**DEEP LEARNING**

**Project-6**

**Question:**

* Follow Chapter 9 of Geron’s code, run either linear regression on the housing data, or logistic regression with the moons data (Exercise 12 of the chapter), with gradient descent with two options: manually computing the gradients and using autodiff.
* Use tf.get\_default\_graph() and tf.Graph.get\_operations() to see the similarity and difference between the graphs generated with and without autodiff. How many nodes are there in these graphs? Draw these graphs with all the nodes and edges.
* Submit a screenshot of your construction and execution of the graphs and also the drawings of the graphs.

**Answer:**

Linear regression was run on the California housing data dataset using gradient descent. Two methods were used:

**1. Manual computation of gradients**

**2. Automatic Differentiating (Autodiff)**

GraphsObtained:

1. Manual computation

There was a total of 37 nodes in the graph.

2. Automatic Differentiation

There was a total of 55 nodes in the graph

**Manual Code**:

# Manual method for gradient descent

import numpy as np

from sklearn.datasets import fetch\_california\_housing

import tensorflow as tf

housing = fetch\_california\_housing()

m,n = housing.data.shape

housing\_data\_plus\_bias = np.c\_[np.ones((m,1)),housing.data]

X = tf.constant(housing\_data\_plus\_bias, dtype=tf.float32, name="X")

y = tf.constant(housing.target.reshape(-1,1), dtype=tf.float32, name="y")

XT = tf.transpose(X)

theta = tf.matmul(tf.matmul(tf.matrix\_inverse(tf.matmul(XT,X)),XT),y)

with tf.Session() as sess:

print(theta.eval())

theta = tf.Variable(tf.random\_uniform([n+1,1],-1.0,1.0),name="theta")

y\_pred = tf.matmul(X,theta,name="predictions")

error = y\_pred - y

mse = tf.reduce\_mean(tf.square(error),name = "mse")

gradients = 2/m\*tf.matmul(XT, error)

learning\_rate = 0.01

training\_op = tf.assign(theta, theta - learning\_rate\* gradients)

init = tf.global\_variables\_initializer()

graph = tf.get\_default\_graph()

operations = graph.get\_operations()

with tf.Session() as sess:

sess.run(init)

writer = tf.summary.FileWriter('logs', graph)

writer.close()

graph = tf.get\_default\_graph()

operations = graph.get\_operations()

print(len(operations))

**Console Output**:

[<tf.Operation 'X' type=Const>, <tf.Operation 'y' type=Const>, <tf.Operation 'transpose/Rank' type=Rank>, <tf.Operation 'transpose/sub/y' type=Const>, <tf.Operation 'transpose/sub' type=Sub>, <tf.Operation 'transpose/Range/start' type=Const>, <tf.Operation 'transpose/Range/delta' type=Const>, <tf.Operation 'transpose/Range' type=Range>, <tf.Operation 'transpose/sub\_1' type=Sub>, <tf.Operation 'transpose' type=Transpose>, <tf.Operation 'MatMul' type=MatMul>, <tf.Operation 'MatrixInverse' type=MatrixInverse>, <tf.Operation 'MatMul\_1' type=MatMul>, <tf.Operation 'MatMul\_2' type=MatMul>, <tf.Operation 'random\_uniform/shape' type=Const>, <tf.Operation 'random\_uniform/min' type=Const>, <tf.Operation 'random\_uniform/max' type=Const>, <tf.Operation 'random\_uniform/RandomUniform' type=RandomUniform>, <tf.Operation 'random\_uniform/sub' type=Sub>, <tf.Operation 'random\_uniform/mul' type=Mul>, <tf.Operation 'random\_uniform' type=Add>, <tf.Operation 'theta' type=VariableV2>, <tf.Operation 'theta/Assign' type=Assign>, <tf.Operation 'theta/read' type=Identity>, <tf.Operation 'predictions' type=MatMul>, <tf.Operation 'sub' type=Sub>, <tf.Operation 'Square' type=Square>, <tf.Operation 'Const' type=Const>, <tf.Operation 'mse' type=Mean>, <tf.Operation 'MatMul\_3' type=MatMul>, <tf.Operation 'mul/x' type=Const>, <tf.Operation 'mul' type=Mul>, <tf.Operation 'mul\_1/x' type=Const>, <tf.Operation 'mul\_1' type=Mul>, <tf.Operation 'sub\_1' type=Sub>, <tf.Operation 'Assign' type=Assign>, <tf.Operation 'init' type=NoOp>]

37 Number of Nodes

**Code:**

**Automatic Differentiating**

# Automatic differentiating

import numpy as np

from sklearn.datasets import fetch\_california\_housing

import tensorflow as tf

from sklearn.preprocessing import StandardScaler

scaler = StandardScaler()

housing = fetch\_california\_housing()

m,n = housing.data.shape

scaled\_housing\_data = scaler.fit\_transform(housing.data)

scaled\_housing\_data\_plus\_bias = np.c\_[np.ones((m, 1)), scaled\_housing\_data]

X = tf.constant(scaled\_housing\_data\_plus\_bias, dtype=tf.float32, name="X")

y = tf.constant(housing.target.reshape(-1, 1), dtype=tf.float32, name="y")

theta = tf.Variable(tf.random\_uniform([n + 1, 1], -1.0, 1.0, seed=42), name="theta")

y\_pred = tf.matmul(X,theta,name="predictions")

error = y\_pred - y

mse = tf.reduce\_mean(tf.square(error),name = "mse")

gradients = 2/m\*tf.matmul(tf.transpose(X), error)

learning\_rate = 0.01

training\_op = tf.assign(theta, theta - learning\_rate\* gradients)

init = tf.global\_variables\_initializer()

gradients = tf.gradients(mse, [theta])[0]

with tf.Session() as sess:

sess.run(init)

# writer = tf.summary.FileWriter('logs', graph)

print(mse.eval())

sess.run(training\_op)

print(mse.eval())

sess.run(training\_op)

graph = tf.get\_default\_graph()

writer = tf.summary.FileWriter('logs', graph)

writer.close()

# graph = tf.get\_default\_graph()

operations = graph.get\_operations()

print(len(operations))

**Ouput:**

2.7544272

2.6659484

[<tf.Operation 'X' type=Const>, <tf.Operation 'y' type=Const>, <tf.Operation 'random\_uniform/shape' type=Const>, <tf.Operation 'random\_uniform/min' type=Const>, <tf.Operation 'random\_uniform/max' type=Const>, <tf.Operation 'random\_uniform/RandomUniform' type=RandomUniform>, <tf.Operation 'random\_uniform/sub' type=Sub>, <tf.Operation 'random\_uniform/mul' type=Mul>, <tf.Operation 'random\_uniform' type=Add>, <tf.Operation 'theta' type=VariableV2>, <tf.Operation 'theta/Assign' type=Assign>, <tf.Operation 'theta/read' type=Identity>, <tf.Operation 'predictions' type=MatMul>, <tf.Operation 'sub' type=Sub>, <tf.Operation 'Square' type=Square>, <tf.Operation 'Const' type=Const>, <tf.Operation 'mse' type=Mean>, <tf.Operation 'transpose/Rank' type=Rank>, <tf.Operation 'transpose/sub/y' type=Const>, <tf.Operation 'transpose/sub' type=Sub>, <tf.Operation 'transpose/Range/start' type=Const>, <tf.Operation 'transpose/Range/delta' type=Const>, <tf.Operation 'transpose/Range' type=Range>, <tf.Operation 'transpose/sub\_1' type=Sub>, <tf.Operation 'transpose' type=Transpose>, <tf.Operation 'MatMul' type=MatMul>, <tf.Operation 'mul/x' type=Const>, <tf.Operation 'mul' type=Mul>, <tf.Operation 'mul\_1/x' type=Const>, <tf.Operation 'mul\_1' type=Mul>, <tf.Operation 'sub\_1' type=Sub>, <tf.Operation 'Assign' type=Assign>, <tf.Operation 'init' type=NoOp>, <tf.Operation 'gradients/Shape' type=Const>, <tf.Operation 'gradients/grad\_ys\_0' type=Const>, <tf.Operation 'gradients/Fill' type=Fill>, <tf.Operation 'gradients/mse\_grad/Reshape/shape' type=Const>, <tf.Operation 'gradients/mse\_grad/Reshape' type=Reshape>, <tf.Operation 'gradients/mse\_grad/Tile/multiples' type=Const>, <tf.Operation 'gradients/mse\_grad/Tile' type=Tile>, <tf.Operation 'gradients/mse\_grad/Const' type=Const>, <tf.Operation 'gradients/mse\_grad/truediv' type=RealDiv>, <tf.Operation 'gradients/Square\_grad/mul/x' type=Const>, <tf.Operation 'gradients/Square\_grad/mul' type=Mul>, <tf.Operation 'gradients/Square\_grad/mul\_1' type=Mul>, <tf.Operation 'gradients/sub\_grad/Shape' type=Const>, <tf.Operation 'gradients/sub\_grad/Shape\_1' type=Const>, <tf.Operation 'gradients/sub\_grad/BroadcastGradientArgs' type=BroadcastGradientArgs>, <tf.Operation 'gradients/sub\_grad/Sum' type=Sum>, <tf.Operation 'gradients/sub\_grad/Reshape' type=Reshape>, <tf.Operation 'gradients/sub\_grad/Sum\_1' type=Sum>, <tf.Operation 'gradients/sub\_grad/Neg' type=Neg>, <tf.Operation 'gradients/sub\_grad/Reshape\_1' type=Reshape>, <tf.Operation 'gradients/predictions\_grad/MatMul' type=MatMul>, <tf.Operation 'gradients/predictions\_grad/MatMul\_1' type=MatMul>]

**55 Number of Nodes**

**Another Approach of coding:**

**CODE:**

%matplotlib inline

import numpy as np

import tensorflow as tf

from sklearn.datasets import fetch\_california\_housing

housing = fetch\_california\_housing()

m, n = housing.data.shape

housing\_data\_plus\_bias = np.c\_[np.ones((m, 1)), housing.data]

from sklearn.preprocessing import StandardScaler

scaler = StandardScaler()

scaled\_housing\_data = scaler.fit\_transform(housing.data)

scaled\_housing\_data\_plus\_bias = np.c\_[np.ones((m, 1)), scaled\_housing\_data]

X = tf.constant(housing\_data\_plus\_bias, dtype=tf.float32, name="X")

y = tf.constant(housing.target.reshape(-1, 1), dtype=tf.float32, name="y")

XT = tf.transpose(X)

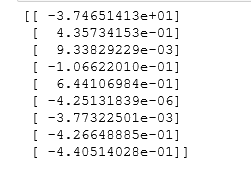
theta = tf.matmul(tf.matmul(tf.matrix\_inverse(tf.matmul(XT, X)), XT), y)

with tf.Session() as sess:

theta\_value = theta.eval()

print(theta.eval())

**OUTPUT:**



**CODE:**

theta = tf.Variable(tf.random\_uniform([n + 1, 1], -1.0, 1.0), name="theta")

y\_pred = tf.matmul(X, theta, name="predictions")

error = y\_pred - y

mse = tf.reduce\_mean(tf.square(error), name="mse")

gradients = 2/m \* tf.matmul(tf.transpose(X), error)

learning\_rate=0.01

training\_op = tf.assign(theta, theta - learning\_rate \* gradients)

init = tf.global\_variables\_initializer()

n\_epochs=1000

graph=tf.get\_default\_graph()

operations=graph.get\_operations()

operations

**OUTPUT:**

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**CODE:**

gradients = tf.gradients(mse, [theta])[0]

with tf.Session() as sess:

sess.run(init)

print(mse.eval())

sess.run(training\_op)

print(mse.eval())

sess.run(training\_op)

**OUTPUT:**

183062.0

7.93176e+14

**CODE:**

graph=tf.get\_default\_graph()

operations=graph.get\_operations()

operations

**OUTPUT:**

[<tf.Operation 'X' type=Const>,

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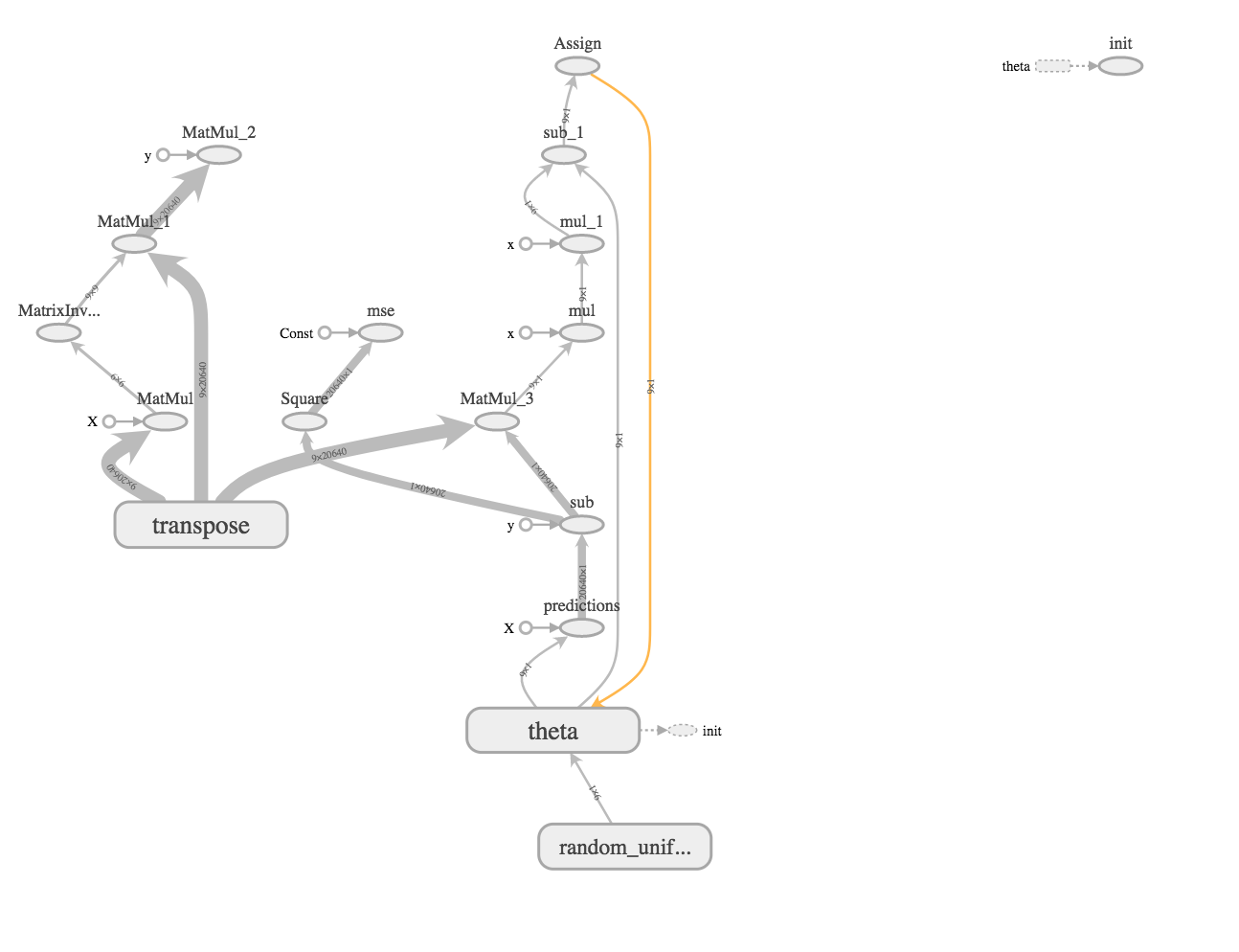
**CODE:**

tf.summary.FileWriter("logs", graph).close()

* Graphs are generated using the following command:

**tensorboard --logdir=logs**

**Without Autodiff:**



**With Autodiff:**

