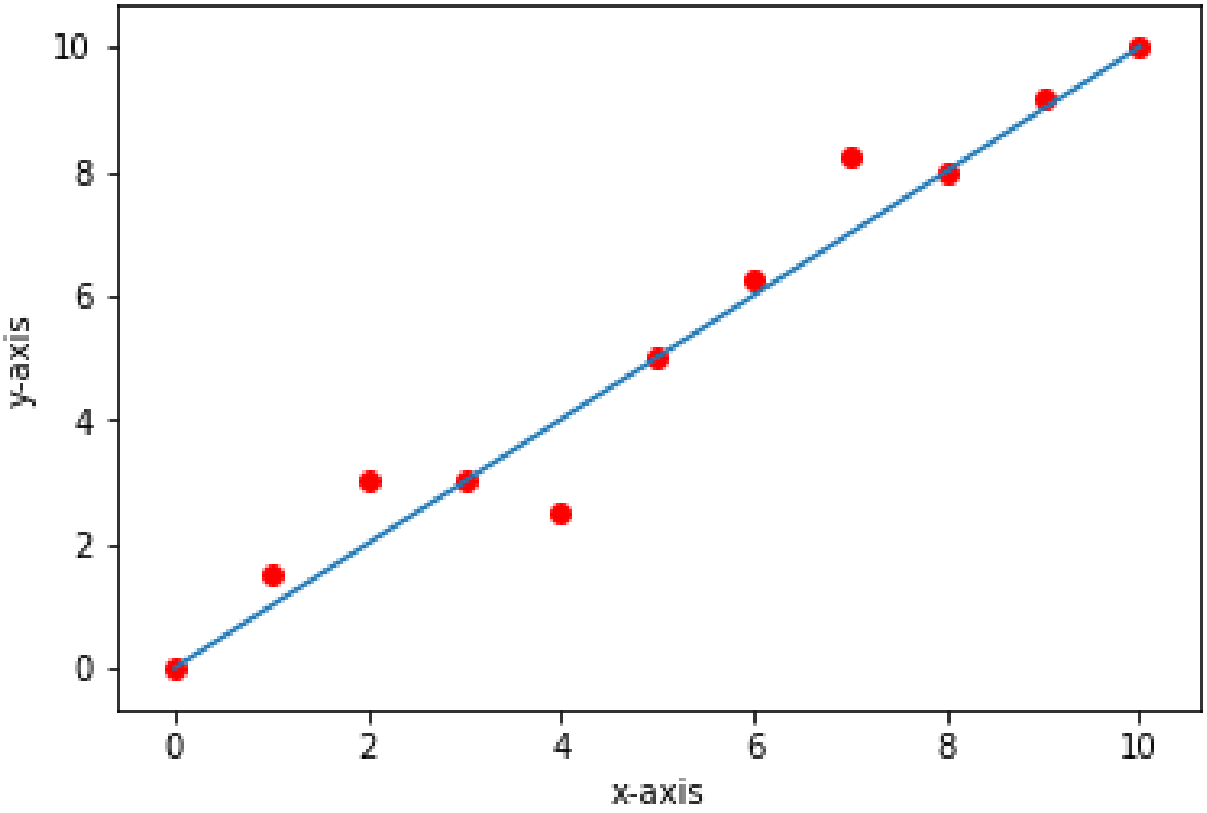
Linear Regression using Tensorflow



The Theory

Linear Regression is the process of fitting a line to the dataset.

Single Variable Linear Regression

The Mathematics

The equation of Line is

$$y = m * x + c$$

Where,

y = dependent variable

X = independent variable

C = intercept

The algorithm is trying to fit a line to the data by adjusting the values of m and c. Its Objective is to attain to a value of m such that for any given value of x it would be properly predicting the value of y.

There are various ways in which we can attain the values of m and c

1. Statistical approach
2. Iterative approach

Here we are using a scikit learn framework which internally uses iterative approach to attain the linear regression

The Dataset

Dataset consists of two columns namely X and y

Where

For List Price Vs. Best Price for a New GMC Pickup dataset

X = List price (in $1000) for a GMC pickup truck

Y = Best price (in $1000) for a GMC pickup truck

The data is taken from *Consumer's Digest.*

For Fire and Theft in Chicago

X = fires per 100 housing units

Y = thefts per 1000 population within the same Zip code in the Chicago metro area

The data is taken from U.S Commission of Civil Rights.

For Auto Insurance in Sweden dataset

X = number of claims

Y = total payment for all the claims in thousands of Swedish Kronor

The data is taken from Swedish Committee on Analysis of Risk Premium in Motor Insurance.

For Gray Kangaroos dataset

X = nasal length (mm ¥10)

Y = nasal width (mm ¥ 10)
for a male gray kangaroo from a random sample of such animals

The data is taken from Australian *Journal of Zoology*, Vol. 28, p607-613.

Link to All Datasets

The Code

The Code was written in three phases

1. Data preprocessing phase
2. Training
3. Prediction and plotting

Data Preprocessing Phase

Imports

Numpy import for array processing, python doesn't have built in array support. The feature of working with native arrays can be used in python with the help of numpy library.

Pandas is a library of python used for working with tables, on importing the data, mostly data will be of table format, for ease manipulation of tables pandas library is imported

Matplotlib is a library of python used to plot graphs, for the purpose of visualizing the results we would be plotting the results with the help of matplotlib library.

Tensorflow import since we are going to use tensorflow framework for building model.

```
# Imports
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
```

```
import tensorflow as tf
```

Reading the dataset from data

In this line of code using the read_excel method of pandas library, the dataset has been imported from data folder and stored in dataset variable.

On visualizing the dataset, it contains of two columns X and Y where X is dependent variable and Y is Independent Variable.

Note : On using Grey Kangaroos dataset,the data is normalised, standardised,having a lot of inbuilt variance and outliers the code would result in a gradient exploding problem.

```
# Reading the dataset from data
dataset = pd.read_csv(r'..\\data\\auto_insurance.csv')
```

On viewing the dataset, it contains of two columns X and Y where X is dependent variable and Y is Independent Variable.

```
In [6]: dataset.head()
Out[6]:
     X      Y
0  108  392.5
1   19   46.2
2   13   15.7
3  124  422.2
4   40  119.4
```

Creating Dependent and Independent variables

The X Column from the dataset is extracted into an X variable of type numpy, similarly the y variable

X is an independent variable

Y is dependent variable Inference

```
# Creating Dependent and Independent variables
X = dataset['X'].values
y = dataset['Y'].values
```

```
In [10]: type(dataset['X'])
Out[10]: pandas.core.series.Series

In [11]: type(dataset['X'].values)
Out[11]: numpy.ndarray
```

On input 10 it would result in a pandas Series object

So, values attribute is used to attain an numpy array

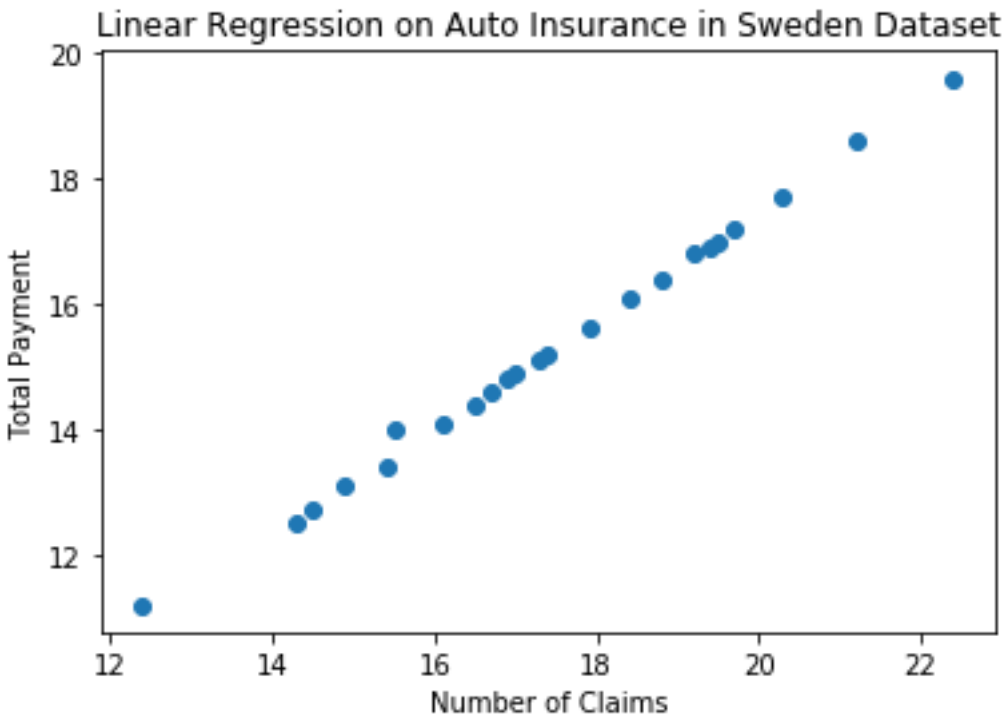
Visualizing the data

The step is to just see how the dataset is

On visualization the data would appear something like this

The X and Y attributes would vary based on dataset.

```
# Visualizing the data
title='Linear Regression on <Dataset>'
x_axis_label = 'X-value < The corresponding attribute of X in dataset >'
y_axis_label = 'y-value < The corresponding attribute of X in dataset >'
plt.scatter(X,y)
plt.title(title)
plt.xlabel(x_axis_label)
plt.ylabel(y_axis_label)
plt.show()
```



Splitting the data into training set and test set

We are splitting the whole dataset into training and test set where training set is used for fitting the line to data and test set is used to check how good the line if for the data.

```
# Splitting the data into training set and test set
X_train,X_test = np.split(X,indices_or_sections = [int(len(X)*0.8)])
y_train,y_test = np.split(y,indices_or_sections = [int(len(X)*0.8)])
```

Reshaping the numpy arrays since the tensorflow model expects 2-D array in further code

In further the tensorflow learning model would be expecting a 2-D array of shape (length,1).

```
# Reshaping the numpy arrays since the tensorflow model expects 2-D array
in further code
X_train = np.reshape(X_train,newshape = (-1,1)).astype('float32')
y_train = np.reshape(y_train,newshape = (-1,1)).astype('float32')
```

```
X_test = np.reshape(X_test,newshape = (-1,1)).astype('float32')
y_test = np.reshape(y_test,newshape = (-1,1)).astype('float32')
```

Training Phase

Variables for training

- Epochs: stands for how many time the whole data is put through on forward propagation and one backward propagation.
- Learning Rate: is a hyperparameter in backpropagation algorithm to adjust the variables in graph based on loss obtained in forward propagation

```
# Variables for training
epochs = 1000
learning_rate = 0.0001
```

Tensors to build the tensor graph

These tensors are created based on the line equation y = m*x + c

- X_tf: placeholder tensor which would hold the values of X train
- m: variable tensor which would hold the value of slope.
- c: variable tensor which would hold the value of intercept
- y_actual = placeholder tensor which would hold the value of ground truth y

```
# Tensors to build the graph
X_tf = tf.placeholder(tf.float32,shape = (None,1),name = 'x_palceholder')
m = tf.Variable(tf.ones([1,1]))
c = tf.Variable(tf.ones(shape=(1,1),dtype=tf.float32),name='intercept')
y_actual = tf.placeholder(tf.float32,shape = (None,1),name =
'y_actual_palceholder')
```

Equation of line in Tensorflow

Creating a graph using line equation

- y_pred: is the resultant graph tensor

```
# Equation of line in Tensorflow
y_pred = tf.add(tf.matmul(X_tf,m),c)
```

Loss Function

Loss is the deviation of predicted value from the ground truth.

The loss is calculated as root mean square formula

$$□_{□□□} = \sqrt{\frac{1}{□}(□_1^2 + □_2^2 + □_3^2 + \cdots + □_□^2)}$$

```
# Loss Function
loss = tf.reduce_mean(tf.square((y_pred - y_actual)))
```

Creating Training step using Gradient Descent Optimizer

- training_step: choosing an optimizer with learning rate and directing it to minimize loss function

```
# Creating Training step using Gradient Descent Optimizer
training_step =
tf.train.GradientDescentOptimizer(learning_rate).minimize(loss)
```

Training

A tensorflow session is created and opened. All the variables are initialized in line 2. The training is run with help of for loop created in line 4 and training_step is run in line 5

- feed_dict: this dictionary feed the input values to the placeholder tensors in graph

```
# Training
with tf.Session() as sess:
    init = tf.global_variables_initializer()
    sess.run(init)
    for i in range(epochs):
        sess.run(training_step,feed_dict= {X_tf:X_train,y_actual:y_train})
```

Prediction Phase

Predicting the Results (the tensorflow session is still active)

By having the values of slope and intercept tensors of linear regression model we are trying to predict the values of test data. Y_pred variable contains all the predicted y-values of the test x-values.

```
# Predicting the Results (the tensorflow session is still active)
    y_predicted = sess.run(y_pred,feed_dict= {X_tf:X_test})
```

Visualizing the Results

As we have predicted the y-values for a set of x-values we are visualizing the results to check how good did our line fit for our predictions.

The plot shows the red points are the data points are actual values where the blue line is the predictions.

```
# Visualizing the Results
plt.scatter(X_test,y_test,c='red')
plt.plot(X_test,y_predicted,c='green')
plt.title(title)
plt.xlabel(x_axis_label)
plt.ylabel(y_axis_label)
plt.show()
```