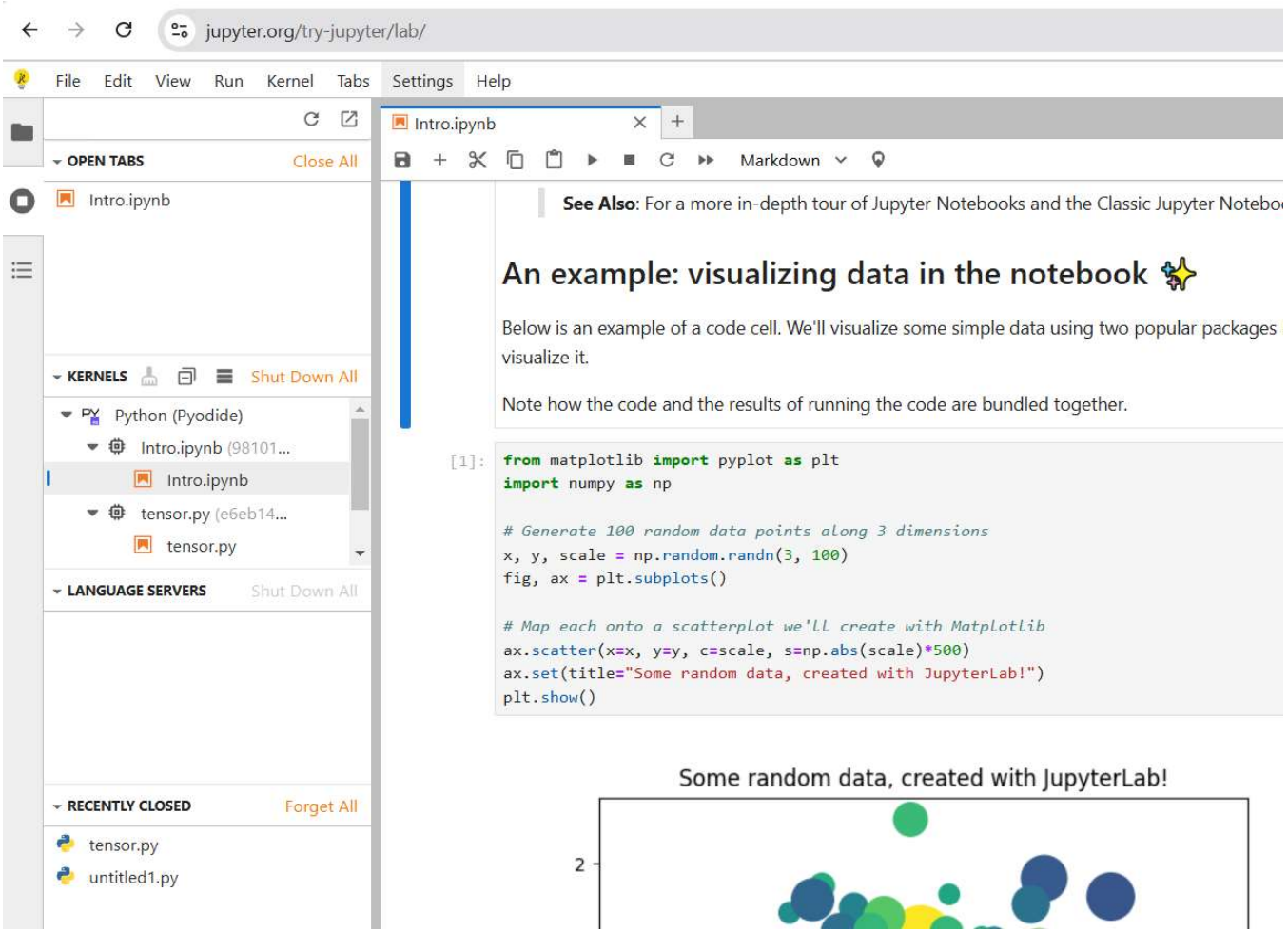


Keras in practice

- Jupyter notebooks:
  - Jupyter notebooks are a great way to run deep-learning experiments.
  - Jupyter notebook, formerly known as IPython (or Interactive Python), is a flexible and powerful open source research tool.
  - It is widely used in the data-science and machine-learning communities.
  - The name Jupyter is an acronym of the three core languages it was designed for: JUlia, PYThon, and R.
  - Project Jupyter supports interactive data science and scientific computing across more than 40 programming languages.

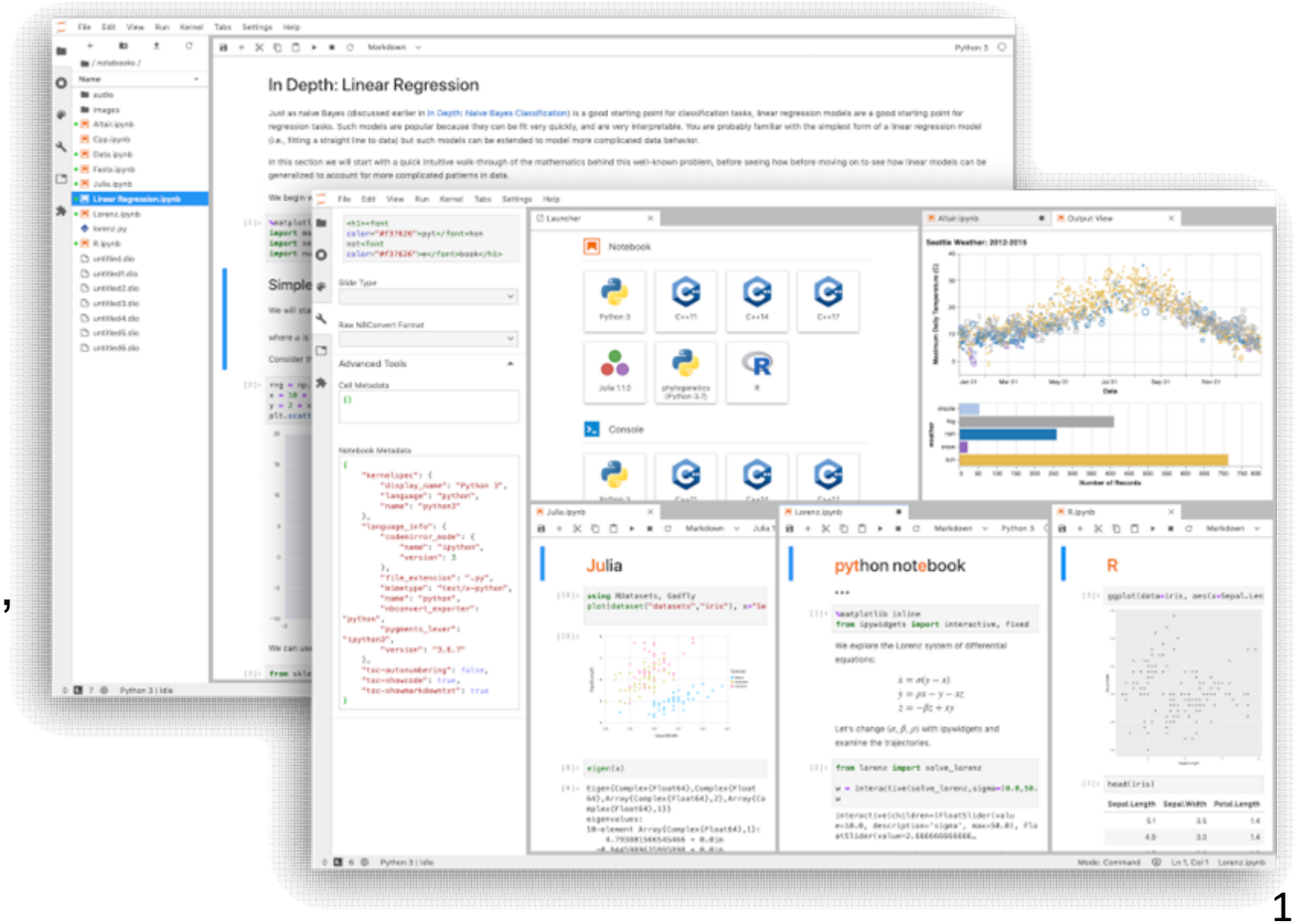
Keras in practice

- Jupyter notebooks:



Keras in practice

- Jupyter notebooks:
  - JupyterLab is the latest web-based interactive development environment for notebooks, code, and data



Keras in practice

4. Keras examples 1: Classifying movie reviews
   - This project classifies movie reviews as positive or negative based on the text content of the reviews.
   - The dataset used for this project is IMDB (Internet Movie Database).
   - The IMDB dataset has 25,000 reviews for training and 25,000 reviews for testing, each set consisting of 50% negative and 50% positive reviews.
   - The IMDB dataset comes packaged with Keras.
   - The reviews (sequences of words) have been turned into sequences of integers, each integer stands for a specific word in a dictionary.

Keras in practice

4. Keras examples 1: Classifying movie reviews

- Load the dataset:

```
from keras.datasets import imdb
(train_data, train_labels), (test_data, test_labels) = imdb.load_data(
num_words=10000)
print(train_data[0])
```

- The argument num_words=10000 means we'll only keep the top 10,000 most frequently occurring words in the training data.

- Each integer stands for a specific word in a dictionary.

```
C:\Users\Study\AppData\Local\Programs\Python\Python38\python.exe C:/Projects/Python4AI/iMDB.py
[1, 14, 22, 16, 43, 530, 973, 1622, 1385, 65, 458, 4468, 66, 3941, 4, 173, 36, 256, 5, 25, 100,
```

Keras in practice

4. Keras examples 1: Classifying movie reviews

- We can quickly decode one of these reviews back to English words:

```
word_index = imdb.get_word_index()
reverse_word_index = dict(
    [(value, key) for (key, value) in word_index.items()])
decoded_review = ' '.join(
    [reverse_word_index.get(i - 3, '?') for i in train_data[0]])
```

word_index is a dictionary mapping words to an integer index.

Reverses it, mapping integer indices to words

Decodes the review. Note that the indices are offset by 3 because 0, 1, and 2 are reserved indices for "padding," "start of sequence," and "unknown."

Keras in practice

4. Keras examples 1: Classifying movie reviews
   - Preparing the data
     - ✓ We can't feed lists of integers into a neural network. We have to turn your lists into tensors.
     - ✓ There are two ways to do that:
       - Padding: Lists are padded to the same length and converted into an integer tensor, which is then processed using an Embedding layer.
       - One-hot encoding: Lists are transformed into high-dimensional binary vectors, where only specific indices are set to 1. These vectors can be fed into a Dense layer.

Keras in practice

4. Keras examples 1: Classifying movie reviews

- Preparing the data
  - ✓ Encoding the integer sequences into a binary matrix

```
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

x_train = vectorize_sequences(train_data)
x_test = vectorize_sequences(test_data)
```

Creates an all-zero matrix of shape (len(sequences), dimension)

Sets specific indices of results[i] to 1s

Vectorized training data

Vectorized test data

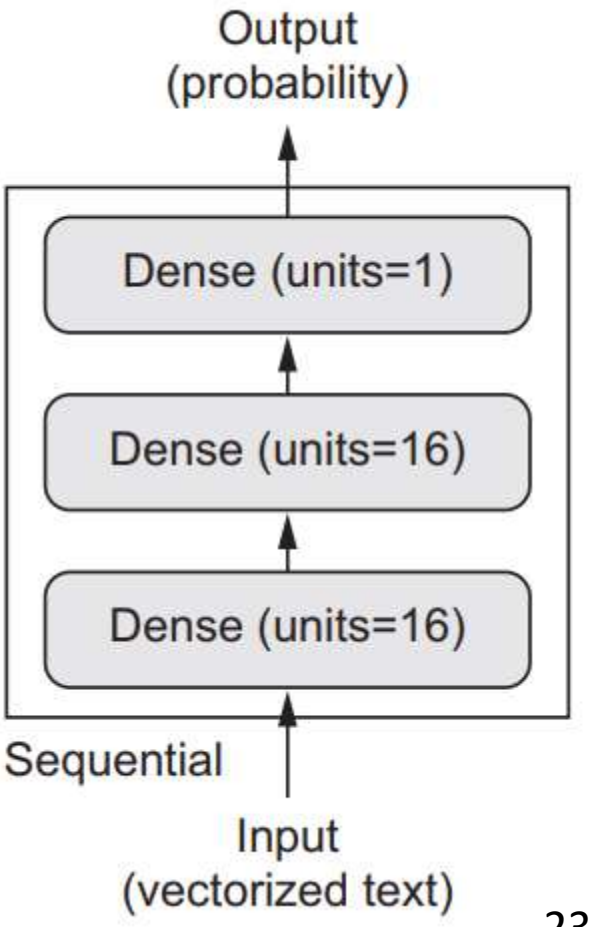
Keras in practice

4. Keras examples 1: Classifying movie reviews
   - Preparing the data
     - ✓ We should also vectorize your labels, which is straightforward:

```
y_train = np.asarray(train_labels).astype('float32')
y_test = np.asarray(test_labels).astype('float32')
```

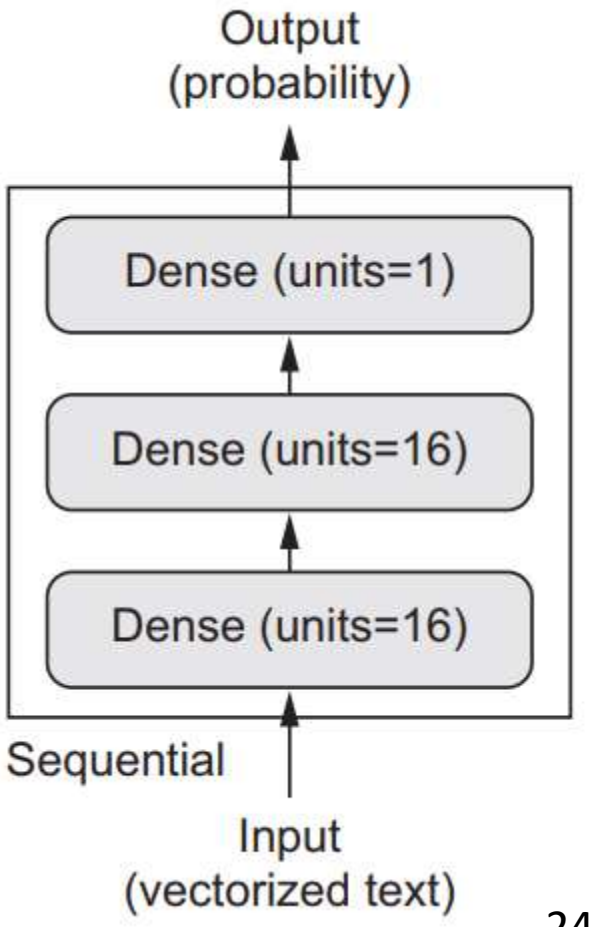
Keras in practice

4. Keras examples 1: Classifying movie reviews
   - Building the network:
     - ✓ The three-layer network
     - ✓ Having 16 hidden units means the weight matrix W will have shape (input_dimension, 16): the dot product with W will project the input data onto a 16-dimensional representation space.
     - ✓ Having more hidden units (a higher-dimensional representation space) allows the network to learn more-complex representations.



Keras in practice

4. Keras examples 1: Classifying movie reviews
   - Building the network:
     - ✓ Two intermediate layers with 16 hidden units each.
     - ✓ A third layer that will output the scalar prediction regarding the sentiment of the current review.



Keras in practice

4. Keras examples 1: Classifying movie reviews
   - Building the network:

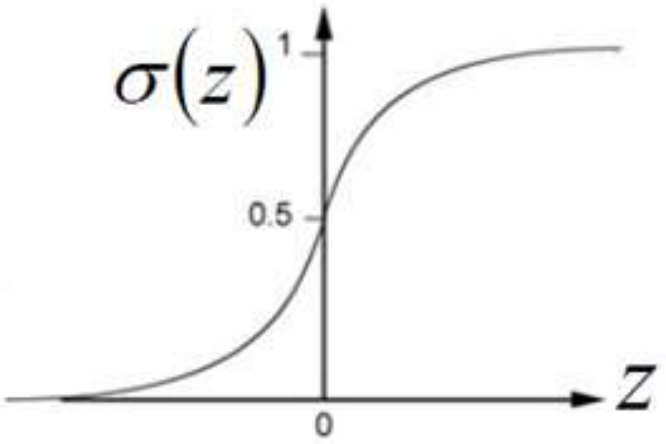
```
from keras import models
from keras import layers

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'))
```

- ✓ The ReLU (rectified linear unit) is a function meant to zero out negative values.
- ✓ The sigmoid function “squashes” arbitrary values into the [0, 1] interval, outputting something that can be interpreted as a probability.

Keras in practice

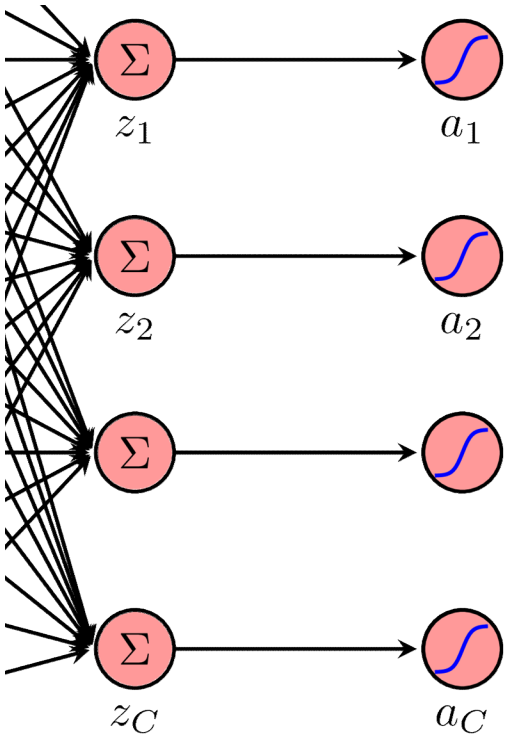
- Sigmoid function

$$\sigma(z) = \frac{1}{1+e^{-z}}$$



Học sâu (deep learning)

- Softmax function
  - Often used in the output layer to calculate the probability for each label.



✓ Create a relationship for the ai values to determine the labels at the output:

$$a_i = \frac{\exp(z_i)}{\sum_{j=1}^{C} \exp(z_j)}, \quad \forall i = 1, 2, \ldots, C$$

$$\Rightarrow \sum_{1}^{i} a_i = 1$$

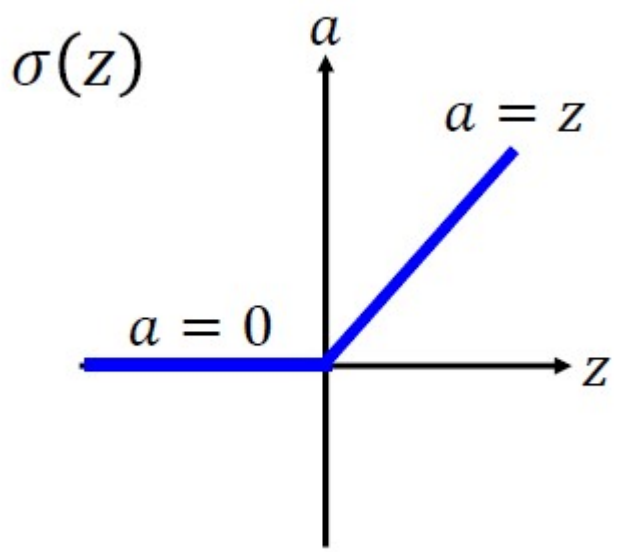
$$\mathbf{a} = \text{softmax}(\mathbf{z}) \in \mathbb{R}^C$$

✓ Calculate the probability for each a_i

Keras in practice

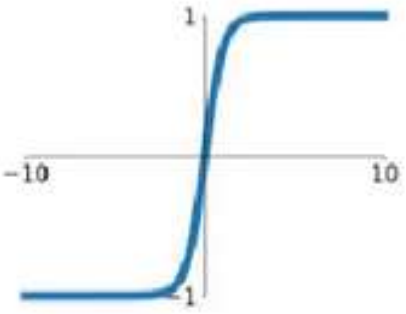
- ReLU (Rectified Linear Unit)
  - Quick calculation

$$f(z) = max(0,z)$$



- tanh

$$\tanh(x) = \frac{e^x - e^{-x}}{e^x + e^{-x}}$$



Keras in practice

4. Keras examples 1: Classifying movie reviews
   - Compiling the model:

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

- ✓ Crossentropy is usually the best choice when we're dealing with models that output probabilities.
- ✓ Crossentropy is a quantity from the field of Information Theory that measures the distance between probability distributions or, in this case, between the ground-truth distribution and our predictions.

Keras in practice

4. Keras examples 1: Classifying movie reviews
   - Training model:

```
47  # Validation data
48  x_val = x_train[:10000]
49  partial_x_train = x_train[10000:]
50  y_val = y_train[:10000]
51  partial_y_train = y_train[10000:]
52
53  # Training your model
54  history = model.fit(partial_x_train,
55                      partial_y_train,
56                      epochs=20,
57                      batch_size=512,
58                      validation_data=(x_val, y_val))
```

Keras in practice

4. Keras examples 1: Classifying movie reviews
   - Training model:
     - ✓ The call to model.fit() returns a History object. This object has a member history, which is a dictionary containing data about everything that happened during training.

```
history_dict = history.history
print(history_dict.keys())
```

```
dict_keys(['loss', 'accuracy', 'val_loss', 'val_accuracy'])
```

Keras in practice

4. Keras examples 1: Classifying movie reviews
   - Plotting the training and validation loss:

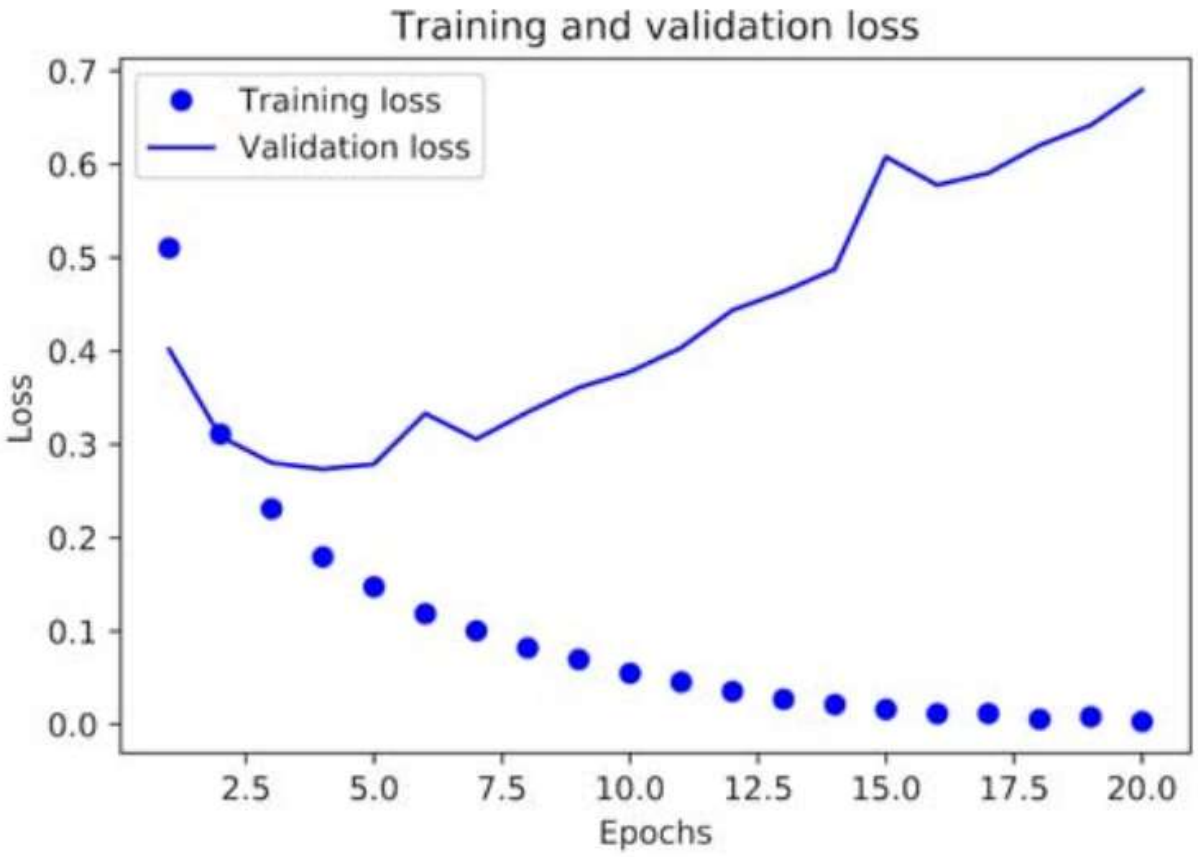
```
import matplotlib.pyplot as plt

history_dict = history.history
loss_values = history_dict['loss']
val_loss_values = history_dict['val_loss']

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

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

plt.show()
```

"bo" is for "blue dot."

"b" is for "solid blue line."

Keras in practice

4. Keras examples 1: Classifying movie reviews
   - Plotting the training and validation loss:



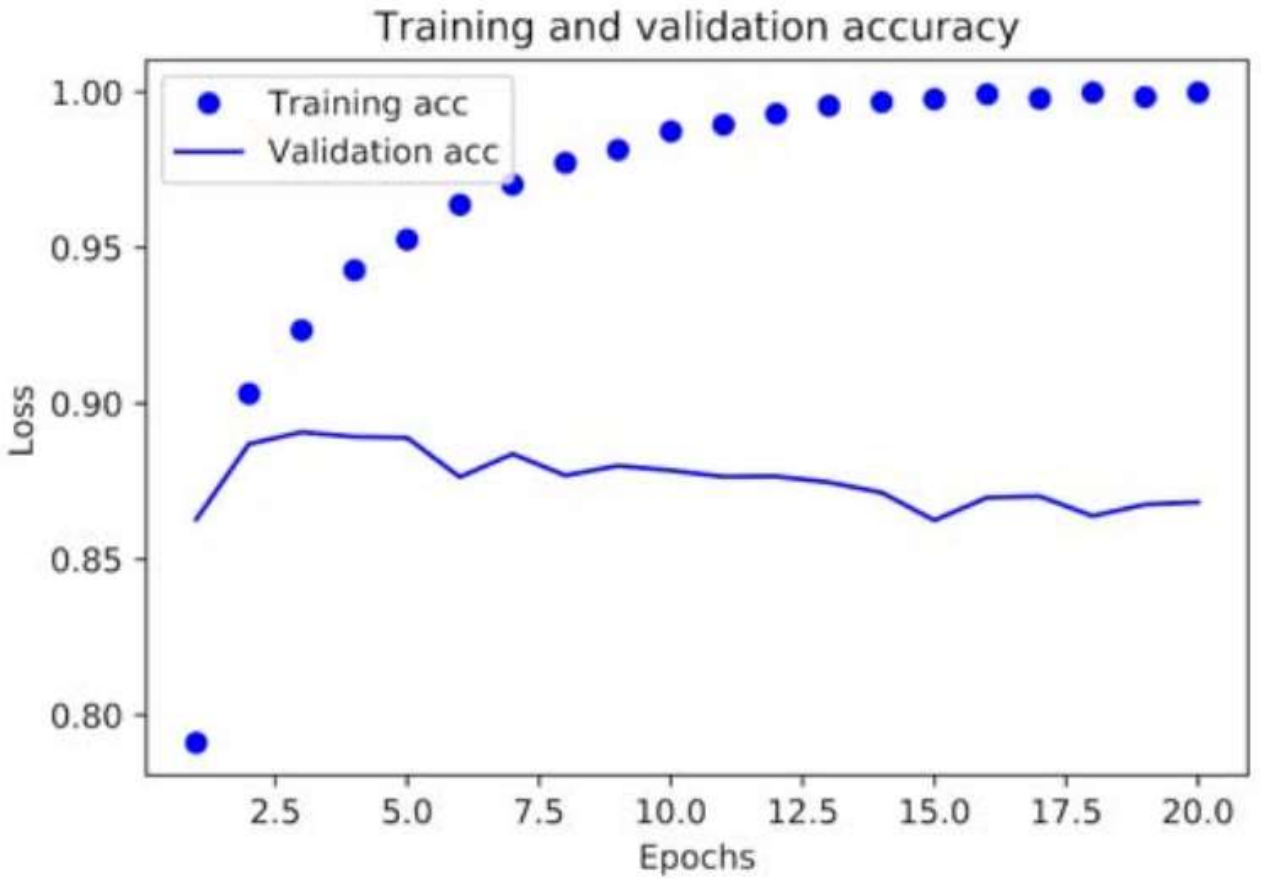
Keras in practice

4. Keras examples 1: Classifying movie reviews
   - Plotting the training and validation accuracy:

```
plt.clf()                          <-- Clears the figure
acc_values = history_dict['acc']
val_acc_values = history_dict['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('Loss')
plt.legend()

plt.show()
```

Keras in practice

4. Keras examples 1: Classifying movie reviews
   - Plotting the training and validation accuracy:



Keras in practice

4. Keras examples 1: Classifying movie reviews
   - Test:

```
results = model.evaluate(x_test, y_test)
print(results)
```

```
[0.2929924130630493, 0.88327999999999995]
```