TensorFlow Regression Example

More Realistic. More data points. Batches.

The tf.estimator is for things that are easier. TensorFlow is more for things that need a specific neural network, customized, whatever...

Imports

In [1]:
```
import numpy as np
import pandas as pd

import matplotlib.pyplot as plt
%matplotlib inline

import tensorflow as tf

from sklearn.model_selection import train_test_split

# remember TensorFlow and SciKit-Learn up here
```

Creating Data

One Million Points!

In [2]:
```
x_data = np.linspace(0.0, 10.0, 1000000) # We're not quite ready for a real dataset
```

In [3]:
```
x_data
```

Out[3]:
```
array([0.000000e+00, 1.000001e-05, 2.000002e-05, ..., 9.999980e+00,
       9.999990e+00, 1.000000e+01])
```

Noise

In [4]:
```
# No random seed (?)
noise = np.random.randn(len(x_data))
```

In [5]:
```
noise
```

Out[5]:
```
array([ 1.70159055,  0.25721029,  0.27707293, ..., -1.44869069,
       -0.75445202, -0.23383496])
```

Now, for the data

$y = mx + b + noise$ just to make it more difficult for the model

Jose, seemingly arbitrarily, chooses $b = 5$ and $m = 0.5$ to start

In [6]:
```
y_true = ( 0.5 * x_data ) + 5 + noise
```

Pandas

In [7]:
```
x_df = pd.DataFrame(data=x_data, columns=['X Data'])
```

In [8]:
```
x_df.head()
```

Out[8]:

	X Data
0	0.00000
1	0.00001
2	0.00002
3	0.00003
4	0.00004

In [9]:
```
y_df = pd.DataFrame(data=y_true, columns=['Y'])
```

In [10]:
```
y_df.head()
```

Out[10]:

	Y
0	6.701591
1	5.257215
2	5.277083
3	5.643431
4	6.226580

In [11]:
```
my_data = pd.concat(
         [ x_df, y_df], axis=1)
             # axis=1 keeps it from stacking on like pancakes
```

Copied from the course notes version:

```
my_data = pd.concat(
        [pd.DataFrame(data=x_data,columns=['X Data']),
         pd.DataFrame(data=y_true,columns=['Y'])
    ],
    axis=1
)
```

In [12]:
```
my_data.head()
```

Out[12]:

	X Data	Y
0	0.00000	6.701591
1	0.00001	5.257215
2	0.00002	5.277083
3	0.00003	5.643431
4	0.00004	6.226580

In [13]:
```
# my_data.plot() might crash the kernel
my_sample = my_data.sample(n=250)
```

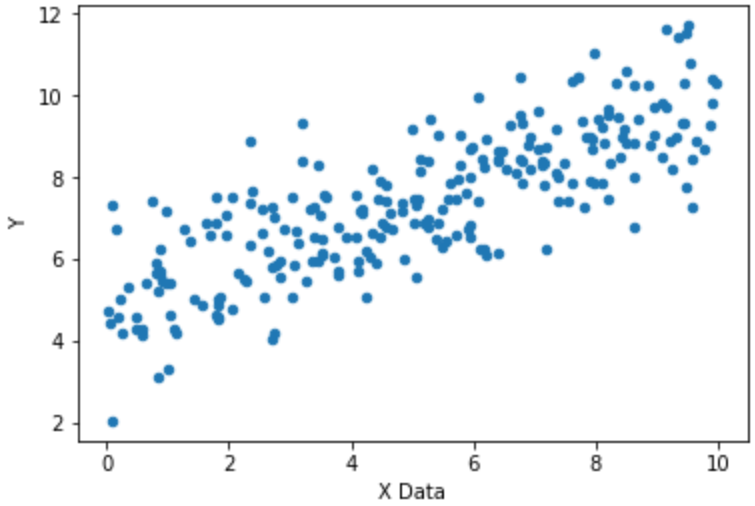
In [14]:
```
my_sample.head()
```

Out[14]:

	X Data	Y
589163	5.891636	7.614337
353099	3.530994	6.483128
319572	3.195723	8.379148
592763	5.927636	8.705950
451280	4.512805	6.901867

In [15]:
```
my_sample.plot(kind='scatter', x = 'X Data', y='Y')
```

Out[15]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x19fcdc201d0>
```



TensorFlow

Batch Size

> We will take the data in batches (1 000 000 points is a lot to pass in at once).

In [16]:
```
# random points to grab, If you had a trillion, probably use smaller batches
batch_size = 8
```

Variables

In [17]:
```
m_pre, b_pre = np.random.randn(2)
```

In [18]:
```
type(m_pre)
```

Out[18]:
```
numpy.float64
```

In [19]:
```
type(b_pre)
```

Out[19]:
```
numpy.float64
```

In [20]:
```
# I didn't follow this, because using 'dtype' instead of 'type' worked
#tf.cast(m_pre, tf.float32)
#tf.cast(b_pre, tf.float32)
```

In [21]:
```
#  DWB, I had to add the type
#+ Jose just used, e.g. 'm = tf.Variable(0.81)'
m = tf.Variable(m_pre, dtype=tf.float32)
b = tf.Variable(b_pre, dtype=tf.float32)

print("Initally: m = " + str(m_pre) + " ; " + "b = " + str(b_pre))
```

```
Initally: m = 0.9219094411077142 ; b = 1.0924033019342743
```

Placeholders

In [22]:
```
x_ph = tf.placeholder(tf.float32, [batch_size])
```

In [23]:
```
y_ph = tf.placeholder(tf.float32, [batch_size])
```

So, I'm getting that placeholders get your data, while variables are what you're trying to predict. I'm not sure that's exactly correct, but it's what I'm getting right now.

Graph

What are we trying to do here? Fit a line to some points. So it's a $y = mx + b$ kind of graph

In [24]:
```
y_model = m * x_ph + b # Had to mess with type to get this to work
```

Loss Function

In [25]:
```
#  Remember that y_value is the true value
#+ Also, we square it to punish the error more,
#+ and thus bring it closer more quickly.
#+ could use '() ** 2' instead of tf.square()

error = tf.reduce_sum(tf.square(y_ph - y_model))
```

Optimizer

In [26]:
```
optimizer = tf.train.GradientDescentOptimizer(learning_rate=0.001)
train = optimizer.minimize(error)
```

Initialize Variables

In [27]:
```
init = tf.global_variables_initializer()
```

Session

In [28]:
```
with tf.Session() as sess:

    sess.run(init)

    batches = 1000

    for i in range(batches):

        rand_index = np.random.randint(len(x_data),
                                       size=batch_size)

        #  DWB: it seems to me we'll only we doing 8000 out
        #+ of the 1e6 points. That will make it go faster, I
        #+ guess.
        #
        #  Jose says we can play around with batches and
        #+ batch_size to see if we have enough data to
        #+ train it well. He seems to suggest that, if we
        #+ were to use more of the training data, we would
        #+ overfit to the training data. Not sure if that
        #+ applies here ... wait, yes it kinda does but not
        #+ in a way that's too concerning - we're taking
        #+ random parts ...

        feed = {x_ph:x_data[rand_index],
                y_ph:y_true[rand_index]}

        sess.run(train, feed_dict=feed)

        #  So, we have it fitting the data with 8 random points
        #+ for each

    ##endof:  for i

    #  Fetch the slope and intercept values (run will go get the
    #+ m and b placeholders)
    model_m, model_b = sess.run([m, b])
```

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

In [29]:
```
model_m # should come out close to our 0.5
```

Out[29]:
```
0.52672875
```

In [30]:
```
model_b #should come out close to our 5
```

Out[30]:
```
4.949375
```

So, we went from whatever our original m and b values were - in my case $m = -1.8$ and $b = 0.5$. The values used for this specific training can be found with the following cell.

In [31]:
```
print("m_init = " + str(m_pre) + " ; " + "b_init = " + str(b_pre))
```

```
m_init = 0.9219094411077142 ; b_init = 1.0924033019342743
```

And we ended up with the `model_m` and `model_b` shown above, which are quite close to the values before noise, m = 0.5, b = 5; Things would look even nicer if we took the error over the value.

In [32]:
```
print("Delta_m = " + str(abs(0.5 - model_m)) + ";\n" + \
      "Delta_b = " + str(abs(5.0 - model_b)))
```

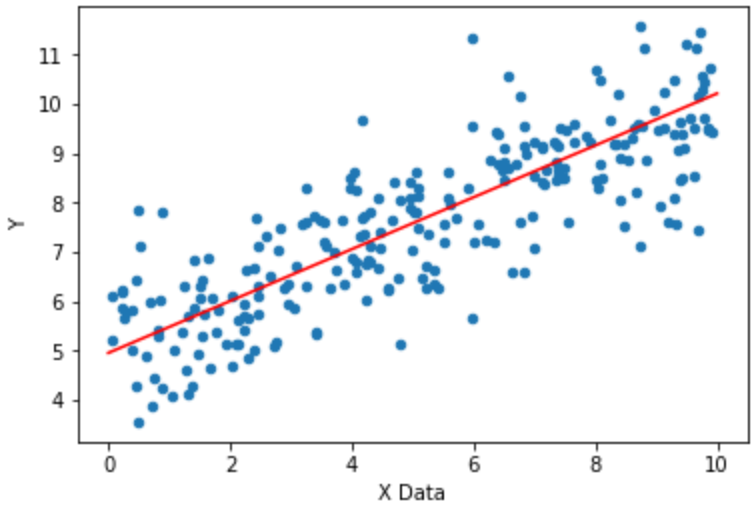
```
Delta_m = 0.02672874927520752;
Delta_b = 0.050624847412109375
```

Results

In [33]:
```
y_hat = x_data * model_m + model_b # rem. y_hat represents the predicted
```

In [34]:
```
my_data.sample(250).plot(kind="scatter",
                         x="X Data", y="Y")
plt.plot(x_data, y_hat, 'r') #  Oh, so I see Pandas is using
                             #+ the matplotlib canvas. Cool!
```

Out[34]: [<matplotlib.lines.Line2D at 0x19fcfa2c780>]



Jose changes the above code for 10k batches, I'm going to have it all re-written, so I can compare better. I will stick it to the anti-Q&R voice by not renaming the variables. Wahahaha!

I though I might have to rename them, then I think I figured that I could get rid of an error that came up by initializing the variables. Nope, had to re-put-in all the code. But I'm not renaming the variables. Wahahaha!

In [35]:
```
#  DWB, I had to add the type
#+ Jose just used, e.g. 'm = tf.Variable(0.81)'
m = tf.Variable(m_pre, dtype=tf.float32)
b = tf.Variable(b_pre, dtype=tf.float32)
print("Initally: m = " + str(m_pre) + " ; " + "b = " + str(b_pre))
x_ph = tf.placeholder(tf.float32, [batch_size])
y_ph = tf.placeholder(tf.float32, [batch_size])
y_model = m * x_ph + b
error = tf.reduce_sum(tf.square(y_ph - y_model))
optimizer = tf.train.GradientDescentOptimizer(learning_rate=0.001)
train = optimizer.minimize(error)
init = tf.global_variables_initializer()
```

```
Initally: m = 0.9219094411077142 ; b = 1.0924033019342743
```

In [36]:
```
with tf.Session() as sess:

    sess.run(init)

    batches = 10000

    for i in range(batches):

        rand_index = np.random.randint(len(x_data),
                                       size=batch_size)

        feed = {x_ph:x_data[rand_index],
                y_ph:y_true[rand_index]}

        sess.run(train, feed_dict=feed)

    ##endof:  for i

    #  Fetch the slope and intercept values (run will go get the
    #+ m and b placeholders)
    model_m, model_b = sess.run([m, b])

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

In [37]:
```
model_m
```

Out[37]:
```
0.51599014
```

In [38]:
```
model_b
```

Out[38]:
```
5.012504
```

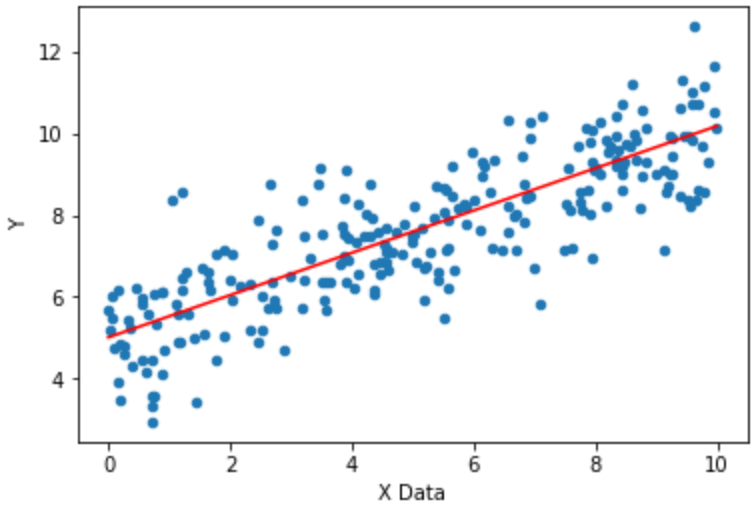
After re-puttting-in the code, I got my answers.

In [39]:
```
print("m_init = " + str(m_pre) + " ; " + "b_init = " + str(b_pre))
print("m_final = " + str(model_m) + " ; " + "b_fin = " + str(model_b))

print("Delta_m = " + str(abs(0.5 - model_m)) + ";\n" + \
      "Delta_b = " + str(abs(5.0 - model_b)))
print()
print("Hmmm ...")
print()
print("Compare to:" + '\n' + \
      "Delta_m = 0.006303846836090088" + '\n' + "and" + \
      '\n' + "Delta_b = 0.055045127868652344" + '\n' +  \
      "for 8000 batches." + \
      '\n\n' + "... interesting ...")
```

```
m_init = 0.9219094411077142 ; b_init = 1.0924033019342743
m_final = 0.51599014 ; b_fin = 5.012504
Delta_m = 0.015990138053894043;
Delta_b = 0.012504100799560547

Hmmm ...

Compare to:
Delta_m = 0.006303846836090088
and
Delta_b = 0.055045127868652344
for 8000 batches.

... interesting ...
```

In [40]:
```
y_hat = x_data * model_m + model_b
my_data.sample(250).plot(kind="scatter",
                         x="X Data", y="Y")
plt.plot(x_data, y_hat, 'r')
```

Out[40]:
```
[<matplotlib.lines.Line2D at 0x19fcfd7e898>]
```



Jose stated that the noise might make it so they might not be so different.

He noted (as I'd been thinking) that we haven't been doing the train/test split. We will with `tf.estimator`

tf.estimator API

> Much simpler API for basic tasks like regression! We'll talk about more abstractions like TF-Slim later on.

Types

```
tf.estimator.LinearClassifier
tf.estimator.LinearRegressor
tf.estimator.DNNClassifier
tf.estimator.DNNRegressor
```

Jose says `DNN` is for Densely-connected Neural Network. I'm not sure that it's not Deep, but I am leaning towards thinking he's right.

Combined-type

```
tf.estimator.DNNLinearCombinedClassifier
tf.estimator.DNNLinearCombinedRegressor
```

Steps

- Define a list of feature columns
- Create the Estimator Model
- Create a Data Input Function
- Call `train`, `evaluate`, and `predict` on the object

We're going to use maybe-not-the-best use case, with just one feature, but it will get us the idea

In [41]:
```
# deeper dive into feature column later
feat_cols = [ tf.feature_column.numeric_column('x', shape=[1]) ]
```

In [42]:
```
estimator = tf.estimator.LinearRegressor(feature_columns=feat_cols)
```

```
INFO:tensorflow:Using default config.
WARNING:tensorflow:Using temporary folder as model directory: C:\Users\Anast\AppData\Local\Temp\tmp4lev76s_
INFO:tensorflow:Using config: {'_save_checkpoints_steps': None, '_keep_checkpoint_every_n_hours': 10000, '_cl
uster_spec': <tensorflow.python.training.server_lib.ClusterSpec object at 0x0000019FCFE10518>, '_num_worker_r
eplicas': 1, '_global_id_in_cluster': 0, '_master': '', '_evaluation_master': '', '_num_ps_replicas': 0, '_ta
sk_id': 0, '_task_type': 'worker', '_save_summary_steps': 100, '_keep_checkpoint_max': 5, '_device_fn': None,
'_is_chief': True, '_train_distribute': None, '_save_checkpoints_secs': 600, '_service': None, '_model_dir':
'C:\\Users\\Anast\\AppData\\Local\\Temp\\tmp4lev76s_', '_tf_random_seed': None, '_log_step_count_steps': 100,
'_session_config': None}
```

Note the output

```
INFO:tensorflow:Using default config.
WARNING:tensorflow:Using temporary folder as model directory: C:\Users\Anast\AppData\Local\Temp\tmpn9_bnvpm
INFO:tensorflow:Using config: {'_session_config': None, '_device_fn': None, '_keep_checkpoint_max': 5, '_cluster_s
pec': <tensorflow.python.training.server_lib.ClusterSpec object at 0x000002E2998E5128>, '_task_type': 'worker', '_
global_id_in_cluster': 0, '_num_worker_replicas': 1, '_log_step_count_steps': 100, '_is_chief': True, '_train_dist
ribute': None, '_save_checkpoints_secs': 600, '_task_id': 0, '_service': None, '_save_summary_steps': 100, '_keep_
checkpoint_every_n_hours': 10000, '_num_ps_replicas': 0, '_master': '', '_tf_random_seed': None, '_evaluation_mast
er': '', '_save_checkpoints_steps': None, '_model_dir': 'C:\\Users\\Anast\\AppData\\Local\\Temp\\tmpn9_bnvpm'}
```

with probably a different string at the end of the path each time.

Train Test Split

> We haven't actually performed a train test split yet! So let's do that on our data now and perform a more realistic version of a Regression Task

In [43]:
```
# type 'train_test_split', then do [Shift] + [Tab] to get the line
x_train, x_eval, y_train, y_eval = \
                train_test_split(x_data, y_true,
                                 test_size=0.3,
                                 random_state=101) # match Jose
```

In [44]:
```
print("x_train.shape = " + str(x_train.shape))
print("y_train.shape = " + str(y_train.shape))
print()
print("x_eval.shape = " + str(x_eval.shape))
print("y_eval.shape = " + str(y_eval.shape))
```

```
x_train.shape = (700000,)
y_train.shape = (700000,)

x_eval.shape = (300000,)
y_eval.shape = (300000,)
```

Set up Estimator Inputs

> ... input_function that kind of serves like your feed dictionary and your batch size indicator ...

Jose

In [45]:
```
# Can also do .pandas_input_fn if you're coming from a Pandas dataframe
input_func = \
    tf.estimator.inputs.numpy_input_fn({'x':x_train},
                                       y_train,
                                       batch_size=4,
                                       num_epochs=None,
                                       shuffle=True
    )
```

In [46]:
```
train_input_func = \
    tf.estimator.inputs.numpy_input_fn({'x':x_train},
                                       y_train,
                                       batch_size=4,
                                       num_epochs=1000,
                                       shuffle=False
    )
#  Why shuffle is False?
#+ Jose says, "And I also wanna set shuffle equal to false.
#+            "Okay, there we go.
#+            "And the reason I have a shuffle equals false
#+            "here for this
#+            "train is because I'm gonna be using this
#+            "train input
#+            "function for evaluation against a test input
#+            "function."
#+ DWB:  The one just below, eval_input_function, which also
#+ DWB: has shuffle=False
#+ DWB:  Not sure I understand this, but let's go with it.
```

In [47]:
```
eval_input_func = \
    tf.estimator.inputs.numpy_input_fn({'x':x_eval},
                                       y_eval,
                                       batch_size=4,
                                       num_epochs=1000,
                                       shuffle=False
    )
```

Train the Estimator

In [48]:
```
estimator.train(input_fn=input_func, steps=1000)
    #  We do  steps=1000 , since we didn't specify training
    #+ epochs for our  input_func .
```

```
INFO:tensorflow:Calling model_fn.
INFO:tensorflow:Done calling model_fn.
INFO:tensorflow:Create CheckpointSaverHook.
INFO:tensorflow:Graph was finalized.
INFO:tensorflow:Running local_init_op.
INFO:tensorflow:Done running local_init_op.
INFO:tensorflow:Saving checkpoints for 0 into C:\Users\Anast\AppData\Local\Temp\tmp4lev76s_\model.ckpt.
INFO:tensorflow:loss = 277.04425, step = 1
INFO:tensorflow:global_step/sec: 1040.02
INFO:tensorflow:loss = 18.916502, step = 101 (0.098 sec)
INFO:tensorflow:global_step/sec: 1348.1
INFO:tensorflow:loss = 24.089243, step = 201 (0.075 sec)
INFO:tensorflow:global_step/sec: 1264.96
INFO:tensorflow:loss = 4.8022146, step = 301 (0.077 sec)
INFO:tensorflow:global_step/sec: 1205.42
INFO:tensorflow:loss = 7.419866, step = 401 (0.084 sec)
INFO:tensorflow:global_step/sec: 1540.21
INFO:tensorflow:loss = 4.0433393, step = 501 (0.064 sec)
INFO:tensorflow:global_step/sec: 1423.04
INFO:tensorflow:loss = 3.2885437, step = 601 (0.070 sec)
INFO:tensorflow:global_step/sec: 1356.6
INFO:tensorflow:loss = 2.6762466, step = 701 (0.075 sec)
INFO:tensorflow:global_step/sec: 1384.59
INFO:tensorflow:loss = 4.750156, step = 801 (0.071 sec)
INFO:tensorflow:global_step/sec: 1321.63
INFO:tensorflow:loss = 0.96655273, step = 901 (0.077 sec)
INFO:tensorflow:Saving checkpoints for 1000 into C:\Users\Anast\AppData\Local\Temp\tmp4lev76s_\model.ckpt.
INFO:tensorflow:Loss for final step: 1.3566413.
```

Out[48]:
```
<tensorflow.python.estimator.canned.linear.LinearRegressor at 0x19fcfdd4c88>
```

Evaluation

In [49]:
```
train_metrics = estimator.evaluate(input_fn=train_input_func,
                                   steps=1000
)
```

```
INFO:tensorflow:Calling model_fn.
INFO:tensorflow:Done calling model_fn.
INFO:tensorflow:Starting evaluation at 2024-01-07-00:39:12
INFO:tensorflow:Graph was finalized.
INFO:tensorflow:Restoring parameters from C:\Users\Anast\AppData\Local\Temp\tmp4lev76s_\model.ckpt-1000
INFO:tensorflow:Running local_init_op.
INFO:tensorflow:Done running local_init_op.
INFO:tensorflow:Evaluation [100/1000]
INFO:tensorflow:Evaluation [200/1000]
INFO:tensorflow:Evaluation [300/1000]
INFO:tensorflow:Evaluation [400/1000]
INFO:tensorflow:Evaluation [500/1000]
INFO:tensorflow:Evaluation [600/1000]
INFO:tensorflow:Evaluation [700/1000]
INFO:tensorflow:Evaluation [800/1000]
INFO:tensorflow:Evaluation [900/1000]
INFO:tensorflow:Evaluation [1000/1000]
INFO:tensorflow:Finished evaluation at 2024-01-07-00:39:14
INFO:tensorflow:Saving dict for global step 1000: average_loss = 1.1106646, global_step = 1000, label/mean =
7.5024686, loss = 4.4426584, prediction/mean = 7.4529824
INFO:tensorflow:Saving 'checkpoint_path' summary for global step 1000: C:\Users\Anast\AppData\Local\Temp\tmp4
lev76s_\model.ckpt-1000
```

In [50]:
```
eval_metrics = estimator.evaluate(input_fn=eval_input_func,
                                  steps=1000
)
```

```
INFO:tensorflow:Calling model_fn.
INFO:tensorflow:Done calling model_fn.
INFO:tensorflow:Starting evaluation at 2024-01-07-00:39:15
INFO:tensorflow:Graph was finalized.
INFO:tensorflow:Restoring parameters from C:\Users\Anast\AppData\Local\Temp\tmp4lev76s_\model.ckpt-1000
INFO:tensorflow:Running local_init_op.
INFO:tensorflow:Done running local_init_op.
INFO:tensorflow:Evaluation [100/1000]
INFO:tensorflow:Evaluation [200/1000]
INFO:tensorflow:Evaluation [300/1000]
INFO:tensorflow:Evaluation [400/1000]
INFO:tensorflow:Evaluation [500/1000]
INFO:tensorflow:Evaluation [600/1000]
INFO:tensorflow:Evaluation [700/1000]
INFO:tensorflow:Evaluation [800/1000]
INFO:tensorflow:Evaluation [900/1000]
INFO:tensorflow:Evaluation [1000/1000]
INFO:tensorflow:Finished evaluation at 2024-01-07-00:39:16
INFO:tensorflow:Saving dict for global step 1000: average_loss = 1.1305045, global_step = 1000, label/mean =
7.492202, loss = 4.522018, prediction/mean = 7.411673
INFO:tensorflow:Saving 'checkpoint_path' summary for global step 1000: C:\Users\Anast\AppData\Local\Temp\tmp4
lev76s_\model.ckpt-1000
```

In [52]:
```
print("train metrics: {}".format(train_metrics)) # Python 3.5 allows this form
print("eval metrics : {}".format(eval_metrics))
print("The loss is pretty close for both, which " + \
      "\nis a good sign that we're not overfitting")
```

```
train metrics: {'prediction/mean': 7.4529824, 'global_step': 1000, 'label/mean': 7.5024686, 'average_loss':
1.1106646, 'loss': 4.4426584}
eval metrics : {'prediction/mean': 7.411673, 'global_step': 1000, 'label/mean': 7.492202, 'average_loss': 1.1
305045, 'loss': 4.522018}
The loss is pretty close for both, which
is a good sign that we're not overfitting
```

Predictions

In [55]:
```
brand_new_data = np.linspace(0, 10, 10)
input_fn_predict = \
    tf.estimator.inputs.numpy_input_fn({'x':brand_new_data},
                                       shuffle=False
    )
```

In [56]:
```
estimator.predict(input_fn=input_fn_predict)
```

Out[56]:
```
<generator object Estimator.predict at 0x0000019FCFEA3AF0>
```

In [57]:
```
# Easy to see the output of the generator by casting it as a list
list(estimator.predict(input_fn=input_fn_predict))
```

```
INFO:tensorflow:Calling model_fn.
INFO:tensorflow:Done calling model_fn.
INFO:tensorflow:Graph was finalized.
INFO:tensorflow:Restoring parameters from C:\Users\Anast\AppData\Local\Temp\tmp4lev76s_\model.ckpt-1000
INFO:tensorflow:Running local_init_op.
INFO:tensorflow:Done running local_init_op.
```

Out[57]:
```
[{'predictions': array([4.2708926], dtype=float32)},
 {'predictions': array([4.9738164], dtype=float32)},
 {'predictions': array([5.6767406], dtype=float32)},
 {'predictions': array([6.3796644], dtype=float32)},
 {'predictions': array([7.082588], dtype=float32)},
 {'predictions': array([7.785512], dtype=float32)},
 {'predictions': array([8.488436], dtype=float32)},
 {'predictions': array([9.1913595], dtype=float32)},
 {'predictions': array([9.894283], dtype=float32)},
 {'predictions': array([10.597208], dtype=float32)}]
```

In [59]:
```
# Repeat, for size
my_list = list(estimator.predict(input_fn=input_fn_predict))
print("\nThere are " + str(len(my_list)) + " entries," + \
      "\nas we expect (as long as there are 10 entries).")
```

```
INFO:tensorflow:Calling model_fn.
INFO:tensorflow:Done calling model_fn.
INFO:tensorflow:Graph was finalized.
INFO:tensorflow:Restoring parameters from C:\Users\Anast\AppData\Local\Temp\tmp4lev76s_\model.ckpt-1000
INFO:tensorflow:Running local_init_op.
INFO:tensorflow:Done running local_init_op.

There are 10 entries,
as we expect (as long as there are 10 entries).
```

In [60]:
```
predictions = [] #could also use  np.array[]
for x in estimator.predict(input_fn=input_fn_predict):
    predictions.append(x['predictions'])
```

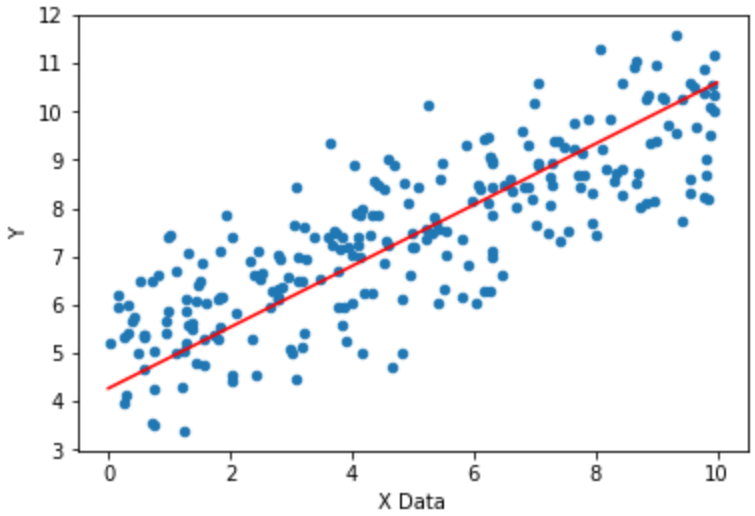
```
INFO:tensorflow:Calling model_fn.
INFO:tensorflow:Done calling model_fn.
INFO:tensorflow:Graph was finalized.
INFO:tensorflow:Restoring parameters from C:\Users\Anast\AppData\Local\Temp\tmp4lev76s_\model.ckpt-1000
INFO:tensorflow:Running local_init_op.
INFO:tensorflow:Done running local_init_op.
```

In [61]:
```
predictions # how did we do?
```

Out[61]:
```
[array([4.2708926], dtype=float32),
 array([4.9738164], dtype=float32),
 array([5.6767406], dtype=float32),
 array([6.3796644], dtype=float32),
 array([7.082588], dtype=float32),
 array([7.785512], dtype=float32),
 array([8.488436], dtype=float32),
 array([9.1913595], dtype=float32),
 array([9.894283], dtype=float32),
 array([10.597208], dtype=float32)]
```

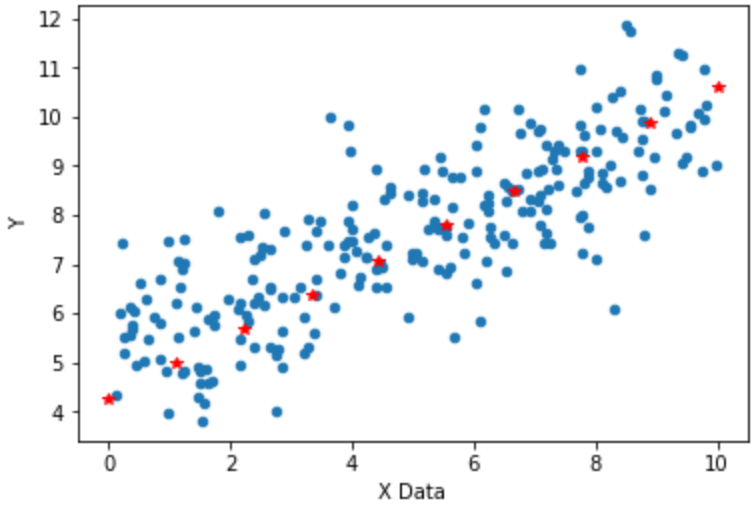
In [64]:
```
my_data.sample(n=250).plot(kind='scatter',
                           x='X Data', y='Y')
plt.plot(brand_new_data, predictions, 'r')
```

Out[64]:
```
[<matplotlib.lines.Line2D at 0x19fd02f5c50>]
```



In [65]:
```
my_data.sample(n=250).plot(kind='scatter',
                           x='X Data', y='Y')
plt.plot(brand_new_data, predictions, 'r*')
```

Out[65]:
```
[<matplotlib.lines.Line2D at 0x19fd10c7ac8>]
```



Jose usually says

Great Job!

around here, which I think is cool.

That's all for now!