Fall 2018

Deep Learning for Computer Vision, Speech, and Language

Liangliang Cao
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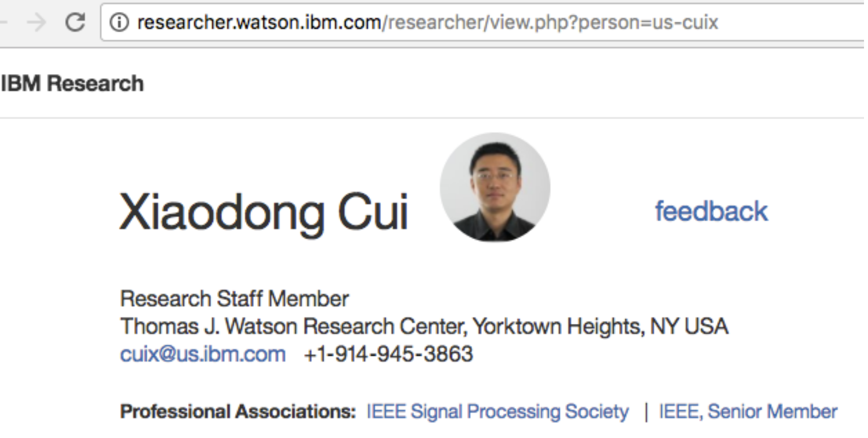
https://columbia6894.github.io/

Outline

- *Who we are*
- *What is deep learning?*
- *Grading*
  - *Homework*
  - *Projects*
- *Course schedule and resource*
- *Some demo of deep learning*

Lectures



researcher.watson.ibm.com/researcher/view.php?person=us-cuix

IBM Research

Xiaodong Cui

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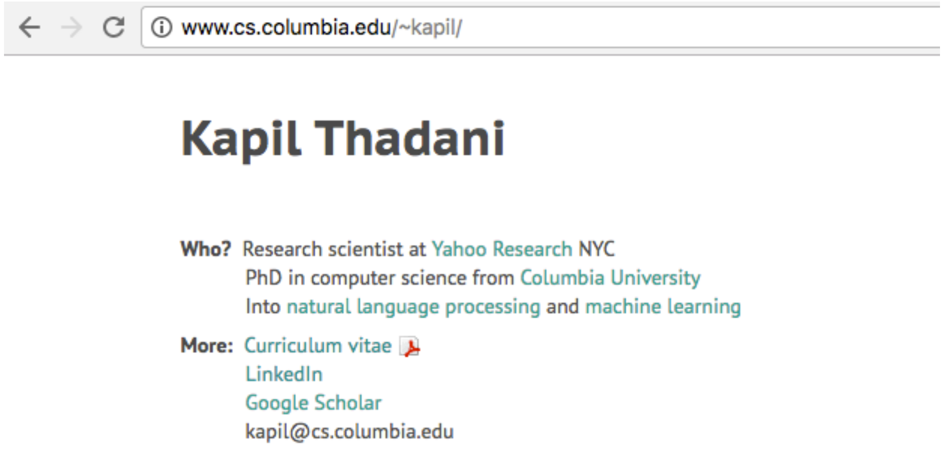
Professional Associations: IEEE Signal Processing Society | IEEE, Senior Member

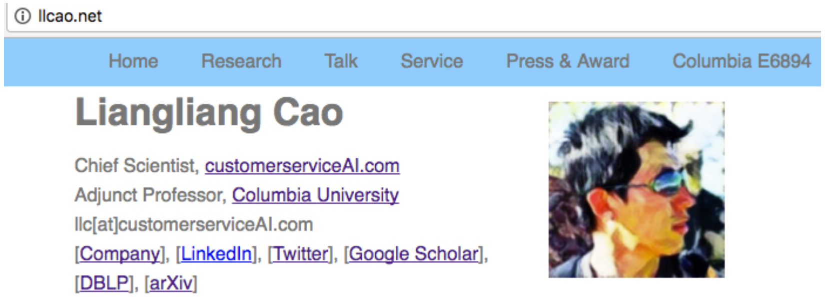


www.cs.columbia.edu/~kapil/

Kapil Thadani

Who? Research scientist at Yahoo Research NYC
PhD in computer science from Columbia University
Into natural language processing and machine learning

More: Curriculum vitae
LinkedIn
Google Scholar
kapil@cs.columbia.edu



llcao.net

Liangliang Cao

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[Company], [LinkedIn], [Twitter], [Google Scholar], [DBLP], [arXiv]

Guest lectures to
be announced

Teaching assistants (To be confirmed)

- ???

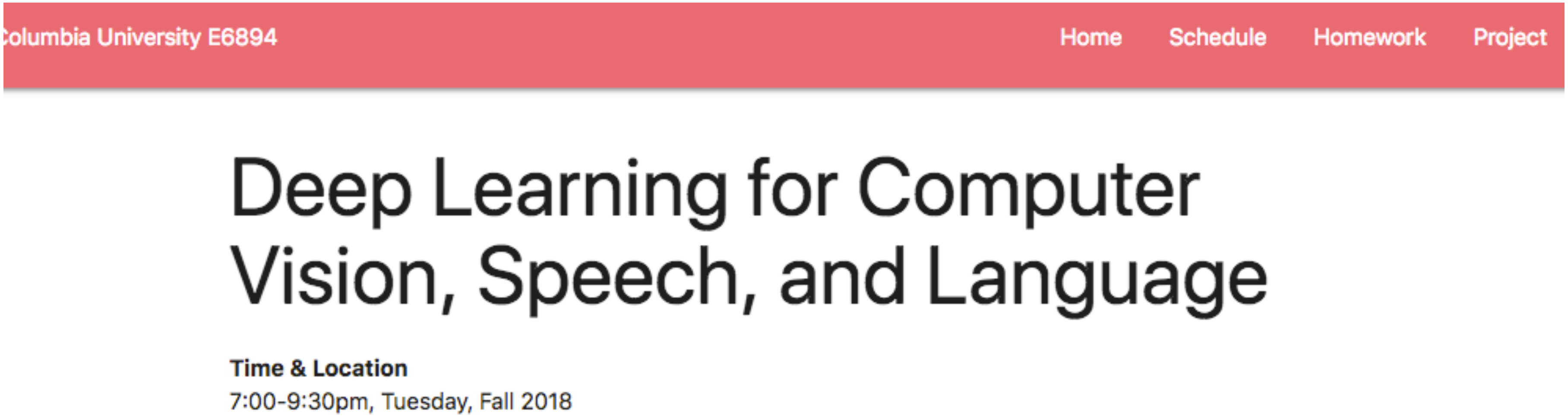
???@columbia.edu

- ???

???@columbia.edu

Website

- Slides and materials will be available on the website https://columbia6894.github.io/



Deep Learning for Computer Vision, Speech, and Language

Time & Location

7:00-9:30pm, Tuesday, Fall 2018

How to register this class?

- Please talk to your department.
  - Currently none of the lecturers has access to the Columbia course system so we have no control of it.

- Current policy:
  - First come first serve
  - Please drop out early if you realize this course is not a good fit

Especially if you cannot finish homework#1, you should drop the class!

Grading

- 40% project
  - In previous class the best team published paper in top/premium conferences

- 40% homework and paper presentation
  - HW1 is important
  - Present one paper on the important research breakthough

- 20% paper presentation and course attendence

Course requirements

- Knowledgeable about NLP and/or speech and/or vision and/or machine learning
- Fluent in Python.
- Know Tensorflow (or pyTorch) or you can learn it quickly
- Willing to work with GPUs.

Why Python?

- Free (*not like Matlab!*)
- Much easier to use than CUDA C/C++
- THE choice for scientific computing and cloud service
- If you do not know python, please consider to drop coz it will be too hard to follow the class.

How to access GPU?

- Build one
  - If you have a (relative new) desktop, you should add a GPU card with $1000 (eg. NVidia GTX1080Ti or Titan XP)
- Rent cloud
  - Google cloud helps free access may come soon

Course schedule

1. Overview (class 1-4)
   - Course overview and Tensorflow basic
   - Review of NN and Optimization
   - Review of NLP basic
   - Review of CNN

2. Deep learning for Speech, Language, and Vision

   Each class focuses one topic with

   a) Lectures by the instructor/guest speaker

   b) One homework per topic

Student presentation

Procedure:

- Form a team with two students
- Select one paper (from the list suggested on the webpage)
- Prepare a 20 mins presentation, at least 15 pages slides
  - Slides should be sent to the instructor one day before the presentation.
- Demos/source code analysis are welcome

Final project

- Team work: 2-3 students per group
- Goal:
  - Develop the state-of-the-art deep learning techniques.
  - Try to solve real problems with the knowledge you learned
- Format:
  - 4 pages double column (e.g., in ICASSP format)
  - or 8 pages single column (e.g., in NIPS format)
- Evaluation
  - Students' vote: Idol Award
  - Instructor's pick: AI conference quality

(I only write recommendation letters for students with conference-quality projects)

Which toolkit shall I use for project

- Tensorflow (huge society, by Google)
  - **Keras** (high level interface)
  - Good for development and deployment

- PyTorch (popular in speech. By Facebook FAIR)
  - Good for research
  - Potential support from Caffe2: object detection

Mastering the tools

- Use Python Notebook (Jupyter)
  - http://jupyter.org/try
  - colab.research.google.com
  - Submit homework with results in python notebook!
- Use Git for team project

  - Create a personal account on github.com

  - Understand git commands

Power of Deep Networks

- AlphaGo Zero by David Silver
- Google Cloud Vision API
- Visual Memory QA
- Super SloMo
- Watson Text to Speech and Watson Speech to Text

Short Break

https://columbia6894.github.io/

Programming: Tensorflow, Keras and Homework

Liangliang Cao

https://columbia6894.github.io/

Install Tensorflow

- Documentation
  - https://www.tensorflow.org/
  - We suggest to use virtual env
- Straightforward installation
  - On cloud, you need setup a project
  - On your local machine, type “pip install tensorflow” and install other related libraries
- In this class, we’ll use Codelab to demonstrate some basic concept
  - https://colab.research.google.com/

Which is True Statement for Tensorflow?

- A python framework of computing math expression
- Designed for large scale data
- Designed for the specific purpose of deep learning

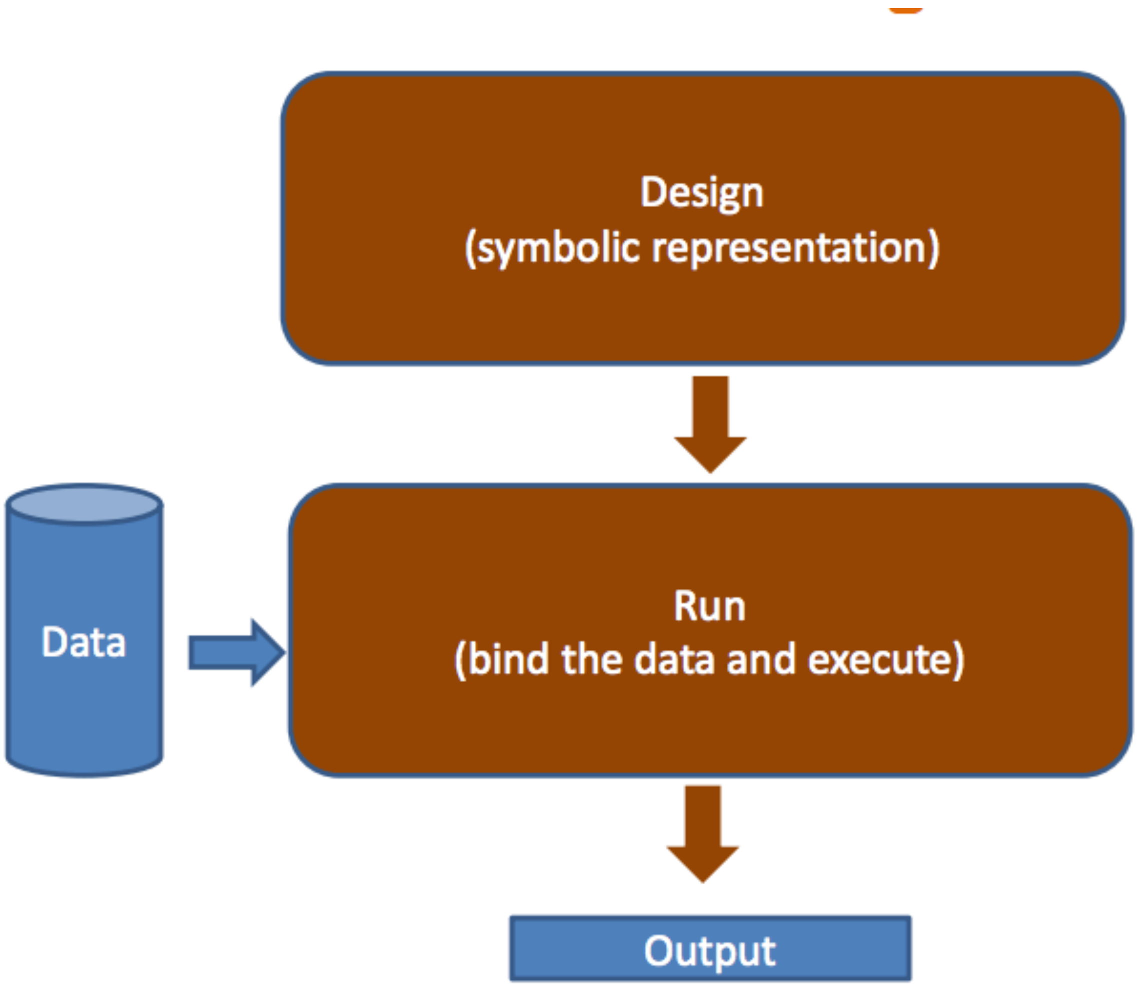
Which is True Statement for Tensorflow?

- A python framework of computing math expression
  - Similar with Theano

- Designed for large scale data
  - Excellent engineering

- ~~Designed for the specific purpose of deep learning~~
  - Tensorflow's low level APIs are for general purpose.

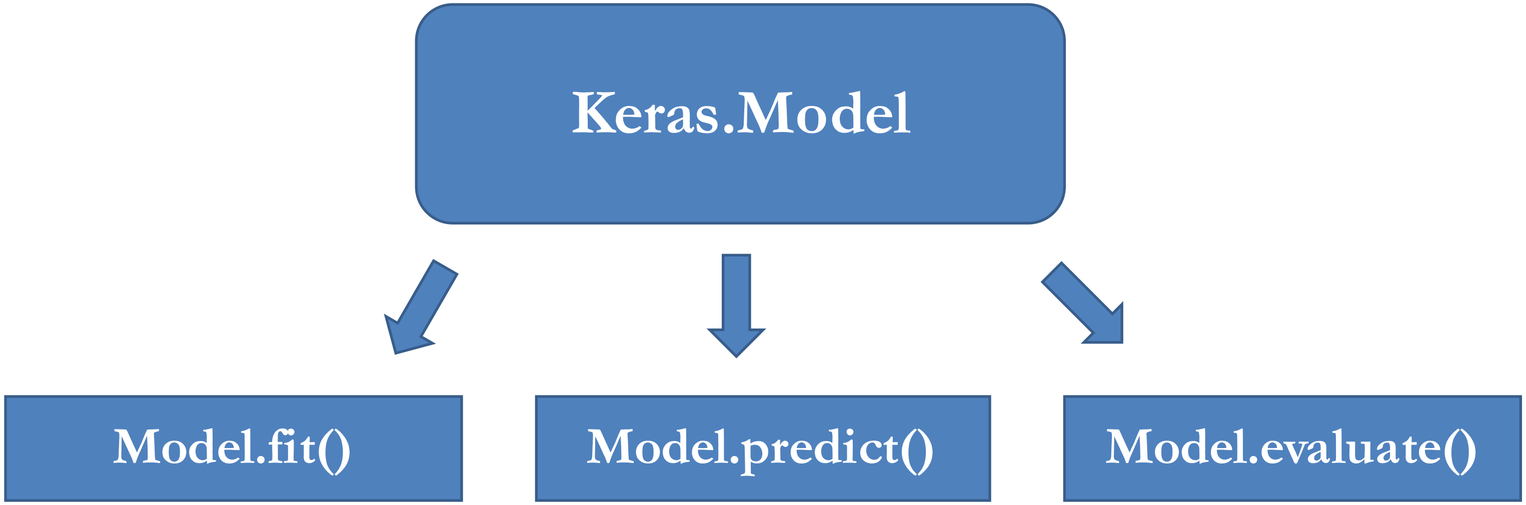
Tensorflow’s Design



Simpler Interface for Machine Learning

Keras is a wrapper of Tensorflow

from tensorflow.python import keras



Keras.Model

Model.fit()

Model.predict()

Model.evaluate()

Reference: https://keras.io/

A Simple Tensorflow Code

```
import tensorflow as tf
a = tf.add(3, 5)
print(a)
```

What is the output?

A Simple Tensorflow Code

```
import tensorflow as tf
a = tf.add([1,2], [2,1])
print(a)
```

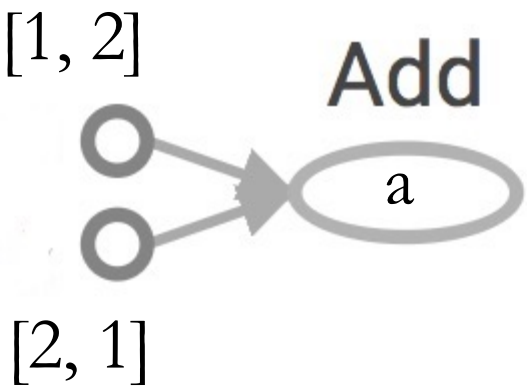
What is the output?

a) [3, 3]
b) Tensor("Add:0", shape=(2, 1), dtype=int32)
c) None of above

A Simple Tensorflow Code

```
import tensorflow as tf
a = tf.add([1,2], [2,1])
print(a)
```

What is the output?



A tf graph includes symbolic objects

A tf session allocates memory to evaluate symbolic objects

A Simple Tensorflow Code

```
import tensorflow as tf
a = tf.add([1,2], [2,1])
print(a)
with tf.Session() as sess:
    print sess.run(a)
```

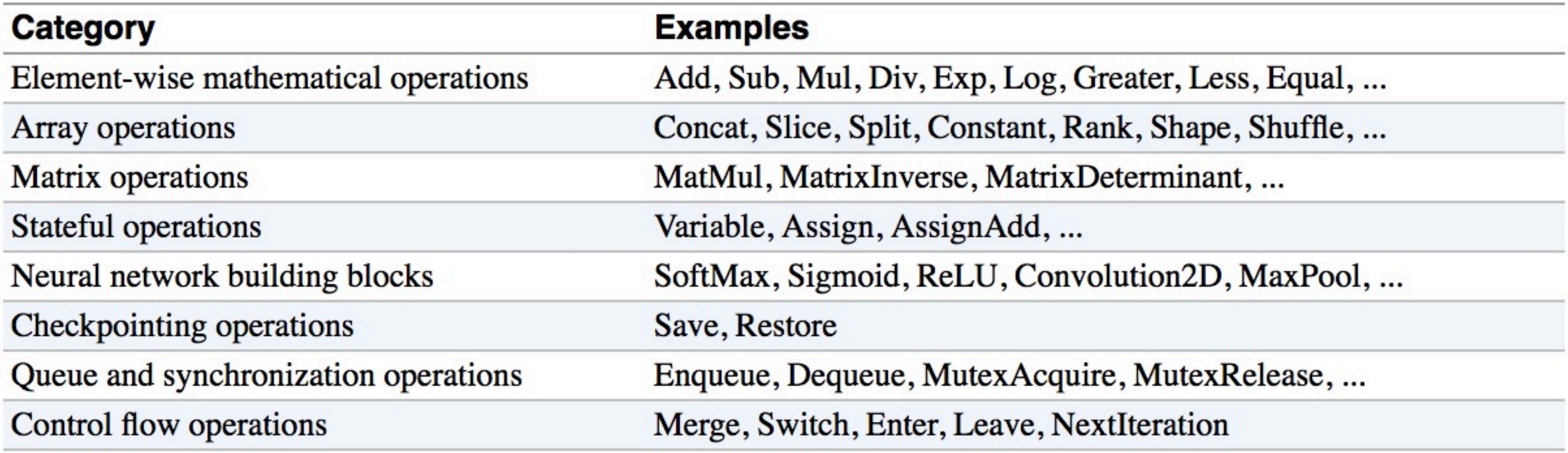
What is the new output?

Why Graph and Session?

- Optimize computation. The graph model will be optimized before evaluating

- Facilitate distributed computation, spread the work across multiple CPUs, GPUs, or TPUs.

Tensorflow Low-level APIs



Category	Examples
Element-wise mathematical operations	Add, Sub, Mul, Div, Exp, Log, Greater, Less, Equal, ...
Array operations	Concat, Slice, Split, Constant, Rank, Shape, Shuffle, ...
Matrix operations	MatMul, MatrixInverse, MatrixDeterminant, ...
Stateful operations	Variable, Assign, AssignAdd, ...
Neural network building blocks	SoftMax, Sigmoid, ReLU, Convolution2D, MaxPool, ...
Checkpointing operations	Save, Restore
Queue and synchronization operations	Enqueue, Dequeue, MutexAcquire, MutexRelease, ...
Control flow operations	Merge, Switch, Enter, Leave, NextIteration

Refer to Chip Huyen’s course on Tensorflow

A Magic Function

```
import tensorflow as tf
x = tf.placeholder(tf.float32)
y =  2*x + x*x
g = tf.gradients(x + y, [x, y])
with tf.Session() as sess:
    print sess.run(g, feed_dict={x:1.0})
```

Tf.gradient allows automat gradient calculation.

Super useful for optimization (next class)

Another Example

```
import tensorflow as tf
X = tf.placeholder(tf.float32,  name='X')
Y = tf.placeholder(tf.float32,  name='Y')

w = tf.get_variable('weights',  initializer=tf.constant(0.0))
b = tf.get_variable('bias',  initializer=tf.constant(0.0))

Y_predicted  = w * X + b
loss = tf.square(Y - Y_predicted,  name='loss')
optimizer = tf.train.GradientDescentOptimizer(learning_rate=0.001).minimize(loss)
with tf.Session() as sess:
    sess.run(tf.global_variables_initializer())
    for i in range(100):  # run 100 epochs
        for x, y in data:
            sess.run(optimizer, feed_dict={X: x, Y:y})
    w_out, b_out = sess.run([w, b])
```

From Tensorflow to Keras

```
import tensorflow as tf

from tensorflow.python.keras.models  import Sequential
from tensorflow.python.keras.layers  import Dense, Activation

model = Sequential()
model.add(Dense(10,  input_dim=100, activation='softmax'))
model.compile(optimizer='sgd',  loss='categorical_crossentropy',  metrics=['accuracy'])
history = model.fit(X_train, Y_train, 128, nb_epoch=5,  validation_data=(X_test,  Y_test))
score = model.evaluate(X_test,  Y_test)
```

From Tensorflow to Keras

```
import tensorflow as tf

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score = model.evaluate(X_test, Y_test)
```

Keras is simpler to use for classification/regression problems.

Keras has a lot of wrapper functions for network building

Keras does not provide many low level APIs for large scale data

Take-home Work

Required:

- Install Jupiter Notebook
- Install Tensorflow and Keras
- Work for homework #1

  https://columbia6894.github.io/homework.html

Suggested:

- Create a github account
- Read Tensorflow and Keras tutorials