파일
업로드 새로고침
드라이브 마운트 해제
..
drive
My Drive
Abroad_Program
Classroom
Colab Notebooks
Fall|2018
Fall|2019
Spring|2018
Spring|2019
Spring|2020
Compiler
Database_System
Information_Security_Theory
Machine_Learning
CAU-MachineLearning
Assignment01
Assignment02
Assignment03
Assignment04
Assignment04.ipy...
assignment_04_a...
data_test.csv
data_train.csv
README.md
PPT
Testing_repo
Multicore_Computing
Network_Application_and_D...
Template.docx
Summer|2018-Purdue
Summer|2019-USC
디스크 76.87 GB 사용 가능

Information

Writer : *Junhyuck Woo*
Std. ID : 20145337
*Assignment*04 : *Linear regression with multiple variables*
Deadline : *Apr* 16, 2020

Library

```
[11] import matplotlib.pyplot as plt; import numpy as np; import csv
```

Data - Train

```
[12] path="/content/drive/My Drive/Spring|2020/Machine_Learning/CAU-MachineLearning/Assignment04/data_train.csv"

     x = []; y = []; z = []; h = [];

     with open(path, newline='') as myfile:
         reader  = csv.reader(myfile, delimiter=',')
         ct = 0
         for i in reader:
             x.append(float(i[0]))
             y.append(float(i[1]))
             z.append(float(i[2]))
             h.append(float(i[3]))
             ct += 1

     x_data = np.array(x)
     y_data = np.array(y)
     z_data = np.array(z)
     h_data = np.array(h)
     m = ct
```

Data - Test

```
[13] path="/content/drive/My Drive/Spring|2020/Machine_Learning/CAU-MachineLearning/Assignment04/data_test.csv"

     x = []; y = []; z = []; h = [];

     with open(path, newline='') as myfile:
         reader  = csv.reader(myfile, delimiter=',')
         ct = 0
         for i in reader:
             x.append(float(i[0]))
             y.append(float(i[1]))
             z.append(float(i[2]))
             h.append(float(i[3]))
             ct += 1

     x_test = np.array(x)
     y_test = np.array(y)
     z_test = np.array(z)
     h_test = np.array(h)
```

Linear Model

$f_\theta(x, y, z) = \theta_0 + \theta_1 x + \theta_1 y + \theta_1 z,$
where $\theta = (\theta_0, \theta_1, \theta_2, \theta_3)$ *and* $\theta_0, \theta_1, \theta_2, \theta_3 \in R$

InitialState
$\theta_0 = 10$
$\theta_1 = 10$
$\theta_2 = 10$
$\theta_3 = 10$

```
[14] theta0 = 10; theta0_old = 0
     theta1 = 10; theta1_old = 0
     theta2 = 10; theta2_old = 0
     theta3 = 10; theta3_old = 0
     theta0_history = [theta0]
     theta1_history = [theta1]
     theta2_history = [theta2]
     theta3_history = [theta3]

     f = theta0 + theta1*x_data + theta2*y_data + theta3*z_data
     f_test = theta0 + theta1*x_test + theta2*y_test + theta3*z_test
```

Objective Function

$J(\theta_0, \theta_1, \theta_2, \theta_3) = \frac{1}{2m} \sum_{i=1}^{m} (f_\theta(x^{(i)}, y^{(i)}, z^{(i)}) - h^{(i)})^2$

```
[15] j = np.sum((f - h_data)**2) / (2*m)
     j_test = np.sum((f_test - h_data)**2) / (2*m)
     j_old = 0
     j_history = [j]
     j_test_history = [j_test]
```

Training Process - Gradient Descent

$\alpha = 0.00002$

$$\theta_0^{(t+1)} := \theta_0^{(t)} - \alpha \frac{1}{m} \sum_{i=1}^{m} (f_\theta(x^{(i)}, y^{(i)}, z^{(i)}) - h^{(i)})$$
$$\theta_1^{(t+1)} := \theta_1^{(t)} - \alpha \frac{1}{m} \sum_{i=1}^{m} (f_\theta(x^{(i)}, y^{(i)}, z^{(i)}) - h^{(i)}) x^{(i)}$$
$$\theta_2^{(t+1)} := \theta_2^{(t)} - \alpha \frac{1}{m} \sum_{i=1}^{m} (f_\theta(x^{(i)}, y^{(i)}, z^{(i)}) - h^{(i)}) y^{(i)}$$
$$\theta_3^{(t+1)} := \theta_3^{(t)} - \alpha \frac{1}{m} \sum_{i=1}^{m} (f_\theta(x^{(i)}, y^{(i)}, z^{(i)}) - h^{(i)}) z^{(i)}$$

```
[16] alpha = 0.00002

     # Check the number of iteration
     iteration = 1

     # Set the two condition because it spent too much time for converge
     while  (iteration < 1048576) or (abs(j - j_old) + abs(theta0 - theta0_old) + abs(theta1 - theta1_old) + abs(theta2 - theta2_old) + abs(theta3 - theta
         # Calculate the theta
         theta0_old = theta0
         theta1_old = theta1
         theta2_old = theta2
         theta3_old = theta3
         theta0 = theta0 - alpha*np.sum(f-h_data)/m
         theta1 = theta1 - alpha*np.sum((f-h_data)*x_data)/m
         theta2 = theta2 - alpha*np.sum((f-h_data)*y_data)/m
         theta3 = theta3 - alpha*np.sum((f-h_data)*z_data)/m

         # Update the j, h
         j_old = j
         f = theta0 + theta1*x_data + theta2*y_data + theta3*z_data
         j = np.sum((f - h_data)**2) / (2*m)

         f_test = theta0 + theta1*x_test + theta2*y_test + theta3*z_test
         j_test = np.sum((f_test - h_test)**2) / (2*m)

         # Record the history of parameter
         theta0_history.append(theta0)
         theta1_history.append(theta1)
         theta2_history.append(theta2)
         theta3_history.append(theta3)
         j_history.append(j)
         j_test_history.append(j_test)

         iteration = iteration +1
```

Check the Convergence

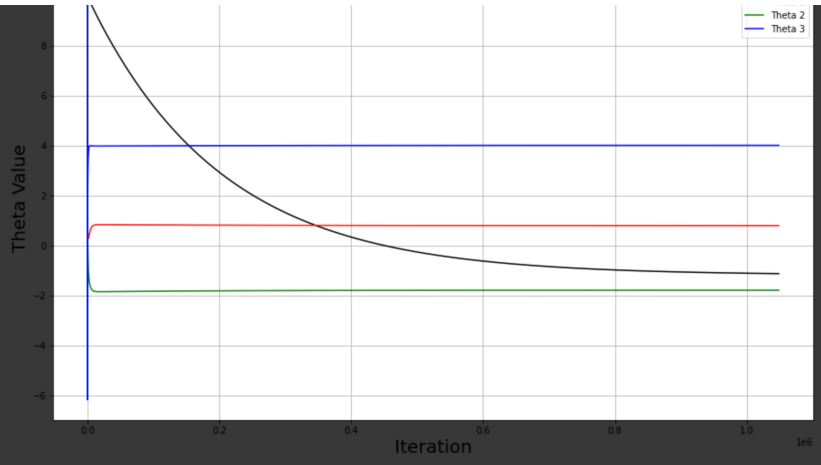
```
[17] # Iteration
     print("# Iteration: " + str(iteration) + '\n')

     # Theta 0
     print("Updated Theta0: "+ str(theta0))
     print("Old Theta0: " + str(theta0_old))
     print("Diff: " + str(theta0 - theta0_old) + '\n')

     # Theta 1
     print("Updated Theta1: "+ str(theta1))
     print("Old Theta1: " + str(theta1_old))
     print("Diff: " + str(theta1 - theta1_old) + '\n')

     # Theta 2
     print("Updated Theta1: "+ str(theta2))
     print("Old Theta1: " + str(theta2_old))
     print("Diff: " + str(theta2 - theta2_old) + '\n')

     # Theta 3
     print("Updated Theta1: "+ str(theta3))
     print("Old Theta1: " + str(theta3_old))
     print("Diff: " + str(theta3 - theta3_old) + '\n')

     # J, Energy Value
     print("Updated J: "+ str(j))
     print("Old J: " + str(j_old))
     print("Diff: " + str(j - j_old) + '\n')
```

```
# Iteration: 1048576

Updated Theta0: -1.1315915325707928
Old Theta0: -1.1315912311904022
Diff: -3.013803906437573e-07

Updated Theta1: 0.7930927395124178
Old Theta1: 0.7930927407011142
Diff: -1.1886964745855266e-09

Updated Theta1: -1.7947307409287647
Old Theta1: -1.7947307427542791
Diff: 1.8255144063061834e-09

Updated Theta1: 4.007792998932928
Old Theta1: 4.007792998058442
Diff: 8.744853730036084e-10

Updated J: 103.45430618097672
Old J: 103.45430618551832
Diff: -4.541604425867263e-09
```

1. Estimated Parameters

```
[18] plt.figure(figsize=(15,9))
     plt.plot(theta0_history, color='black', label='Theta 0')
     plt.plot(theta1_history, color='red', label='Theta 1')
     plt.plot(theta2_history, color='green', label='Theta 2')
     plt.plot(theta3_history, color='blue', label='Theta 3')
     plt.grid()
     plt.legend()
     plt.title('Estimated Parameters', fontsize=40)
     plt.xlabel('Iteration', fontsize=20)
     plt.ylabel('Theta Value', fontsize=20)
```

```
Text(0, 0.5, 'Theta Value')
```



2. Training Error

```
[19] plt.figure(figsize=(15,9))
     plt.plot(j_history, color='blue', label='Training Error')
     plt.grid()
     plt.legend()
     plt.title('Training Error', fontsize=40)
     plt.xlabel('Iteration', fontsize=20)
     plt.ylabel('Error', fontsize=20)
```

```
Text(0, 0.5, 'Error')
```

3. Testing Error

```
plt.figure(figsize=(15,9))
plt.plot(j_test_history, color='red', label='Testing Error')
plt.grid()
plt.legend()
plt.title('Training Error', fontsize=40)
plt.xlabel('Iteration', fontsize=20)
plt.ylabel('Error', fontsize=20)
```

```
Text(0, 0.5, 'Error')
```