linear_regression

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1 Learn Tensorflow via a linear regression model

In this excercise, you will learn tensorflow in steps. Please use python 3 and tensorflow >=1.4.0.

```
In [5]: # A bit of setup

        import numpy as np
        import tensorflow as tf
        import matplotlib.pyplot as plt

        from implementations.a_tensorflow import regression_graph
        from plot_graph import show_graph


        %matplotlib inline
        plt.rcParams['figure.figsize'] = (10.0, 8.0) # set default size of plots
        plt.rcParams['image.interpolation'] = 'nearest'
        plt.rcParams['image.cmap'] = 'gray'

        # for auto-reloading external modules
        # see http://stackoverflow.com/questions/1907993/autoreload-of-modules-in-ipython
        %load_ext autoreload
        %autoreload 2
```

```
The autoreload extension is already loaded. To reload it, use:
  %reload_ext autoreload
```

1.1 Tensorflow graph

In the first step, we test a tensorflow graph with all constants. Please read `a_tensorflow.regression_graph()`. It calculates the squared loss for the linear regression model.

1.1.1 Question 1:

Please run the code in the cell below, comment out the first line, and then run the cell multiple times. Why does the right-most graph get numbers on it nodes with your runs?

```
In [153]: tf.reset_default_graph()
          loss = regression_graph() # the first function in a_tensorflow
          show_graph(loss.graph)
```

```
<IPython.core.display.HTML object>
```

Note 1: use `tf.Session()` to run the graph and evaluate the value of a graph node. Note 2: retrieve a graph node by its name.

1.1.2 Question 2:

Please uncomment the last two lines and evaluate the loss.

```
In [154]: tf.reset_default_graph()
          loss = regression_graph(print_info=True)
          session = tf.Session()

          # retrieve the variable from the graph
          f = tf.get_default_graph().get_tensor_by_name('score:0')
          print("We retrieve f from the graph and show its value: ", session.run(f))

          #print('The loss is ')
          #session.run(loss)
```

```
Msg from the function: we can evaluate any value in the graph with tf.Session
Msg from the function: the value of f = w * x + b is 2.18
We retrieve f from the graph and show its value:  2.18
```

1.2 Tensorflow graph with vectors

We can get a tensor's shape with its member function `get_shape()`. Note that this function is python function, not a tensorflow operation, so it runs when you build the graph.

We can also use the tensorflow operation `tf.shape()` to get the shape of a tensor. Since it is an operation, it is part of the graph. You need to run the operation to get the actual value.

1.2.1 Question 3:

Complete the code in the function `regression_graph_vectorized` so the following cell can run.

```
In [82]: from implementations.a_tensorflow import regression_graph_vectorized
         tf.reset_default_graph()
         loss = regression_graph_vectorized(print_info=True)

         print(tf.Session().run(loss))
```

```
By w.get_shape(), we get the shape of the tensor w: (2,)
With tf.shape(w), we get the shape of w as a one-element tensor: Tensor("Shape:0", shape=(1,),
The shape of tf.matmul(x, w) is: (3, 1)
The shape of tf.squeeze(tf.matmul(x, w)) is: (3,)
35.343597
```

1.3 Place holder in Tensorflow graph

A `placeholder` holds space for the data that will be fed into the graph in the future. It can has shape `None` in one or more dimensions. The size of that dimension will be decided by the data.

1.3.1 Question 4:

Please implement the function `regression_graph_with_placeholder` and get the cell below run.

```
In [69]: from implementations.a_tensorflow import regression_graph_with_placeholder
         tf.reset_default_graph()

         # build a graph with place holders
         x = tf.placeholder(shape=[None, 2], dtype=tf.float32, name='feature')
         y = tf.placeholder(shape=[None], dtype=tf.float32, name='label')

         print('The place holder x is:', x) # take a look of the place holder

         loss = regression_graph_with_placeholder(x=x, y=y)

         # need to feed in actual values to x and y to evaluate the variable loss

         # numpy values
         np.random.seed(seed=2019)
         npx = np.random.random_sample([10, 2])
         npy = np.squeeze(npx.dot([[0.3], [0.6]])) + 1.0 + 0.05 * np.random.random_sample([10]

         # this line cannot run because you need to feed in values for place holders. Can you
         tf.Session().run(loss)

         #tf.Session().run(loss, feed_dict={x: npx, y: npy})


         # feed in a different set of data
         npx = np.random.random_sample([10, 2])
         npy = np.squeeze(npx.dot([[0.7], [0.9]])) + 1.0 + 0.05 * np.random.random_sample([10]

         # it get a different loss value
         #tf.Session().run(loss, feed_dict={x: npx, y: npy})
```

```
The place holder x is: Tensor("feature:0", shape=(?, 2), dtype=float32)
```

```
Out[69]: 14.469966
```

1.4 Tensorflow graph with variables

We need to use tf.Variable to declare variables that we can optimize later. We often use Variables for model parameters, which are mutable. We seldomly use Variables for data.

1.4.1 Question 5:

Please implement the function regression_graph_with_variable and get the cell below run.

```
In [114]: from implementations.a_tensorflow import regression_graph_with_variable
          tf.reset_default_graph()

          w = tf.Variable(np.full(shape=[2], fill_value=1.6, dtype=np.float32), name='weight')
          b = tf.Variable(tf.constant(0.9), name='bias')

          loss = regression_graph_with_variable(w=w, b=b)


          session = tf.Session()

          #init = tf.global_variables_initializer()
          #session.run(init)

          session.run(loss) # you cannot directly run loss because you need to initialize vari
```

```
Out[114]: 35.343597
```

1.5 Gradient calculation

Tensorflow can calculate gradient with respect to a Variable (but not a constant or a placeholder). Let's use an optimizer to optimize a gradient.

1.5.1 Question 6:

Please read the documentation of compute_gradients and apply_gradients. Can you update w and b ten times and make the loss smaller?

```
In [115]: # initialize an optimizer
          opt = tf.train.GradientDescentOptimizer(learning_rate=0.01)
          grads_vars = opt.compute_gradients(loss, var_list=[w, b])
          update = opt.apply_gradients(grads_vars)


          print('The current loss is: ', session.run(loss))
          print('The current variable gradients and values are')
          print(session.run(grads_vars))

          #for iter in range(10):  # can you run multiple steps to minimize the loss?
          session.run(update)

          print('The current loss is: ', session.run(loss))
          print('The current variable gradients and values are')
          print(session.run(grads_vars))
```

```
The current loss is:  35.343597
The current variable gradients and values are
[(array([ 9.504, 19.008], dtype=float32), array([1.6, 1.6], dtype=float32)), (35.64, 0.9)]
The current loss is:  20.22711
The current variable gradients and values are
[(array([ 7.2116356, 14.343437 ], dtype=float32), array([1.5049601, 1.40992  ], dtype=float32)
```

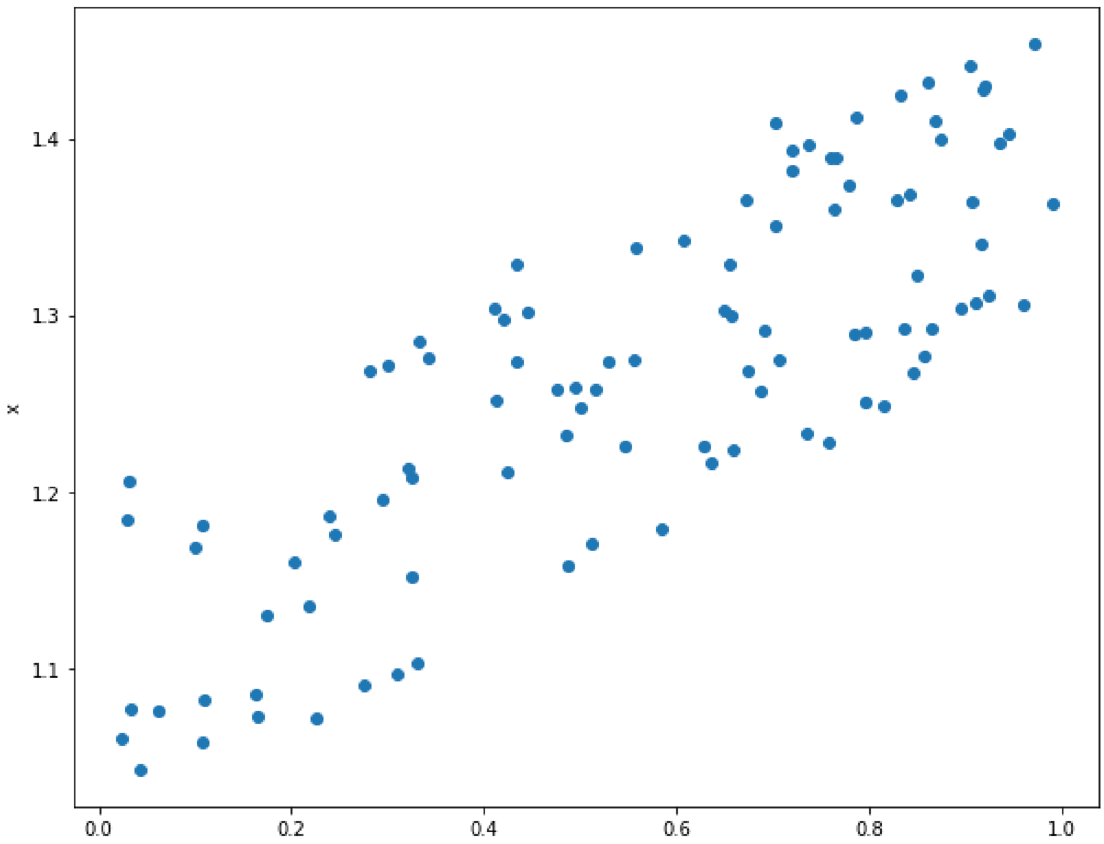
1.6 Compose the full version of linear regression

1.6.1 Question 7:

Can you use all techniques you have learned above to compose a full version of linear regression?

We use data with one feature only so we can plot the data easily. Assume the feature matrix is npx and the label is npy.

```
In [121]: # plot the data before fitting the model.
          # numpy values
          N = 100
          npx = np.random.random_sample([N, 1])
          npy = np.squeeze(npx.dot([[0.3]])) + 1.0 + 0.2 * np.random.random_sample([N])

          plt.plot(npx, npy, 'o')
          plt.ylabel('y')
          plt.ylabel('x')
          plt.show()
```

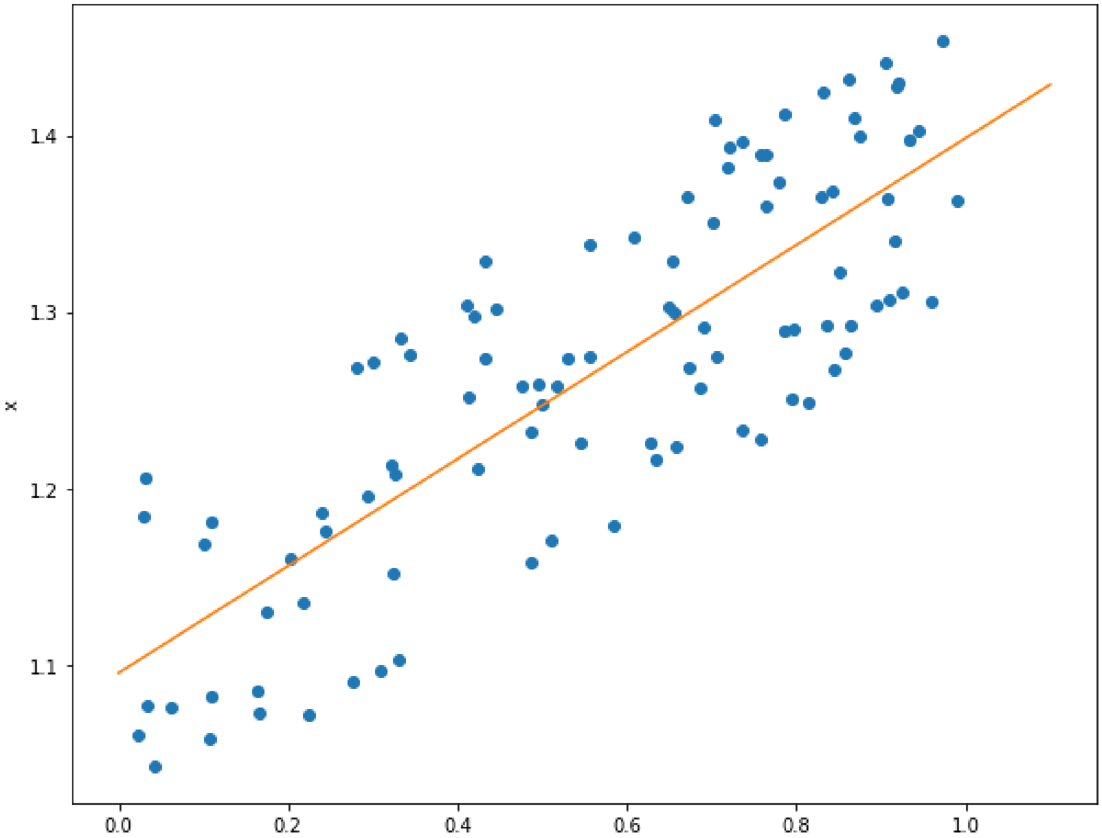


```
In [142]: from implementations.a_tensorflow import regression_graph_full
          tf.reset_default_graph()

          #x = tf.placeholder(shape=??, dtype=tf.float32, name='feature')
          #y = tf.placeholder(shape=??, dtype=tf.float32, name='label')

          #w = tf.Variable(np.full(shape=?, fill_value=1.6, dtype=np.float32), name='weight')
          #b = tf.Variable(tf.constant(0.9), name='bias')

          loss = regression_graph_full(x=x, y=y, w=w, b=b) # you need to implement this functi

          # get an optimizer
          opt = tf.train.GradientDescentOptimizer(learning_rate=0.001)

          # calculate the gradient with compute_gradients
          #grads_vars = ??

          # get an update operation with apply_gradients
          #update = ??
          # get a session
          session = tf.Session()

          # initialize your variables, namely w and b
          #session.run(??)

          # get feeding dictionary
          feed_dict={x: npx, y: npy}


          print('The current loss is: ', session.run(loss, feed_dict=feed_dict))
          print('The current variable gradients and values are')
          print(session.run(grads_vars)) # something is missing here?

          for iter in range(1000):  # Run 1000 steps to minimize the loss

              # perform gradient steps by running the update operation
              #session.run(??)

              if iter % 100 == 1:
                  print('Loss values become: ', session.run(loss, feed_dict=feed_dict))


          # obtain the trained model
          npw = session.run(w)
          npb = session.run(b)
```

```
The current loss is:  42.28681
The current variable gradients and values are
[(array([80.82121], dtype=float32), array([1.6], dtype=float32)), (107.27521, 0.9)]
Loss values become:  18.15213
Loss values become:  1.1406087
Loss values become:  0.43377265
Loss values become:  0.366474
Loss values become:  0.36006635
Loss values become:  0.35945624
Loss values become:  0.35939822
Loss values become:  0.35939267
Loss values become:  0.35939217
Loss values become:  0.35939205
```

```
In [147]: # Plot the result

          x_line = np.arange(12) / 10.0
          y_line = x_line * np.squeeze(npw) + npb
```

```
plt.plot(npx, npy, 'o')
plt.plot(x_line, y_line)
plt.ylabel('y')
plt.ylabel('x')
plt.show()
```



```
In [ ]:
```