Tensorflow Practice 1

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Practice Room Account

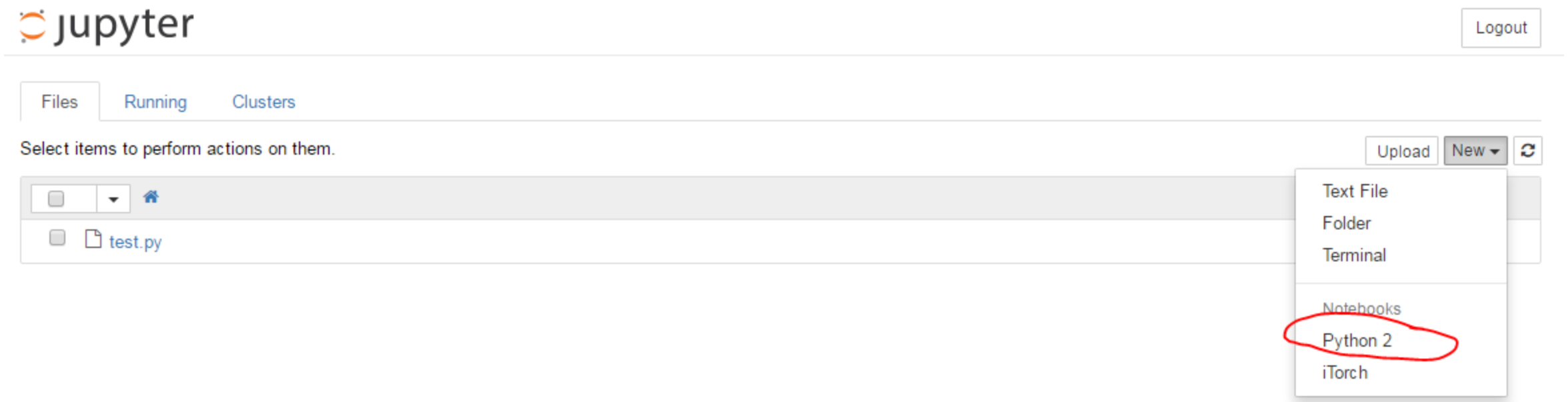
- https://goo.gl/i7cdZa
- Change your password with **passwd** command

IPython Notebook

- Run following command in the terminal
  - jupyter notebook

- Type following URL in your browser
  - http://localhost:8888/

IPython Notebook



Get Started

In [1]:
```
import tensorflow as tf
import numpy as np

# Create 100 phony x, y data points in NumPy, y = x * 0.1 + 0.3
x_data = np.random.rand(100).astype(np.float32)
y_data = x_data * 0.1 + 0.3

# Try to find values for W and b that compute y_data = W * x_data + b
# (We know that W should be 0.1 and b 0.3, but TensorFlow will
# figure that out for us.)
W = tf.Variable(tf.random_uniform([1], -1.0, 1.0))
b = tf.Variable(tf.zeros([1]))
y = W * x_data + b

# Minimize the mean squared errors.
loss = tf.reduce_mean(tf.square(y - y_data))
optimizer = tf.train.GradientDescentOptimizer(0.5)
train = optimizer.minimize(loss)

# Before starting, initialize the variables.  We will 'run' this first.
init = tf.initialize_all_variables()

# Launch the graph.
sess = tf.Session()
sess.run(init)

# Fit the line.
for step in range(201):
    sess.run(train)
    if step % 20 == 0:
        print(step, sess.run(W), sess.run(b))

# Learns best fit is W: [0.1], b: [0.3]

sess.close()
```

```
(0, array([-0.36417484], dtype=float32), array([ 0.72749555], dtype=float32))
(20, array([-0.05833205], dtype=float32), array([ 0.38157225], dtype=float32))
(40, array([ 0.05364964], dtype=float32), array([ 0.3238796], dtype=float32))
(60, array([ 0.08643132], dtype=float32), array([ 0.30699056], dtype=float32))
(80, array([ 0.09602787], dtype=float32), array([ 0.30204645], dtype=float32))
(100, array([ 0.0988372], dtype=float32), array([ 0.3005991], dtype=float32))
(120, array([ 0.09965961], dtype=float32), array([ 0.30017537], dtype=float32))
(140, array([ 0.09990035], dtype=float32), array([ 0.30005133], dtype=float32))
(160, array([ 0.09997084], dtype=float32), array([ 0.30001503], dtype=float32))
(180, array([ 0.09999146], dtype=float32), array([ 0.30000442], dtype=float32))
(200, array([ 0.0999975], dtype=float32), array([ 0.30000129], dtype=float32))
```

Get Started

```
import tensorflow as tf
import numpy as np

# Create 100 phony x, y data points in NumPy, y = x * 0.1 + 0.3
x_data = np.random.rand(100).astype(np.float32)
y_data = x_data * 0.1 + 0.3
```

- np.random.rand(100) Returns a vector of 100 random values ranged [0, 1)
- astype(np.float32) NumPy uses float64 as default, so we change the type to float32 which is the optimized data type in GPU.
- x_data * 0.1 Performs element-wised multiplication.

https://www.tensorflow.org/versions/r0.10/get_started/index.html

Get Started

```
# Try to find values for W and b that compute y_data = W * x_data + b
# (We know that W should be 0.1 and b 0.3, but TensorFlow will figure that out for us.)
W = tf.Variable(tf.random_uniform([1], -1.0, 1.0))
b = tf.Variable(tf.zeros([1]))
y = W * x_data + b
```

- tf.Variable(<initial-value>, ...) Creates a variable in the **graph**.
- tf.random_uniform([1], -1.0, 1.0)) Creates a tensor (not a value) which will generate a value shaped [1] from uniform distribution [-1, 1].
- tf.zeros([1]) Creates a constant tensor (not a value) with all elements set to zero. [1] is shape.
- **y** is not a specific value but a symbolic variable defined by structured expressions.

Get Started

```
# Minimize the mean squared errors.
loss = tf.reduce_mean(tf.square(y - y_data))
optimizer = tf.train.GradientDescentOptimizer(0.5)
train = optimizer.minimize(loss)
```

- tf.square(...) Computes square of x element-wise.
- tf.reduce_mean(...) Computes the mean of elements across dimensions of a tensor.
- tf.train.GradientDescentOptimizer(...) Construct a new gradient descent optimizer.
- optimizer.minimize(loss) Calling minimize() takes care of both computing the gradients and applying them to the variables. It returns an operation object that updates trainable variables using gradient descent.

Get Started

```
# Before starting, initialize the variables. We will 'run' this first.
init = tf.initialize_all_variables()

# Launch the graph.
sess = tf.Session()
sess.run(init)
```

- tf.Session() A **Session** object encapsulates the environment in which **Operation** objects are executed, and **Tensor** objects are evaluated.
- sess.run(init) **init** is an operation object. sess.run(...) executes operations or evaluate values of tensor objects.

Get Started

```
# Fit the line.
for step in range(201):
    sess.run(train)
    if step % 20 == 0:
        print(step, sess.run(W), sess.run(b))

sess.close()
```

- for step in range(201): Iterate from 0 to 200.
- **train** is an operation object.
- **W** and **b** are tensor objects.

MNIST Classification

In [2]:
```
import tensorflow as tf
```

In [3]:
```
from tensorflow.examples.tutorials.mnist import input_data
mnist = input_data.read_data_sets('MNIST_data', one_hot=True)
```

```
Extracting MNIST_data/train-images-idx3-ubyte.gz
Extracting MNIST_data/train-labels-idx1-ubyte.gz
Extracting MNIST_data/t10k-images-idx3-ubyte.gz
Extracting MNIST_data/t10k-labels-idx1-ubyte.gz
```

In [6]:
```
with tf.Session() as sess:
    # Create the model
    x = tf.placeholder(tf.float32, [None, 784])
    W = tf.Variable(tf.zeros([784, 10]))
    b = tf.Variable(tf.zeros([10]))
    y = tf.nn.softmax(tf.matmul(x, W) + b)

    # Define loss and optimizer
    y_ = tf.placeholder(tf.float32, [None, 10])
    cross_entropy = tf.reduce_mean(-tf.reduce_sum(y_ * tf.log(y), reduction_indices=[1]))
    train_step = tf.train.GradientDescentOptimizer(0.5).minimize(cross_entropy)

    # Train
    tf.initialize_all_variables().run()
    for i in range(1000):
        batch_xs, batch_ys = mnist.train.next_batch(100)
        train_step.run({x: batch_xs, y_: batch_ys})

    # Test trained model
    correct_prediction = tf.equal(tf.argmax(y, 1), tf.argmax(y_, 1))
    accuracy = tf.reduce_mean(tf.cast(correct_prediction, tf.float32))
    print(accuracy.eval({x: mnist.test.images, y_: mnist.test.labels}))
```

```
0.92
```

https://www.tensorflow.org/versions/r0.10/tutorials/mnist/pros/index.html

MNIST Classification – Load Data

```
from tensorflow.examples.tutorials.mnist import input_data
mnist = input_data.read_data_sets('MNIST_data', one_hot=True)
```

- one_hot Represents labels as vectors of zeros and ones where only one of the entries is one.
  - 0 -> [1, 0, 0, 0, 0, 0, 0, 0, 0, 0]
  - 1 -> [0, 1, 0, 0, 0, 0, 0, 0, 0, 0]
  - 2 -> [0, 0, 1, 0, 0, 0, 0, 0, 0, 0]
  - …

MNIST Classification – With

```
with tf.Session() as sess:
    ...
```

- The above code is similar to the following:

```
sess = tf.Session()
try:
    ...
catch something
    sess.close()
sess.close()
```

MNIST Classification – Create the model

```
# Create the model   y = xW + b
x = tf.placeholder(tf.float32, [None, 784])
W = tf.Variable(tf.zeros([784, 10]))
b = tf.Variable(tf.zeros([10]))
y = tf.nn.softmax(tf.matmul(x, W) + b)
```

- tf.placeholder Placeholders are tensors that user feed specific values when running the session.
- [None, 784] In this case, we put None to allow any size of the mini-batch.
- tf.matmul(x, W) Computes dot product. The shape of the result is [None, 10].
- … + b It adds bias vector for each instance (broadcasting).
- tf.nn.softmax(some_matrix) Computes softmax for each instance (row).

Quiz: What is the shape of **y**?

MNIST Classification – Loss and Optimizer

```
# Define loss and optimizer
y_ = tf.placeholder(tf.float32, [None, 10])
cross_entropy = tf.reduce_mean(-tf.reduce_sum(y_ * tf.log(y), reduction_indices=[1]))
train_step = tf.train.GradientDescentOptimizer(0.5).minimize(cross_entropy)
```

- y_ It is true output of the model.
- tf.reduce_sum(some_matrix, reduction_indices=[1]) Computes summation per row.
- tf.log(y + 1E-14) would be more stable than tf.log(y).

MNIST Classification – Train

```
# Train
tf.initialize_all_variables().run()
for i in range(1000):
    batch_xs, batch_ys = mnist.train.next_batch(100)
    train_step.run({x: batch_xs, y_: batch_ys})
```

- .run() We can execute operators by calling run() when session is bounded.
- run({x: batch_xs, y_: batch_ys}) Always don't forget to feed specific values to the placeholders.

MNIST Classification – Test

```
# Test trained model
correct_prediction = tf.equal(tf.argmax(y, 1), tf.argmax(y_, 1))
accuracy = tf.reduce_mean(tf.cast(correct_prediction, tf.float32))
print(accuracy.eval({x: mnist.test.images, y_: mnist.test.labels}))
```

- tf.argmax(y, dimension=1) Finds an index of maximum value for each row.
- tf.equal(x1, x2) Returns the truth value of (x1 == x2) element-wise.
- tf.cast(correct_prediction, tf.float32)) We cast the data type from bool to float32.
- tensor_object.eval(...) Evaluates value of the tensor object.

Quiz: What is the shape of **correct_prediction**?

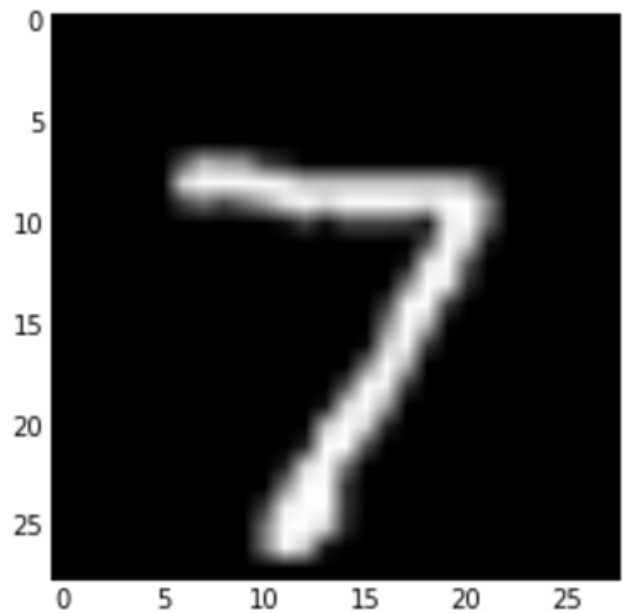
Bonus – Draw Numbers

In [11]:
```
import matplotlib.pyplot as plt
%matplotlib inline

img = mnist.test.images[0]
print img.shape
img = img.reshape(28, 28)
plt.imshow(img, cmap='gray')
```

```
(784,)
```

Out[11]:
```
<matplotlib.image.AxesImage at 0x7fe47f2e6a50>
```



Bonus – Putting a Hole

In [12]:
```
hole_img = img
hole_img[8:8+7, 10:10+7] = 0
plt.imshow(hole_img, cmap='gray')
```

Out[12]: <matplotlib.image.AxesImage at 0x7fe47b962110>