Intro to TensorFlow

Your guides

Josh Gordon
@random_forests

Wolff Dobson
@greenexecutive

Welcome & Logistics

- Thanks for coming!
- Today we'll get started with TensorFlow
- Format is a mix of talks and Jupyter notebooks
- Content for beginners and experienced developers

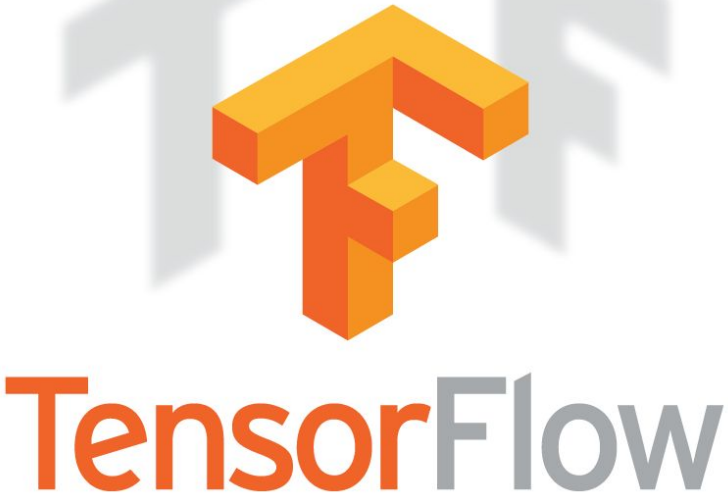
These slides + code
goo.gl/nrdsxM

What can we do better?
goo.gl/8ReQxN

Outline

- **Pretrained models**
  - Inception & TensorFlow for Poets
- **Higher-level APIs**
  - mnist with tf.contrib.learn
- **Lower-level APIs**
  - Fibonacci sequence, Linear Regression, and Deep Neural Networks
- **Bonus material**
  - Deep Dream, Neural Style

Getting Started



- Fast, flexible, and scalable open-source machine learning library
- One system for research and production
- Runs on CPU, GPU, TPU, and Mobile
- Apache 2.0 license

A multidimensional array.

A graph of operations.

Deep Learning

Current state of the art in:

- **Image**: *recognition, captioning, enhancement, completion*
- **Language**: *translation, parsing, summarization*
- **Speech**: *recognition, generation*
- **Games**: *AlphaGo, Atari*
- And much more.

Open Source Models

github.com/tensorflow/models

Inception

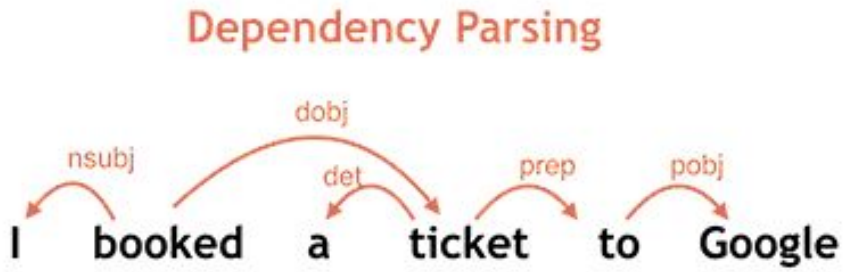
An Alaskan Malamute (left) and a Siberian Husky (right). Images from Wikipedia.

https://research.googleblog.com/2016/08/improving-inception-and-image.html

Show and Tell

https://research.googleblog.com/2016/09/show-and-tell-image-captioning-open.html

Parsey McParseface



https://research.googleblog.com/2016/05/announcing-syntaxnet-worlds-most.html

Text Summarization

Original text

- *Alice and Bob took the train to visit the zoo. They saw a **baby giraffe, a lion, and a flock of colorful tropical birds**.*

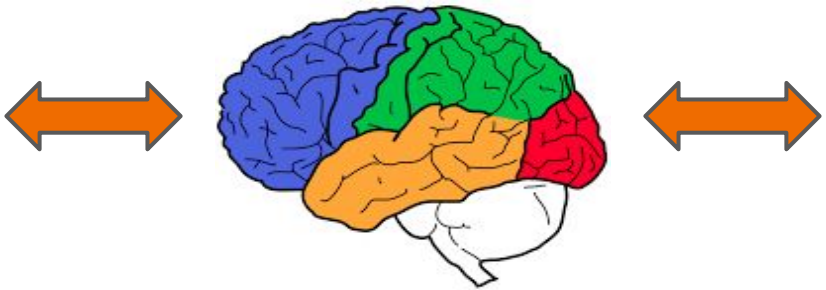
Abstractive summary

- *Alice and Bob visited the zoo and saw **animals and birds**.*

https://research.googleblog.com/2016/08/text-summarization-with-tensorflow.html

“Universal” Machine Learning

Speech
Text
Search
Queries
Images
Videos
Labels
Entities
Words
Audio
Features



Speech
Text
Search
Queries
Images
Videos
Labels
Entities
Words
Audio
Features

Install TensorFlow
0_test_install.ipynb

goo.gl/nrdsxM

Demo: working with Jupyter notebooks

IS THIS A

CAT or DOG?

CAT DOG

OUTPUT LAYER

ACTIVATED NEURONS

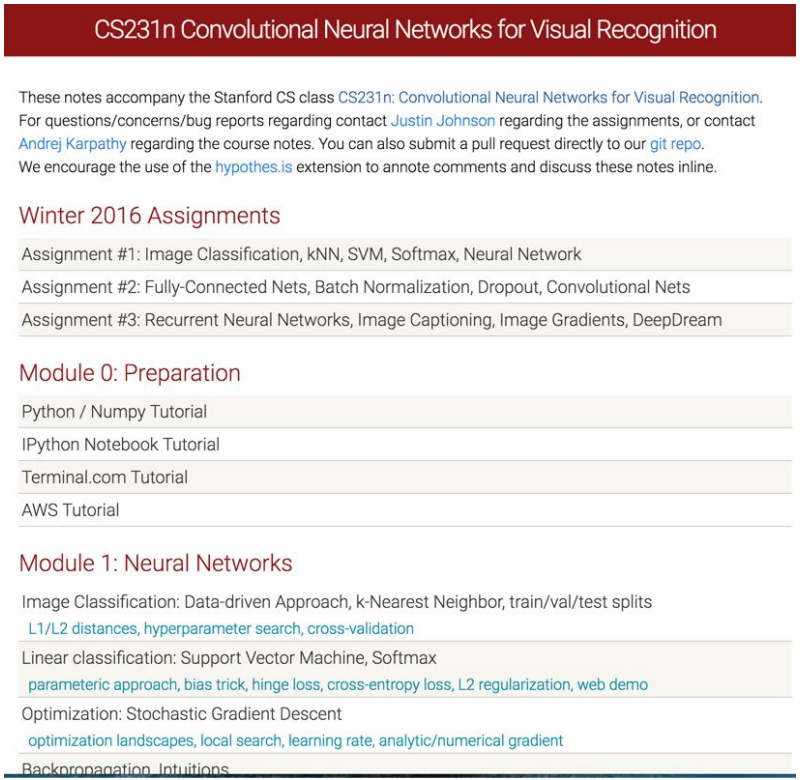
INPUT LAYER

DEEP *neural* NETWORK

Demo: TensorFlow Playground

playground.tensorflow.org

Stanford's CS231n



CS231n Convolutional Neural Networks for Visual Recognition

These notes accompany the Stanford CS class CS231n: Convolutional Neural Networks for Visual Recognition.
For questions/concerns/bug reports regarding contact Justin Johnson regarding the assignments, or contact Andrej Karpathy regarding the course notes. You can also submit a pull request directly to our git repo.
We encourage the use of the hypothes.is extension to annote comments and discuss these notes inline.

Winter 2016 Assignments

Assignment #1: Image Classification, kNN, SVM, Softmax, Neural Network

Assignment #2: Fully-Connected Nets, Batch Normalization, Dropout, Convolutional Nets

Assignment #3: Recurrent Neural Networks, Image Captioning, Image Gradients, DeepDream

Module 0: Preparation

Python / Numpy Tutorial

IPython Notebook Tutorial

Terminal.com Tutorial

AWS Tutorial

Module 1: Neural Networks

Image Classification: Data-driven Approach, k-Nearest Neighbor, train/val/test splits
L1/L2 distances, hyperparameter search, cross-validation

Linear classification: Support Vector Machine, Softmax
parameteric approach, bias trick, hinge loss, cross-entropy loss, L2 regularization, web demo

Optimization: Stochastic Gradient Descent
optimization landscapes, local search, learning rate, analytic/numerical gradient

Backpropagation, Intuitions

Neural Networks in TensorFlow

Options

1. Use a pre-trained model
2. Use a higher-level API that builds on top of TensorFlow
3. Define and train your network directly in TensorFlow

More control, more effort

1) Pretrained Models

Remember Inception?

- Load the graph and learned weights
- Use the model

Images via Wikipedia

www.tensorflow.org/tutorials/image_recognition/index.html

Demo: classifying images with Inception

Inception

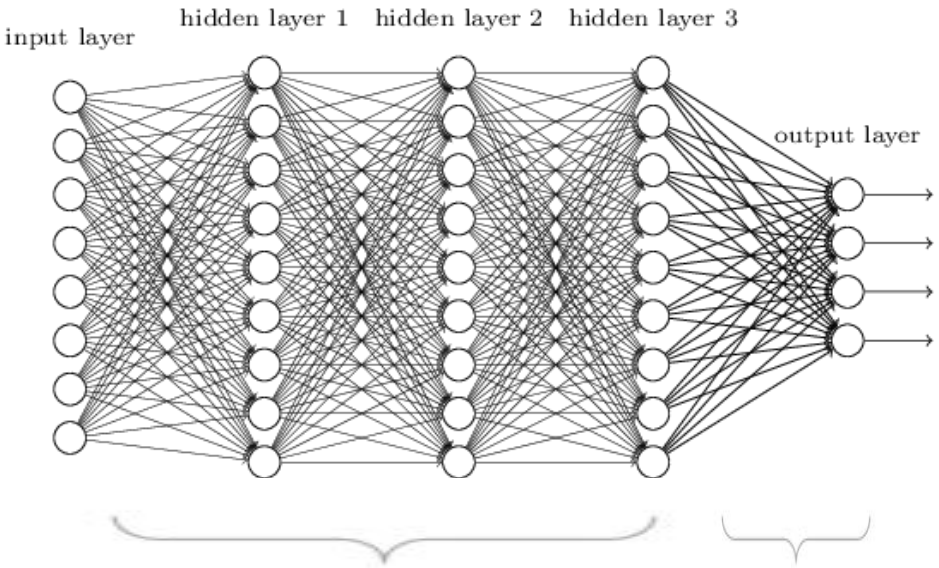
- 1,000 categories: pandas, cats, bears
- Performs about as well as people on this task
- Training took ~2 weeks on a single machine
- Open sourced **implementation** (so you can train on your own data) and a **pretrained model** (so you can experiment right away)

https://research.googleblog.com/2016/08/improving-inception-and-image.html

But...

- Animals are great.
- What if you want to train an image classifier on your own data?

Transfer Learning



Most of the network is unchanged

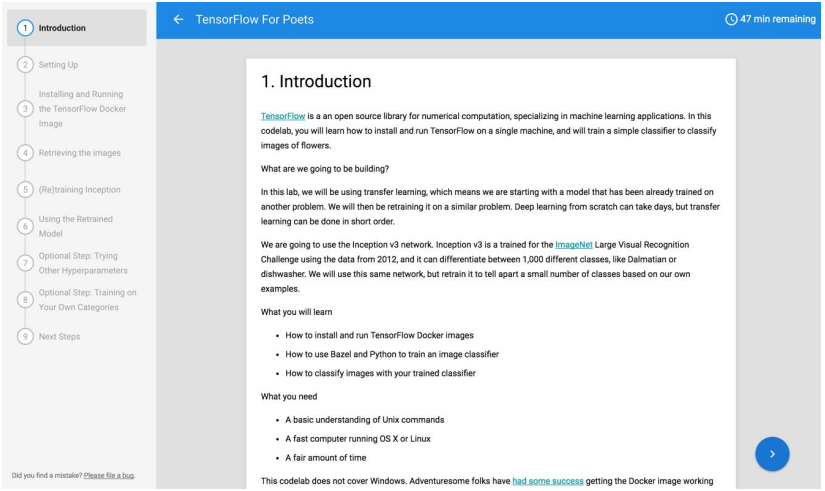
Only the last layer of weights and the outputs are updated

Image: neuralnetworksanddeeplearning.com

Advantages

- Minutes vs weeks
- Handful of training data
- Reuse learned features
- Two ways to do this
  a. Directly in TensorFlow (tutorial)
  b. TensorFlow for Poets

TensorFlow for Poets



Codelab - goo.gl/xGsB9d

Video - goo.gl/KewA03

Credit: Pete Warden - thank you!

Claude Monet - Bouquet of Sunflowers
Images from the Metropolitan Museum of Art (with permission)

2) Higher-level APIs

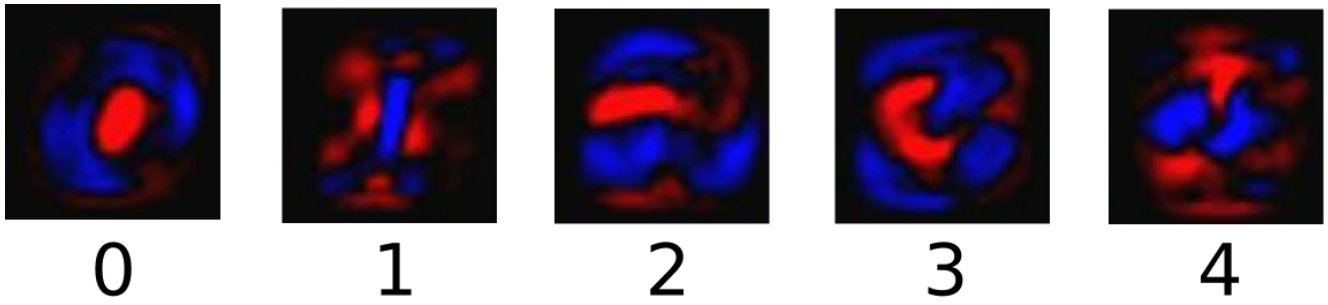
2) Higher-level APIs

- tf.contrib.learn
  a. Implements a sklearn-inspired API
  b. Creates the graph for you behind the scenes

MNIST: 3_mnist_high_level.ipynb
goo.gl/nrdsxM

“The only benchmark that matters”

goo.gl/nrdsxM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1
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9

Want to learn more?

tf.contrib.learn tutorials

- Quickstart
- Linear models
- Wide and Deep

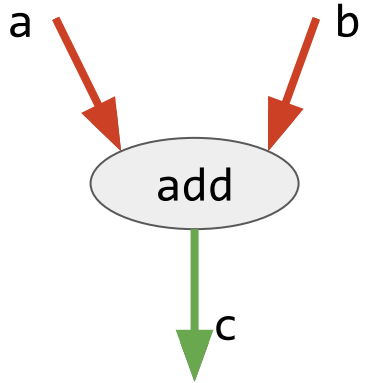
3) Lower-level APIs

Under the hood

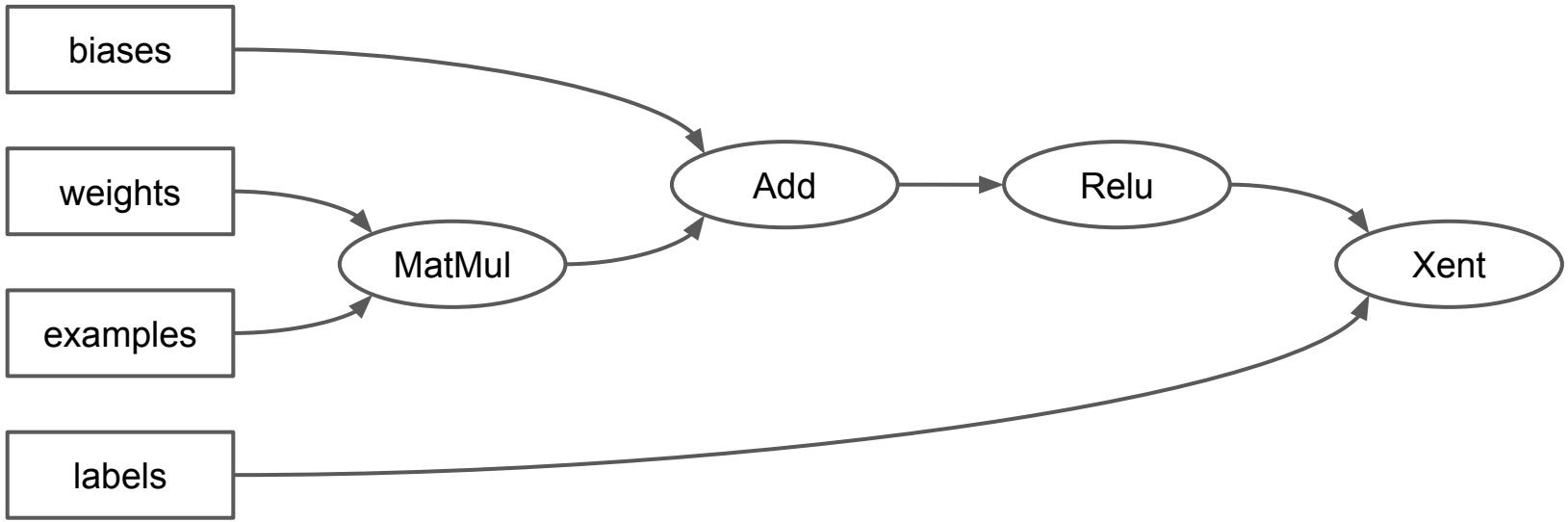
Part 1: Graphs and Sessions

Build a graph; then run it.

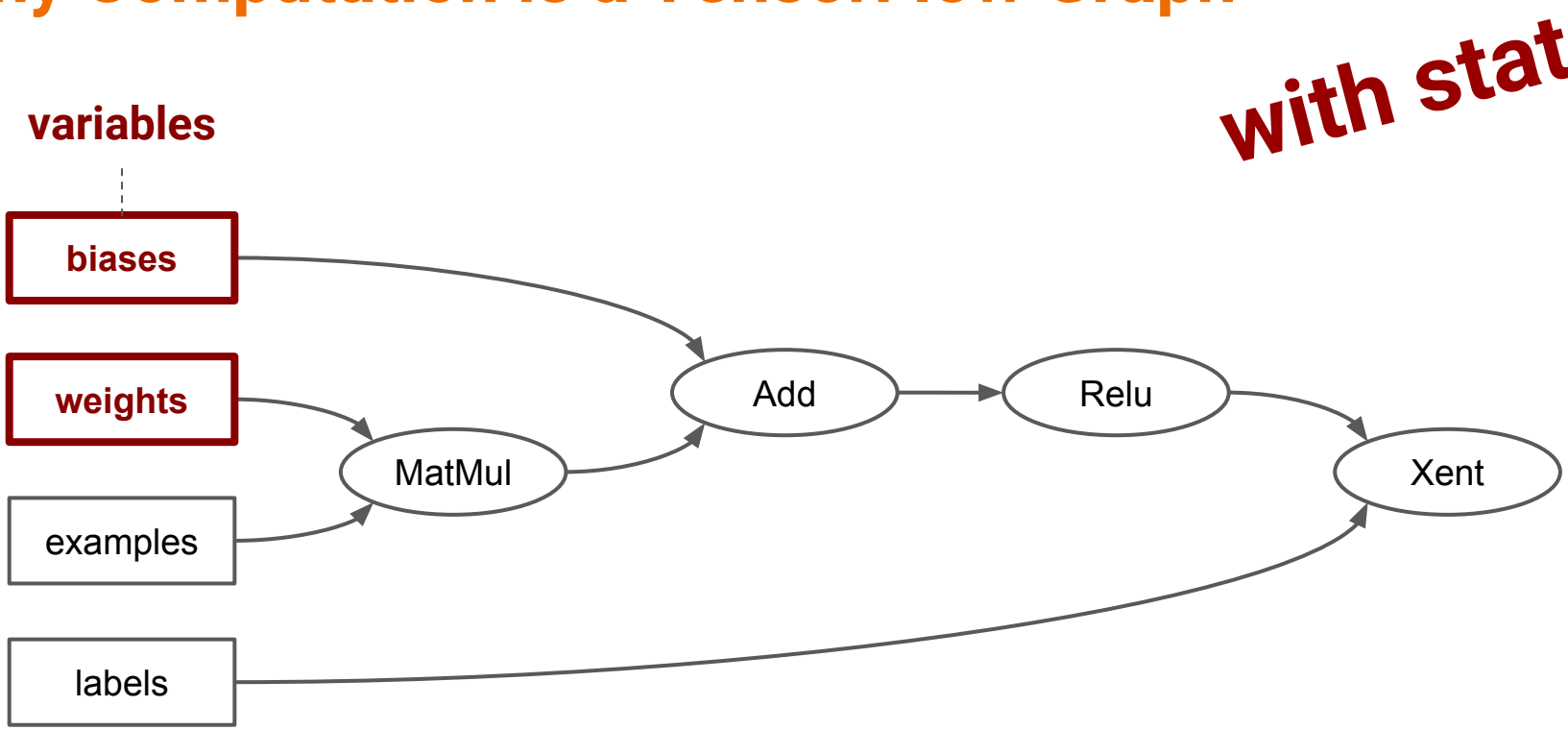
```
...
c = tf.add(a, b)


...

session = tf.Session()
value_of_c = session.run(c, {a=1, b=2})
```



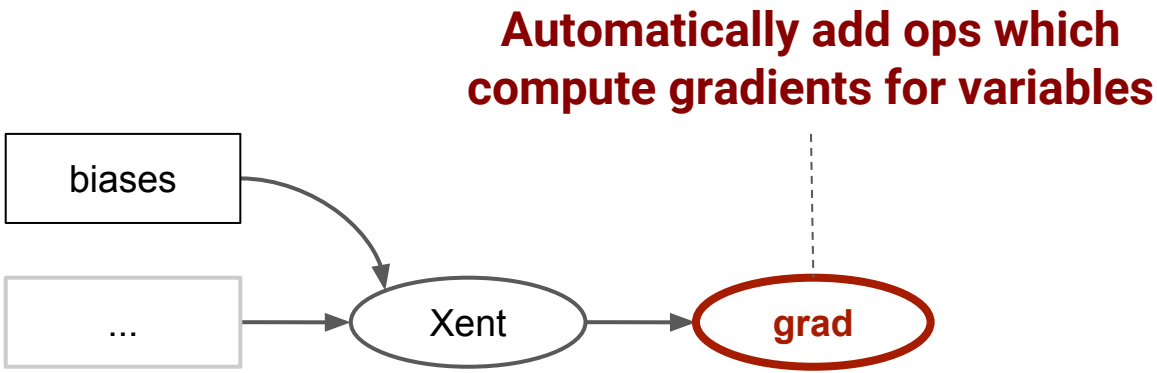
Any Computation is a TensorFlow Graph



Any Computation is a TensorFlow Graph

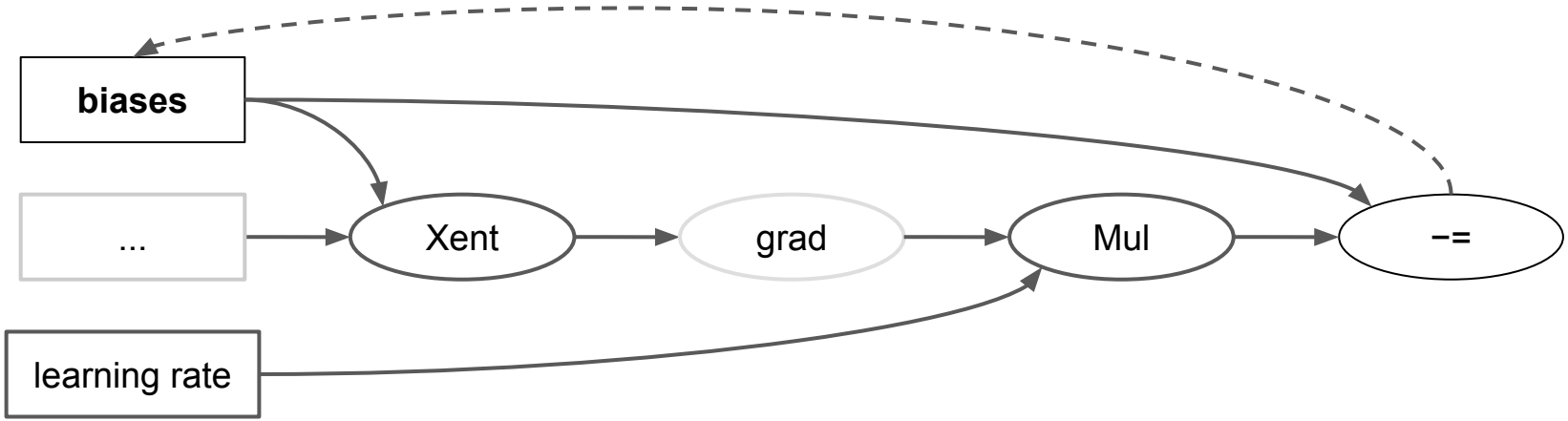


Automatic Differentiation

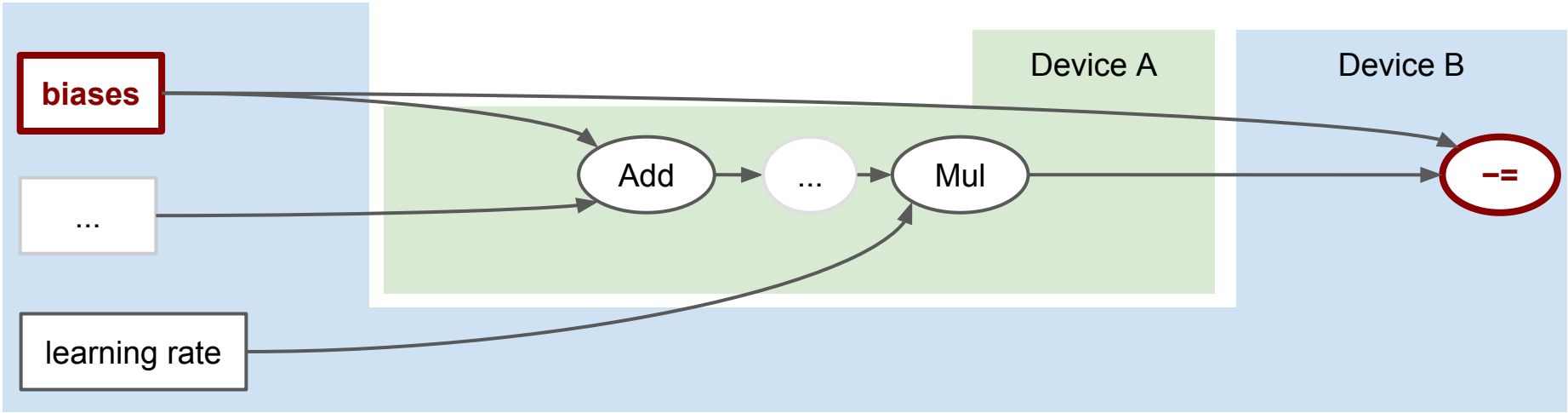


Automatic Differentiation

Simple gradient descent:

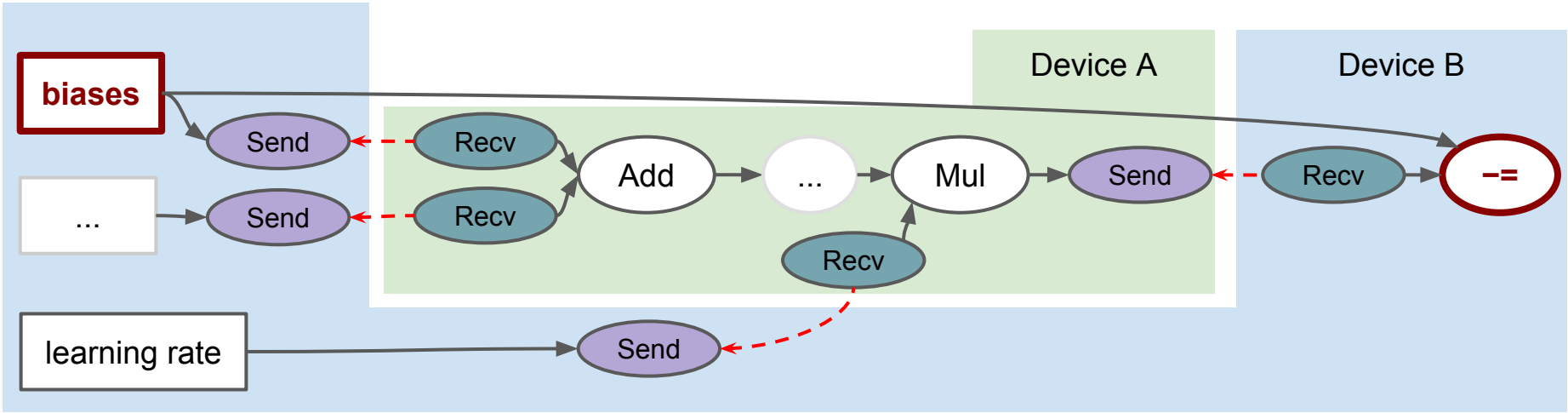


Graphs can be distributed and assigned to devices



Devices: Processes, Machines, CPUs, GPUs, TPUs, etc

Send and Receive Nodes



Devices: Processes, Machines, CPUs, GPUs, TPUs, etc

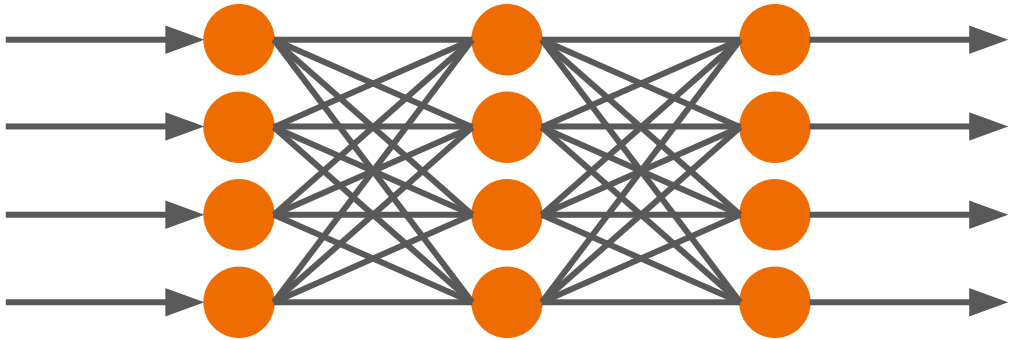
Fibonacci Sequence: 1_warm_up.ipynb
goo.gl/nrdsxM

Or, if you prefer:

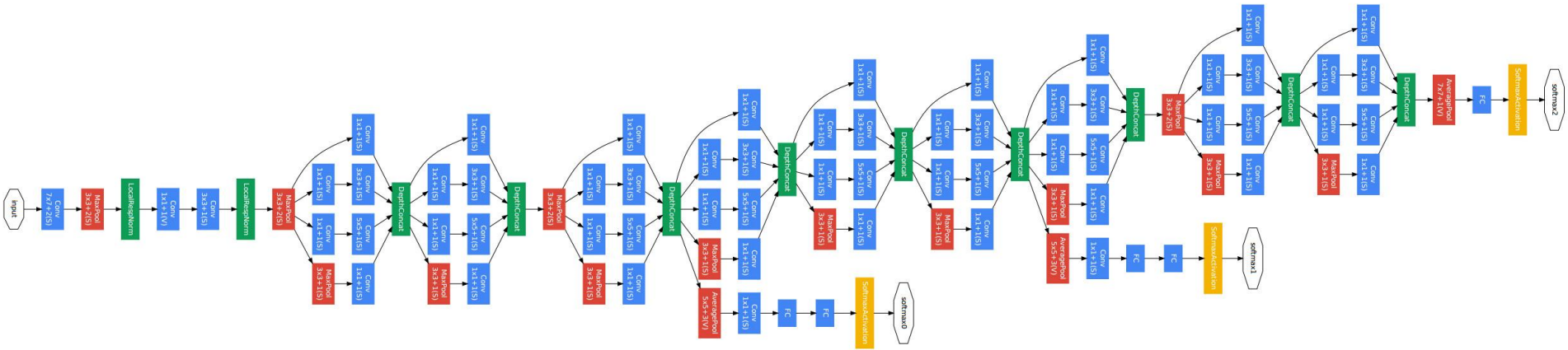
TensorFlow for Poets
goo.gl/xGsB9d

But why?

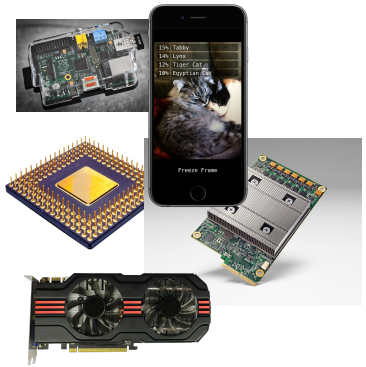
Neural Networks, yesterday



Inception (2015)

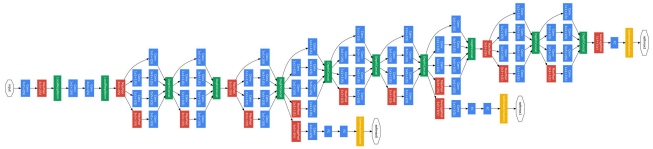


Machine Learning gets complex quickly



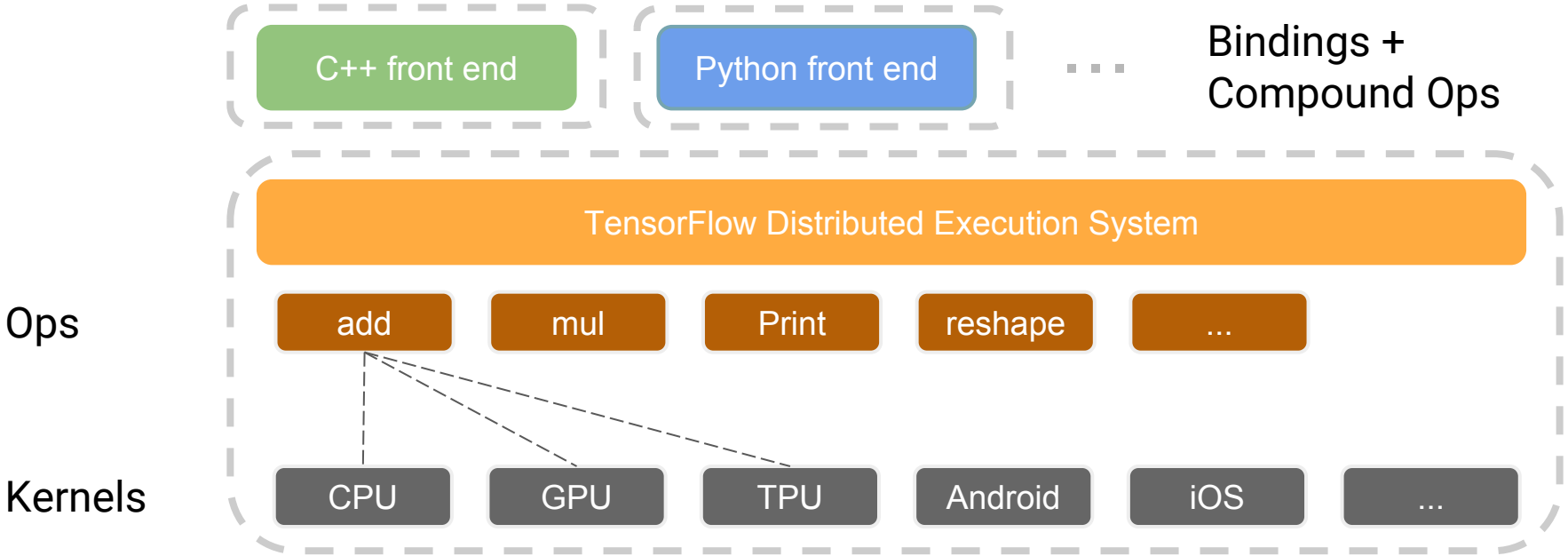
Heterogenous systems

Distributed systems



Modeling complexity

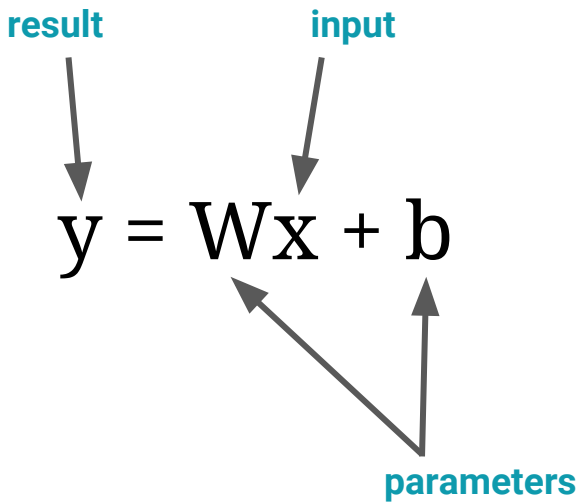
Architecture

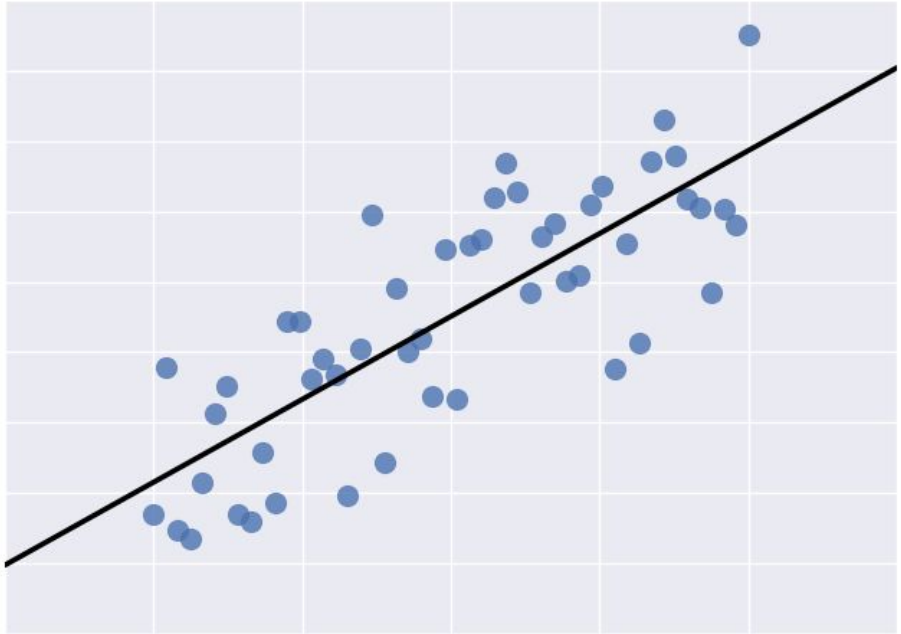


Under the hood

Part 2: Inference, Loss, Training

Linear Regression





What are we trying to do?

Mystery equation: `y = 0.1 * x + 0.3 + noise`

Model: `y = W * x + b`

Objective: Given enough (`x`, `y`) value samples, figure out the value of `W` and `b`.

y = Wx + b in TensorFlow

```
import tensorflow as tf
```

y = Wx + b in TensorFlow

```
import tensorflow as tf

x = tf.placeholder(shape=[None],
                   dtype=tf.float32, name=”x”)
```

y = Wx + b in TensorFlow

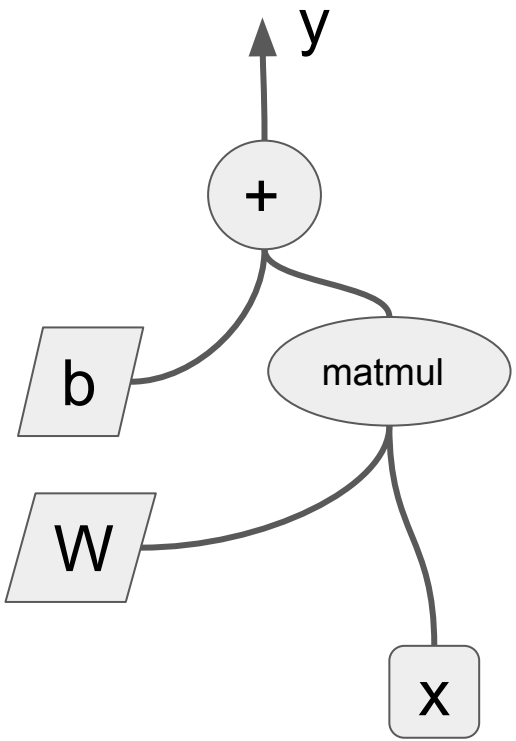
```
import tensorflow as tf

x = tf.placeholder(shape=[None],
                   dtype=tf.float32, name=”x”)

W = tf.get_variable(shape=[], name=”W”)
```

y = Wx + b in TensorFlow

```
import tensorflow as tf

x = tf.placeholder(shape=[None],
                   dtype=tf.float32, name=”x”)

W = tf.get_variable(shape=[], name=”W”)

b = tf.get_variable(shape=[], name=”b”)
```

y = Wx + b in TensorFlow

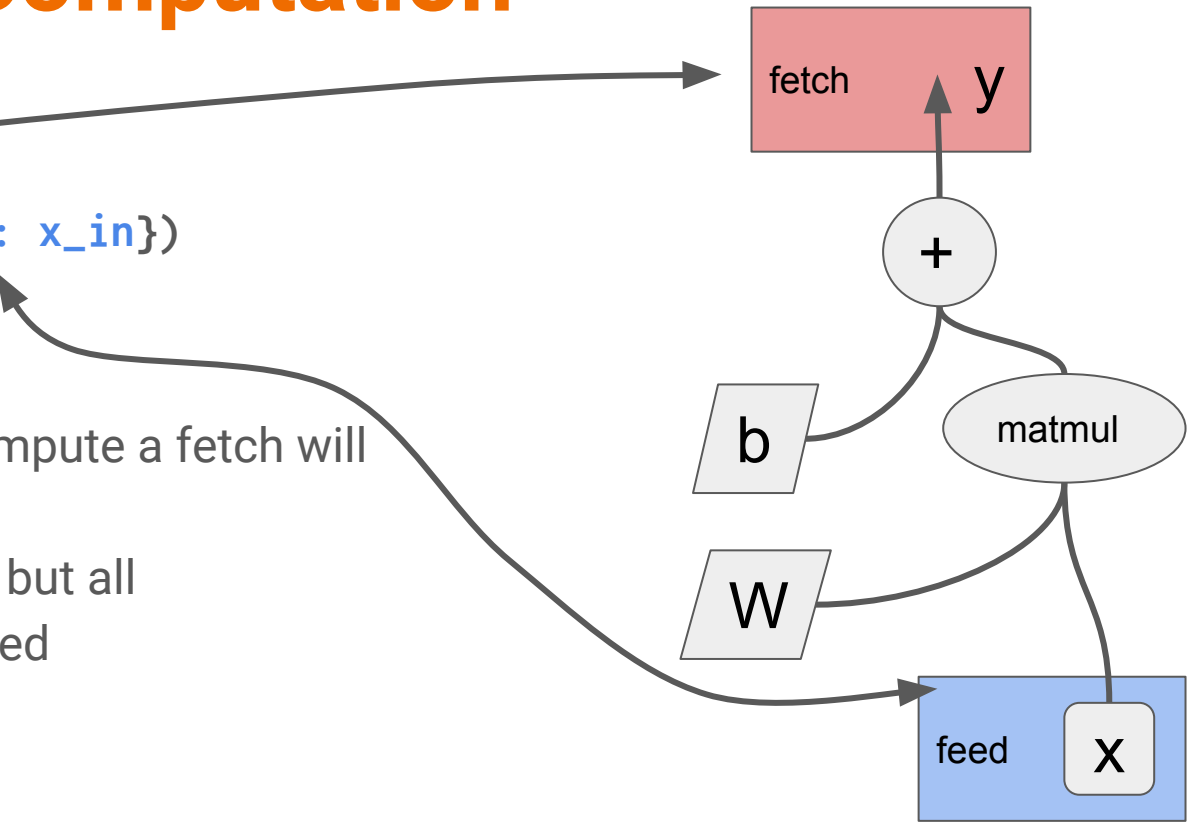
```
import tensorflow as tf

x = tf.placeholder(shape=[None],
                   dtype=tf.float32, name=”x”)

W = tf.get_variable(shape=[], name=”W”)

b = tf.get_variable(shape=[], name=”b”)

y = W * x + b
```



Running the Computation

```
x_in = 3

sess.run(y, feed_dict={x: x_in})
```

- Only what's used to compute a fetch will be evaluated
- All Tensors can be fed, but all placeholders must be fed



Putting it all together

```
import tensorflow as tf
x = tf.placeholder(shape=[None],
                   dtype=tf.float32,
                   name='x')
W = tf.get_variable(shape=[], name='W')
b = tf.get_variable(shape=[], name='b')
y = W * x + b

with tf.Session() as sess:

  sess.run(tf.initialize_all_variables())

  print(sess.run(y, feed_dict={x: x_in}))
```

Build the graph

Prepare execution environment

Initialize variables

Run the computation (usually often)

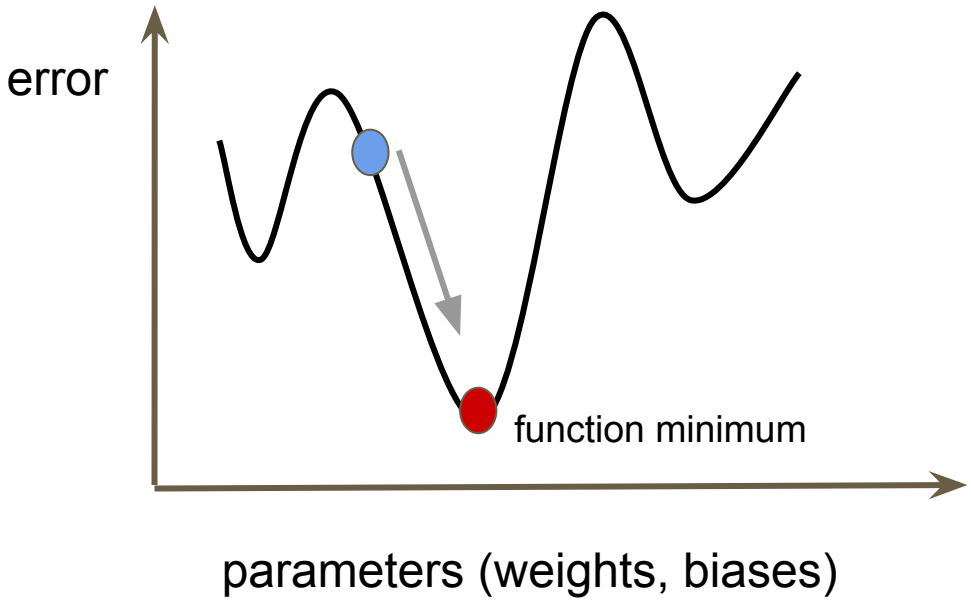
Define a Loss

Given y, y_train compute a loss, for instance:

$$L = (y - y_{train})^2$$

```
# create an operation that calculates loss.
loss = tf.reduce_mean(tf.square(y - y_train))
```

Minimize loss: optimizers




```
tf.train.AdadeltaOptimizer

tf.train.AdagradOptimizer

tf.train.AdagradDAOptimizer

tf.train.AdamOptimizer

…
```

Train

Feed (x, y_{label}) pairs and adjust W and b to decrease the loss.

$$W \leftarrow W - \eta \left(dL/dW \right)$$

$$b \leftarrow b - \eta \left(dL/db \right)$$

TensorFlow computes gradients automatically

```
# Create an optimizer

optimizer = tf.train.GradientDescentOptimizer(0.5)

# Create an operation that minimizes loss.

train = optimizer.minimize(loss)
```

Learning rate

Putting it all together

```
loss = tf.reduce_mean(tf.square(y - y_train))
optimizer = tf.train.GradientDescentOptimizer(0.5)
train = optimizer.minimize(loss)
with tf.Session() as sess:
  sess.run(tf.initialize_all_variables())
  for i in range(1000):
    sess.run(train, feed_dict={x: x_in[i],
                               y_label: y_in[i]})
```

Define a loss

Create an optimizer

Op to minimize the loss

Initialize variables

Iteratively run the training op

Linear Regression
2_linear_regression.ipynb

goo.gl/nrdsxM

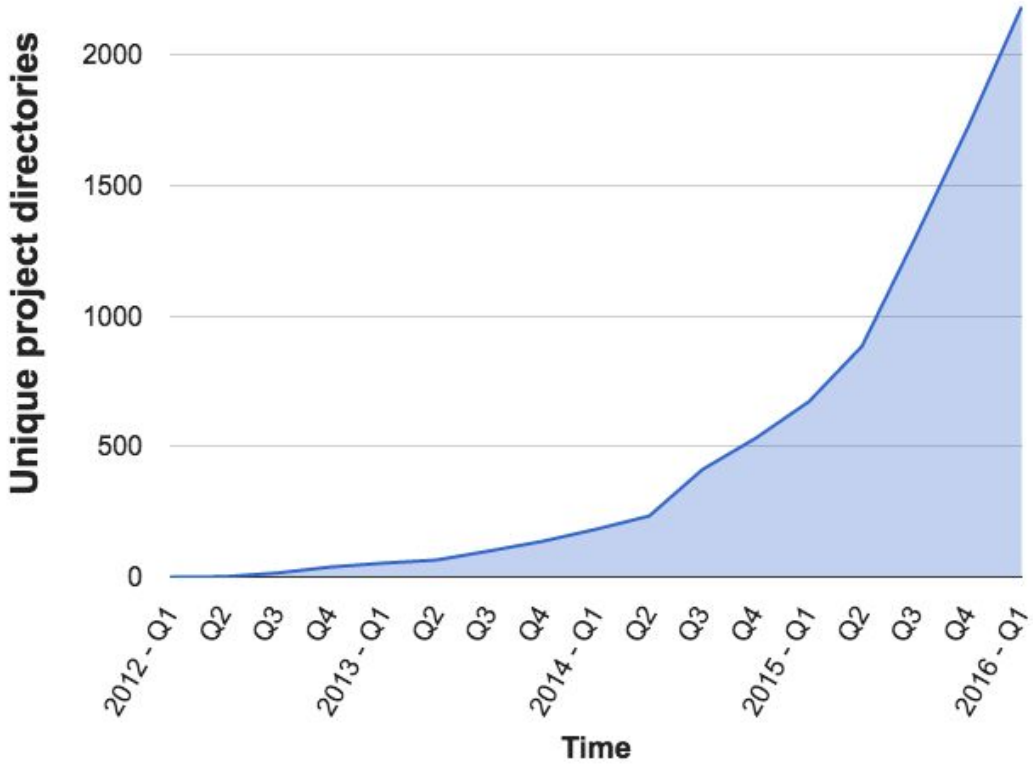
Defining your own neural networks
4_mnist_low_level.ipynb

goo.gl/nrdsxM

Deep Learning at Google

Growing Use of Deep Learning at Google

of directories containing model description files



AlphaGo

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NEWS Find local news

Home UK World Business Politics Tech Science Health Education Entertainment & Arts More

Technology

Google achieves AI 'breakthrough' at Go

An artificial intelligence program developed by Google beats Europe's top player at the ancient Chinese game of Go, about a decade earlier than expected.

27 January 2016 | Technology

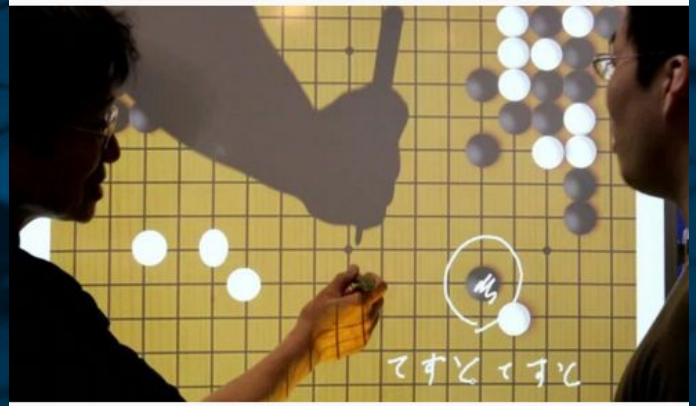
How did they do it?

What is the game Go?

Facebook trains AI to beat humans at Go

Google's AI just cracked the game that supposedly no computer could beat

By Mike Murphy | January 27, 2016

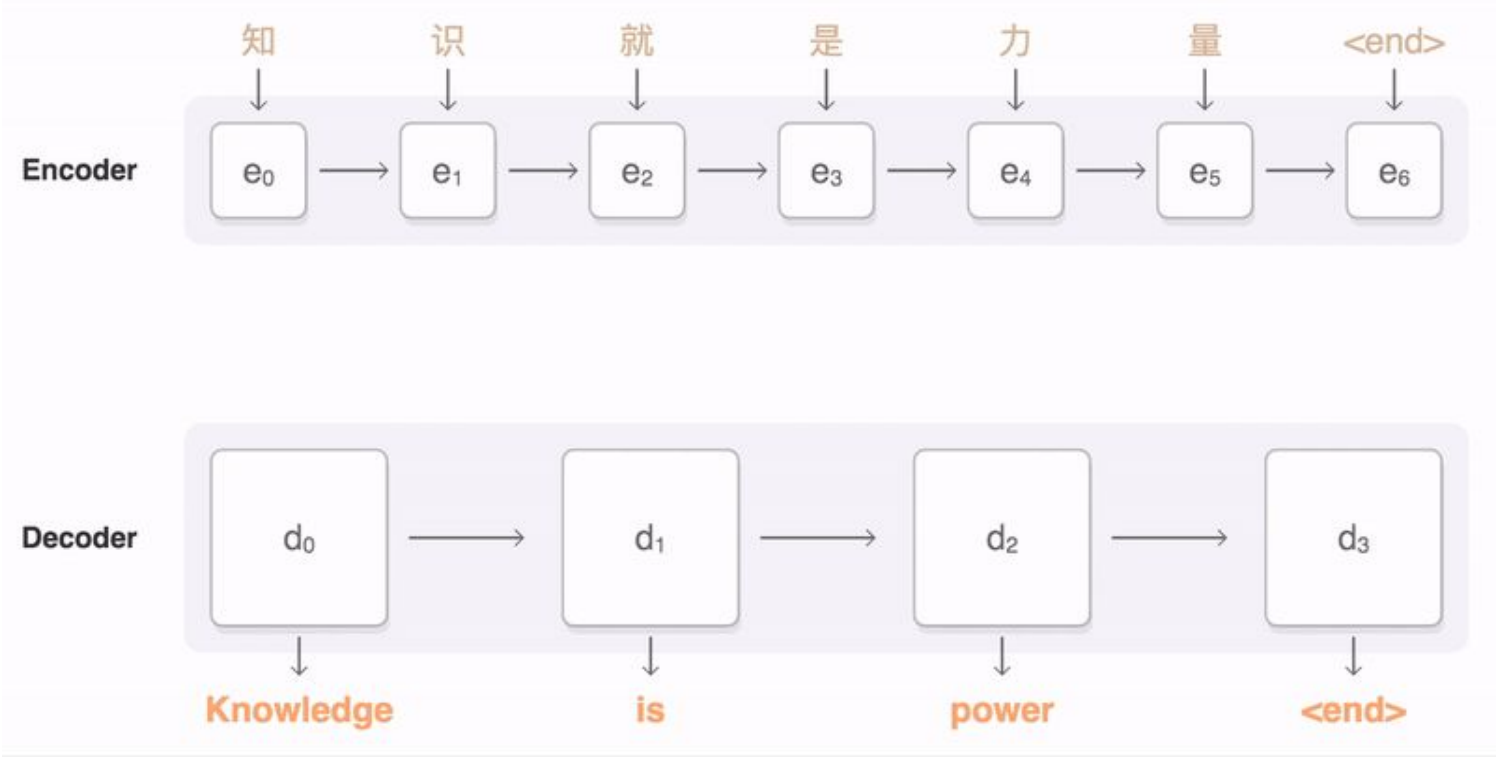


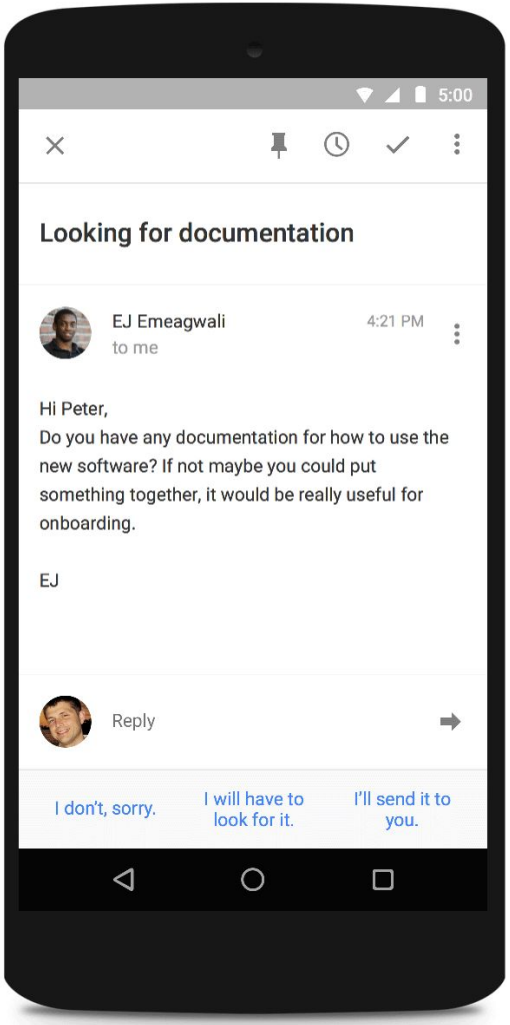
Going up. (Reuters/Kiyoshi Ota)

Computers have slowly started to encroach on activities we previously believed only the brilliantly sophisticated human brain could handle. IBM's Deep Blue supercomputer beat Grand Master Garry Kasparov at chess in 1997, and in 2011 IBM's Watson beat former human winners at the quiz game *Jeopardy*. But the ancient board game Go has long been one of the major goals of artificial intelligence research. It's understood to be one of the most difficult games for computers to handle due to the sheer number of possible moves a player can make at any given point. Until now, that is.


EXIT

Google Neural Machine Translation



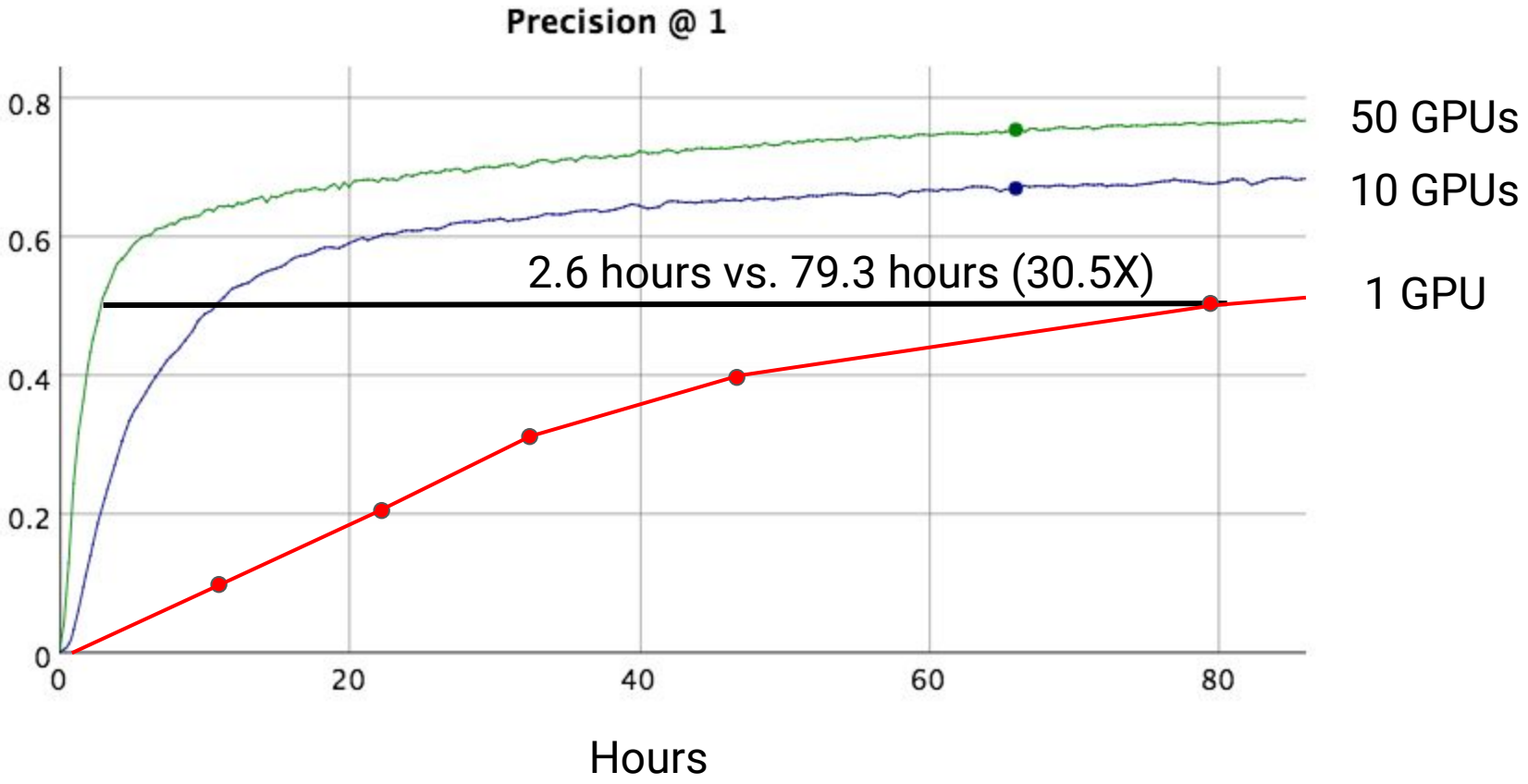


Smart reply in Inbox by Gmail

10%

of all responses sent on mobile

Image Model (Inception) Synchronous Training



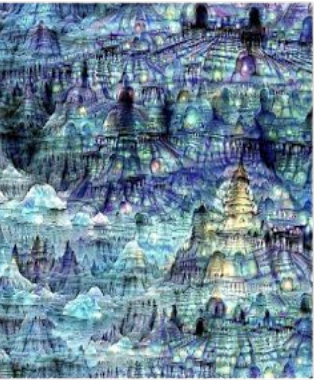
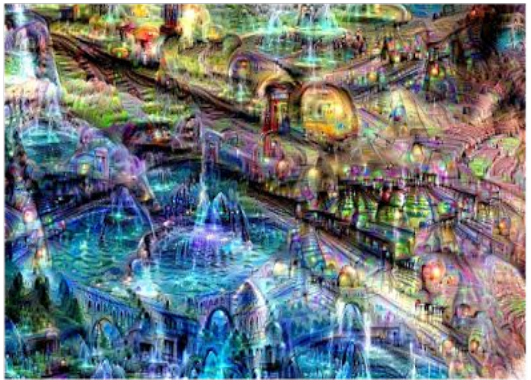
Bonus material

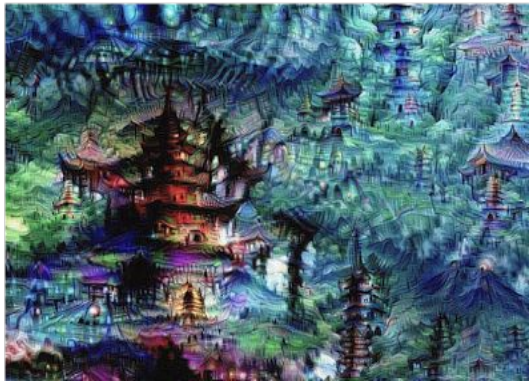
Image: Leonid Afremov – Rain Princess

Image: Stephen Wilkes, National Geographic


goo.gl/fyDxhC






goo.gl/OCYseb

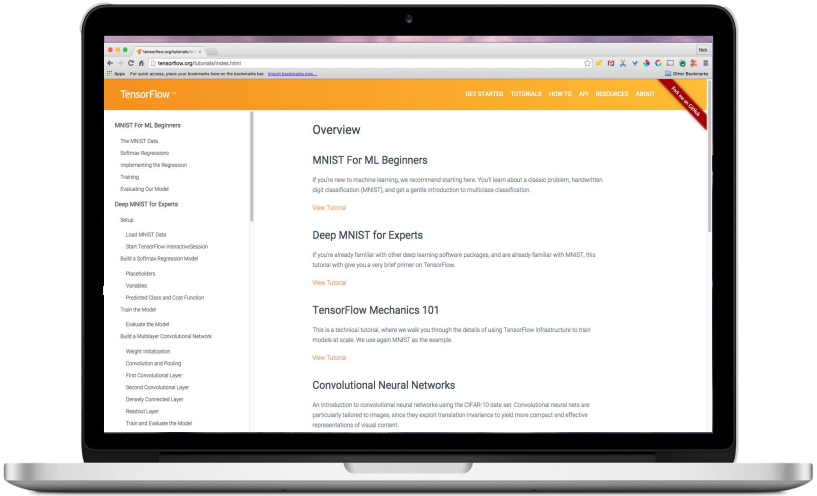
Next steps

Tutorials and code
tensorflow.org

Deep Learning by Google
Udacity class goo.gl/iHssII

Totally new to ML?
Recipes goo.gl/KewA03

Learn more about Neural Networks?
cs231n.github.io



Thank you and have fun!

Josh Gordon
@random_forests

Wolff Dobson
@greenexecutive