Basic Models in TensorFlow

CS 20SI:
TensorFlow for Deep Learning Research
Lecture 3
1/20/2017

Agenda

Review

Linear regression in TensorFlow

Optimizers

Logistic regression on MNIST

Loss functions

Review

Computation graph

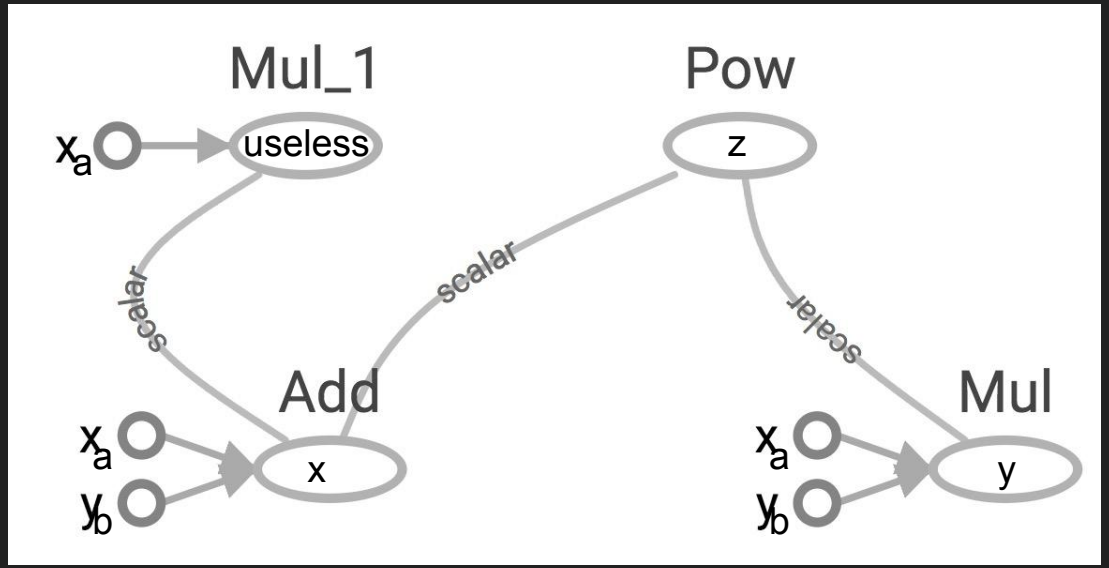
TensorFlow separates definition of computations from their execution

Phase 1: assemble a graph

Phase 2: use a session to execute operations in the graph.

TensorBoard

```
a = 2

b = 3

x = tf.add(a, b)

y = tf.mul(a, b)

useless = tf.mul(a, x)

z = tf.pow(y, x)

with tf.Session() as sess:

      z = sess.run(z)
```



Create a FileWriter object to write your graph to event files

tf.constant and tf.Variable

Constant values are stored in the graph definition

Sessions allocate memory to store variable values

tf.placeholder and feed_dict

Feed values into placeholders by dictionary (feed_dict)

You can feed values in variables too

Avoid lazy loading

1. Separate the assembling of graph and executing ops
2. Use Python attribute to ensure a function is only loaded the first time it's called

Go to GitHub

From examples

`03_linear_regression_starter.py`

`03_logistic_regression_mnist_starter.py`

From data

`Get the file fire_theft.xls`

Linear Regression

Model relationship between a scalar dependent variable y and independent variables X

The City of Chicago

X: number of incidents of fire
Y: number of incidents of theft

Want

X: number of incidents of fire
Y: number of incidents of theft
Predict Y from X

Model

$$w * X + b$$

$$(Y - Y_{predicted})^2$$

Phase 1: Assemble our graph

Step 1: Read in data

I already did that for you

Step 2: Create placeholders for inputs and labels

```
tf.placeholder(dtype, shape=None, name=None)
```

Step 3: Create weight and bias

```
tf.Variable(initial_value=None, trainable=True, collections=None,
                    name=None, dtype=None, ...)
```

Step 4: Build model to predict Y

```
Y_predicted = X * w + b
```

Step 5: Specify loss function

```
tf.square(Y - Y_predicted, name="loss")
```

Step 6: Create optimizer

```
tf.train.GradientDescentOptimizer(learning_rate=0.001).minimize(loss)
```

Phase 2: Train our model

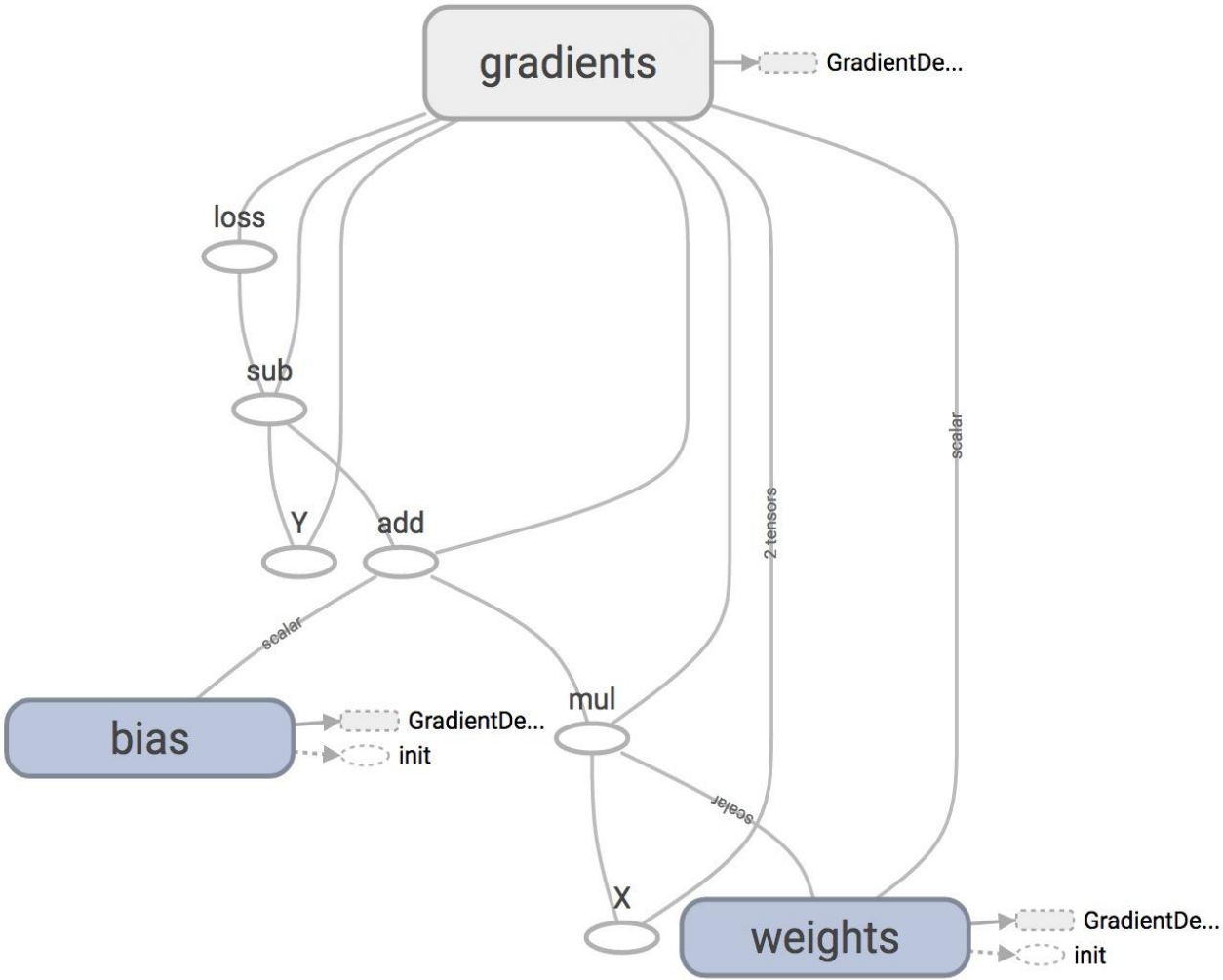
Initialize variables

Run optimizer op

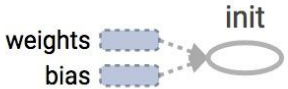
(with data fed into placeholders for inputs and labels)

See your model in TensorBoard

```
Step 1: writer = tf.summary.FileWriter('./my_graph/03/linear_reg', sess.graph)

Step 2: $ tensorboard --logdir='./my_graph'
```


gradients
GradientDe...
loss
sub
Y
add
scalar
2 tensors
scalar
bias
GradientDe...
init
mul
scalar
X
weights
GradientDe...
init


weights
gradients
bias
GradientDesc...

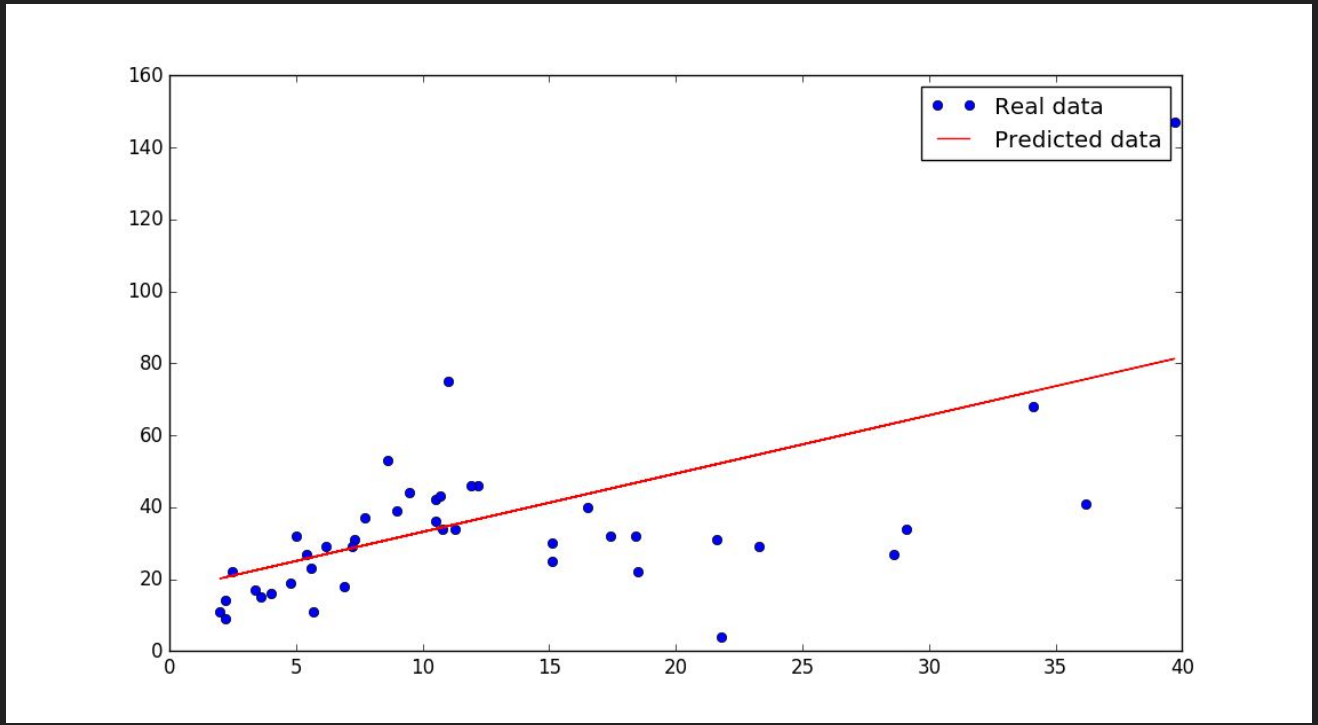

init
weights
bias

Plot the results with matplotlib

Step 1: Uncomment the plotting code at the end of your program

Step 2: Run it again

If run into problem of matplotlib in virtual environment, go to GitHub/setups and see the file possible setup problems


Real data
Predicted data
160
140
120
100
80
60
40
20
0
0
5
10
15
20
25
30
35
40

ValueError?

ValueError?

```
w, b = sess.run([w, b])
```

How does TensorFlow know what variables to update?

Optimizer

```
optimizer = tf.train.GradientDescentOptimizer(learning_rate=0.001).minimize(loss)

_, l = sess.run([optimizer, loss], feed_dict={X: x, Y:y})
```

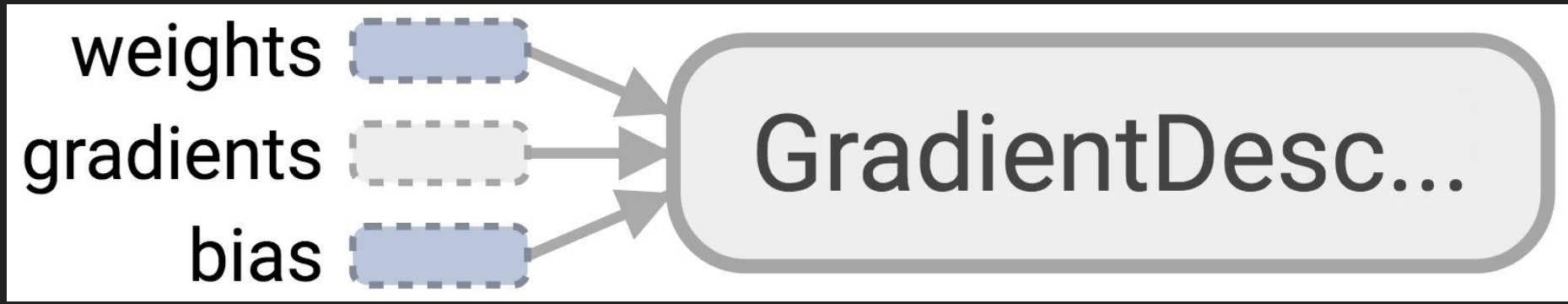
Optimizer

```
optimizer = tf.train.GradientDescentOptimizer(learning_rate=0.001).minimize(loss)

_, l = sess.run([optimizer, loss], feed_dict={X: x, Y:y})
```

Session looks at all trainable variables that loss depends on and update them

Optimizer

Session looks at all trainable variables that optimizer depends on and update them



Trainable variables

```
tf.Variable(initial_value=None, trainable=True, collections=None,
validate_shape=True, caching_device=None, name=None, variable_def=None, dtype=None,
expected_shape=None, import_scope=None)
```

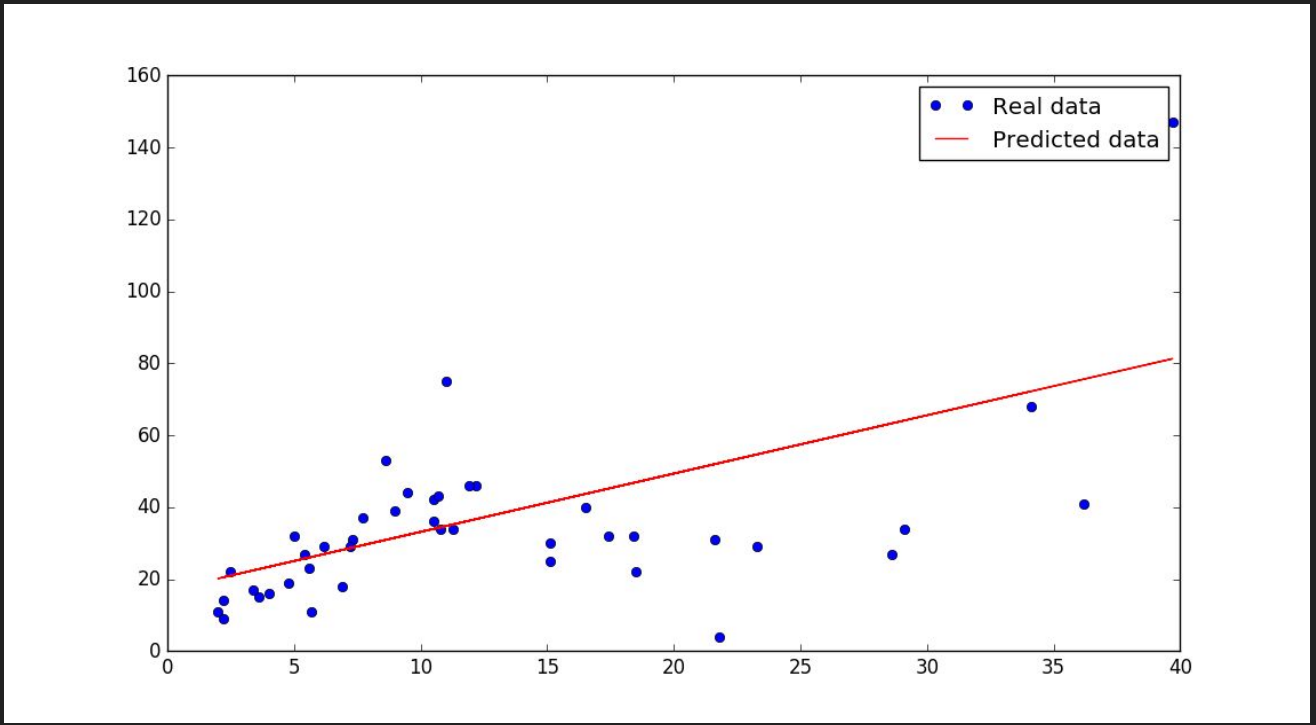
List of optimizers in TF

```
tf.train.GradientDescentOptimizer

tf.train.AdagradOptimizer

tf.train.MomentumOptimizer

tf.train.AdamOptimizer

tf.train.ProximalGradientDescentOptimizer

tf.train.ProximalAdagradOptimizer

tf.train.RMSPropOptimizer

And more
```

Discussion question

1. How to know that our model is correct?
2. How to improve our model?

How to improve our model



Huber loss

Robust to outliers

Intuition: if the difference between the predicted value and the real value is small, square it

If it’s large, take its absolute value

$$L_\delta(y, f(x)) = \begin{cases} \frac{1}{2}(y - f(x))^2 & \text{for} |y - f(x)| \leq \delta, \\ \delta\,|y - f(x)| - \frac{1}{2}\delta^2 & \text{otherwise.} \end{cases}$$

Implementing Huber loss

Can’t write:

```
if Y - Y_predicted < delta:
```

$$L_\delta(y, f(x)) = \begin{cases} \frac{1}{2}(y - f(x))^2 & \text{for} |y - f(x)| \leq \delta, \\ \delta\,|y - f(x)| - \frac{1}{2}\delta^2 & \text{otherwise.} \end{cases}$$

Huber loss

```
def huber_loss(labels, predictions, delta=1.0):
    residual = tf.abs(predictions - labels)
    condition = tf.less(residual, delta)
    small_res = 0.5 * tf.square(residual)
    large_res = delta * residual - 0.5 * tf.square(delta)
    return tf.select(condition, small_res, large_res)
```

$$L_\delta(y, f(x)) = \begin{cases} \frac{1}{2}(y - f(x))^2 & \text{for} |y - f(x)| \le \delta, \\ \delta\,|y - f(x)| - \frac{1}{2}\delta^2 & \text{otherwise.} \end{cases}$$

Assignment 1

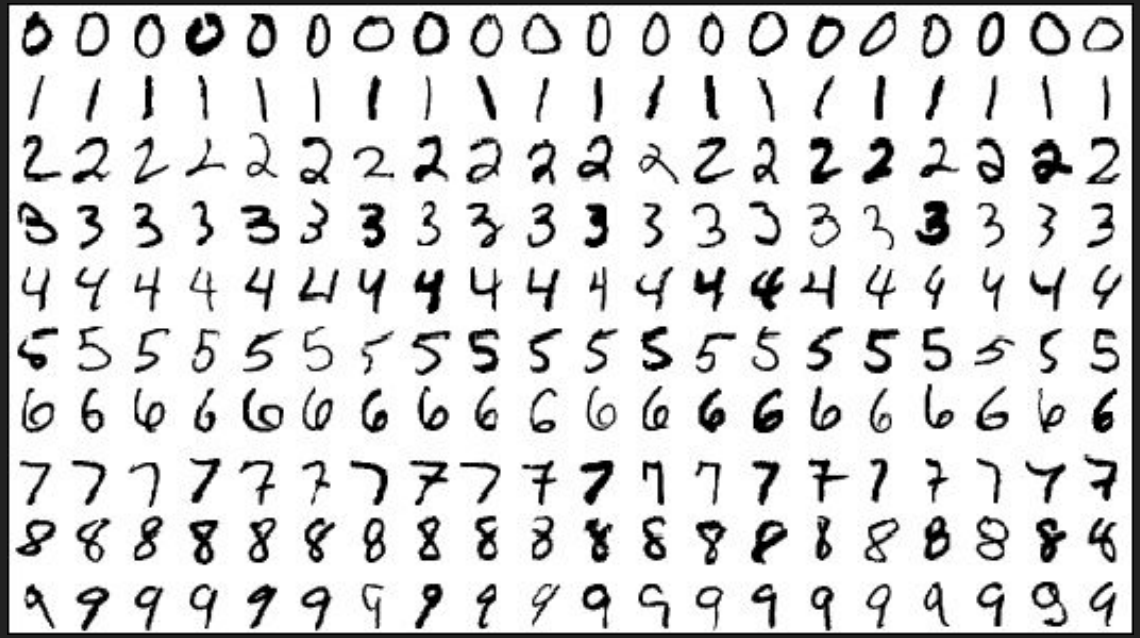
Out midnight today
Due 1/31
Optional Interactive Grading

Logistic Regression


Then he separated the light from the darkness
The first logistic regression model

MNIST Database

Each image is a 28x28 array, flattened out to be a 1-d tensor of size 784



MNIST

X: image of a handwritten digit
Y: the digit value

Want

X: image of a handwritten digit
Y: the digit value
Recognize the digit in the image

Model

```
logits = X * w + b

Y_predicted = softmax(logits)

loss = cross_entropy(Y, Y_predicted)
```

*Y is a one-hot vector

Batch ‘em up

```
X = tf.placeholder(tf.float32, [batch_size, 784], name="image")

Y = tf.placeholder(tf.float32, [batch_size, 10], name="label")
```

*Y is a one-hot vector

Process data

```
from tensorflow.examples.tutorials.mnist import input_data
MNIST = input_data.read_data_sets("/data/mnist", one_hot=True)
```

Process data

```
from tensorflow.examples.tutorials.mnist import input_data
MNIST = input_data.read_data_sets("/data/mnist", one_hot=True)

MNIST.train: 55,000 examples
MNIST.validation: 5,000 examples
MNIST.test: 10,000 examples
```

Phase 1: Assemble our graph

Step 2: Create placeholders for inputs and labels

```
X = tf.placeholder(tf.float32, [batch_size, 784], name="image")

Y = tf.placeholder(tf.float32, [batch_size, 10], name="label")
```

Step 3: Create weight and bias

```
tf.Variable(initial_value=None, trainable=True, collections=None,
                    name=None, dtype=None, ...)
```

Step 4: Build model to predict Y

```
logits = X * w + b
```

Step 5: Specify loss function

```
entropy = tf.nn.softmax_cross_entropy_with_logits(logits, Y)

loss = tf.reduce_mean(entropy)
```

Step 6: Create optimizer

```
tf.train.GradientDescentOptimizer(learning_rate=0.001).minimize(loss)
```

Phase 2: Train our model

Initialize variables

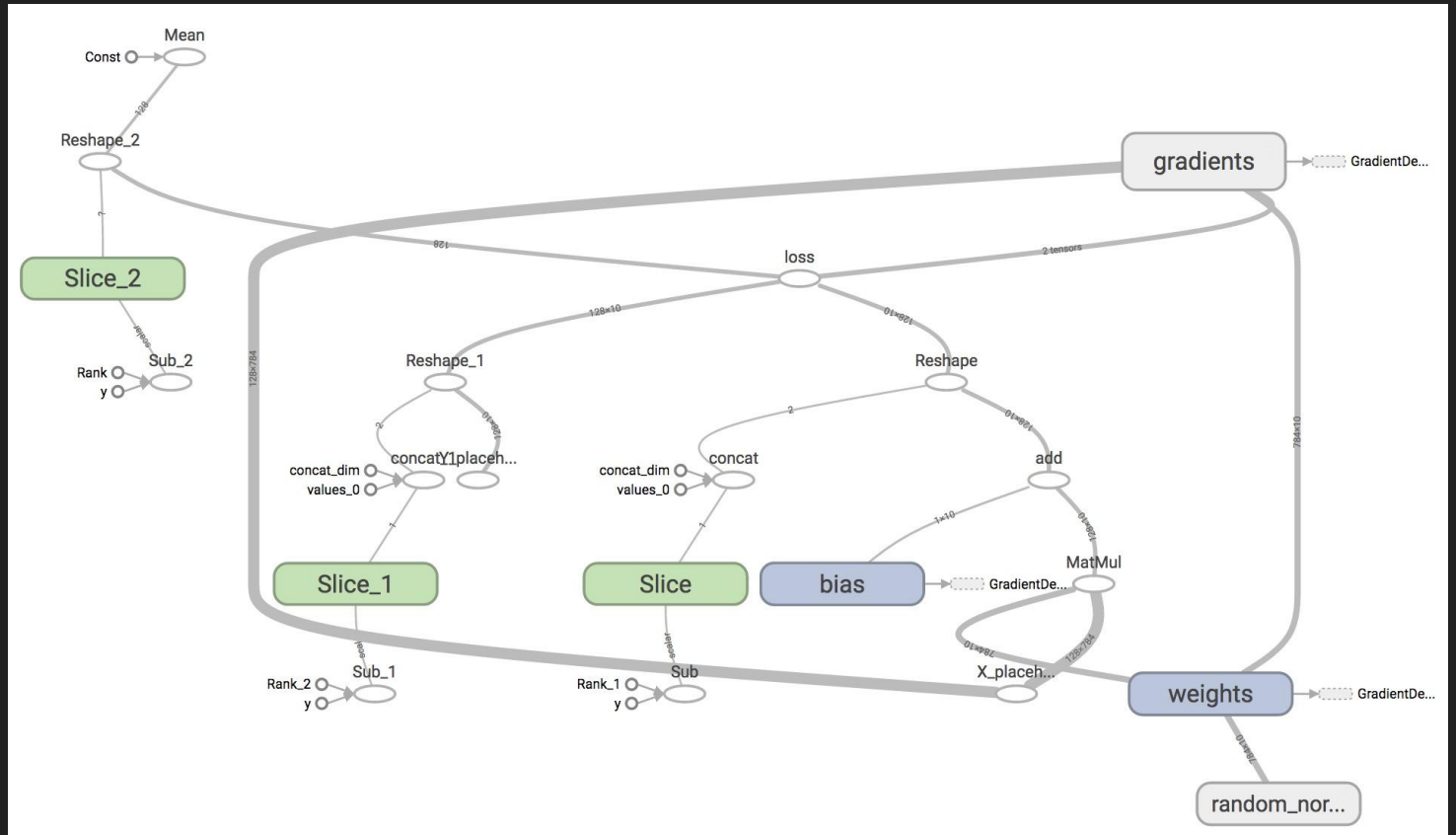
Run optimizer op

(with data fed into placeholders for inputs and labels)

Run our model

```
Average loss epoch 0: 1.28812279526

Average loss epoch 1: 0.732620414598

Average loss epoch 2: 0.600486441648

Average loss epoch 3: 0.53647331619

Average loss epoch 4: 0.497578099683

...

Average loss epoch 9: 0.41295143427

Total time: 8.83596801758 seconds

Optimization Finished!

Accuracy 0.8977
```

TensorBoard it



Next class

Structure your model in TensorFlow

Example: word2vec

Feedback: huyenn@stanford.edu

Thanks!