TensorFlow

Applications for natural language processing

COT-6930 Natural Language Processing
Spring 2019
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What we will cover today

What TensorFlow is

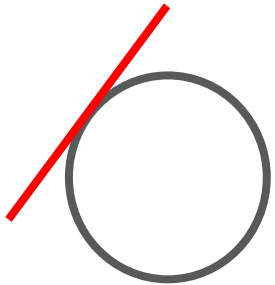
A brief introduction to TensorFlow

Motivation to use TensorFlow

Applications for natural language processing

TensorFlow and natural language processing

Going off on a (short) tangent



What is a tensor?

A generic name for n-dimensional data structures

Scalar
0D tensor

Rank = 0

'a'

Vector
1D tensor

Rank = 1

'a'
'b'
'c'

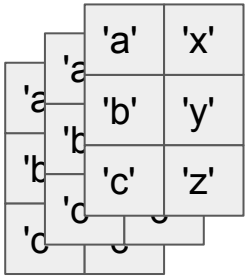
Matrix
2D tensor

Rank = 2

'a'	'x'
'b'	'y'
'c'	'z'

Tensor
(n)D tensor

Rank = n



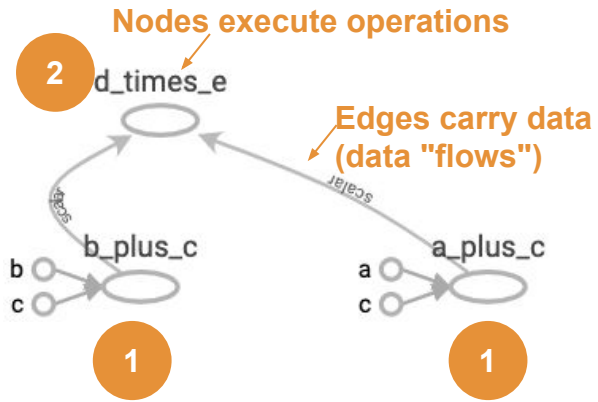
What is TensorFlow?

It is a generic, high-performance computation engine

It represents computations as a graphs

```
a = 2
b = 2
c = 1

d = b + c
e = a + c

result = d * e
```

```
a = tf.constant(2.0, name='a')
b = tf.constant(2.0, name='b')
c = tf.constant(1.0, name='c')

d = tf.add(b, c, name='b_plus_c')
e = tf.add(a, c, name='a_plus_c')

result = tf.multiply(d, e, name='d_times_e')
```



Why "generic computation engine" matters

We can define and "package" higher-level operations

They can be efficiently distributed for parallel execution

They can be reused in different environments

Let's look at another example...

High-level ops "packaged"

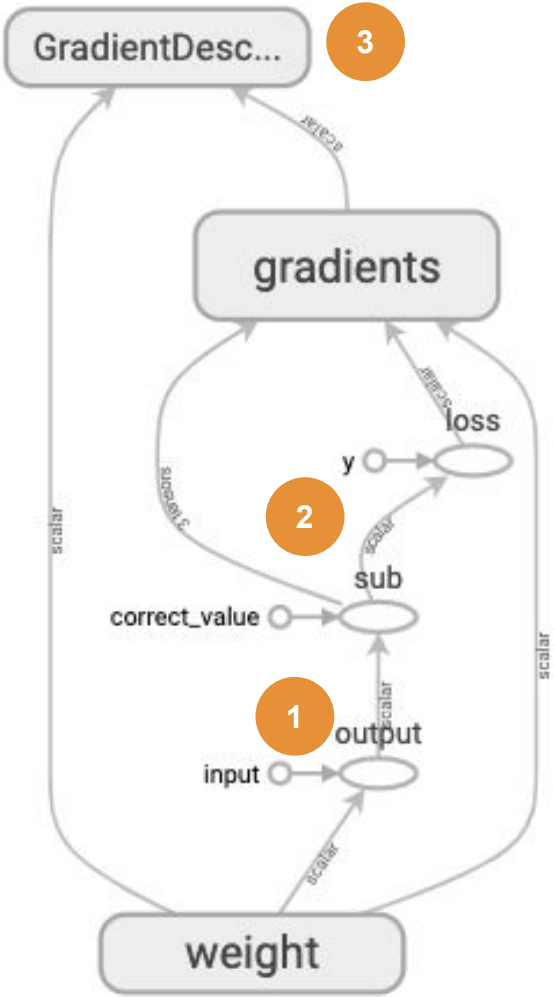
The building block of neural networks

- A neuron: input * weight = output (*)
- Optimized with SGD (stochastic gradient descent)


```
x = tf.constant(1.0, name='input')
w = tf.Variable(0.8, name='weight')
y = tf.multiply(w, x, name='output')

y_ = tf.constant(-1.0, name='correct_value')
loss = tf.pow(y - y_, 2, name='loss')

train_step =
    tf.train.GradientDescentOptimizer(0.025).minimize(loss)
```

1 2 3

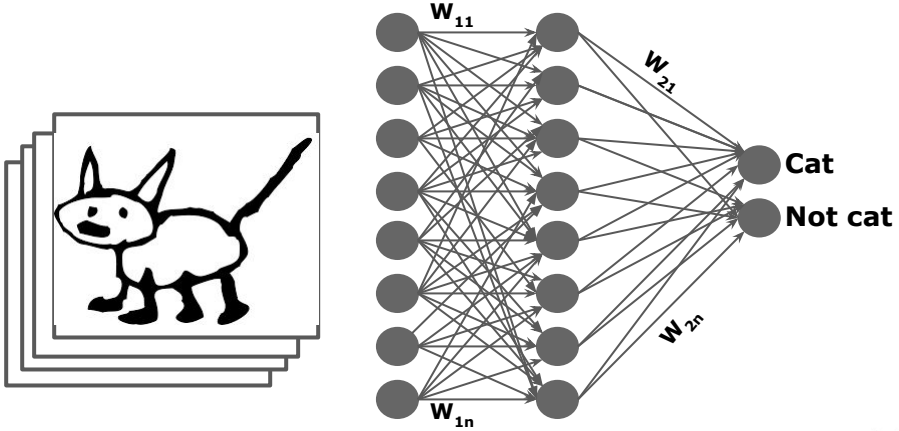
Higher-level operation



(*) Technically, this is missing a non-linearity after the output to be a neuron. It's simplified for illustration.

Why "high-performance" matters

Neural networks have millions of connections (parameters) and are trained on millions of samples



This results in billions of floating point matrix operations

$$(\mathrm{W}^{l+1})^T \delta^{l+1} = \begin{bmatrix} w_{11}^{l+1} & \dots & w_{m1}^{l+1} & \dots & w_{M1}^{l+1} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ w_{1k}^{l+1} & \dots & w_{mk}^{l+1} & \dots & w_{Mk}^{l+1} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ w_{1K}^{l+1} & \dots & w_{mK}^{l+1} & \dots & w_{MK}^{l+1} \end{bmatrix} \begin{bmatrix} \delta_1^{l+1} \\ \vdots \\ \delta_m^{l+1} \\ \vdots \\ \delta_M^{l+1} \end{bmatrix} \begin{bmatrix} \sum_{m=1}^{M} \delta_m^{l+1} w_{m1}^{l+1} \\ \vdots \\ \sum_{m=1}^{M} \delta_m^{l+1} w_{mk}^{l+1} \\ \vdots \\ \sum_{m=1}^{M} \delta_m^{l+1} w_{mK}^{l+1} \end{bmatrix}$$

TensorFlow is more than a library

TensorFlow Hub: reusable modules

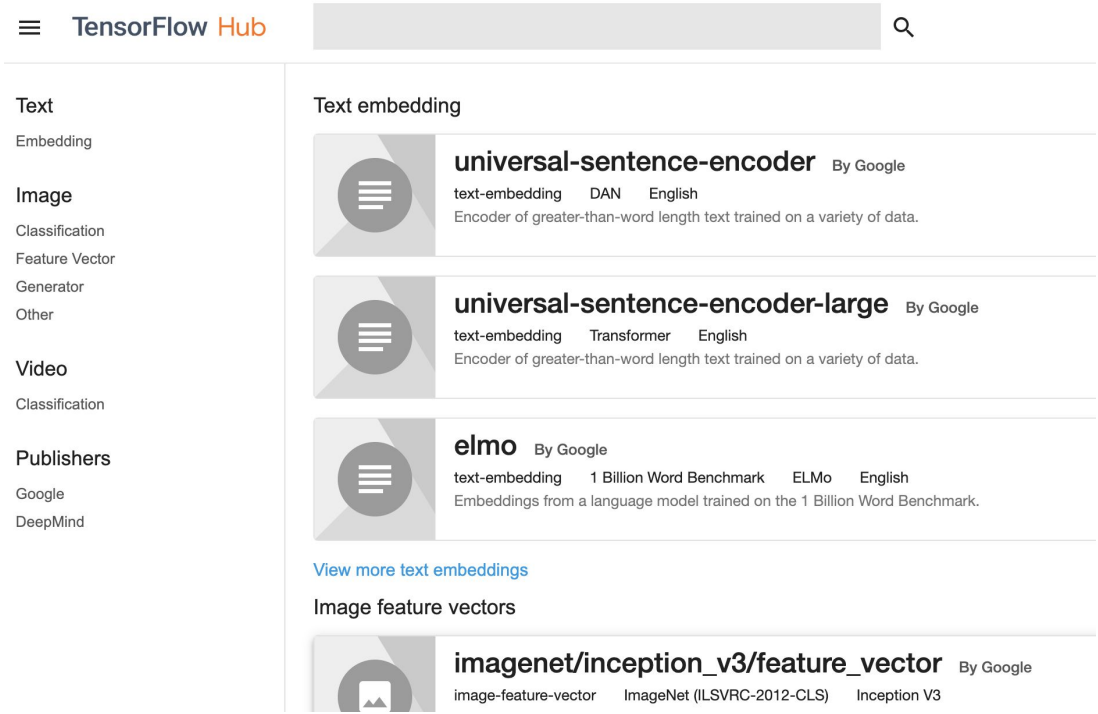
TensorBoard: debugging and visualization tools

Deployment models: TensorFlow, TensorFlow.js, TensorFlow Lite

Reusable modules
TensorFlow Hub

A collection of ready-to-use models for several domains

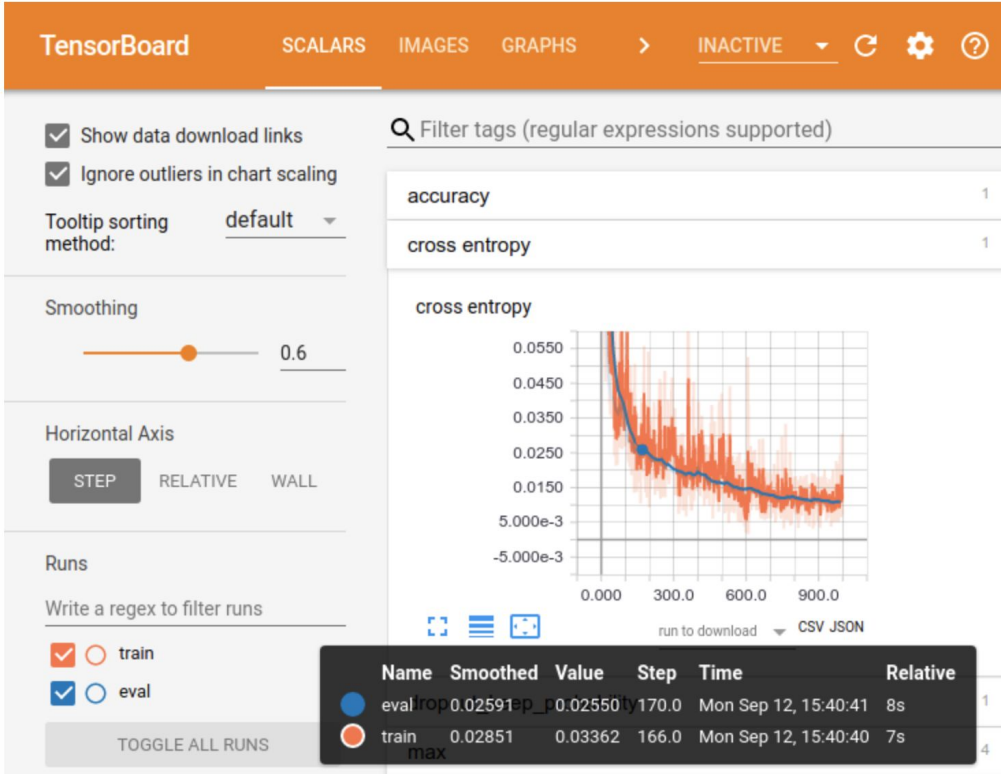
Pick one and start using it, or fine tune for your application



Debugging and Visualization TensorBoard

Visualize and debug machine learning

Perform "what if" analysis without full retraining



Deployment models
TensorFlow.js, TensorFlow Lite

TensorFlow.js: run TensorFlow training and models inside a browser (or Node.js)

TensorFlow Lite: models optimized to run in low-powered devices (smartphones, smart appliances, etc.)

Putting it all together...

TensorFlow is…

- …a generic computation engine that supports highly-parallelized execution on specialized hardware (GPUs, TPUs)
- …adapted to run on diverse environments (TensorFlow, TensorFlow.js, TensorFlow Lite)
- …backed by a collection of reusable modules (TensorFlow Hub) and a visualization/debugging tool (Tensorboard)

Back from the tangent…

TensorFlow
and
Natural Language Processing

TensorFlow and NLP

Utilities

Utility functions for natural language processing

Word and sentence embedding

Pretrained word and sentence embeddings for natural language processing

Visualizations

Tensorboard visualizations specific for NLP

TensorFlow utility functions

All concepts we learned in this class are available in TensorFlow

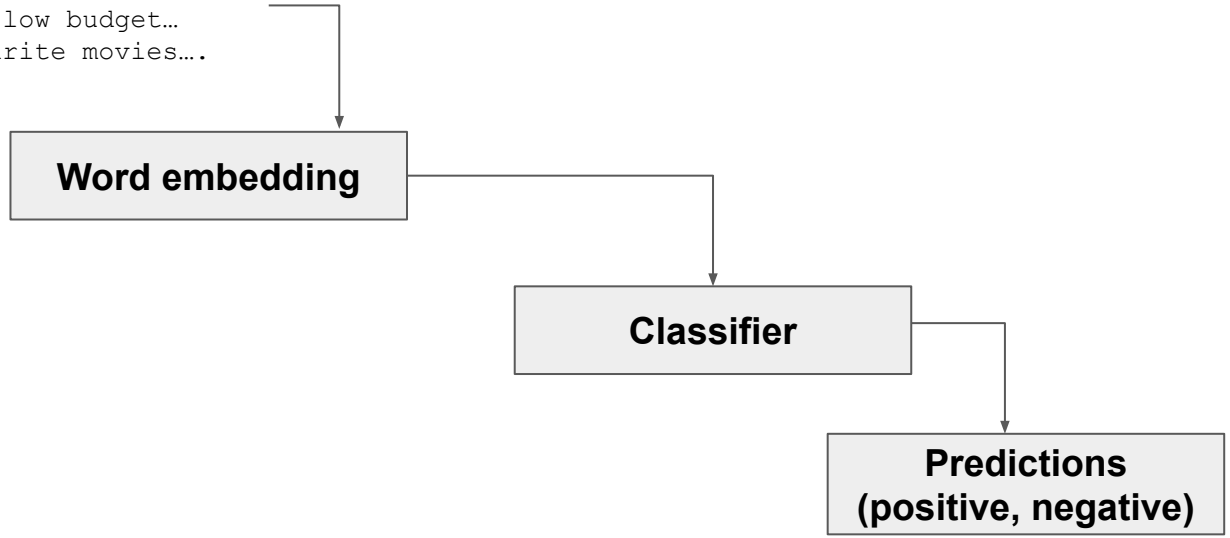
- From the simple ones
  - tokenizer, vocabulary creation, n-grams, tf-idf

- To more complex ones:
  - word (text) embedding, recurrent neural networks, such as LTSM

TensorFlow NLP example

Movie sentiment classifier - the high level view

```
With the mixed reviews this got I wasn't expecting…
This film has a lot of raw potential. The script is…
Cage (1989) was another one of those low budget…
Home Alone 3 is one of my least favourite movies….
```



TensorFlow NLP example

Movie sentiment classifier - TensorFlow code

```
With the mixed reviews this got I wasn't expecting…
This film has a lot of raw potential. The script is…
Cage (1989) was another one of those low budget…
Home Alone 3 is one of my least favourite movies….
```

```
# Neural network classifier, with two layers

estimator = tf.estimator.DNNClassifier(
    hidden_units=[500, 100],
    feature_columns=[embedded_text_feature_column],
    n_classes=2,

optimizer=tf.train.AdagradOptimizer(learning_rate=0.003))
```

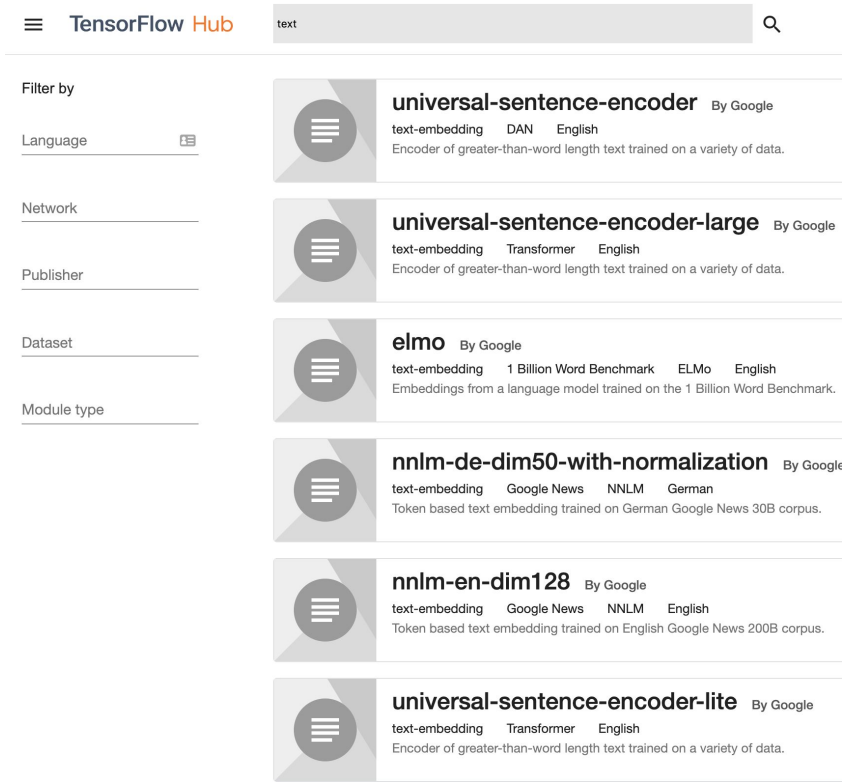
Word embedding

Classifier

Predictions (positive, negative)

```
# pretrained (on Google News) word embedding (also tokenizes)

embedded_text_feature_column = hub.text_embedding_column(
    key="sentence",
    module_spec="https://tfhub.dev/google/nnlm-en-dim128/1")
```

TensorFlow NLP pretrained embeddings

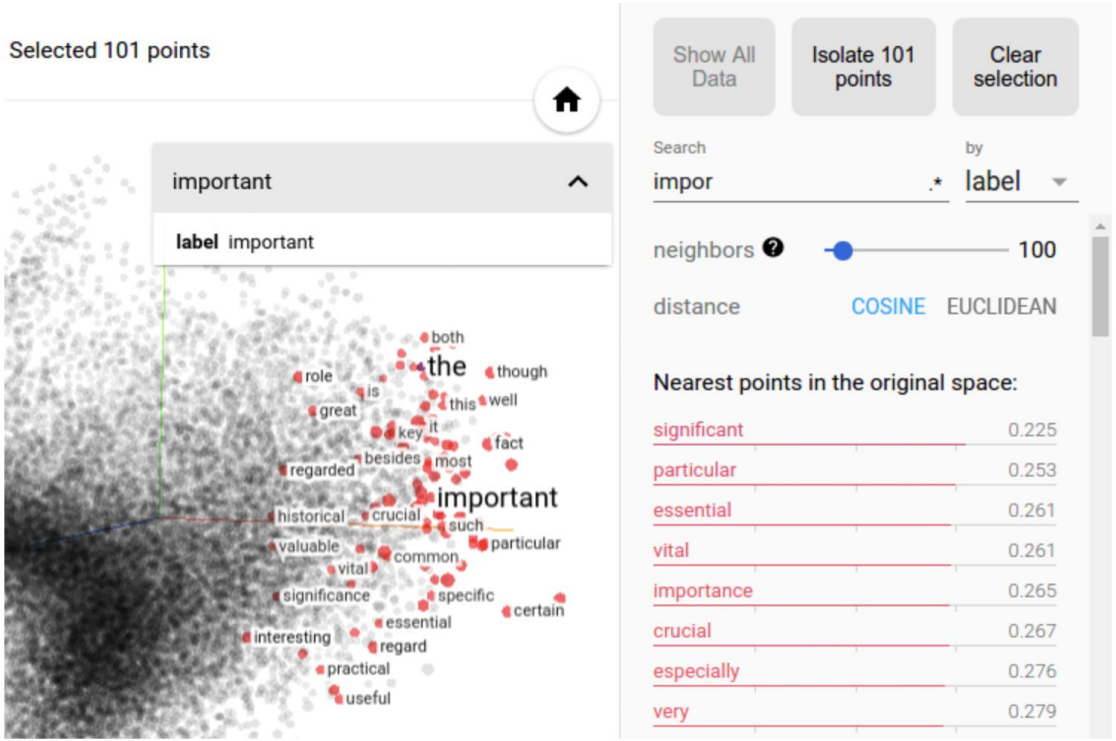


...more, not shown here

Word and sentence (!) level embeddings, trained on various corpora, including Google's gigantic

TensorBoard NLP visualizations

[Embedding projector]



Recap

TensorFlow + NLP recap

- It's a generic, high-performing computation library + trained models + tools
- Directly applicable to natural language processing
- For practitioners
  - It has many useful pretrained models in TensorFlow Hub
  - It has a visual inspection and debugging tool
  - It supports multiple platforms (Unix, MacOS, Windows, iOS, Android)
- For researchers
  - It's a platform to create your own network architectures and optimization functions
  - Easy access to benchmarks (pretrained models)
  - Collect performance and behavior data with Tensorboard
- For both
  - Active community, many tutorials and books
  - High performance out of the box

More information

- TensorFlow, TensorFlow Hub, TensorBoard
- Understanding and visualizing graphs
- Chapter 1 of O'reilly's “Hello, TensorFlow!” tutorial, a great introduction to TensorFlow
- A complete neural machine translation (seq2seq) tutorial

Where to get started with TensorFlow and NLP

- A great, easy to follow text classification with movie reviews