First Neurons

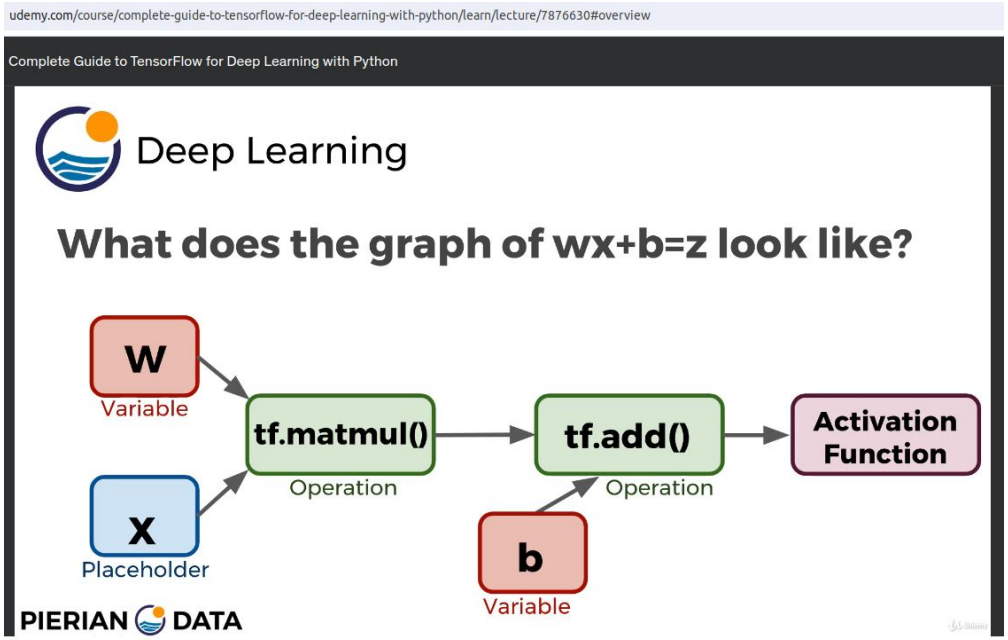
In [2]:
```
import numpy as np
import tensorflow as tf

import matplotlib.pyplot as plt
%matplotlib inline
```

Set Random Seeds for same results

In [3]:
```
np.random.seed(101)
tf.set_random_seed(101)
```

The graph we will be building

Getting a very simple linear fit to some 2d data.



Data Setup

Setting Up some Random Data for Demonstration Purposes

In [4]:
```
rand_a = np.random.uniform(0, 100, (5, 5))
rand_a
```

Out[4]:
```
array([[51.63986277, 57.06675869,  2.84742265, 17.15216562, 68.52769817],
       [83.38968626, 30.69662197, 89.36130797, 72.15438618, 18.99389542],
       [55.42275911, 35.2131954 , 18.18924027, 78.56017619, 96.54832224],
       [23.23536618,  8.35614337, 60.35484223, 72.89927573, 27.62388285],
       [68.53063288, 51.78674742,  4.84845374, 13.78692376, 18.69674261]])
```

In [5]:
```
rand_b = np.random.uniform(0, 100, (5, 1))
rand_b
```

Out[5]:
```
array([[99.43179012],
       [52.06653967],
       [57.87895355],
       [73.48190583],
       [54.19617722]])
```

Placeholders

In [6]:
```
a = tf.placeholder(tf.float32)
```

In [7]:
```
b = tf.placeholder(tf.float32) # we're not using the shape parameter for now.
```

Operations

In [8]:
```
add_op = a + b  # Could do tf.add(a, b), and [Shift]+[Tab] to look at the docs
```

In [9]:
```
mult_op = a * b # Could do tf.multiply(a, b)
```

Running Sessions to create Graphs with Feed Dictionaries

In [10]:
```
with tf.Session() as sess:

    add_result = sess.run(add_op, feed_dict={a:10, b:20})
    print(add_result)

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

```
30.0
```

In [11]:
```
with tf.Session() as sess:

    add_result = sess.run(add_op, feed_dict={a:rand_a, b:rand_b})
    print(add_result)

    print('\n')

    mult_result = sess.run(mult_op, feed_dict={a:rand_a, b:rand_b})
    print(mult_result)

##endof:  with tf.Session as sess
```

```
[[151.07166  156.49855  102.27921  116.58396  167.95949 ]
 [135.45622   82.76316  141.42784  124.22093   71.06043 ]
 [113.30171   93.09215   76.06819  136.43912  154.42728 ]
 [ 96.71727   81.83804  133.83675  146.38118  101.10579 ]
 [122.72681  105.982925  59.044632  67.9831    72.89292 ]]


[[5134.644   5674.25     283.12433 1705.4707  6813.8315 ]
 [4341.8125  1598.267   4652.734   3756.8293   988.94635]
 [3207.8113  2038.1029  1052.7742  4546.9805  5588.1157 ]
 [1707.379    614.02527 4434.989   5356.7773  2029.8555 ]
 [3714.0984  2806.6438   262.76764  747.19855 1013.292  ]]
```

Multiplication was element-by-element rather than a `dot` multiply.

Example Neural Network

In [12]:
```
n_features = 10
n_dense_neurons = 3
```

In [13]:
```
# Placeholder for x
x = tf.placeholder(tf.float32,) #  shape is defined, though the 'None' is
                                #+ because it depends on how big of a
                                #+ batch of data you're feeding into your NN
                                #+ feautures. We should be expecting 'x'
                                #+ to be receiving an array with n_samples
                                #+ by n_features
```

In [14]:
```
W = tf.Variable(tf.random_normal([n_features, n_dense_neurons]))

b = tf.Variable(tf.ones([n_dense_neurons])) # dimension must allow
                                            # matrix multiplication
```

Operation Activation Function

In [15]:
```
xW = tf.matmul(x, W) # It will do the dot multiplication, now.
```

In [16]:
```
z = tf.add(xW, b)
```

In [17]:
```
a = tf.sigmoid(z)
```

Variable Initializer!

In [18]:
```
init = tf.global_variables_initializer()
```

In [19]:
```
with tf.Session() as sess:

    sess.run(init) # do this for a session

    layer_out = sess.run(a, feed_dict={x:np.random.random([1, n_features])})
                            # feeding it one sample

##endof:  with ... sess
```

In [20]:
```
# print the result
print(layer_out)
      #  Mine doesn't match his Jose's, even though I used
      #+ the same random seed and had the same results above
      #+ ... (?)
      #+ He says it might be different, depending on how many
      #+ times we had run random. I guess he ran random a few
      #+ times in between
```

```
[[0.19592889 0.8423014  0.36188066]]
```

We just passed in random numbers for `W` and `b`; we're not adjusting them.

We still need to finish off this process with optimization! Let's learn how to do this next.

Full Network Example

Let's work on a regression example, we are trying to solve a very simple equation:

y = mx + b

y will be the y_labels and x is the x_data. We are trying to figure out the slope and the intercept for the line that best fits our data!

Artificial Data (Some Made Up Regression Data)

a.k.a. (what the lecture calls it)

Simple Regression Example

In [21]:
```
x_data = np.linspace(0, 10, 10) + np.random.uniform(-1.5, 1.5, 10)
```

In [22]:
```
x_data
```

Out[22]:
```
array([-1.20856056, -0.08034641,  2.82674411,  4.50477294,  3.42312535,
        4.88227319,  7.18414126,  6.77068715,  9.4930023 ,  9.96290567])
```

In [23]:
```
y_label = np.linspace(0, 10, 10) + np.random.uniform(-1.5, 1.5, 10)
```

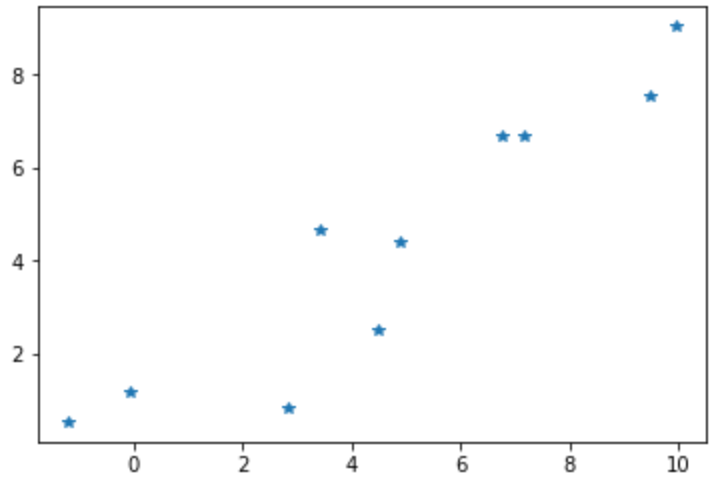
In [24]:
```
y_label
```

Out[24]:
```
array([0.5420333 , 1.17575569, 0.85241231, 2.50514314, 4.67005971,
       4.41685654, 6.66701681, 6.69180648, 7.54731409, 9.03483077])
```

But that one matched (?). Maybe since it's np.random.uniform ...

In [25]:
```
plt.plot(x_data, y_label, '*') #  What have we created?
                               #+ Hopefully something with
                               #+ a linear trend.
```

Out[25]:
```
[<matplotlib.lines.Line2D at 0x1bdd1932400>]
```



Variables

Remember, trying to solve $y = mx + b$

In [26]:
```
np.random.rand(2)
```

Out[26]:
```
array([0.44236813, 0.87758732])
```

Just copying them in - 0.44 and 0.88. Wait, he wants us to use something different.

In [27]:
```
m, b = np.random.rand(2)
```

In [28]:
```
print("m = " + str(m) + " ; " + "b = " + str(b))
```

```
m = 0.949264128985194 ; b = 0.4781674167895694
```

The optimizer needs tensors. Otherwise, trying to run 'optimizer.minimize(error)' below will give:

```
---------------------------------------------------------------------------
AttributeError                            Traceback (most recent call last)
<ipython-input-40-f5a4ebeb180e> in <module>()
      1 optimizer = tf.train.GradientDescentOptimizer(learning_rate=0.001)
----> 2 train = optimizer.minimize(error)

~\.conda\envs\tfdeeplearning\lib\site-packages\tensorflow\python\training\optimizer.py in \\
minimize(self, loss, global_step, var_list, gate_gradients, aggregation_method, \\
         colocate_gradients_with_ops, name, grad_loss)
    398         aggregation_method=aggregation_method,
    399         colocate_gradients_with_ops=colocate_gradients_with_ops,
--> 400         grad_loss=grad_loss)
    401
    402     vars_with_grad = [v for g, v in grads_and_vars if g is not None]

~\.conda\envs\tfdeeplearning\lib\site-packages\tensorflow\python\training\optimizer.py in \\
compute_gradients(self, loss, var_list, gate_gradients, aggregation_method, \\
                  colocate_gradients_with_ops, grad_loss)
    492                         "Optimizer.GATE_OP, Optimizer.GATE_GRAPH.  Not %s" %
    493                         gate_gradients)
--> 494     self._assert_valid_dtypes([loss])
    495     if grad_loss is not None:
    496       self._assert_valid_dtypes([grad_loss])

~\.conda\envs\tfdeeplearning\lib\site-packages\tensorflow\python\training\optimizer.py in \\
_assert_valid_dtypes(self, tensors)
    870     valid_dtypes = self._valid_dtypes()
    871     for t in tensors:
--> 872       dtype = t.dtype.base_dtype
    873       if dtype not in valid_dtypes:
    874         raise ValueError(

AttributeError: 'numpy.dtype' object has no attribute 'base_dtype'
```

That's why I can't *just* pull them out of the array, like I did. I'll cast them.

In [29]:
```
m = tf.Variable(m)
b = tf.Variable(b)
  # It's pythonic to repeat the variable, but I don't like it.
```

Cost Function

In [30]:
```
error = 0
```

In [31]:
```
# zip will do tuples with points

for x, y in zip(x_data, y_label):
    y_hat = m*x + b # predicted y, m and b are tries

    error += (y - y_hat) ** 2
##endof:  for x, y ...
```

Optimizer

Learning rate: we don't want to overshoot the value, nor do we want to take forever to train things. Computations are expensive, and that matters with networks, because time matters.

In [32]:
```
optimizer = tf.train.GradientDescentOptimizer(learning_rate=0.001)
train = optimizer.minimize(error)
```

Initialize Variables

In [33]:
```
init = tf.global_variables_initializer()
```

Create Session and Run!

In [34]:
```
with tf.Session() as sess:

    sess.run(init)

    training_steps = 1 # probably way too low

    for i in range(training_steps):

        sess.run(train)

    ##endof:  for i ...

    final_slope, final_intercept = sess.run([m, b]) # expecting a very bad job

#endof:  with ... sess
```

In [35]:
```
final_slope
```

Out[35]: 0.845772131354643

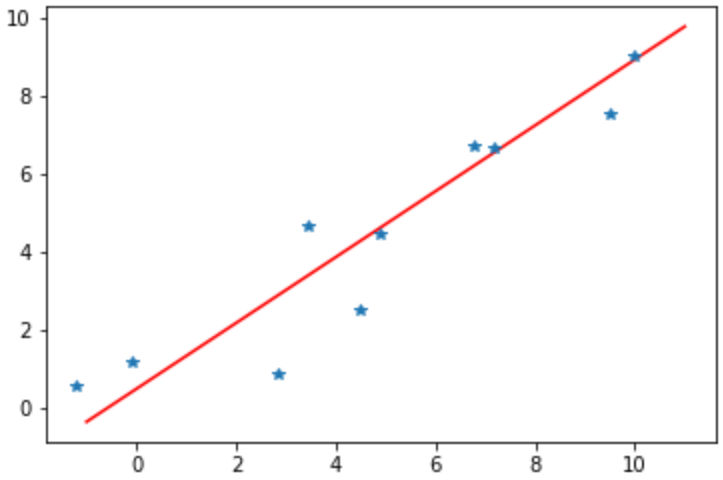
In [36]:
```
final_intercept
```

Out[36]: 0.4661391986240503

Evaluate Results

In [37]:
```
x_test = np.linspace(-1, 11, 10) # Make plot look a little nicer

# y = mx + b
y_pred_plot = final_slope * x_test + final_intercept

plt.plot(x_test, y_pred_plot, 'r')

plt.plot(x_data, y_label, '*')
```

Out[37]:
```
[<matplotlib.lines.Line2D at 0x1bdd2d790f0>]
```



It did decently with one epoch (one step). Let's go with 100.

Do it with 100 epochs

In [38]:
```
with tf.Session() as sess_100:

    sess_100.run(init)

    #training_steps = 1 # 100 will be better
    epochs = 100

    for i in range(epochs):

        sess_100.run(train)

    ##endof:  for i ...

    # Fetch the results
    final_slope_100, final_intercept_100 = sess_100.run([m, b])

#endof:  with ... sess_100
```

In [39]:
```
final_slope_100
```

Out[39]:
```
0.7845093432798748
```

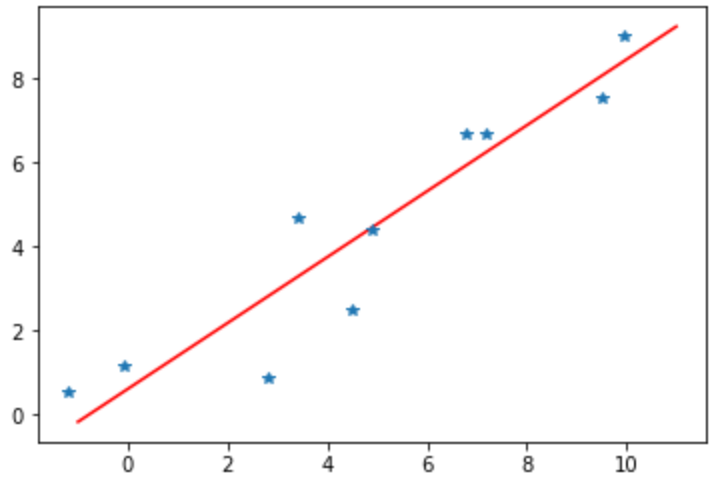
In [40]:
```
final_intercept_100
```

Out[40]:
```
0.6109625996718991
```

Evaluate with 100 epochs

In [41]:
```
x_test = np.linspace(-1, 11, 10) # Make plot look a little nicer

# y = mx + b
y_pred_plot_100 = final_slope_100 * x_test + final_intercept_100

plt.plot(x_test, y_pred_plot_100, 'r')

plt.plot(x_data, y_label, '*')
```

Out[41]:
```
[<matplotlib.lines.Line2D at 0x1bdd2d922e8>]
```



That does indeed seem better

That's all for now!