With TF 1.0!

Lab 10

NN, ReLu, Xavier, Dropout, and Adam

Sung Kim <hunkim+ml@gmail.com>
Code: https://github.com/hunkim/DeepLearningZeroToAll/

Call for comments

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Other slides: https://goo.gl/jPtWNt

Picture from http://www.tssablog.org/archives/3280

With TF 1.0!

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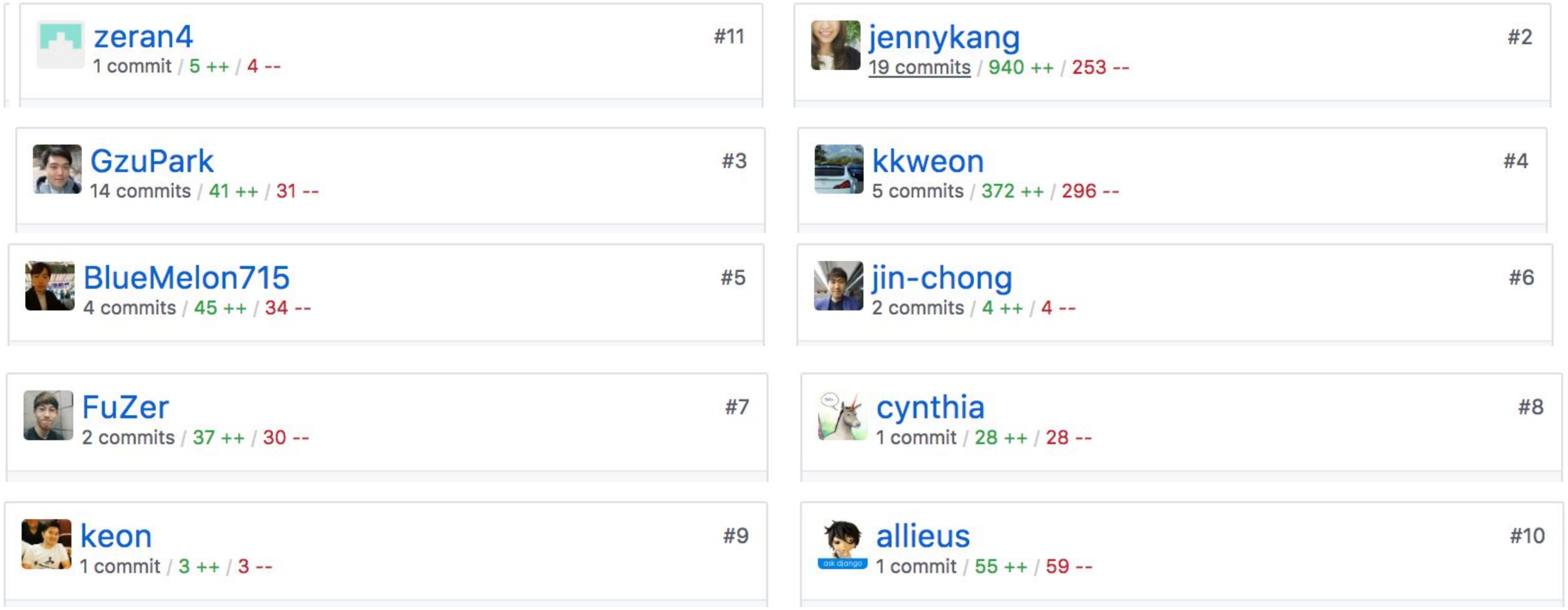


zeran4 #11
1 commit / 5 ++ / 4 --

jennykang #2
19 commits / 940 ++ / 253 --

GzuPark #3
14 commits / 41 ++ / 31 --

kkweon #4
5 commits / 372 ++ / 296 --

BlueMelon715 #5
4 commits / 45 ++ / 34 --

jin-chong #6
2 commits / 4 ++ / 4 --

FuZer #7
2 commits / 37 ++ / 30 --

cynthia #8
1 commit / 28 ++ / 28 --

keon #9
1 commit / 3 ++ / 3 --

allieus #10
1 commit / 55 ++ / 59 --

Softmax classifier for MNIST

```python
# weights & bias for nn layers
W = tf.Variable(tf.random_normal([784, 10]))
b = tf.Variable(tf.random_normal([10]))
hypothesis = tf.matmul(X, W) + b
# define cost/loss & optimizer
cost = tf.reduce_mean(tf.nn.softmax_cross_entropy_with_logits(logits=hypothesis, labels=Y))
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate).minimize(cost)
# initialize
sess = tf.Session()
sess.run(tf.global_variables_initializer())

# train my model
for epoch in range(training_epochs):
   avg_cost = 0
   total_batch = int(mnist.train.num_examples / batch_size)

   for i in range(total_batch):
       batch_xs, batch_ys = mnist.train.next_batch(batch_size)
       feed_dict = {X: batch_xs, Y: batch_ys}
       c, _ = sess.run([cost, optimizer], feed_dict=feed_dict)
       avg_cost += c / total_batch

   print('Epoch:', '%04d' % (epoch + 1), 'cost =', '{:.9f}'.format(avg_cost))

print('Learning Finished!')

# Test model and check accuracy
correct_prediction = tf.equal(tf.argmax(hypothesis, 1), tf.argmax(Y, 1))
accuracy = tf.reduce_mean(tf.cast(correct_prediction, tf.float32))
print('Accuracy:', sess.run(accuracy, feed_dict={X: mnist.test.images, Y: mnist.test.labels}))
```

```
Epoch: 0001 cost = 5.888845987
Epoch: 0002 cost = 1.860620173
Epoch: 0003 cost = 1.159035648
Epoch: 0004 cost = 0.892340870
Epoch: 0005 cost = 0.751155428
Epoch: 0006 cost = 0.662484806
Epoch: 0007 cost = 0.601544010
Epoch: 0008 cost = 0.556526115
Epoch: 0009 cost = 0.521186961
Epoch: 0010 cost = 0.493068354
Epoch: 0011 cost = 0.469686249
Epoch: 0012 cost = 0.449967254
Epoch: 0013 cost = 0.433519321
Epoch: 0014 cost = 0.419000337
Epoch: 0015 cost = 0.406490815
Learning Finished!
Accuracy: 0.9035
```

https://github.com/hunkim/DeepLearningZeroToAll/blob/master/lab-10-1-mnist_softmax.py

With TF 1.0!

Lab 7-2

MNIST data

Sung Kim <hunkim+ml@gmail.com>
Code: https://github.com/hunkim/DeepLearningZeroToAll/

Softmax classifier for MNIST

```python
# weights & bias for nn layers
W = tf.Variable(tf.random_normal([784, 10]))
b = tf.Variable(tf.random_normal([10]))
hypothesis = tf.matmul(X, W) + b
# define cost/loss & optimizer
cost = tf.reduce_mean(tf.nn.softmax_cross_entropy_with_logits(logits=hypothesis, labels=Y))
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate).minimize(cost)
# initialize
sess = tf.Session()
sess.run(tf.global_variables_initializer())

# train my model
for epoch in range(training_epochs):
   avg_cost = 0
   total_batch = int(mnist.train.num_examples / batch_size)

   for i in range(total_batch):
       batch_xs, batch_ys = mnist.train.next_batch(batch_size)
       feed_dict = {X: batch_xs, Y: batch_ys}
       c, _ = sess.run([cost, optimizer], feed_dict=feed_dict)
       avg_cost += c / total_batch

   print('Epoch:', '%04d' % (epoch + 1), 'cost =', '{:.9f}'.format(avg_cost))

print('Learning Finished!')

# Test model and check accuracy
correct_prediction = tf.equal(tf.argmax(hypothesis, 1), tf.argmax(Y, 1))
accuracy = tf.reduce_mean(tf.cast(correct_prediction, tf.float32))
print('Accuracy:', sess.run(accuracy, feed_dict={X: mnist.test.images, Y: mnist.test.labels}))
```

```
Epoch: 0001 cost = 5.888845987
Epoch: 0002 cost = 1.860620173
Epoch: 0003 cost = 1.159035648
Epoch: 0004 cost = 0.892340870
Epoch: 0005 cost = 0.751155428
Epoch: 0006 cost = 0.662484806
Epoch: 0007 cost = 0.601544010
Epoch: 0008 cost = 0.556526115
Epoch: 0009 cost = 0.521186961
Epoch: 0010 cost = 0.493068354
Epoch: 0011 cost = 0.469686249
Epoch: 0012 cost = 0.449967254
Epoch: 0013 cost = 0.433519321
Epoch: 0014 cost = 0.419000337
Epoch: 0015 cost = 0.406490815
Learning Finished!
Accuracy: 0.9035
```

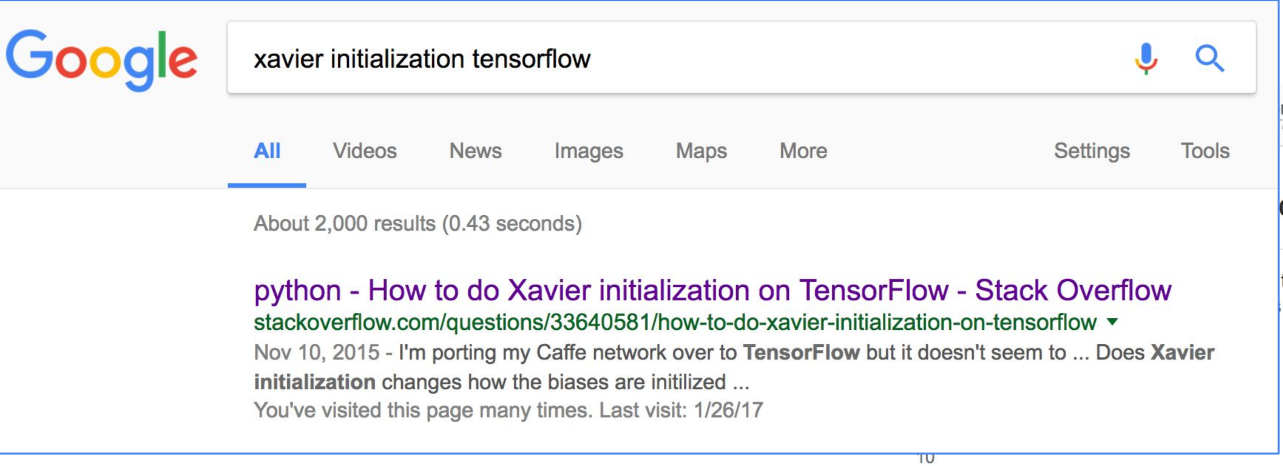
https://github.com/hunkim/DeepLearningZeroToAll/blob/master/lab-10-1-mnist_softmax.py

NN for MNIST

```python
# input place holders
X = tf.placeholder(tf.float32, [None, 784])
Y = tf.placeholder(tf.float32, [None, 10])

# weights & bias for nn layers
W1 = tf.Variable(tf.random_normal([784, 256]))
b1 = tf.Variable(tf.random_normal([256]))
L1 = tf.nn.relu(tf.matmul(X, W1) + b1)

W2 = tf.Variable(tf.random_normal([256, 256]))
b2 = tf.Variable(tf.random_normal([256]))
L2 = tf.nn.relu(tf.matmul(L1, W2) + b2)

W3 = tf.Variable(tf.random_normal([256, 10]))
b3 = tf.Variable(tf.random_normal([10]))
hypothesis = tf.matmul(L2, W3) + b3

# define cost/loss & optimizer
cost = tf.reduce_mean(tf.nn.softmax_cross_entropy_with_logits(
   logits=hypothesis, labels=Y))
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate).minimize(cost)
```

```
Epoch: 0001 cost = 141.207671860
Epoch: 0002 cost = 38.788445864
Epoch: 0003 cost = 23.977515479
Epoch: 0004 cost = 16.315132428
Epoch: 0005 cost = 11.702554882
Epoch: 0006 cost = 8.573139748
Epoch: 0007 cost = 6.370995680
Epoch: 0008 cost = 4.537178684
Epoch: 0009 cost = 3.216900532
Epoch: 0010 cost = 2.329708954
Epoch: 0011 cost = 1.715552875
Epoch: 0012 cost = 1.189857912
Epoch: 0013 cost = 0.820965160
Epoch: 0014 cost = 0.624131458
Epoch: 0015 cost = 0.454633765
Learning Finished!
Accuracy: 0.9455
```

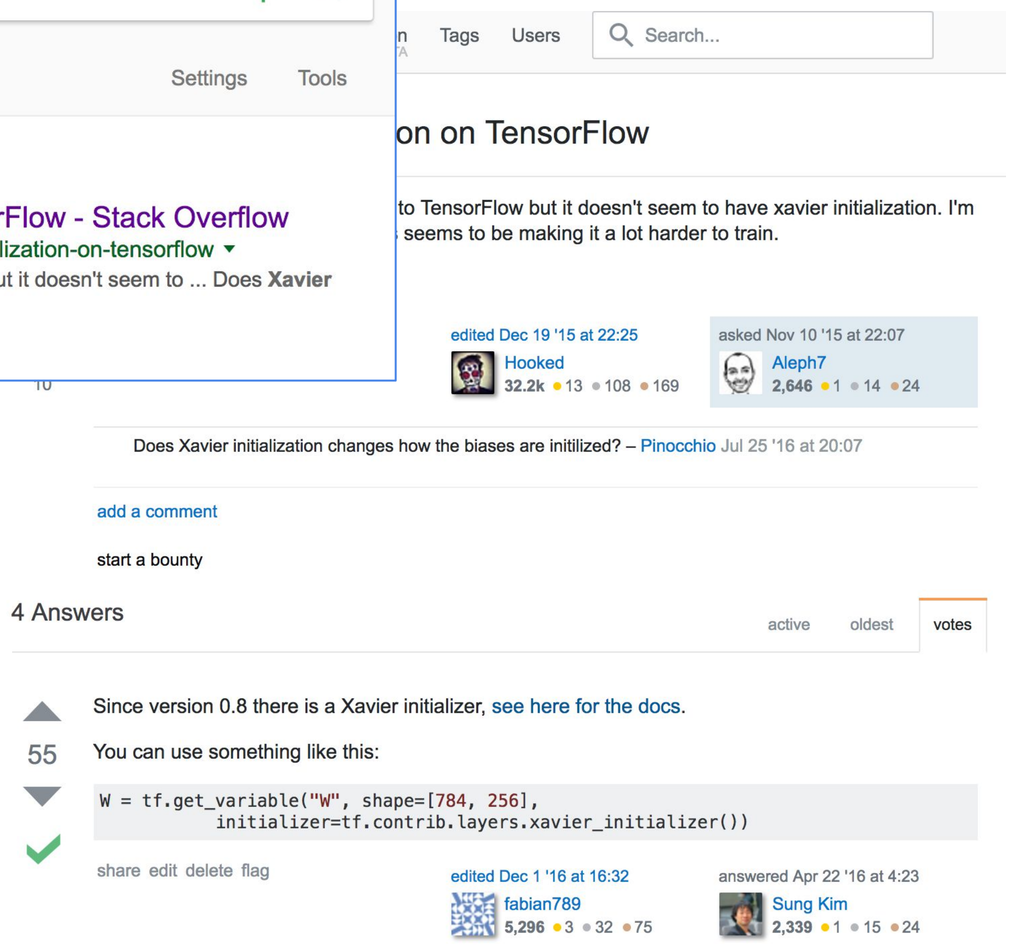
https://github.com/hunkim/DeepLearningZeroToAll/blob/master/lab-10-2-mnist_nn.py



xavier initialization tensorflow

About 2,000 results (0.43 seconds)

python - How to do Xavier initialization on TensorFlow - Stack Overflow
stackoverflow.com/questions/33640581/how-to-do-xavier-initialization-on-tensorflow
Nov 10, 2015 - I'm porting my Caffe network over to **TensorFlow** but it doesn't seem to ... Does **Xavier initialization** changes how the biases are initilized ...
You've visited this page many times. Last visit: 1/26/17



on on TensorFlow

to TensorFlow but it doesn't seem to have xavier initialization. I'm
seems to be making it a lot harder to train.

10

edited Dec 19 '15 at 22:25
Hooked
32.2k ●13 ●108 ●169

asked Nov 10 '15 at 22:07
Aleph7
2,646 ●1 ●14 ●24

Does Xavier initialization changes how the biases are initilized? – Pinocchio Jul 25 '16 at 20:07

add a comment

start a bounty

4 Answers

55

Since version 0.8 there is a Xavier initializer, see here for the docs.

You can use something like this:

```
W = tf.get_variable("W", shape=[784, 256],
           initializer=tf.contrib.layers.xavier_initializer())
```

edited Dec 1 '16 at 16:32
fabian789
5,296 ●3 ●32 ●75

answered Apr 22 '16 at 4:23
Sung Kim
2,339 ●1 ●15 ●24

http://stackoverflow.com/questions/33640581/how-to-do-xavier-initialization-on-tensorflow

Xavier for MNIST

```python
# input place holders
X = tf.placeholder(tf.float32, [None, 784])
Y = tf.placeholder(tf.float32, [None, 10])

# weights & bias for nn layers
# http://stackoverflow.com/questions/33640581
W1 = tf.get_variable("W1", shape=[784, 256],
                     initializer=tf.contrib.layers.xavier_initializer())
b1 = tf.Variable(tf.random_normal([256]))
L1 = tf.nn.relu(tf.matmul(X, W1) + b1)

W2 = tf.get_variable("W2", shape=[256, 256],
                     initializer=tf.contrib.layers.xavier_initializer())
b2 = tf.Variable(tf.random_normal([256]))
L2 = tf.nn.relu(tf.matmul(L1, W2) + b2)

W3 = tf.get_variable("W3", shape=[256, 10],
                     initializer=tf.contrib.layers.xavier_initializer())
b3 = tf.Variable(tf.random_normal([10]))
hypothesis = tf.matmul(L2, W3) + b3

# define cost/loss & optimizer
cost = tf.reduce_mean(tf.nn.softmax_cross_entropy_with_logits(
   logits=hypothesis, labels=Y))
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate).minimize(cost)
```

```
Epoch: 0001 cost = 0.301498963
Epoch: 0002 cost = 0.107252513
Epoch: 0003 cost = 0.064888892
Epoch: 0004 cost = 0.044463030
Epoch: 0005 cost = 0.029951642
Epoch: 0006 cost = 0.020663404
Epoch: 0007 cost = 0.015853033
Epoch: 0008 cost = 0.011764387
Epoch: 0009 cost = 0.008598264
Epoch: 0010 cost = 0.007383116
Epoch: 0011 cost = 0.006839140
Epoch: 0012 cost = 0.004672963
Epoch: 0013 cost = 0.003979437
Epoch: 0014 cost = 0.002714260
Epoch: 0015 cost = 0.004707661
Learning Finished!
Accuracy: 0.9783
```

https://github.com/hunkim/DeepLearningZeroToAll/blob/master/lab-10-3-mnist_nn_xavier.py

Xavier for MNIST

```
# input place holders
X = tf.placeholder(tf.float32, [None, 784])
Y = tf.placeholder(tf.float32, [None, 10])

# weights & bias for nn layers
# http://stackoverflow.com/questions/3364
W1 = tf.get_variable("W1", shape=[784, 25
                     initializer=tf.contri                            ))
b1 = tf.Variable(tf.random_normal([256]))
L1 = tf.nn.relu(tf.matmul(X, W1) + b1)

W2 = tf.get_variable("W2", shape=[256, 25
                     initializer=tf.contri                          ())
b2 = tf.Variable(tf.random_normal([256]))
L2 = tf.nn.relu(tf.matmul(L1, W2) + b2)

W3 = tf.get_variable("W3", shape=[256, 10
                     initializer=tf.contri                          ())
b3 = tf.Variable(tf.random_normal([10]))
hypothesis = tf.matmul(L2, W3) + b3

# define cost/loss & optimizer
cost = tf.reduce_mean(tf.nn.softmax_cross_entropy_with_logits(
   logits=hypothesis, labels=Y))
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate).minimize(cost)
```

```
Epoch: 0001 cost = 141.207671860
Epoch: 0002 cost = 38.788445864
Epoch: 0003 cost = 23.977515479
Epoch: 0004 cost = 16.315132428
Epoch: 0005 cost = 11.702554882
Epoch: 0006 cost = 8.573139748
Epoch: 0007 cost = 6.370995680
Epoch: 0008 cost = 4.537178684
Epoch: 0009 cost = 3.216900532
Epoch: 0010 cost = 2.329708954
Epoch: 0011 cost = 1.715552875
Epoch: 0012 cost = 1.189857912
Epoch: 0013 cost = 0.820965160
Epoch: 0014 cost = 0.624131458
Epoch: 0015 cost = 0.454633765
Learning Finished!
Accuracy: 0.9455 (normal dist)
```

```
Epoch: 0001 cost = 0.301498963
Epoch: 0002 cost = 0.107252513
Epoch: 0003 cost = 0.064888892
Epoch: 0004 cost = 0.044463030
Epoch: 0005 cost = 0.029951642
Epoch: 0006 cost = 0.020663404
Epoch: 0007 cost = 0.015853033
Epoch: 0008 cost = 0.011764387
Epoch: 0009 cost = 0.008598264
Epoch: 0010 cost = 0.007383116
Epoch: 0011 cost = 0.006839140
Epoch: 0012 cost = 0.004672963
Epoch: 0013 cost = 0.003979437
Epoch: 0014 cost = 0.002714260
Epoch: 0015 cost = 0.004707661
Learning Finished!
Accuracy: 0.9783 (xavier)
```

https://github.com/hunkim/DeepLearningZeroToAll/blob/master/lab-10-3-mnist_nn_xavier.py

Deep NN for MNIST

```python
W1 = tf.get_variable("W1", shape=[784, 512],
     initializer=tf.contrib.layers.xavier_initializer())
b1 = tf.Variable(tf.random_normal([512]))
L1 = tf.nn.relu(tf.matmul(X, W1) + b1)

W2 = tf.get_variable("W2", shape=[512, 512],
                     initializer=tf.contrib.layers.xavier_initializer())
b2 = tf.Variable(tf.random_normal([512]))
L2 = tf.nn.relu(tf.matmul(L1, W2) + b2)

W3 = tf.get_variable("W3", shape=[512, 512],
                     initializer=tf.contrib.layers.xavier_initializer())
b3 = tf.Variable(tf.random_normal([512]))
L3 = tf.nn.relu(tf.matmul(L2, W3) + b3)

W4 = tf.get_variable("W4", shape=[512, 512],
                     initializer=tf.contrib.layers.xavier_initializer())
b4 = tf.Variable(tf.random_normal([512]))
L4 = tf.nn.relu(tf.matmul(L3, W4) + b4)

W5 = tf.get_variable("W5", shape=[512, 10],
                     initializer=tf.contrib.layers.xavier_initializer())
b5 = tf.Variable(tf.random_normal([10]))
hypothesis = tf.matmul(L4, W5) + b5

# define cost/loss & optimizer
cost = tf.reduce_mean(tf.nn.softmax_cross_entropy_with_logits(logits=hypothesis, labels=Y))
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate).minimize(cost)
```

```
Epoch: 0001 cost = 0.266061549
Epoch: 0002 cost = 0.080796588
Epoch: 0003 cost = 0.049075800
Epoch: 0004 cost = 0.034772298
Epoch: 0005 cost = 0.024780529
Epoch: 0006 cost = 0.017072763
Epoch: 0007 cost = 0.014031383
Epoch: 0008 cost = 0.013763446
Epoch: 0009 cost = 0.009164047
Epoch: 0010 cost = 0.008291388
Epoch: 0011 cost = 0.007319742
Epoch: 0012 cost = 0.006434021
Epoch: 0013 cost = 0.005684378
Epoch: 0014 cost = 0.004781207
Epoch: 0015 cost = 0.004342310
Learning Finished!
Accuracy: 0.9742
```

https://github.com/hunkim/DeepLearningZeroToAll/blob/master/lab-10-4-mnist_nn_deep.py

Dropout for MNIST

```python
# dropout (keep_prob) rate  0.7 on training, but should be 1 for testing
keep_prob = tf.placeholder(tf.float32)

W1 = tf.get_variable("W1", shape=[784, 512])
b1 = tf.Variable(tf.random_normal([512]))
L1 = tf.nn.relu(tf.matmul(X, W1) + b1)
L1 = tf.nn.dropout(L1, keep_prob=keep_prob)

W2 = tf.get_variable("W2", shape=[512, 512])
b2 = tf.Variable(tf.random_normal([512]))
L2 = tf.nn.relu(tf.matmul(L1, W2) + b2)
L2 = tf.nn.dropout(L2, keep_prob=keep_prob)
…
# train my model
for epoch in range(training_epochs):
    ...
   for i in range(total_batch):
       batch_xs, batch_ys = mnist.train.next_batch(batch_size)
       feed_dict = {X: batch_xs, Y: batch_ys, keep_prob: 0.7}
       c, _ = sess.run([cost, optimizer], feed_dict=feed_dict)
       avg_cost += c / total_batch

# Test model and check accuracy
correct_prediction = tf.equal(tf.argmax(hypothesis, 1), tf.argmax(Y, 1))
accuracy = tf.reduce_mean(tf.cast(correct_prediction, tf.float32))
print('Accuracy:', sess.run(accuracy, feed_dict={
     X: mnist.test.images, Y: mnist.test.labels, keep_prob: 1}))
```

```
Epoch: 0001 cost = 0.447322626
Epoch: 0002 cost = 0.157285590
Epoch: 0003 cost = 0.121884535
Epoch: 0004 cost = 0.098128681
Epoch: 0005 cost = 0.082901778
Epoch: 0006 cost = 0.075337573
Epoch: 0007 cost = 0.069752543
Epoch: 0008 cost = 0.060884363
Epoch: 0009 cost = 0.055276413
Epoch: 0010 cost = 0.054631256
Epoch: 0011 cost = 0.049675195
Epoch: 0012 cost = 0.049125314
Epoch: 0013 cost = 0.047231930
Epoch: 0014 cost = 0.041290121
Epoch: 0015 cost = 0.043621063
Learning Finished!
Accuracy: 0.9804!!
```

https://github.com/hunkim/DeepLearningZeroToAll/blob/master/lab-10-5-mnist_nn_dropout.py

Optimizers

```
train = tf.train.GradientDescentOptimizer(learning_rate=0.1).minimize(cost)
```

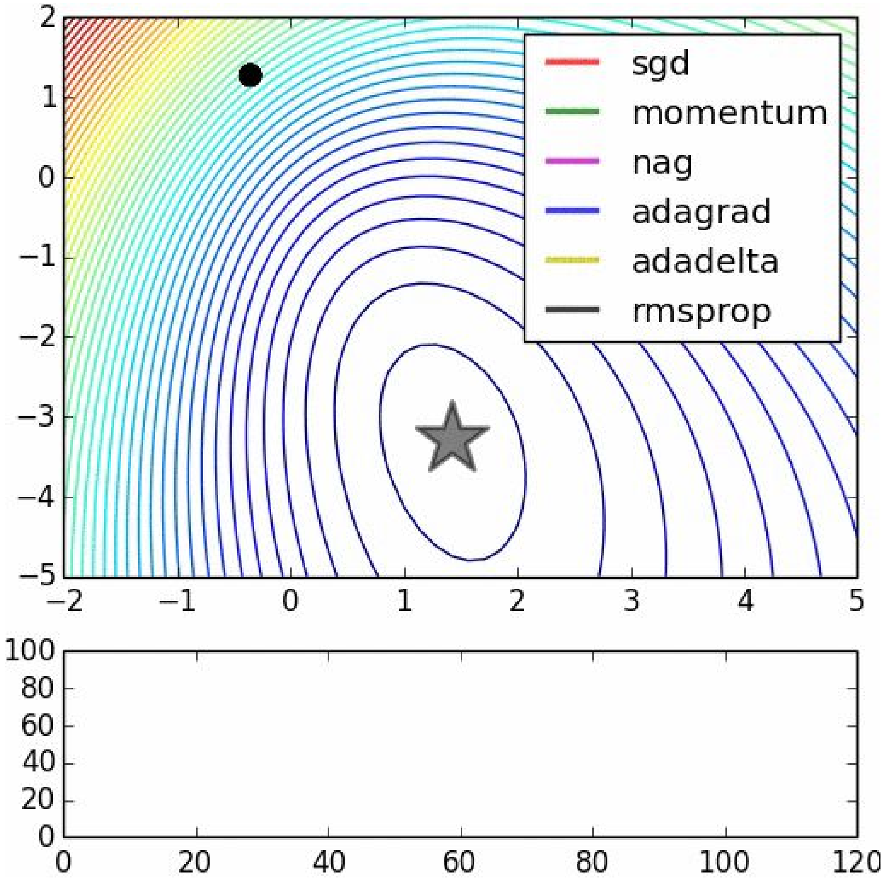
https://www.tensorflow.org/api_guides/python/train

Optimizers

```
train = tf.train.GradientDescentOptimizer(learning_rate=0.1).minimize(cost)
```

- tf.train.AdadeltaOptimizer
- tf.train.AdagradOptimizer
- tf.train.AdagradDAOptimizer
- tf.train.MomentumOptimizer
- tf.train.AdamOptimizer
- tf.train.FtrlOptimizer
- tf.train.ProximalGradientDescentOptimizer
- tf.train.ProximalAdagradOptimizer
- tf.train.RMSPropOptimizer

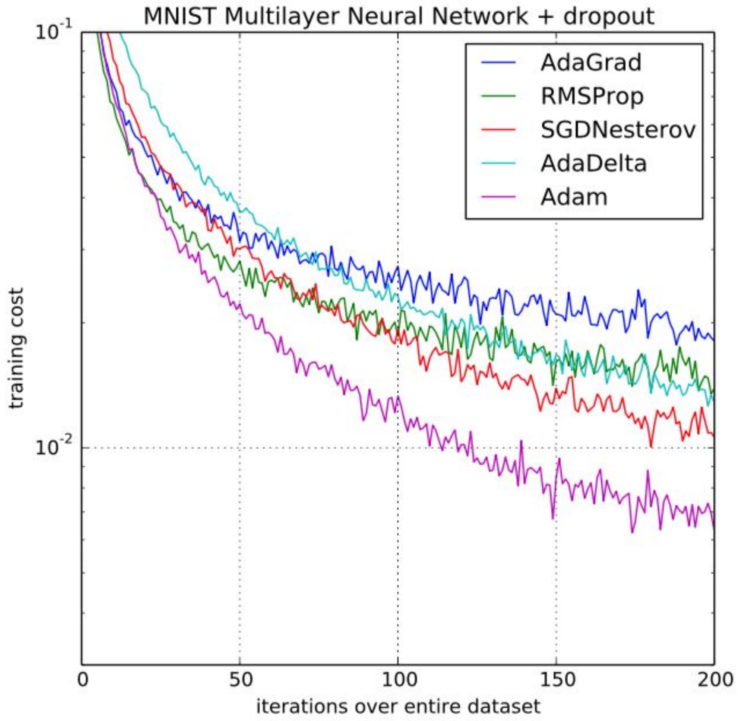
https://www.tensorflow.org/api_guides/python/train



http://www.denizyuret.com/2015/03/alec-radfords-animations-for.html

ADAM: a method for stochastic optimization

[Kingma et al. 2015]

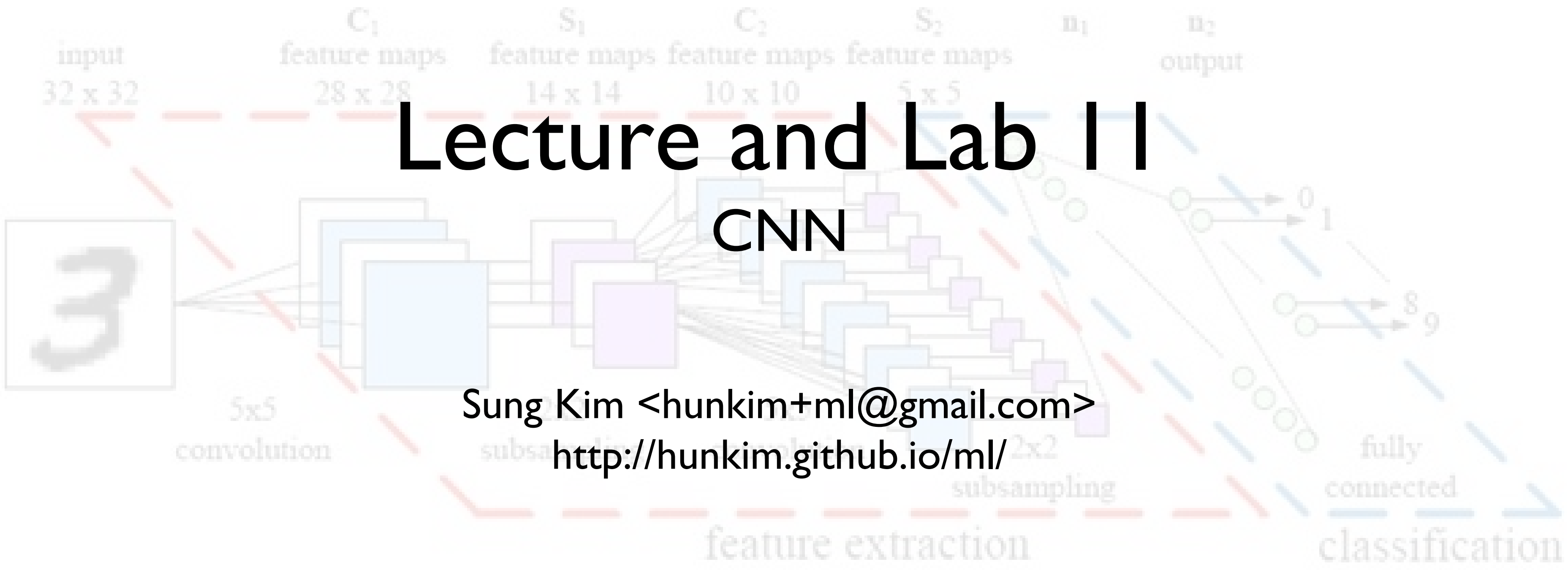


Use Adam Optimizer

```
# define cost/loss & optimizer
cost = tf.reduce_mean(tf.nn.softmax_cross_entropy_with_logits(
                                                 logits=hypothesis, labels=Y))
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate).minimize(cost)
```

Summary

- Softmax VS Neural Nets for MNIST, 90% and 94.5%
- Xavier initialization: 97.8%
- Deep Neural Nets with Dropout: **98%**
- Adam and other optimizers
- Exercise: Batch Normalization
  - https://github.com/hunkim/DeepLearningZeroToAll/blob/master/lab-10-6-mnist_nn_batchnorm.ipynb



Lecture and Lab 11

CNN

Sung Kim <hunkim+ml@gmail.com>
http://hunkim.github.io/ml/