TensorFlowBasics

December 20, 2017

1 TensorFlow Basics

```
In [75]: import tensorflow as tf
```

1.1 Simple constants

```
In [76]: hello = tf.constant("Hello ")
         world = tf.constant("World")
         with tf.Session() as sess:
             result = sess.run(hello+world)
         print(result)
```

```
b'Hello World'
```

1.2 Operations

```
In [77]: a = tf.constant(10)
         b = tf.constant(20)
         with tf.Session() as sess:
             addition = sess.run(a+b)
             multiplication = sess.run(a*b)
         print(addition)
         print(multiplication)
```

```
30
200
```

1.3 Working with a group of operations

```
In [78]: const = tf.constant(10)
         fill_mat = tf.fill((4,4),10)
         myzeros = tf.zeros((4,4))
         myones = tf.ones((4,4))
         myrandn = tf.random_normal((4,4), mean = 0, stddev = 1.0)
         myrandu = tf.random_uniform((4,4), minval=0, maxval =1)
         my_ops = [const, fill_mat, myzeros, myones, myrandn, myrandu]
```

```
with tf.Session() as sess:
    for op in my_ops:
        print(op)
        print(sess.run(op))
        print()
```

```
Tensor("Const_7:0", shape=(), dtype=int32)
10

Tensor("Fill:0", shape=(4, 4), dtype=int32)
[[10 10 10 10]
 [10 10 10 10]
 [10 10 10 10]
 [10 10 10 10]]

Tensor("zeros:0", shape=(4, 4), dtype=float32)
[[ 0.  0.  0.  0.]
 [ 0.  0.  0.  0.]
 [ 0.  0.  0.  0.]
 [ 0.  0.  0.  0.]]

Tensor("ones:0", shape=(4, 4), dtype=float32)
[[ 1.  1.  1.  1.]
 [ 1.  1.  1.  1.]
 [ 1.  1.  1.  1.]
 [ 1.  1.  1.  1.]]

Tensor("random_normal:0", shape=(4, 4), dtype=float32)
[[-0.22524352  0.48237228 -0.82078487  3.01135111]
 [ 0.00545869 -0.834593   -0.92740136  0.69436634]
 [-0.65776408 -1.27777672 -0.1419917   0.52560955]
 [ 1.68673515 -1.74032402 -0.78021753 -1.37309158]]

Tensor("random_uniform:0", shape=(4, 4), dtype=float32)
[[ 0.57191324  0.23138583  0.64000297  0.05784225]
 [ 0.70652795  0.35563576  0.8453964   0.2437402 ]
 [ 0.60556591  0.20199621  0.04805243  0.81644404]
 [ 0.12995601  0.93353736  0.22052491  0.71197939]]
```

1.4 Matrix multiplication

In [79]:
```
a = tf.constant([[1,2],[3,4]])
b = tf.constant([[10],[100]])
result = tf.matmul(a,b)
with tf.Session() as sess:
    print(sess.run(result))
```

```
[[210]
 [430]]
```

1.5 Graphs

```
In [80]: graph_one = tf.get_default_graph()
         graph_two = tf.Graph()
         with graph_two.as_default():
             print(graph_two is tf.get_default_graph())
         print(graph_one is tf.get_default_graph())
```

```
True
True
```

1.6 Variables and Placeholders

```
In [81]: sess = tf.InteractiveSession()
```

1.6.1 Variables

```
In [82]: my_tensor = tf.random_uniform((4,4),0,1)
         my_var = tf.Variable(initial_value= my_tensor)

         init = tf.global_variables_initializer()
         sess.run(init)

         sess.run(my_var)
```

```
Out[82]: array([[ 0.84827316,  0.7577678 ,  0.55914938,  0.30990303],
                [ 0.95548916,  0.70689785,  0.23078871,  0.48589516],
                [ 0.71285999,  0.14615691,  0.81334543,  0.25708985],
                [ 0.82702184,  0.70338643,  0.70925617,  0.55189872]], dtype=float32)
```

1.6.2 Placeholders

```
In [83]: ph = tf.placeholder(tf.float32)
```

1.7 More tensorFlow Graphs

```
In [84]: import numpy as np
         np.random.seed(101)
         tf.set_random_seed(101)
         """
         Simple calculation example
         """
         rand_a = np.random.uniform(0,100,(5,5))
         rand_b = np.random.uniform(0,100,(5,1))
```

```
a = tf.placeholder(tf.float32)
b = tf.placeholder(tf.float32)
add_op = a + b
mult_op = a * b
with tf.Session() as sess:
    add_result = sess.run(add_op, feed_dict={a:rand_a,b:rand_b})
    mult_result = sess.run(mult_op, feed_dict={a:rand_a,b:rand_b})
print(add_result)
print()
print(mult_result)
```

```
[[ 151.07165527  156.49855042  102.27921295  116.58396149  167.95948792]
 [ 135.45622253   82.76316071  141.42784119  124.22093201   71.06043243]
 [ 113.30171204   93.09214783   76.06819153  136.43911743  154.42727661]
 [  96.7172699    81.83804321  133.83674622  146.38117981  101.10578918]
 [ 122.72680664  105.98292542   59.04463196   67.98310089   72.89292145]]

[[ 5134.64404297  5674.25         283.12432861  1705.47070312
   6813.83154297]
 [ 4341.8125      1598.26696777  4652.73388672  3756.8293457    988.9463501 ]
 [ 3207.8112793   2038.10290527  1052.77416992  4546.98046875
   5588.11572266]
 [ 1707.37902832   614.02526855  4434.98876953  5356.77734375
   2029.85546875]
 [ 3714.09838867  2806.64379883   262.76763916   747.19854736
   1013.29199219]]
```

1.8 Example Neural Network

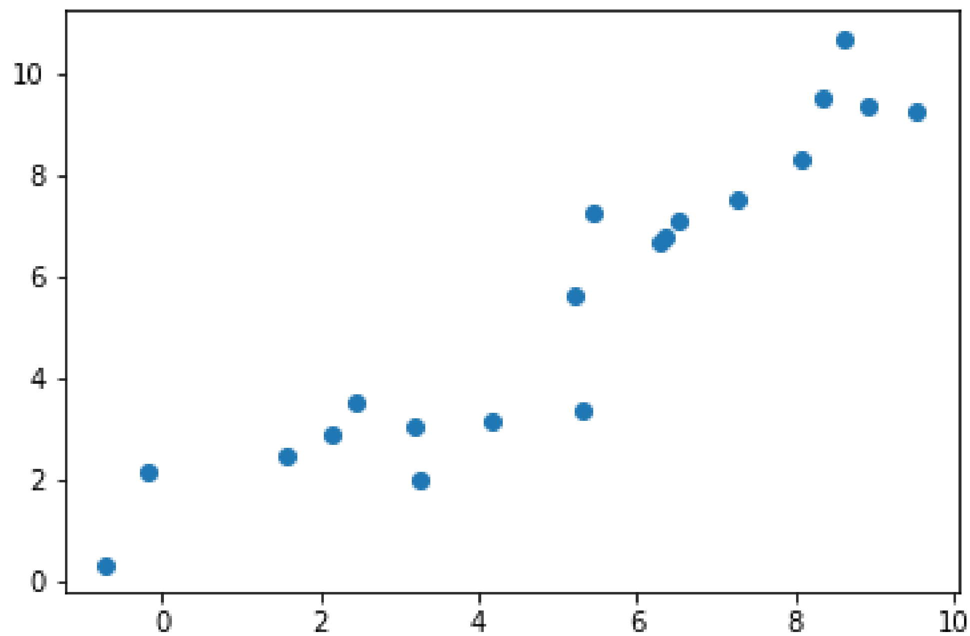
```
In [85]: n_features = 10
         n_dense_neurons = 3
         x = tf.placeholder(tf.float32, (None, n_features))
         W = tf.Variable(tf.random_normal([n_features, n_dense_neurons]))
         b = tf.Variable(tf.ones([n_dense_neurons]))
         xW = tf.matmul(x,W)
         z = tf.add(xW, b)
         a = tf.sigmoid(z)
         init = tf.global_variables_initializer()
         with tf.Session() as sess:
             sess.run(init)
             layer_out = sess.run(a, feed_dict={x:np.random.random([1,n_features])})
         print(layer_out)
```

```
[[ 0.9905979   0.99483466  0.40837812]]
```

1.9 Simple Regression Example

In [86]:
```
import matplotlib.pyplot as plt
%matplotlib inline
"""
Random numbers with some noise
"""
x_data = np.linspace(0,10,20) + np.random.uniform(-1,2,20)
y_label = np.linspace(0,10,20) + np.random.uniform(-1,2,20)
plt.scatter(x_data, y_label)
```

Out[86]:
```
<matplotlib.collections.PathCollection at 0x2aead915f60>
```

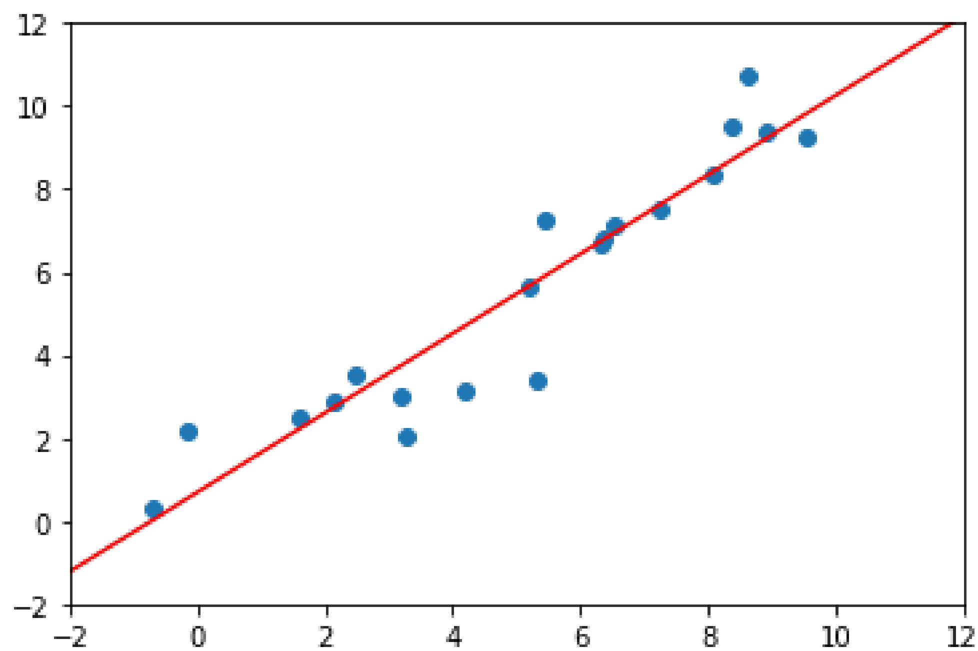


Regression for y=mx+b

In [87]:
```
m = tf.Variable(np.random.rand(1))
b = tf.Variable(np.random.rand(1))
error = 0
for x,y in zip(x_data, y_label):
    y_hat = m*x + b
    error += (y-y_hat)**2
#Gradient Descent
optimizer = tf.train.GradientDescentOptimizer(learning_rate=0.001)
train = optimizer.minimize(error)
init = tf.global_variables_initializer()
with tf.Session() as sess:
    sess.run(init)
```

```
    training_steps = 500
    for i in range(training_steps):
        sess.run(train)
    final_slope, final_intercept = sess.run([m,b])
x_test = np.linspace(-2,12,20)
y_pred_plot = final_slope*x_test + final_intercept
plt.plot(x_test, y_pred_plot,'r')
plt.scatter(x_data, y_label)
plt.xlim(-2,12)
plt.ylim(-2,12)
```

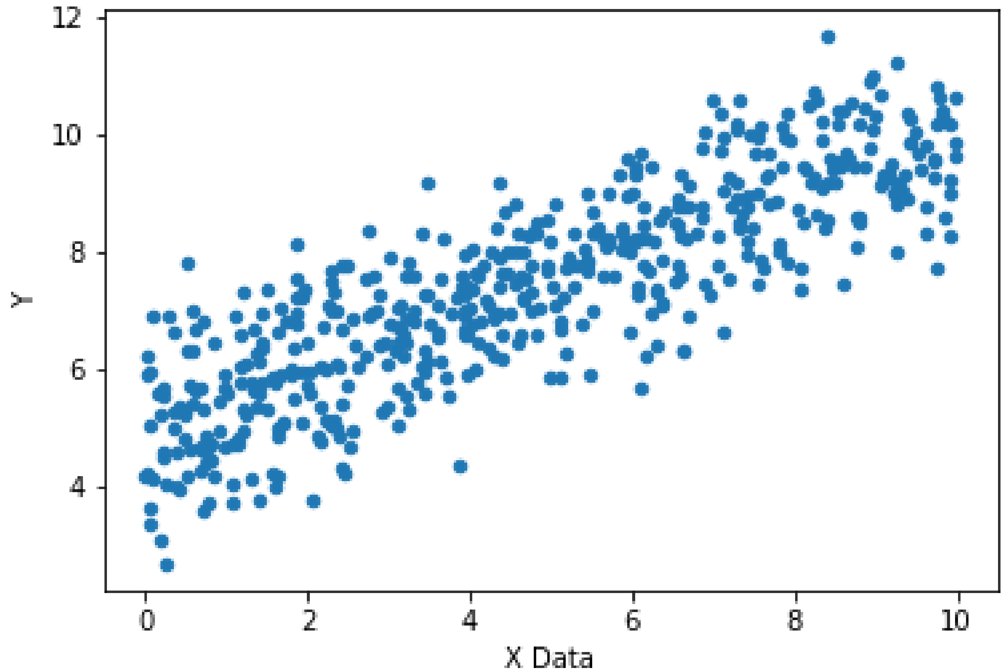
Out[87]: (-2, 12)



1.10 Larger Dataset Regression

In [88]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
x_data = np.linspace(0.0,10.0,1000000)
noise = np.random.randn(len(x_data))
y_true = (.5 * x_data) + 5 + noise
x_df = pd.DataFrame(data=x_data, columns = ['X Data'])
y_df = pd.DataFrame(data=y_true, columns = ['Y'])
my_data = pd.concat([x_df,y_df],axis=1)
my_data.sample(n=500).plot(kind = 'scatter', x='X Data', y = 'Y')
```

Out[88]: <matplotlib.axes._subplots.AxesSubplot at 0x2b0781fe978>

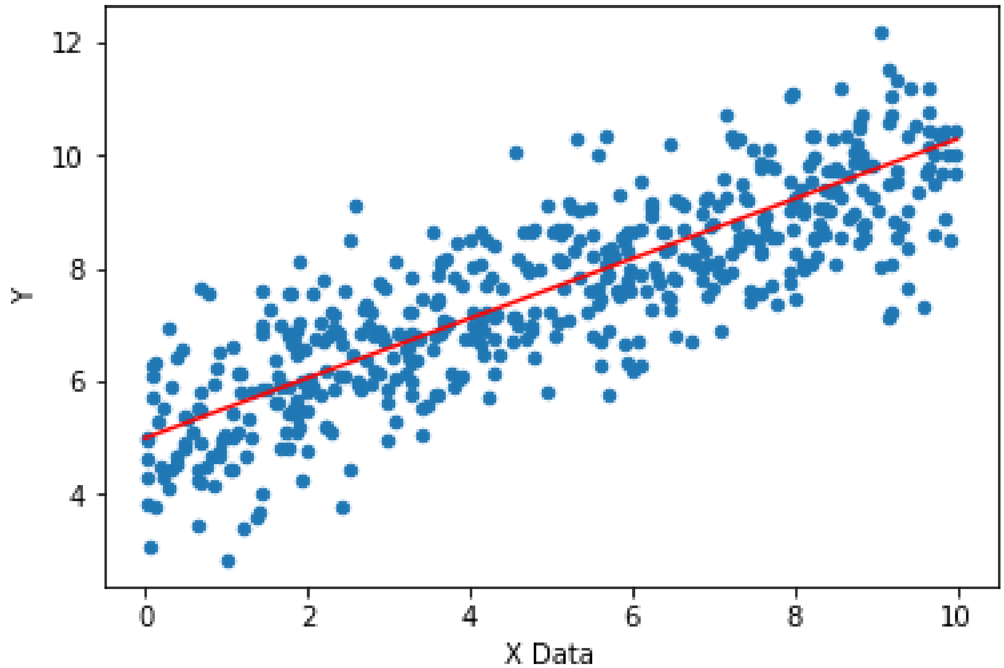


In [89]:
```
batch_size = 8
m = tf.Variable(np.random.randn(1))
b = tf.Variable(np.random.randn(1))
xph = tf.placeholder(tf.float64, [batch_size])
yph = tf.placeholder(tf.float64, [batch_size])
y_model = m * xph + b
error = tf.reduce_sum(tf.square(yph-y_model))
optimizer = tf.train.GradientDescentOptimizer(learning_rate = .001)
train = optimizer.minimize(error)
init = tf.global_variables_initializer()

with tf.Session() as sess:
    sess.run(init)
    batches = 5000
    for i in range(batches):
        rand_ind = np.random.randint(len(x_data), size=batch_size)
        feed = {xph:x_data[rand_ind],yph:y_true[rand_ind]}
        sess.run(train,feed_dict = feed)
    model_m, model_b = sess.run([m,b])

y_hat = x_data * model_m + model_b
my_data.sample(n=500).plot(kind = 'scatter', x='X Data', y = 'Y')
plt.plot(x_data,y_hat,'r')
```

Out[89]: [<matplotlib.lines.Line2D at 0x2b07821eb00>]



1.11 TensorFlow Estimator

In [90]:
```
import tensorflow as tf
feat_cols = [tf.feature_column.numeric_column('x', shape=[1])]
estimator = tf.estimator.LinearRegressor(feature_columns = feat_cols)

#Training sets and test sets
from sklearn.model_selection import train_test_split
x_train, x_test, y_train, y_test = train_test_split(
    x_data, y_true, test_size = .3, random_state = 101)

input_func = tf.estimator.inputs.numpy_input_fn({'x':x_train}, y_train,
                                                 batch_size = 8, num_epochs = None,
                                                shuffle = True)
train_input_func = tf.estimator.inputs.numpy_input_fn({'x':x_train}, y_train,
                                                 batch_size = 8, num_epochs = 1000,
                                                shuffle = False)
test_input_func = tf.estimator.inputs.numpy_input_fn({'x':x_test}, y_test,
                                                 batch_size = 8, num_epochs = 1000,
                                                shuffle = False)
estimator.train(input_fn=input_func,steps=1000)
```

```
INFO:tensorflow:Using default config.
WARNING:tensorflow:Using temporary folder as model directory: C:\Users\Ripti\AppData\Local\Temp\
```

```
INFO:tensorflow:Using config: {'_model_dir': 'C:\\Users\\Ripti\\AppData\\Local\\Temp\\tmppexpu9c
INFO:tensorflow:Create CheckpointSaverHook.
INFO:tensorflow:Saving checkpoints for 1 into C:\Users\Ripti\AppData\Local\Temp\tmppexpu9cm\mode
INFO:tensorflow:loss = 587.854, step = 1
INFO:tensorflow:global_step/sec: 436.786
INFO:tensorflow:loss = 17.1739, step = 101 (0.232 sec)
INFO:tensorflow:global_step/sec: 474.863
INFO:tensorflow:loss = 32.2359, step = 201 (0.210 sec)
INFO:tensorflow:global_step/sec: 481.145
INFO:tensorflow:loss = 18.5654, step = 301 (0.211 sec)
INFO:tensorflow:global_step/sec: 465.578
INFO:tensorflow:loss = 14.1275, step = 401 (0.211 sec)
INFO:tensorflow:global_step/sec: 508.848
INFO:tensorflow:loss = 13.2055, step = 501 (0.196 sec)
INFO:tensorflow:global_step/sec: 486.507
INFO:tensorflow:loss = 8.24483, step = 601 (0.208 sec)
INFO:tensorflow:global_step/sec: 457.21
INFO:tensorflow:loss = 13.2243, step = 701 (0.218 sec)
INFO:tensorflow:global_step/sec: 448.581
INFO:tensorflow:loss = 9.94372, step = 801 (0.223 sec)
INFO:tensorflow:global_step/sec: 524.92
INFO:tensorflow:loss = 10.9645, step = 901 (0.191 sec)
INFO:tensorflow:Saving checkpoints for 1000 into C:\Users\Ripti\AppData\Local\Temp\tmppexpu9cm\m
INFO:tensorflow:Loss for final step: 16.3635.
```

```
Out[90]: <tensorflow.python.estimator.canned.linear.LinearRegressor at 0x2b0643dec18>
```

train_metrics = estimator.evaluate(input_fn=train_input_func, steps=1000)
test_metrics = estimator.evaluate(input_fn=test_input_func, steps=1000)

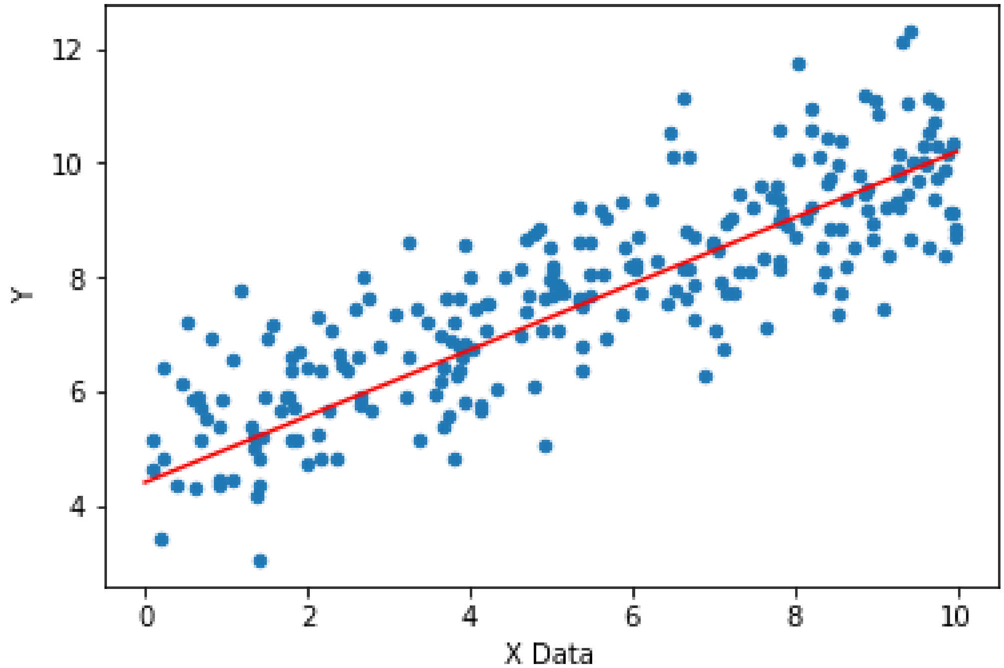
```
In [91]: print('TRAINING DATA')
         print(train_metrics)
         print('TEST DATA')
         print(test_metrics)
```

```
TRAINING DATA
{'average_loss': 1.1141723, 'loss': 8.9133787, 'global_step': 1000}
TEST DATA
{'average_loss': 1.1259887, 'loss': 9.0079098, 'global_step': 1000}
```

```
In [92]: new_data = np.linspace(0,10,10)
         input_fn_predict = tf.estimator.inputs.numpy_input_fn({'x':new_data}, shuffle = False)
         predictions = []
         for pred in estimator.predict(input_fn=input_fn_predict):
             predictions.append(pred['predictions'])
         my_data.sample(n=250).plot(kind='scatter',x='X Data', y='Y')
         plt.plot(new_data, predictions,  'r')
```

```
INFO:tensorflow:Restoring parameters from C:\Users\Ripti\AppData\Local\Temp\tmppexpu9cm\model.ck
```

Out[92]: [<matplotlib.lines.Line2D at 0x2b07a5e1748>]



1.12 Tensorflow Classifications

For when you have categorical data; let's use a binary classification.

In [93]:
```python
import pandas as pd
diabetus = pd.read_csv('pima-indians-diabetes.csv')
diabetus.head()
```

Out[93]:
```
   Number_pregnant  Glucose_concentration  Blood_pressure  Triceps   Insulin  \
0                6               0.743719        0.590164  0.353535  0.000000
1                1               0.427136        0.540984  0.292929  0.000000
2                8               0.919598        0.524590  0.000000  0.000000
3                1               0.447236        0.540984  0.232323  0.111111
4                0               0.688442        0.327869  0.353535  0.198582

        BMI  Pedigree  Age  Class Group
0  0.500745  0.234415   50      1     B
1  0.396423  0.116567   31      0     C
2  0.347243  0.253629   32      1     B
3  0.418778  0.038002   21      0     B
4  0.642325  0.943638   33      1     C
```

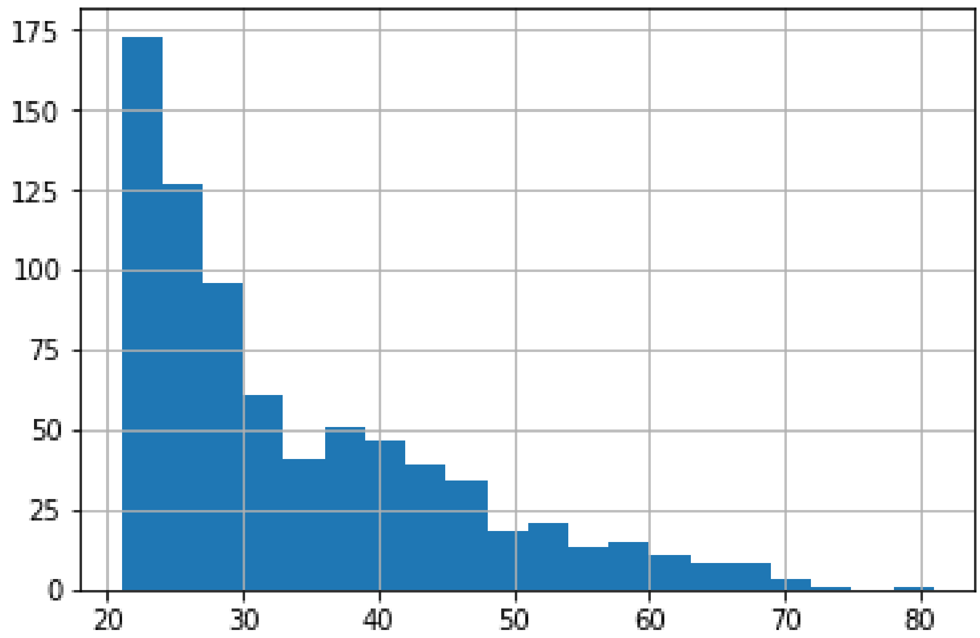
```
In [94]: # Normalization
         cols_to_norm = ['Number_pregnant', 'Glucose_concentration',
                         'Blood_pressure', 'Triceps',
                         'Insulin', 'BMI', 'Pedigree']
         diabetus[cols_to_norm] = diabetus[cols_to_norm].apply(
             lambda x:(x-x.min())/(x.max()-x.min()))
```

```
In [95]: # Continuous features
         num_preg = tf.feature_column.numeric_column('Number_pregnant')
         plasma_gluc = tf.feature_column.numeric_column('Glucose_concentration')
         dias_press = tf.feature_column.numeric_column('Blood_pressure')
         tricep = tf.feature_column.numeric_column('Triceps')
         insulin = tf.feature_column.numeric_column('Insulin')
         bmi = tf.feature_column.numeric_column('BMI')
         diabetes_pedigree = tf.feature_column.numeric_column('Pedigree')
         age = tf.feature_column.numeric_column('Age')

         # Categorical features
         assigned_group = tf.feature_column.categorical_column_with_vocabulary_list(
             'Group',['A','B','C','D'])
```

1.12.1 Converting Continuous to Categorical

```
In [96]: import matplotlib.pyplot as plt
         %matplotlib inline
         diabetus['Age'].hist(bins=20)
         age_buckets = tf.feature_column.bucketized_column(
             age, boundaries=[20,30,40,50,60,70,80])
         feat_cols = [num_preg ,plasma_gluc,dias_press ,tricep ,
                      insulin,bmi,diabetes_pedigree ,assigned_group, age_buckets]
```



1.12.2 Training and Test Sets

```
In [97]: from sklearn.model_selection import train_test_split
         x_data = diabetus.drop('Class',axis=1)
         labels = diabetus['Class']
         X_train, X_test, y_train, y_test = train_test_split(x_data,labels,
                                                             test_size=0.33, random_state=101)
         input_func = tf.estimator.inputs.pandas_input_fn(x=X_train,y=y_train,
                                                batch_size=10,num_epochs=1000,shuffle=True)
         model = tf.estimator.LinearClassifier(feature_columns=feat_cols,n_classes=2)
         model.train(input_fn=input_func,steps=1000)
```

```
INFO:tensorflow:Using default config.
WARNING:tensorflow:Using temporary folder as model directory: C:\Users\Ripti\AppData\Local\Temp\
INFO:tensorflow:Using config: {'_model_dir': 'C:\\Users\\Ripti\\AppData\\Local\\Temp\\tmp05nr32m
INFO:tensorflow:Create CheckpointSaverHook.
INFO:tensorflow:Saving checkpoints for 1 into C:\Users\Ripti\AppData\Local\Temp\tmp05nr32m5\mode
INFO:tensorflow:loss = 6.93147, step = 1
INFO:tensorflow:global_step/sec: 127.351
INFO:tensorflow:loss = 5.57055, step = 101 (0.785 sec)
INFO:tensorflow:global_step/sec: 149.08
INFO:tensorflow:loss = 5.15163, step = 201 (0.671 sec)
INFO:tensorflow:global_step/sec: 155.834
INFO:tensorflow:loss = 4.82526, step = 301 (0.643 sec)
INFO:tensorflow:global_step/sec: 148.857
INFO:tensorflow:loss = 6.45611, step = 401 (0.671 sec)
```

```
INFO:tensorflow:global_step/sec: 145.597
INFO:tensorflow:loss = 5.20896, step = 501 (0.687 sec)
INFO:tensorflow:global_step/sec: 143.09
INFO:tensorflow:loss = 6.39312, step = 601 (0.700 sec)
INFO:tensorflow:global_step/sec: 148.856
INFO:tensorflow:loss = 5.7191, step = 701 (0.671 sec)
INFO:tensorflow:global_step/sec: 142.274
INFO:tensorflow:loss = 4.20419, step = 801 (0.703 sec)
INFO:tensorflow:global_step/sec: 144.124
INFO:tensorflow:loss = 5.41011, step = 901 (0.696 sec)
INFO:tensorflow:Saving checkpoints for 1000 into C:\Users\Ripti\AppData\Local\Temp\tmp05nr32m5\m
INFO:tensorflow:Loss for final step: 3.82677.
```

```
Out[97]: <tensorflow.python.estimator.canned.linear.LinearClassifier at 0x2b06d8ca3c8>
```

1.12.3 Evaluating the Model

```
In [98]: eval_input_func = tf.estimator.inputs.pandas_input_fn(
               x=X_test,
               y=y_test,
               batch_size=10,
               num_epochs=1,
               shuffle=False)
         results = model.evaluate(eval_input_func)
         results
```

```
WARNING:tensorflow:Casting <dtype: 'float32'> labels to bool.
WARNING:tensorflow:Casting <dtype: 'float32'> labels to bool.
INFO:tensorflow:Starting evaluation at 2017-12-21-02:40:17
INFO:tensorflow:Restoring parameters from C:\Users\Ripti\AppData\Local\Temp\tmp05nr32m5\model.ck
INFO:tensorflow:Finished evaluation at 2017-12-21-02:40:18
INFO:tensorflow:Saving dict for global step 1000: accuracy = 0.732283, accuracy_baseline = 0.657
```

```
Out[98]: {'accuracy': 0.73228347,
          'accuracy_baseline': 0.65748036,
          'auc': 0.78271043,
          'auc_precision_recall': 0.61937535,
          'average_loss': 0.53361279,
          'global_step': 1000,
          'label/mean': 0.34251967,
          'loss': 5.2129865,
          'prediction/mean': 0.35916343}
```

```
In [99]: # Predictions
         pred_input_func = tf.estimator.inputs.pandas_input_fn(
               x=X_test,
               batch_size=10,
```

```
            num_epochs=1,
            shuffle=False)
        predictions = model.predict(pred_input_func)
```

Let's use a Dense Neural Network

```
In [100]: embedded_group_col = tf.feature_column.embedding_column(
              assigned_group, dimension=4)
          feat_cols = [num_preg ,plasma_gluc,dias_press ,tricep ,insulin,
                       bmi,diabetes_pedigree ,embedded_group_col, age_buckets]
          input_func = tf.estimator.inputs.pandas_input_fn(
              x=X_train,y=y_train,batch_size=10,num_epochs=1000,shuffle=True)

          dnn_model = tf.estimator.DNNClassifier(hidden_units=[10,10,10],
                                                 feature_columns=feat_cols,n_classes=2)
          dnn_model.train(input_fn=input_func,steps=1000)
```

```
INFO:tensorflow:Using default config.
WARNING:tensorflow:Using temporary folder as model directory: C:\Users\Ripti\AppData\Local\Temp\
INFO:tensorflow:Using config: {'_model_dir': 'C:\\Users\\Ripti\\AppData\\Local\\Temp\\tmpbv82dg_
INFO:tensorflow:Create CheckpointSaverHook.
INFO:tensorflow:Saving checkpoints for 1 into C:\Users\Ripti\AppData\Local\Temp\tmpbv82dg_3\mode
INFO:tensorflow:loss = 7.01344, step = 1
INFO:tensorflow:global_step/sec: 131.478
INFO:tensorflow:loss = 5.80182, step = 101 (0.761 sec)
INFO:tensorflow:global_step/sec: 142.598
INFO:tensorflow:loss = 6.48086, step = 201 (0.700 sec)
INFO:tensorflow:global_step/sec: 147.34
INFO:tensorflow:loss = 7.30843, step = 301 (0.679 sec)
INFO:tensorflow:global_step/sec: 142.884
INFO:tensorflow:loss = 6.47545, step = 401 (0.700 sec)
INFO:tensorflow:global_step/sec: 138.675
INFO:tensorflow:loss = 4.0591, step = 501 (0.723 sec)
INFO:tensorflow:global_step/sec: 144.264
INFO:tensorflow:loss = 2.52048, step = 601 (0.693 sec)
INFO:tensorflow:global_step/sec: 152.498
INFO:tensorflow:loss = 3.87574, step = 701 (0.654 sec)
INFO:tensorflow:global_step/sec: 142.214
INFO:tensorflow:loss = 3.00031, step = 801 (0.705 sec)
INFO:tensorflow:global_step/sec: 147.312
INFO:tensorflow:loss = 2.53928, step = 901 (0.678 sec)
INFO:tensorflow:Saving checkpoints for 1000 into C:\Users\Ripti\AppData\Local\Temp\tmpbv82dg_3\m
INFO:tensorflow:Loss for final step: 4.76311.
```

```
Out[100]: <tensorflow.python.estimator.canned.dnn.DNNClassifier at 0x2b07a4cc6a0>
```

```
In [101]: eval_input_func = tf.estimator.inputs.pandas_input_fn(
              x = X_test, y = y_test, batch_size = 10, num_epochs = 1, shuffle = False)
```

In [102]: dnn_model.evaluate(eval_input_func)

```
WARNING:tensorflow:Casting <dtype: 'float32'> labels to bool.
WARNING:tensorflow:Casting <dtype: 'float32'> labels to bool.
INFO:tensorflow:Starting evaluation at 2017-12-21-02:40:30
INFO:tensorflow:Restoring parameters from C:\Users\Ripti\AppData\Local\Temp\tmpbv82dg_3\model.ck
INFO:tensorflow:Finished evaluation at 2017-12-21-02:40:31
INFO:tensorflow:Saving dict for global step 1000: accuracy = 0.751969, accuracy_baseline = 0.657
```

Out[102]:

```
{'accuracy': 0.7519685,
 'accuracy_baseline': 0.65748036,
 'auc': 0.81444001,
 'auc_precision_recall': 0.68500859,
 'average_loss': 0.50868565,
 'global_step': 1000,
 'label/mean': 0.34251967,
 'loss': 4.9694676,
 'prediction/mean': 0.37802684}
```

2 Saving and Loading Models

In [103]:

```python
import numpy as np
import tensorflow as tf
import matplotlib.pyplot as plt
%matplotlib inline

np.random.seed(101)
tf.set_random_seed(101)

# Artificial Data
x_data = np.linspace(0,10,10) + np.random.uniform(-1.5,1.5,10)
y_label = np.linspace(0,10,10) + np.random.uniform(-1.5,1.5,10)
m = tf.Variable(np.random.rand(1))
b = tf.Variable(np.random.rand(1))
error = tf.reduce_mean(y_label - (m*x_data+b))
optimizer = tf.train.GradientDescentOptimizer(learning_rate=0.001)
train = optimizer.minimize(error)
init = tf.global_variables_initializer()
```

2.1 Saving the Model

In [104]:

```python
saver = tf.train.Saver()
with tf.Session() as sess:
    sess.run(init)
    epochs = 100
    for i in range(epochs):
        sess.run(train)
```

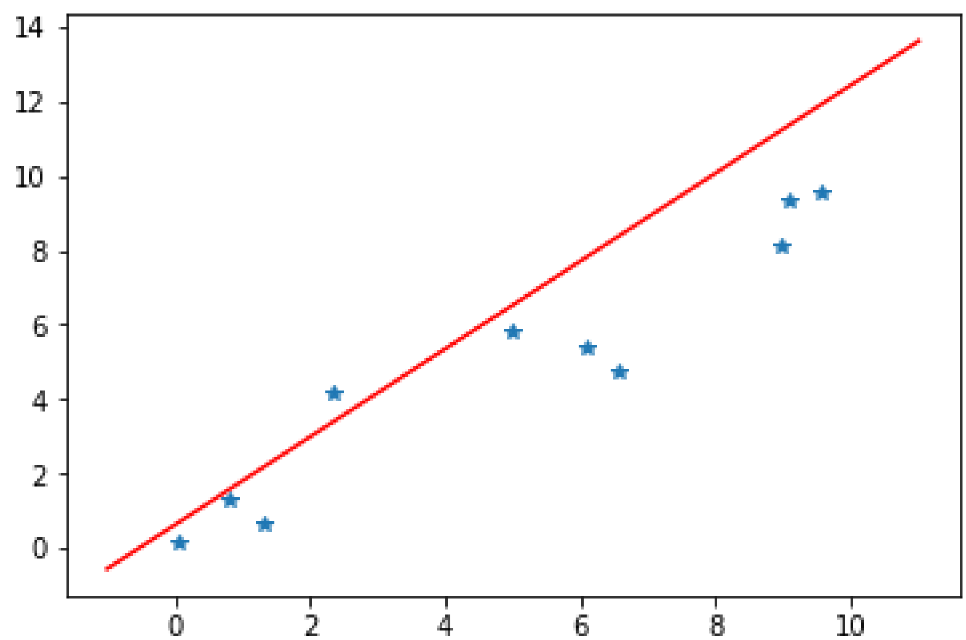
```
    # Fetch Back Results
    final_slope , final_intercept = sess.run([m,b])
    saver.save(sess,'new_models/model_from_course.ckpt')

x_test = np.linspace(-1,11,10)
y_pred_plot = final_slope*x_test + final_intercept

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

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

Out[104]: [<matplotlib.lines.Line2D at 0x2aeaecc77f0>]



2.2 Loading a Model

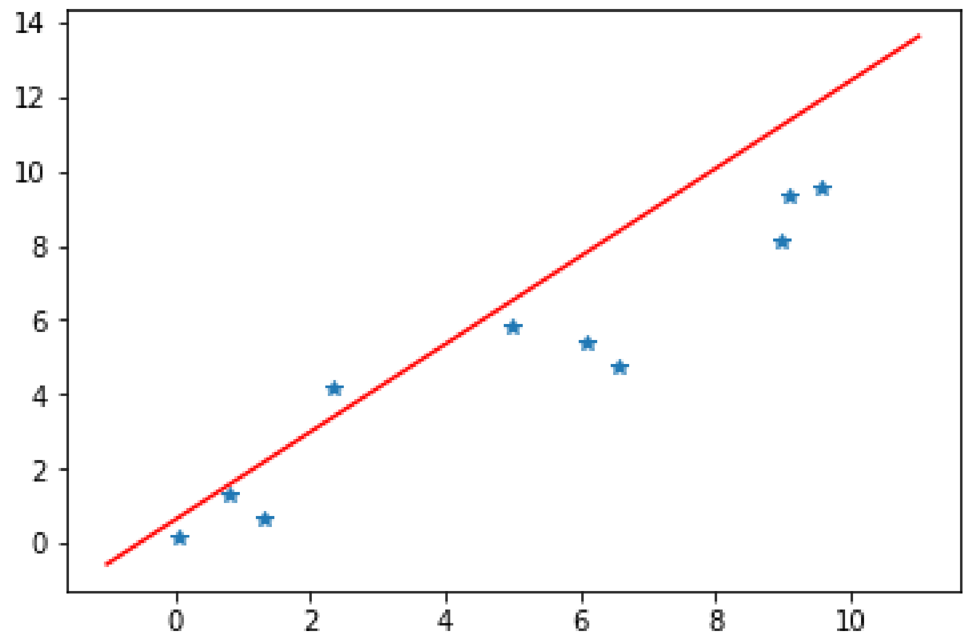
In [105]:
```
with tf.Session() as sess:
    # Restore the model
    saver.restore(sess,'new_models/model_from_course.ckpt')
    # Fetch Back Results
    restored_slope , restored_intercept = sess.run([m,b])
x_test = np.linspace(-1,11,10)
y_pred_plot = restored_slope*x_test + restored_intercept

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

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

```
INFO:tensorflow:Restoring parameters from new_models/model_from_course.ckpt
```

Out[105]: [<matplotlib.lines.Line2D at 0x2b06c820f98>]



3 Regression Exercise

3.1 The Data

Import the cal_housing.csv file with pandas. Separate it into a training (70%) and testing set(30%).

In [106]:
```
import pandas as pd
housing = pd.read_csv('cal_housing_clean.csv')
housing.head()
```

Out[106]:
```
   housingMedianAge  totalRooms  totalBedrooms  population  households  \
0              41.0       880.0          129.0       322.0       126.0
1              21.0      7099.0         1106.0      2401.0      1138.0
2              52.0      1467.0          190.0       496.0       177.0
3              52.0      1274.0          235.0       558.0       219.0
4              52.0      1627.0          280.0       565.0       259.0

   medianIncome  medianHouseValue
0        8.3252          452600.0
1        8.3014          358500.0
```

```
2        7.2574          352100.0
3        5.6431          341300.0
4        3.8462          342200.0
```

In [107]:
```
housing.describe().transpose()
```

Out[107]:
```
                    count           mean            std         min  \
housingMedianAge  20640.0      28.639486      12.585558      1.0000
totalRooms        20640.0    2635.763081    2181.615252      2.0000
totalBedrooms     20640.0     537.898014     421.247906      1.0000
population        20640.0    1425.476744    1132.462122      3.0000
households        20640.0     499.539680     382.329753      1.0000
medianIncome      20640.0       3.870671       1.899822      0.4999
medianHouseValue  20640.0  206855.816909  115395.615874  14999.0000

                          25%          50%           75%          max
housingMedianAge      18.0000      29.0000      37.00000      52.0000
totalRooms          1447.7500    2127.0000    3148.00000   39320.0000
totalBedrooms        295.0000     435.0000     647.00000    6445.0000
population           787.0000    1166.0000    1725.00000   35682.0000
households           280.0000     409.0000     605.00000    6082.0000
medianIncome           2.5634       3.5348       4.74325      15.0001
medianHouseValue  119600.0000  179700.0000  264725.00000  500001.0000
```

In [108]:
```
from sklearn.model_selection import train_test_split
x_data = housing.drop(['medianHouseValue'],axis=1)
y_val = housing['medianHouseValue']
X_train, X_test, y_train, y_test = train_test_split(
    x_data,y_val,test_size=0.3,random_state=101)
```

3.2 Scale the Feature Data

Use sklearn preprocessing to create a MinMaxScaler for the feature data. Fit this scaler only to the training data. Then use it to transform X_test and X_train. Then use the scaled X_test and X_train along with pd.Dataframe to re-create two dataframes of scaled data.

In [109]:
```
from sklearn.preprocessing import MinMaxScaler
scaler = MinMaxScaler()
scaler.fit(X_train)
X_train = pd.DataFrame(data=scaler.transform(X_train),
                       columns = X_train.columns,index=X_train.index)
X_test = pd.DataFrame(data=scaler.transform(X_test),
                      columns = X_test.columns,index=X_test.index)
```

3.3 Create Feature Columns

Create the necessary tf.feature_column objects for the estimator. They should all be trated as continuous numeric_columns.

Create the input function for the estimator object. (play around with batch_size and num_epochs)

Create the estimator model. Use a DNNRegressor. Play around with the hidden units!

Train the model for ~1,000 steps. (Later come back to this and train it for more and check for improvement)

```
In [115]: import tensorflow as tf
          age = tf.feature_column.numeric_column('housingMedianAge')
          rooms = tf.feature_column.numeric_column('totalRooms')
          bedrooms = tf.feature_column.numeric_column('totalBedrooms')
          pop = tf.feature_column.numeric_column('population')
          households = tf.feature_column.numeric_column('households')
          income = tf.feature_column.numeric_column('medianIncome')
          feat_cols = [ age,rooms,bedrooms,pop,households,income]
          input_func = tf.estimator.inputs.pandas_input_fn(
              x=X_train,y=y_train ,
              batch_size=10,num_epochs=1000,shuffle=True)
          model = tf.estimator.DNNRegressor(hidden_units=[6,6,6],feature_columns=feat_cols)
          # model.train(input_fn=input_func,steps=25000)
```

```
INFO:tensorflow:Using default config.
WARNING:tensorflow:Using temporary folder as model directory: C:\Users\Ripti\AppData\Local\Temp\
INFO:tensorflow:Using config: {'_model_dir': 'C:\\Users\\Ripti\\AppData\\Local\\Temp\\tmpt8ltkpu
```

Create a prediction input function and then use the .predict method off your estimator model to create a list or predictions on your test data.

Calculate the RMSE

```
In [113]: from sklearn.metrics import mean_squared_error
          predict_input_func = tf.estimator.inputs.pandas_input_fn(
                x=X_test,
                batch_size=10,
                num_epochs=1,
                shuffle=False)
          pred_gen = model.predict(predict_input_func)
          predictions = list(pred_gen)

          final_preds = []
          for pred in predictions:
              final_preds.append(pred['predictions'])
          mean_squared_error(y_test,final_preds)**0.5
```

```
INFO:tensorflow:Restoring parameters from C:\Users\Ripti\AppData\Local\Temp\tmpjhqgpype\model.ck
```

```
Out[113]: 96258.035354416352
```

4 Classification Exercise

4.1 THE DATA

Read in the census_data.csv data with pandas

In [118]:
```
import pandas as pd
census = pd.read_csv("census_data.csv")
census.head()
```

Out[118]:
```
   age         workclass   education  education_num       marital_status  \
0   39         State-gov   Bachelors             13        Never-married
1   50  Self-emp-not-inc   Bachelors             13   Married-civ-spouse
2   38           Private     HS-grad              9             Divorced
3   53           Private        11th              7   Married-civ-spouse
4   28           Private   Bachelors             13   Married-civ-spouse

            occupation    relationship    race   gender  capital_gain  \
0         Adm-clerical   Not-in-family   White     Male          2174
1      Exec-managerial         Husband   White     Male             0
2    Handlers-cleaners   Not-in-family   White     Male             0
3    Handlers-cleaners         Husband   Black     Male             0
4       Prof-specialty            Wife   Black   Female             0

   capital_loss  hours_per_week  native_country income_bracket
0             0              40   United-States          <=50K
1             0              13   United-States          <=50K
2             0              40   United-States          <=50K
3             0              40   United-States          <=50K
4             0              40            Cuba          <=50K
```

TensorFlow won't be able to understand strings as labels, you'll need to use pandas .apply() method to apply a custom function that converts them to 0s and 1s. This might be hard if you aren't very familiar with pandas, so feel free to take a peek at the solutions for this part.

Convert the Label column to 0s and 1s instead of strings.

In [119]:
```
census['income_bracket'].unique()
def label_fix(label):
    if label==' <=50K':
        return 0
    else:
        return 1
census['income_bracket'] = census['income_bracket'].apply(label_fix)
```

4.2 Perform a Train Test Split on the Data

Create the Feature Columns for tf.esitmator

Take note of categorical vs continuous values!

Create the tf.feature_columns for the categorical values. Use vocabulary lists or just use hash buckets.

Create the continuous feature_columns for the continuous values using numeric_column
Put all these variables into a single list with the variable name feat_cols
Create Input Function
Batch_size is up to you. But do make sure to shuffle!
Create your model with tf.estimator
Create a LinearClassifier.(If you want to use a DNNClassifier, keep in mind you'll need to create embedded columns out of the cateogrical feature that use strings, check out the previous lecture on this for more info.)
Train your model on the data, for at least 5000 steps.

In [122]:
```
import tensorflow as tf
from sklearn.model_selection import train_test_split
x_data = census.drop('income_bracket',axis=1)
y_labels = census['income_bracket']

X_train, X_test, y_train, y_test = train_test_split(x_data,y_labels,test_size=0.3,rand

# Categorical
gender = tf.feature_column.categorical_column_with_vocabulary_list(
    "gender", ["Female", "Male"])
occupation = tf.feature_column.categorical_column_with_hash_bucket(
    "occupation", hash_bucket_size=1000)
marital_status = tf.feature_column.categorical_column_with_hash_bucket(
    "marital_status", hash_bucket_size=1000)
relationship = tf.feature_column.categorical_column_with_hash_bucket(
    "relationship", hash_bucket_size=1000)
education = tf.feature_column.categorical_column_with_hash_bucket(
    "education", hash_bucket_size=1000)
workclass = tf.feature_column.categorical_column_with_hash_bucket(
    "workclass", hash_bucket_size=1000)
native_country = tf.feature_column.categorical_column_with_hash_bucket(
    "native_country", hash_bucket_size=1000)

# Continuous
age = tf.feature_column.numeric_column("age")
education_num = tf.feature_column.numeric_column("education_num")
capital_gain = tf.feature_column.numeric_column("capital_gain")
capital_loss = tf.feature_column.numeric_column("capital_loss")
hours_per_week = tf.feature_column.numeric_column("hours_per_week")

feat_cols = [gender,occupation,marital_status,relationship,
             education,workclass,native_country,age,
             education_num,capital_gain,capital_loss,hours_per_week]
input_func=tf.estimator.inputs.pandas_input_fn(
    x=X_train,y=y_train,batch_size=100,num_epochs=None,shuffle=True)
model = tf.estimator.LinearClassifier(feature_columns=feat_cols)

# model.train(input_fn=input_func,steps=5000)
```

```
INFO:tensorflow:Using default config.
WARNING:tensorflow:Using temporary folder as model directory: C:\Users\Ripti\AppData\Local\Temp\
INFO:tensorflow:Using config: {'_model_dir': 'C:\\Users\\Ripti\\AppData\\Local\\Temp\\tmpfd82o3_
```

4.3 Evaluation

Create a prediction input function. Remember to only supprt X_test data and keep shuffle=False.

Use model.predict() and pass in your input function. This will produce a generator of predictions, which you can then transform into a list, with list()

Create a list of only the class_ids key values from the prediction list of dictionaries, these are the predictions you will use to compare against the real y_test values.

Import classification_report from sklearn.metrics and then see if you can figure out how to use it to easily get a full report of your model's performance on the test data.

```
In [121]: from sklearn.metrics import classification_report
          pred_fn = tf.estimator.inputs.pandas_input_fn(
              x=X_test,batch_size=len(X_test),shuffle=False)
          predictions = list(model.predict(input_fn=pred_fn))
          final_preds = []
          for pred in predictions:
              final_preds.append(pred['class_ids'][0])
          print(classification_report(y_test,final_preds))
```

```
INFO:tensorflow:Restoring parameters from C:\Users\Ripti\AppData\Local\Temp\tmpfimvx4k1\model.ck
             precision    recall  f1-score   support

          0       0.86      0.92      0.89      7436
          1       0.69      0.53      0.60      2333

avg / total       0.82      0.83      0.82      9769
```