P0: Introduction to Keras

Natural Language Understanding

Interuniversity Master’s Degree in Artificial Intelligence
Academic Year 2023-2024

UNIVERSIDADE DA CORUÑA

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UniversidadeVigo

v1

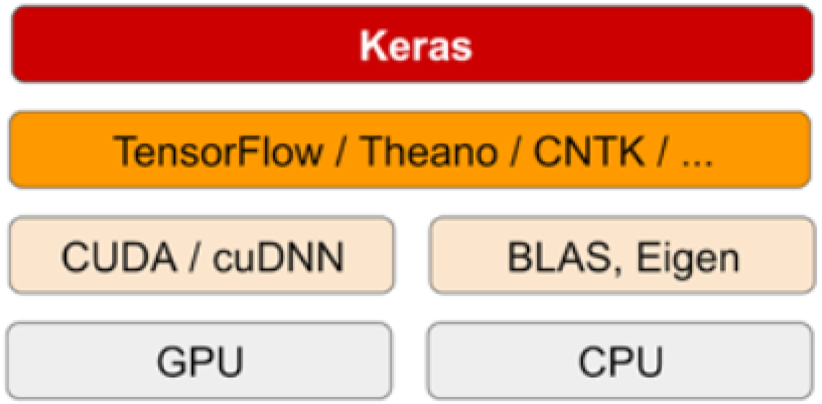
Objectives P0

- Introduce Keras and programming environments for Python notebooks
- Get acquainted with basic libraries useful for NLU (preprocessing, tokenization, embeddings, etc.)
- Be able to train and use neural network models for classification problems in a text domain

Python and notebooks

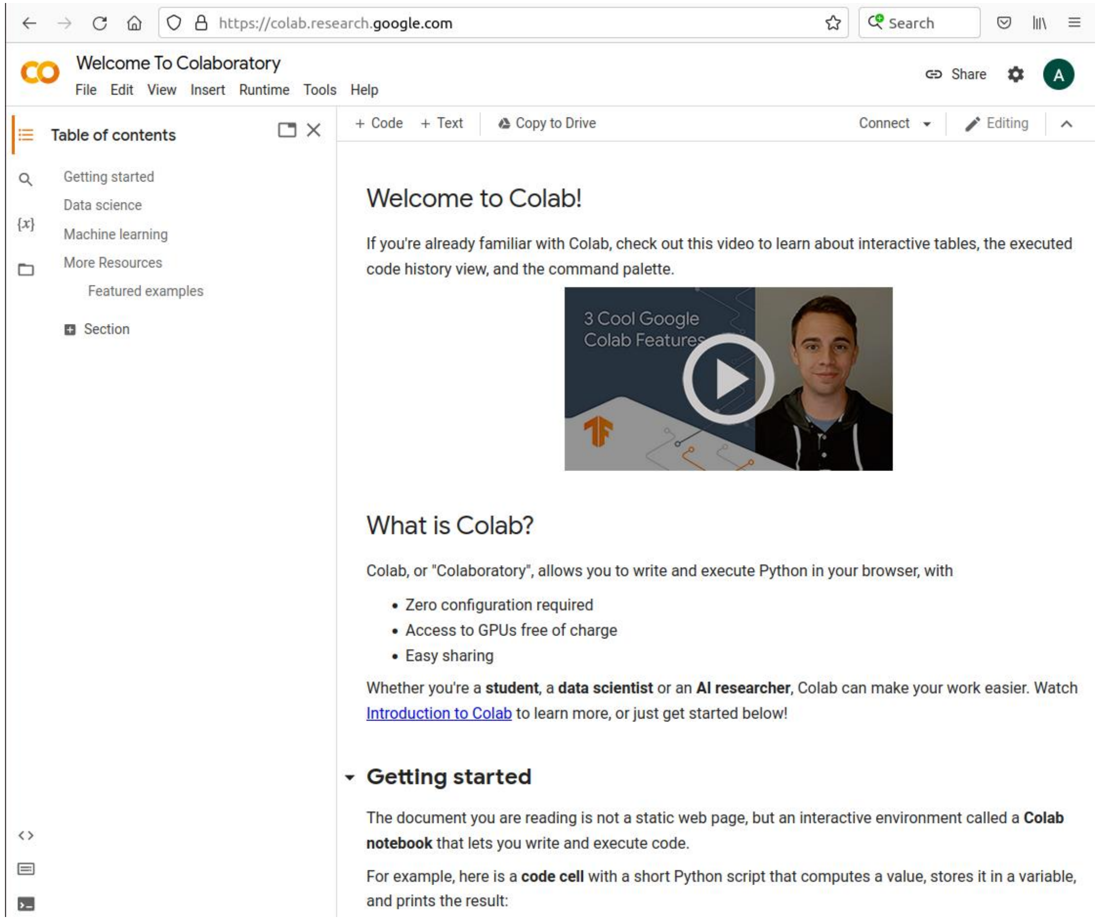
- Jupyter notebooks
  - https://jupyter.org
  - Great to run deep learning experiments
  - Combine interactive and incremental running and documenting (text-editing) into a single Web GUI
  - Requires installing libraries in your local computer
- Google Colaboratory
  - https://colab.research.google.com/
  - Looks like an online notebook, you can upload your own jupyter notebooks
  - No configuration and installation needed (Keras available already)
  - Access to GPU/TPU free of charge (if really needed)

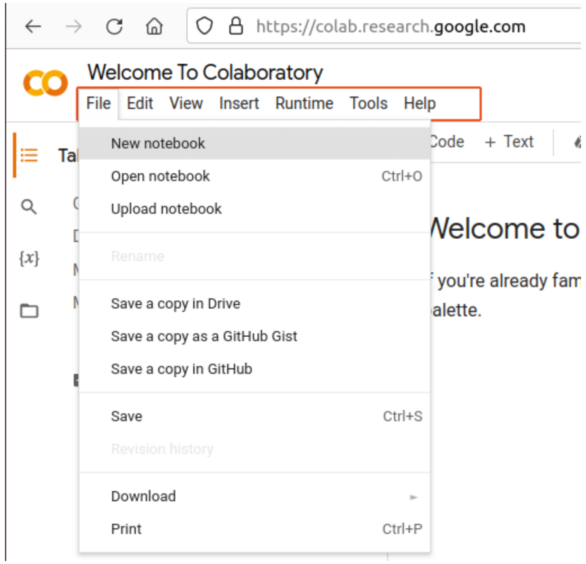
KERAS



- The Python Deep Learning API
- URL: https://keras.io/
- Model-level library with high-level building blocks for developing deep-learning models
  - user-friendly API
  - same code to run seamlessly on CPU or GPU
  - built-in support for convolutional networks, recurrent networks (for sequence processing)...

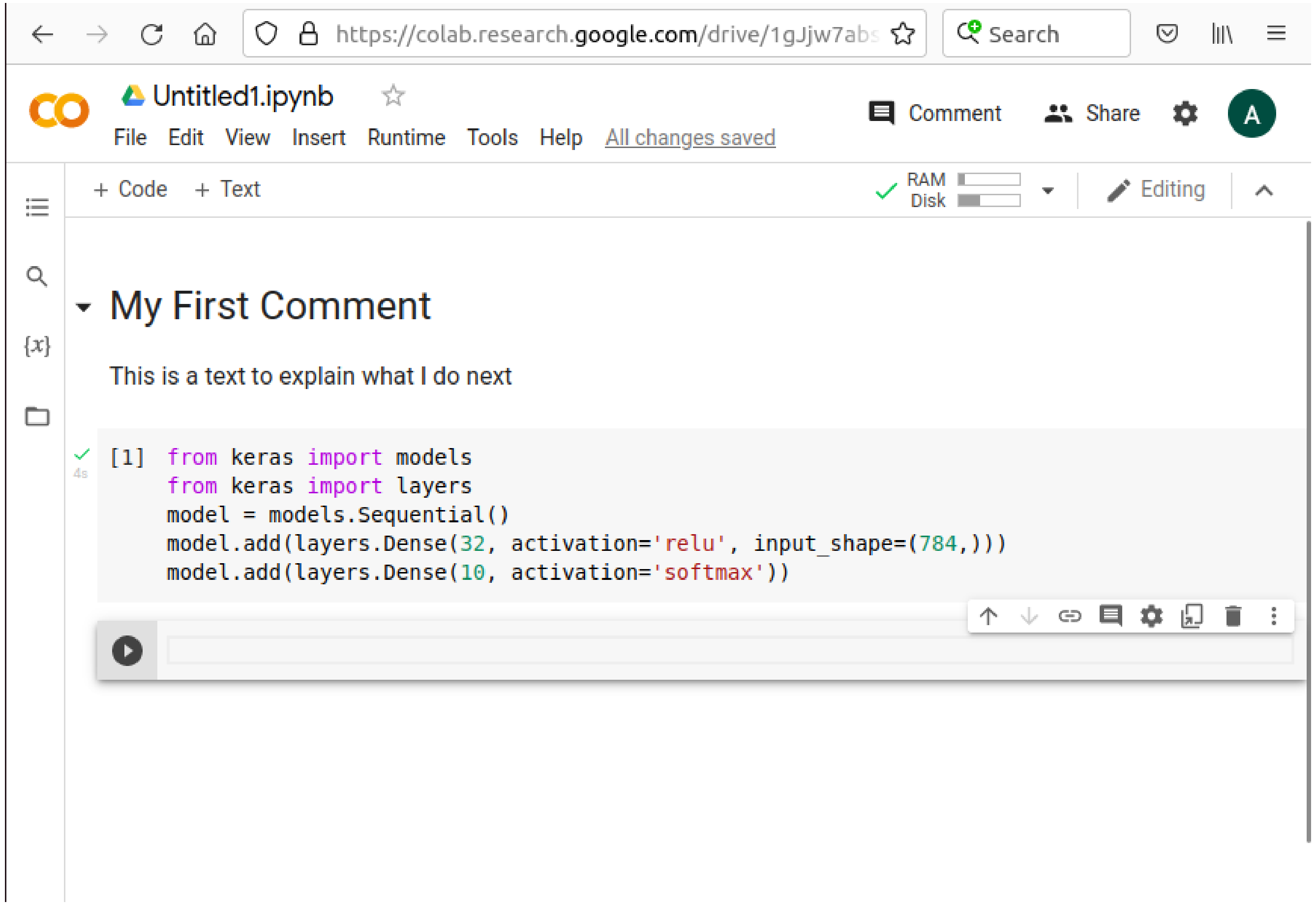
Colab





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

Colab environment



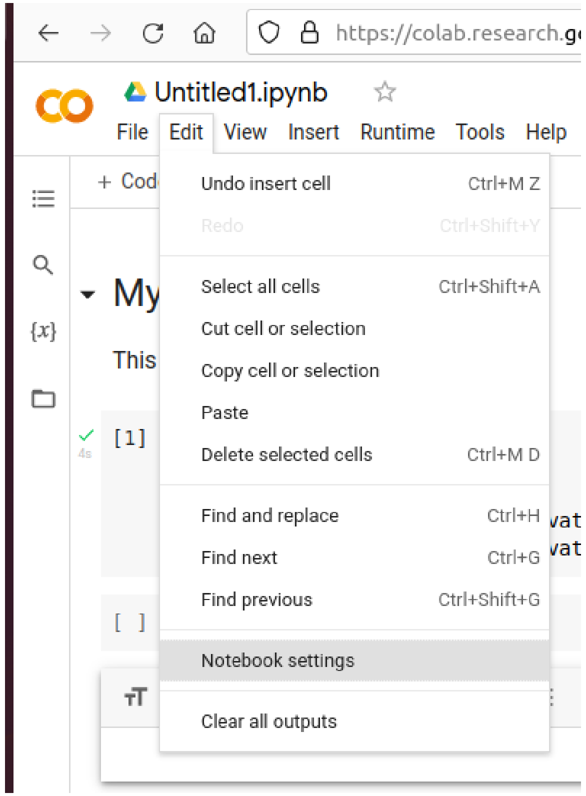
Text cells

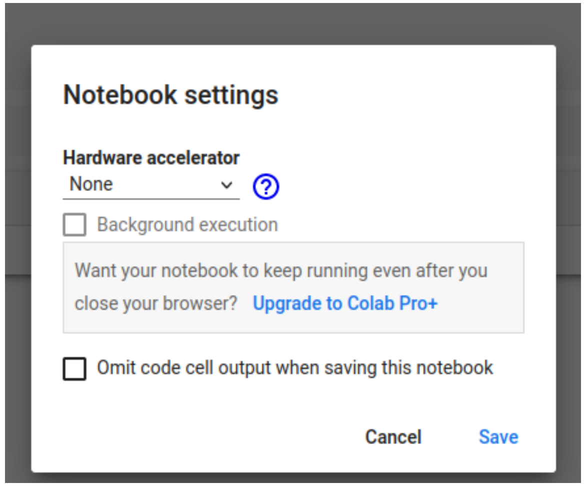
- Formatting and style in Markdown

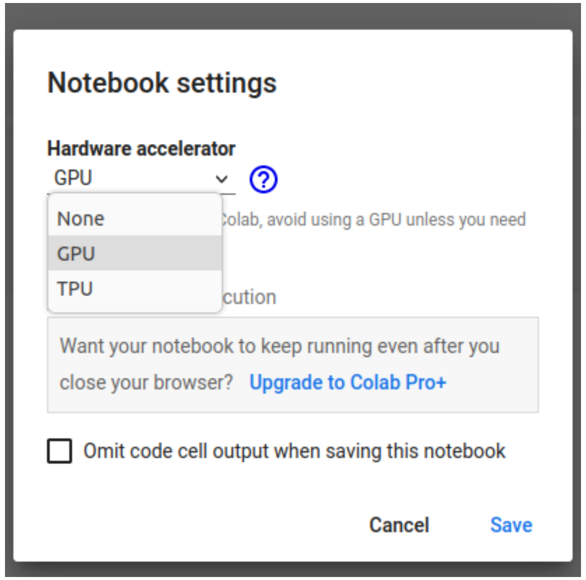
Code cells

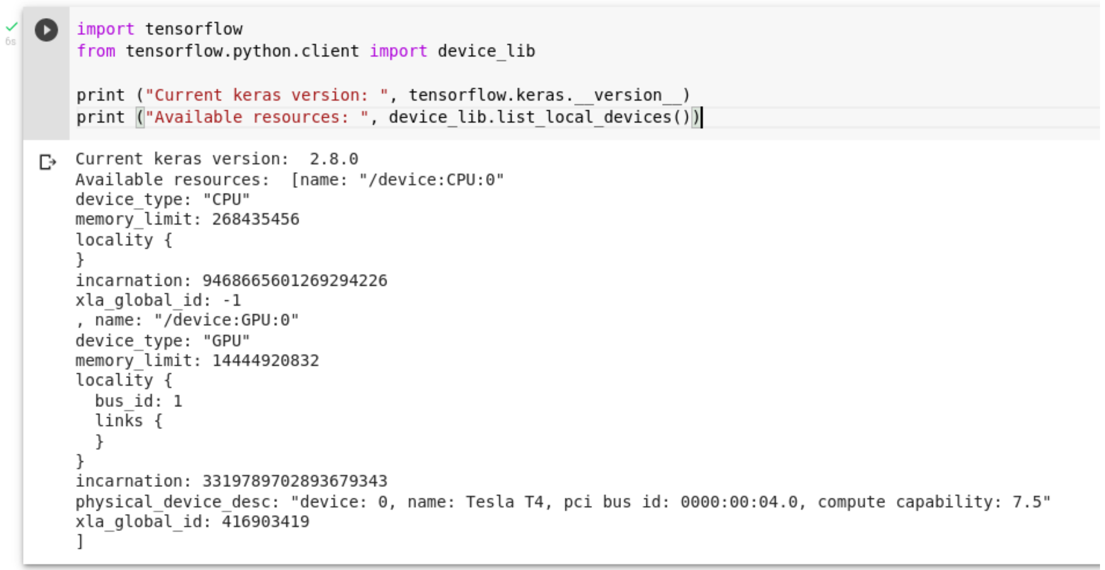
- control on order to run cells interactively
- GPU/TPU may be available

Colab GPU/TPU use *







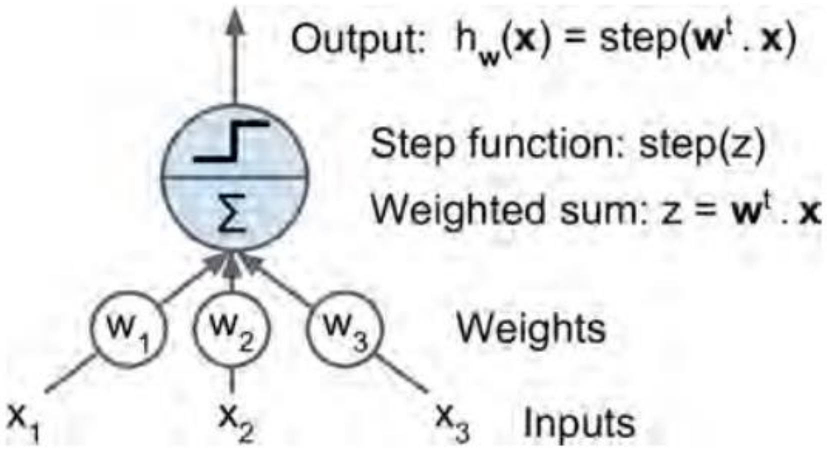


*enable it only if really necessary

Part I

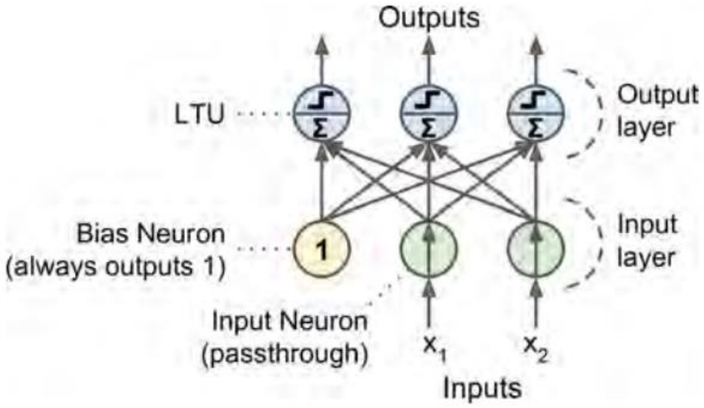
Formative assignment (P0_part1.ipynb)

The Perceptron and Artificial Neural Networks

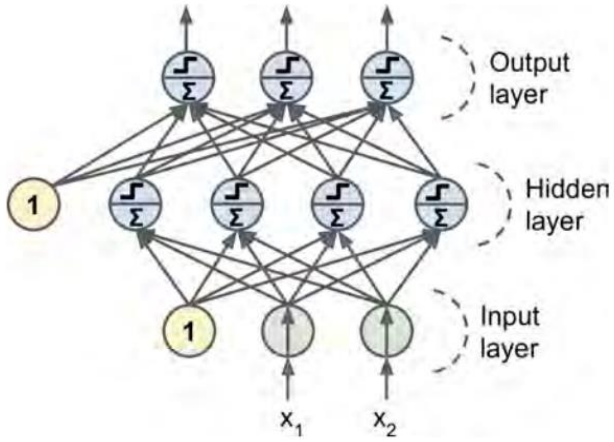


$(z = w_1\, x_1 + w_2\, x_2 + \cdots + w_n\, x_n = \mathbf{w}^T \cdot \mathbf{x})$

Liner Threshold unit



Perceptron



Multi-layer Perceptron

Workflow overview

Define data

- Define your training data: input tensors and target tensors

Define layers

- Define a network of layers (or model)

Configure

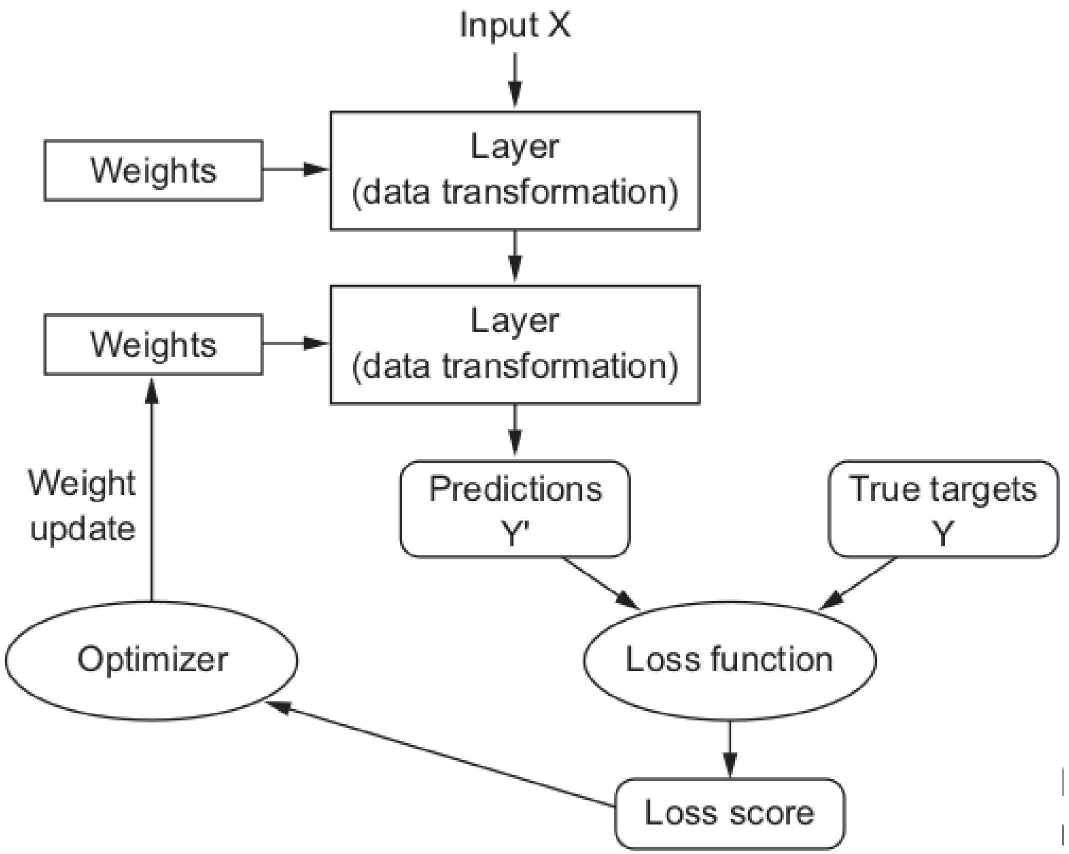
- Configure the learning process by choosing a loss functions, an optimizer and some metrics to monitor and guide the learning process

Train

- Train your model using the fit method

Evaluate

- Evaluate your model with the test data



Inspecting the provided Keras code

Three Examples

- Example 1: Prediction of patients with diabetes
- Example 2: Digit recognition with the MNIST dataset
- Example 3: Classifying sentiment of movie reviews

Your goal

- To inspect and run the code, looking at how the workflow is adapted to different problems in Keras
- Discuss with your partner key aspects about the code and outcomes
- Try out small changes to the provided code

Example 3: Classifying movie reviews

- Internet Movie Database (IMDB)
- Dataset: https://ai.stanford.edu/~amaas/data/sentiment/
  - Included in Keras already, will be downloaded first time you use it
- 50K polarized reviews
  - 25K for training, 25K for testing, each with 50-50% negative/positive review labels
- The goal is to learn to classify whether a review is positive or negative based on the text
  - Binary classification problem

Define Data

- train_data and test_data are lists of reviews
- each review is a list of word indices (encoding a sequence of words)
- train_labels and test_labels are lists of 0s and 1s, where 0 stands for negative and 1 stands for positive

```
from keras.datasets import imdb

# only keep the top num_words most frequent. Discard rare words.
(train_data, train_labels), (test_data, test_labels) = imdb.load_data(num_words=10000)


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]])


print(decoded_review)
```

- word_index maps words to integers

Define Data

```
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)

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

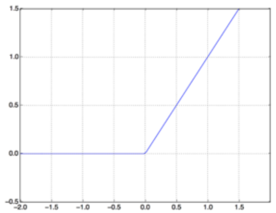
- Numpy has a bunch of useful operations to deal with vectors, arrays, tensors
- Remember that NNs don´t work with words but with numbers as input
- Vectorize to keep length manageable and get a specific data representation
  - Kind of one-hot encoding with 0s and 1s whether terms/tokens are or not present in a given review
- Also vectorize labels

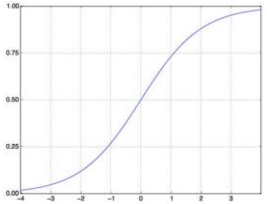
Define Layers

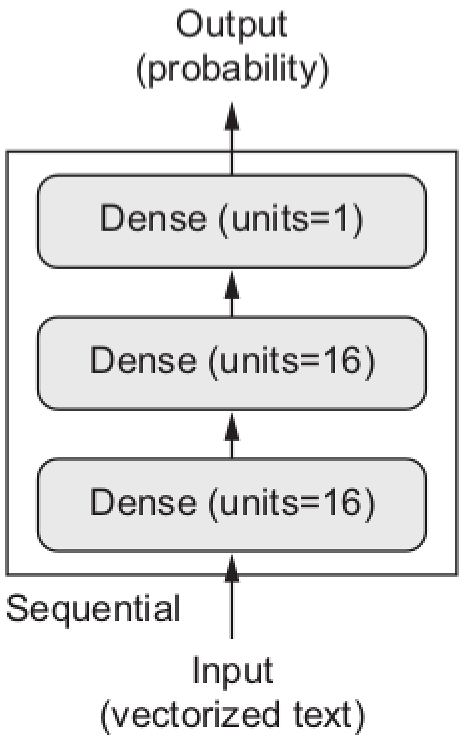
```
from keras import models
from keras import layers


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.summary()
```

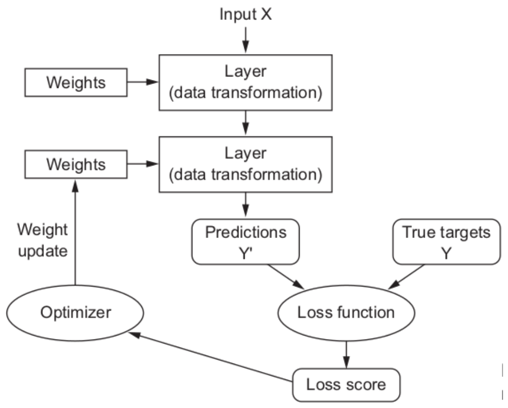






- Input layer is set to 10000 tokens in agreement with the vectorization done before
- Dense layers, fully connected
- Output layer with a neuron with a sigmoid function

Configure




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

```
from keras import optimizers
model.compile(optimizer=optimizers.rmsprop_v2.RMSprop(learning_rate=0.001),loss='binary_crossentropy
', metrics=['accuracy'])
```

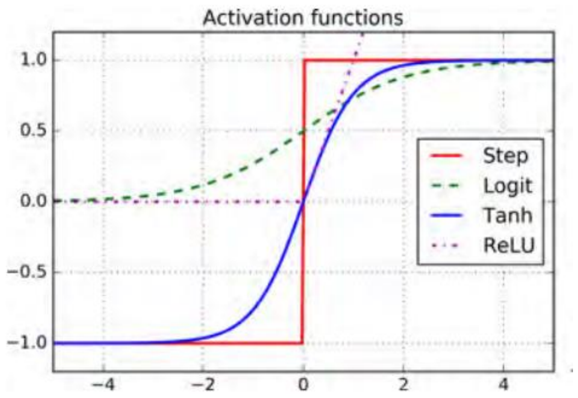
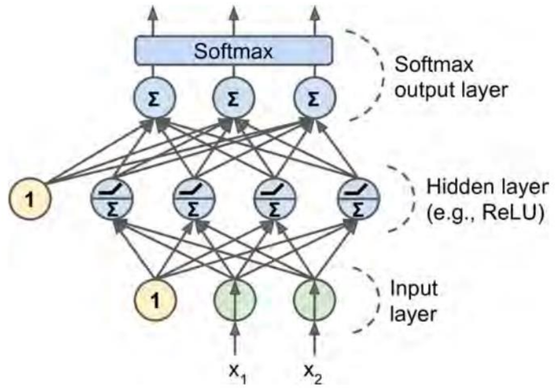
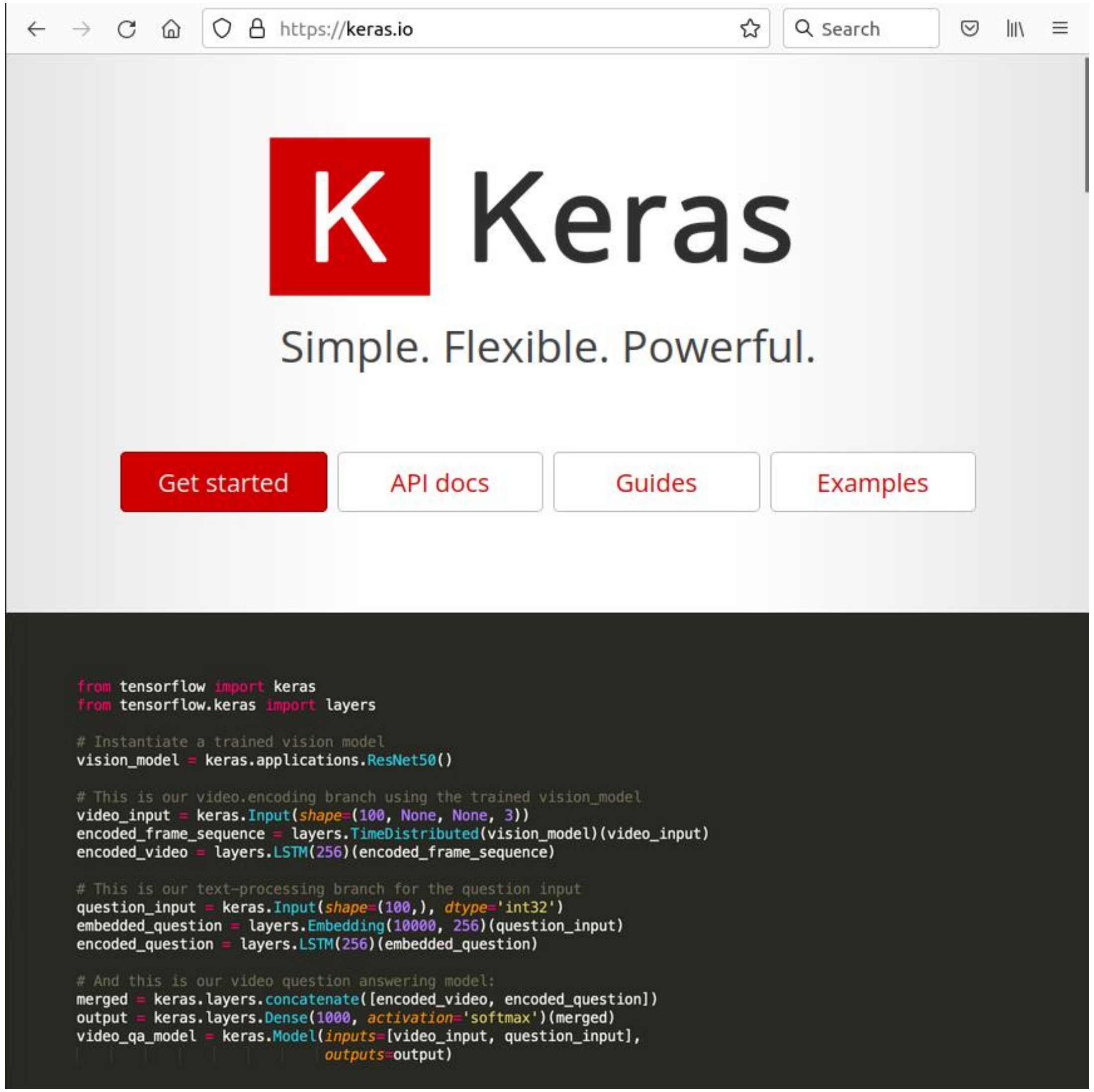


Table 4.1 Choosing the right last-layer activation and loss function for your model

Problem type	Last-layer activation	Loss function
Binary classification	`sigmoid`	`binary_crossentropy`
Multiclass, single-label classification	`softmax`	`categorical_crossentropy`
Multiclass, multilabel classification	`sigmoid`	`binary_crossentropy`
Regression to arbitrary values	None	`mse`
Regression to values between 0 and 1	`sigmoid`	`mse` or `binary_crossentropy`



Resources


https://keras.io
Search
Keras
Simple. Flexible. Powerful.
Get started
API docs
Guides
Examples
from tensorflow import keras
from tensorflow.keras import layers
# Instantiate a trained vision model
vision_model = keras.applications.ResNet50()
# This is our video.encoding branch using the trained vision_model
video_input = keras.Input(shape=(100, None, None, 3))
encoded_frame_sequence = layers.TimeDistributed(vision_model)(video_input)
encoded_video = layers.LSTM(256)(encoded_frame_sequence)
# This is our text-processing branch for the question input
question_input = keras.Input(shape=(100,), dtype='int32')
embedded_question = layers.Embedding(10000, 256)(question_input)
encoded_question = layers.LSTM(256)(embedded_question)
# And this is our video question answering model:
merged = keras.layers.concatenate([encoded_video, encoded_question])
output = keras.layers.Dense(1000, activation='softmax')(merged)
video_qa_model = keras.Model(inputs=[video_input, question_input],
outputs=output)

Train

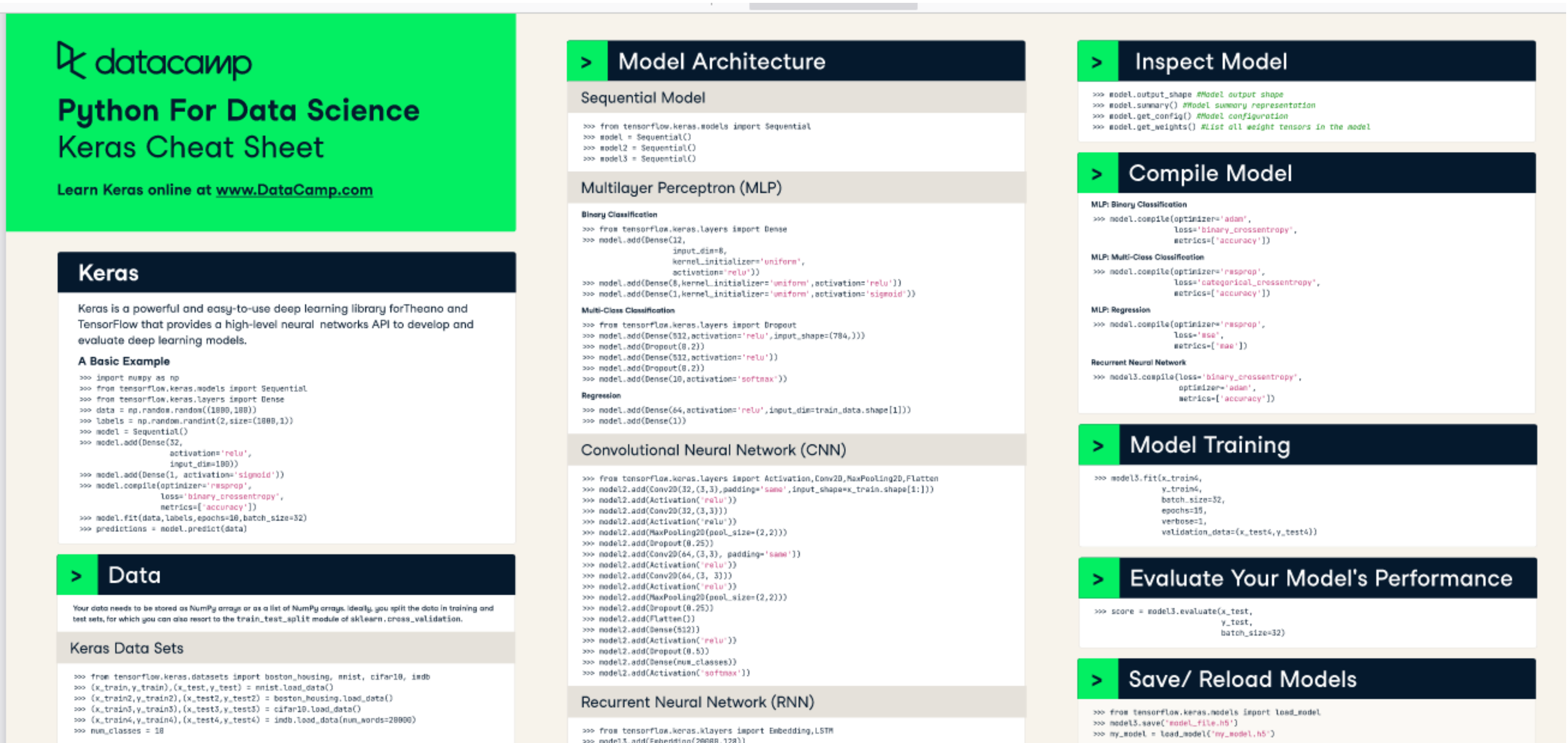
```
x_val = x_train[:10000]
partial_x_train = x_train[10000:]
y_val = y_train[:10000]
partial_y_train = y_train[10000:]

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

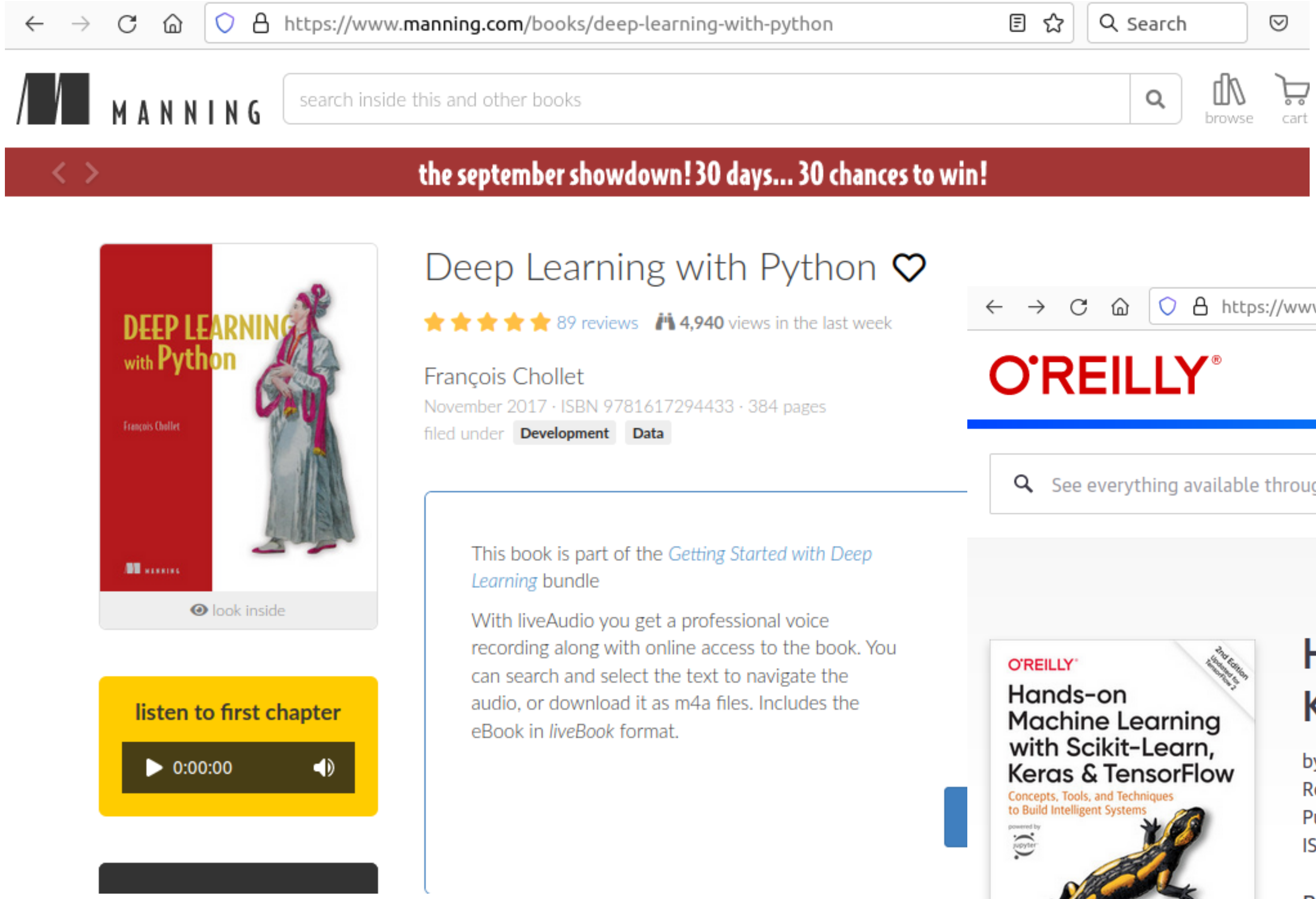
- We can set a subset for validation as in the example or using the
- With .fit() train for 20 epochs in minibatches of 512 samples
- model.fit() returns a History object.
    - Try history_dict = history.history,... for plotting training/validation loss/accuracy history

Resources

- Cheatsheet Keras: https://www.datacamp.com/cheat-sheet/keras-cheat-sheet-neural-networks-in-python



Resources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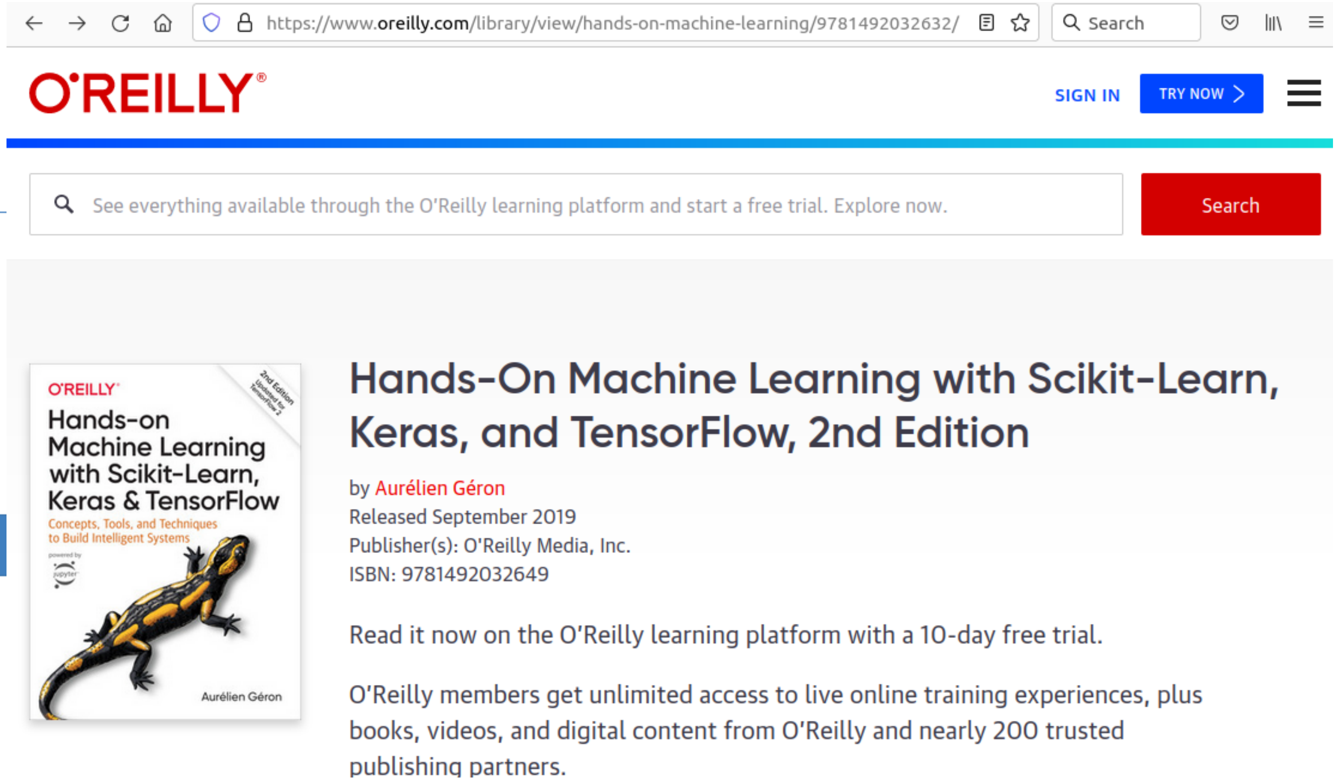
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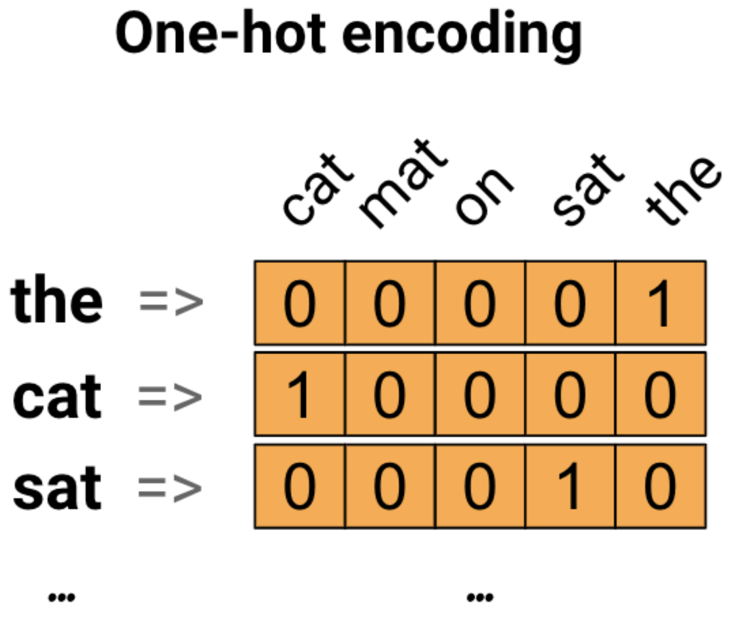
Working with text input

- Texts are composed of documents, paragraphs, words, characters,…
  - Sample review: "A thrilling movie. Absolutely recommended for those loving action..."

  - Tokenization: how to get from raw text to words (or tokens)
  - Words as tokens?
    - What about US, USA, United States of America? Mr. Jones vs. Indiana Jones? Absolutely vs. Absolutely vs. Absolute? Pictured/picturing vs. picture vs. pictur?

- Regardless how we tokenize, input must be numbers to feed NNs
  - We need Encodings and Embeddings

One-hot Encoding



- Raw text = "The cat sat on the mat"
- Word-level Tokens = "cat", "mat", "on", "sat", "the"

- Length of vocabulary = 5
- One-hot vector for "cat" token = [1, 0, 0, 0, 0]

- A sentence can be encoded using one-hot vectors: [1,1,1,1,1] *
- or a sequence of integer indexes: [5, 1, 4, 2, 3]

- What would it happen if...
  - switched the vector for "cat" and "the"?
  - there were several documents?
  - there were many documents leading to (a realistic situation with) thousands tokens?
    - Can we handle unlimited number of tokens?
    - Advantages and disadvantages of one-hot binary encoding vs. Sequences?
    - Can we keep the order of the word tokens in our chosen representation or are they like bag of words?

* toy unrealistic example to raise discussion

Word Embeddings

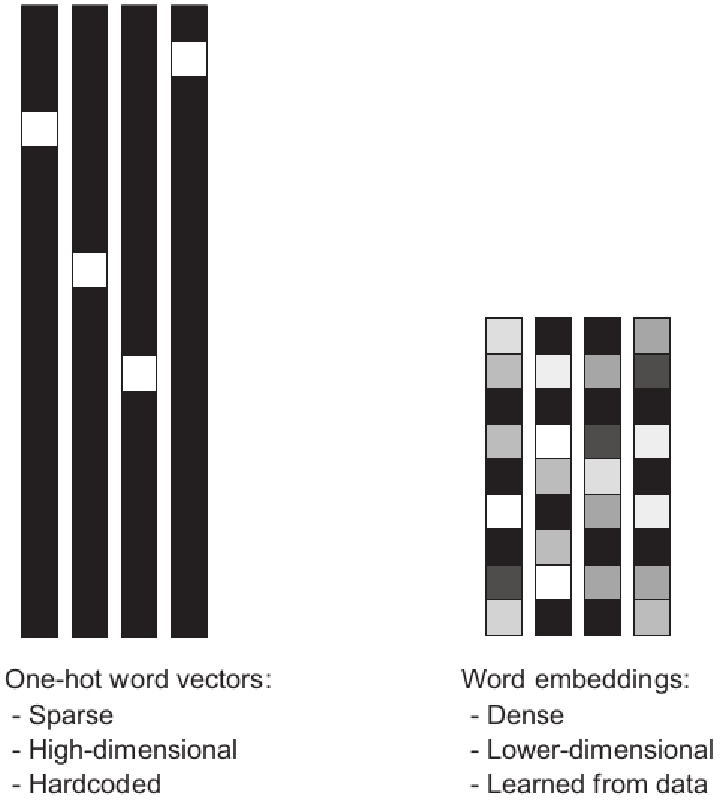
A 4-dimensional embedding

cat =>	1.2	-0.1	4.3	3.2
mat =>	0.4	2.5	-0.9	0.5
on =>	2.1	0.3	0.1	0.4
...		...		

- Lower-dimension and dense representation
- Vector values are learned from data (so not intended for humans)
- But enables meaningful vector arithmetic operations in properly trained embeddings (e.g., what is the "king – man + woman? => queen)

- What would it happen if...
  - there were several documents?
  - there were many documents leading to thousands tokens?
    - Can we handle unlimited number of tokens?
    - Advantages and disadvantages of one-hot encoding vs. Word embedding?
    - Can we keep the order of the word tokens in our chosen representation?

One-hot Encoding vs. Word Embeddings



- Find out more about these practical issues:
  - https://www.tensorflow.org/text/guide/word_embeddings

Part II

Summative assignment (P0_student_assignment_part2.ipynb)

P0 Final Assignment