Deep Learning Software

Spring 2020

Today

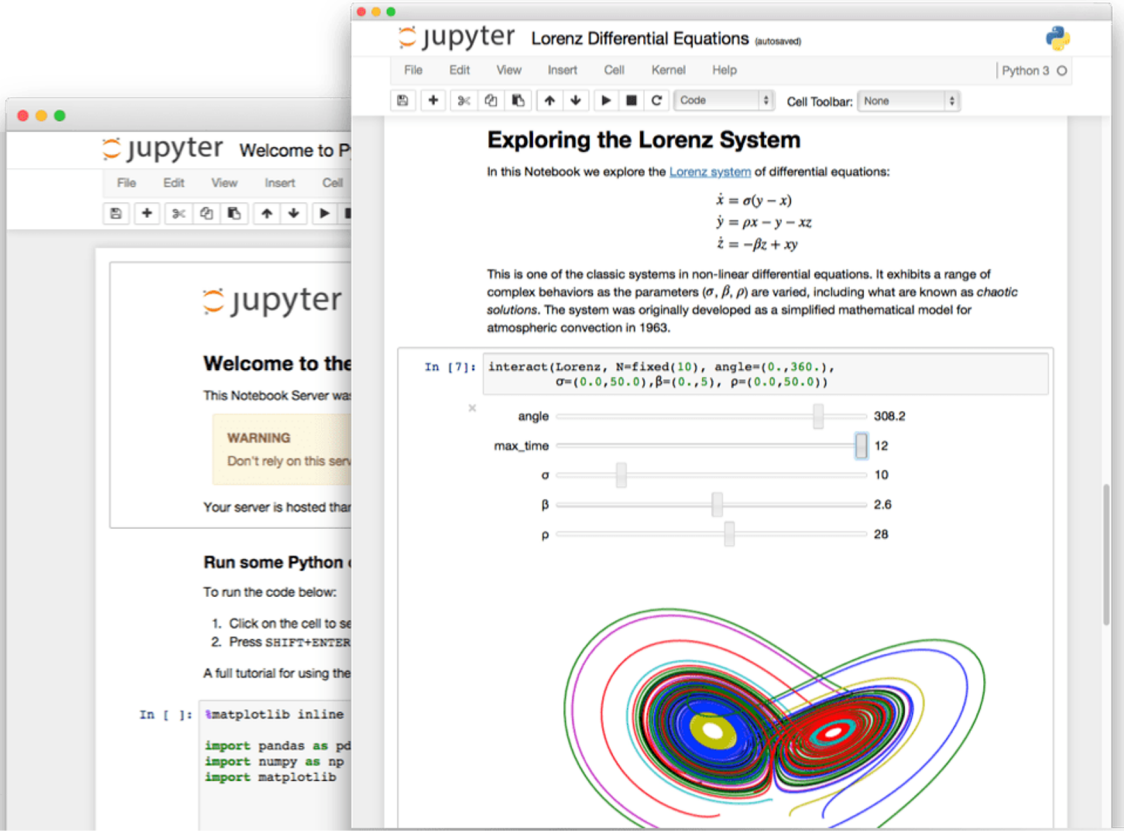
- Homework 1 is out, due Feb 6
- Conda and Jupyter Notebook
- Deep Learning Software
  - Keras
  - Tensorflow
  - Numpy
- Google Cloud Platform

Conda

- A package management system for Python

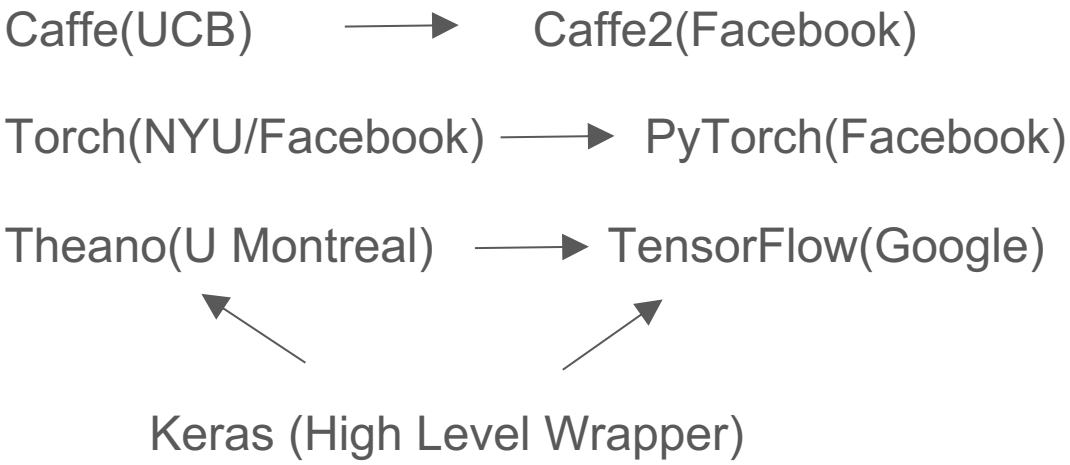
Jupyter notebook

- A web application that where you can code, interact, record and plot.
- Allow for remote interaction when you are working on the cloud
- You will be using it for HW1



Deep Learning Software

Deep Learning Software

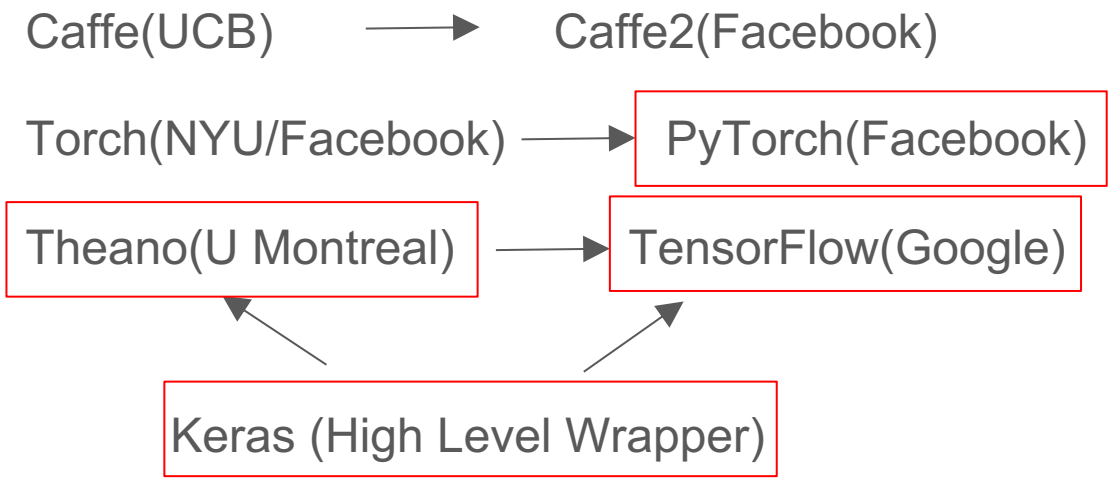


Paddle (Baidu)

CNTK(Microsoft)

MXNet(Amazon)

Deep Learning Software: Most Popular



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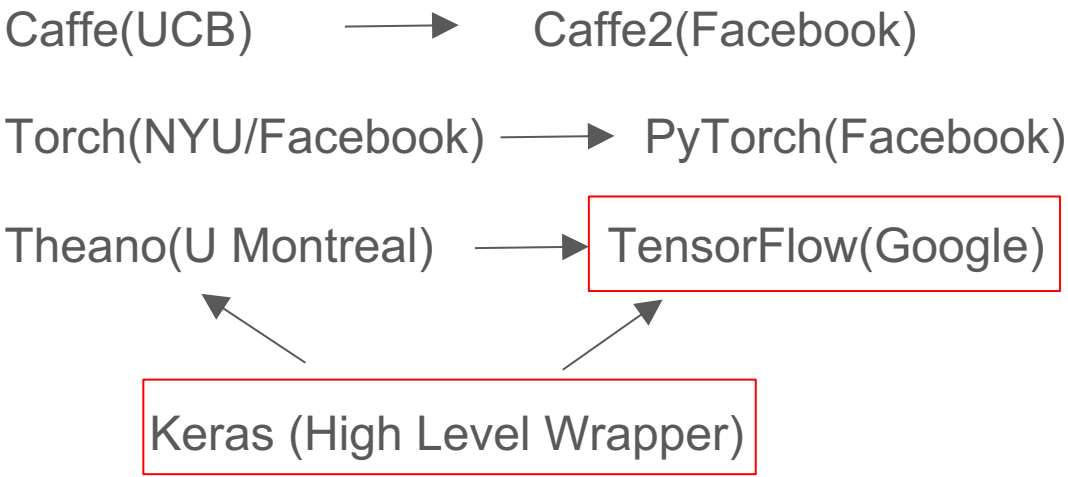
Deep Learning Software: Today



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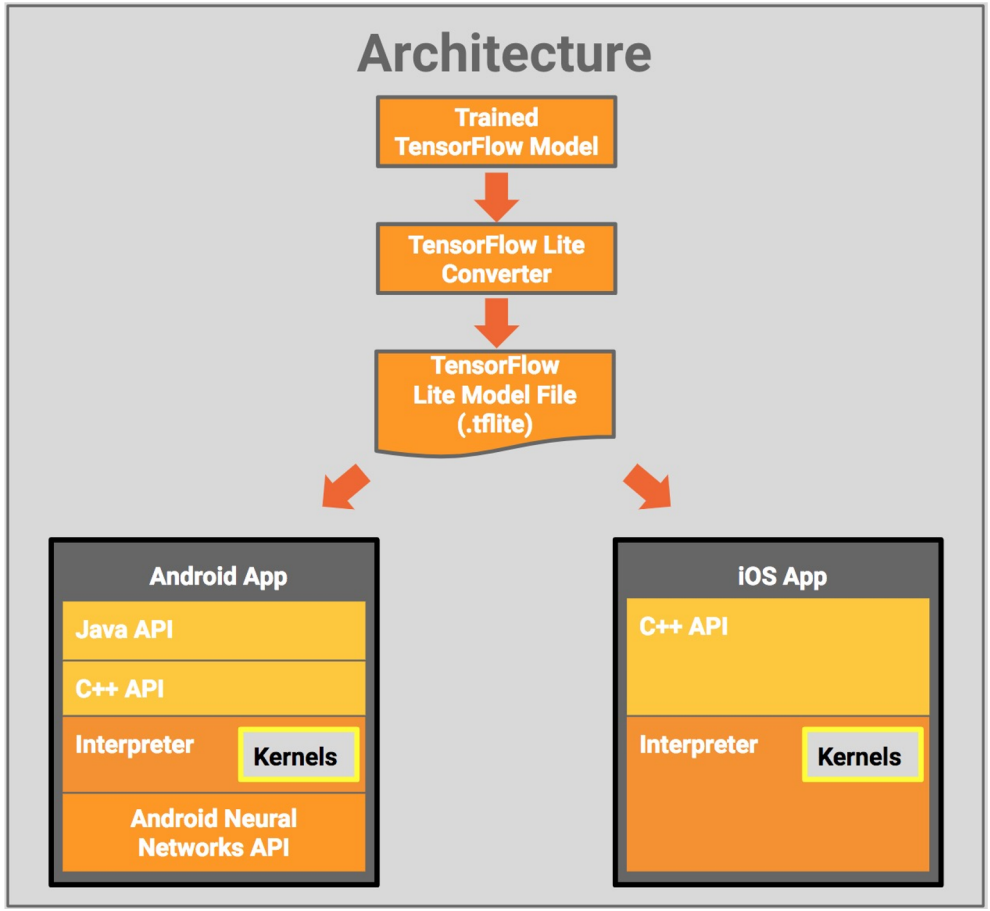
Mobile Platform

- Tensorflow Lite:
  - Released last November



Why do we use deep learning frameworks?

- Easily build big computational graphs
  - Not the case in HW1
- Easily compute gradients in computational graphs
- GPU support (cuDNN, cuBLA...etc)
  - Not required in HW1

Keras

- A high-level deep learning framework
- Built on other deep-learning frameworks
  - Theano
  - Tensorflow
  - CNTK
- Easy and Fun!

Keras: A High-level Wrapper

- Pass on a layer of instances in the constructor

```
from keras.models import Sequential
from keras.layers import Dense, Activation

model = Sequential([
    Dense(32, input_shape=(784,)),
    Activation('relu'),
    Dense(10),
    Activation('softmax'),
])
```

- Or: simply add layers. Make sure the dimensions match.

```
model = Sequential()
model.add(Dense(32, input_dim=784))
model.add(Activation('relu'))
```

Keras: Compile and train!

```
# For a single-input model with 2 classes (binary classification):

model = Sequential()
model.add(Dense(32, activation='relu', input_dim=100))
model.add(Dense(1, activation='sigmoid'))
model.compile(optimizer='rmsprop',
              loss='binary_crossentropy',
              metrics=['accuracy'])

# Generate dummy data
import numpy as np
data = np.random.random((1000, 100))
labels = np.random.randint(2, size=(1000, 1))

# Train the model, iterating on the data in batches of 32 samples
model.fit(data, labels, epochs=10, batch_size=32)
```

Epoch: 1 epoch means going through
all the training dataset once

Numpy

- The **fundamental** package in Python for:
  - Scientific Computing
  - Data Science
- Think in terms of vectors/Matrices
  - Refrain from using for loops!
  - Similar to Matlab

```
>>> import numpy as np
>>> a = np.arange(15).reshape(3, 5)
>>> a
array([[ 0,  1,  2,  3,  4],
       [ 5,  6,  7,  8,  9],
       [10, 11, 12, 13, 14]])
>>> a.shape
(3, 5)
>>> a.ndim
2
>>> a.dtype.name
'int64'
>>> a.itemsize
8
>>> a.size
15
>>> type(a)
<type 'numpy.ndarray'>
>>> b = np.array([6, 7, 8])
>>> b
array([6, 7, 8])
>>> type(b)
<type 'numpy.ndarray'>
```

Numpy

- Basic vector operations
  - Sum, mean, argmax….
- Linear Algebra operations

```
>>> import numpy as np
>>> a = np.array([[1.0, 2.0], [3.0, 4.0]])
>>> print(a)
[[ 1.  2.]
 [ 3.  4.]]

>>> a.transpose()
array([[ 1.,  3.],
       [ 2.,  4.]])

>>> np.linalg.inv(a)
array([[-2. ,  1. ],
       [ 1.5, -0.5]])

>>> u = np.eye(2) # unit 2x2 matrix; "eye" represents "I"
>>> u
array([[ 1.,  0.],
       [ 0.,  1.]])
>>> j = np.array([[0.0, -1.0], [1.0, 0.0]])

>>> np.dot (j, j) # matrix product
array([[-1.,  0.],
       [ 0., -1.]])

>>> np.trace(u)  # trace
2.0
```

Numpy

- Indexing, Slicing, Iterating

```
import numpy as np

# Create the following rank 2 array with shape (3, 4)
# [[ 1  2  3  4]
#  [ 5  6  7  8]
#  [ 9 10 11 12]]
a = np.array([[1,2,3,4], [5,6,7,8], [9,10,11,12]])

# Use slicing to pull out the subarray consisting of the first 2 rows
# and columns 1 and 2; b is the following array of shape (2, 2):
# [[2 3]
#  [6 7]]
b = a[:2, 1:3]

# A slice of an array is a view into the same data, so modifying it
# will modify the original array.
print(a[0, 1])   # Prints "2"
b[0, 0] = 77     # b[0, 0] is the same piece of data as a[0, 1]
print(a[0, 1])   # Prints "77"
```

Numpy

- Broadcasting

```
import numpy as np

# We will add the vector v to each row of the matrix x,
# storing the result in the matrix y
x = np.array([[1,2,3], [4,5,6], [7,8,9], [10, 11, 12]])
v = np.array([1, 0, 1])
y = x + v  # Add v to each row of x using broadcasting
print(y)  # Prints "[[ 2  2  4]
          #          [ 5  5  7]
          #          [ 8  8 10]
          #          [11 11 13]]"
```

Numpy Example

- Find the nearest value from a given value in an array

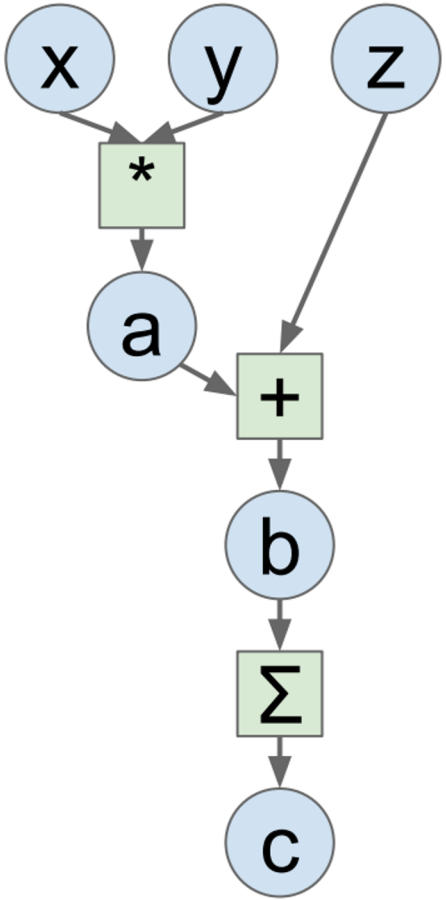
```
1  Z = np.random.uniform(0,1,10)
2  z = 0.5
3  m = Z.flat[np.abs(Z - z).argmin()]
4  print(m)
```

```
0.438601513462
```

Computational Graphs

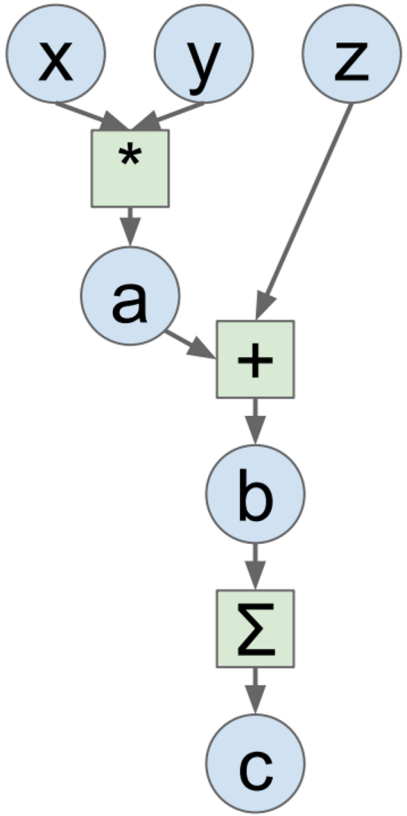
- f(x,y,z) = sum(x*y + z)
- x,y,z can be scalars, vectors, matrices, tensors.

```
import numpy as np
np.random.seed(0)

N, D = 3, 4

x = np.random.randn(N, D)
y = np.random.randn(N, D)
z = np.random.randn(N, D)

a = x * y
b = a + z
c = np.sum(b)
```



Computational Graphs- Numpy

```
import numpy as np
np.random.seed(0)

N, D = 3, 4

x = np.random.randn(N, D)
y = np.random.randn(N, D)
z = np.random.randn(N, D)

a = x * y
b = a + z
c = np.sum(b)

grad_c = 1.0
grad_b = grad_c * np.ones((N, D))
grad_a = grad_b.copy()
grad_z = grad_b.copy()
grad_x = grad_a * y
grad_y = grad_a * x
```



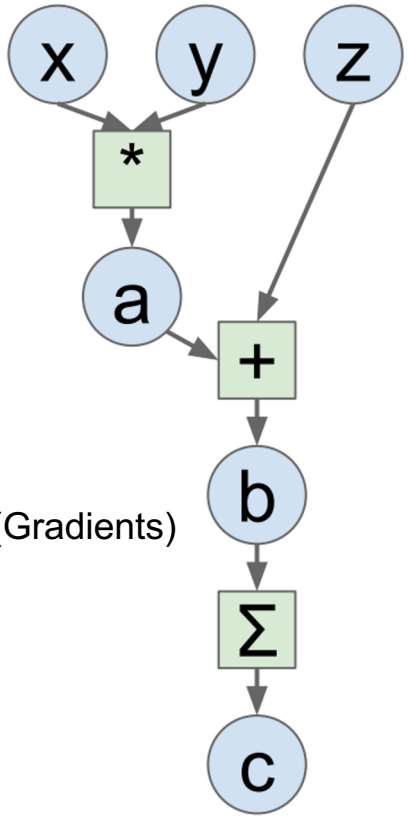
Tensorflow

```
import numpy as np
np.random.seed(0)
import tensorflow as tf

N, D = 3, 4

with tf.device('/gpu:0'):
    x = tf.placeholder(tf.float32)
    y = tf.placeholder(tf.float32)
    z = tf.placeholder(tf.float32)

    a = x * y
    b = a + z
    c = tf.reduce_sum(b)

grad_x, grad_y, grad_z = tf.gradients(c, [x, y, z])

with tf.Session() as sess:
    values = {
        x: np.random.randn(N, D),
        y: np.random.randn(N, D),
        z: np.random.randn(N, D),
    }
    out = sess.run([c, grad_x, grad_y, grad_z],
                   feed_dict=values)
    c_val, grad_x_val, grad_y_val, grad_z_val = out
```

Define Variables

Define New Variables(Gradients)

Define Functions



Comparison

Framework	Pros/Cons
Theano	Development completed, No development in progress, Static
Tensorflow	Actively developed, big community, Static
PyTorch	Better for Research, relatively new, Dynamic
Keras	High-level, Easy, Not flexible

Resources

- Great Documentation on all of the DL software
- Deeplearning.ai
- State-of-art result for machine learning problems
    - https://github.com/RedditSota/state-of-the-art-result-for-machine-learning-problems

Acknowledgment

- Based on material from
  - Spring 2019 Course