# Multiple Linear Regression

Dr. Dongchul Kim

# Multiple LR

We have another example of multivariable data like below.

Three independent variables

| $x_1$ | $x_2$ | $x_3$ | y |
|-------|-------|-------|-------|
| 3.9 | 2.1 | 7.5 | 19.05 |
| 2.1 | 3.2 | 4.5 | 13.25 |
| 4.7 | 4.1 | 7.8 | 22.05 |
| 8.5 | 5.4 | 1.2 | 12.05 |
| 1.9 | 3.4 | 6.2 | 16.75 |
| 6.3 | 4.3 | 7.7 | 22.85 |
| 8.9 | 4.4 | 3.3 | 15.45 |

```python
import numpy as np

data = np.array([[3.9,2.1,7.5,19.05],
                 [2.1,3.2,4.5,13.25],
                 [4.7,4.1,7.8,22.05],
                 [8.5,5.4,1.2,12.05],
                 [1.9,3.4,6.2,16.75],
                 [6.3,4.3,7.7,22.85],
                 [8.9,4.4,3.3,15.45]])
x = data[:, :-1]
y = data[:, -1]

# initialization
w1, w2, w3 = 0, 0, 0
b = 0

# learning rate
alpha = 0.05

# GD
for i in range(10000):
    w1 = w1 - alpha * (1 / len(data)) * sum((x[:, 0]*w1+x[:, 1]*w2+x[:, 2]*w3 + b - y) * x[:, 0])
    w2 = w2 - alpha * (1 / len(data)) * sum((x[:, 0]*w1+x[:, 1]*w2+x[:, 2]*w3 + b - y) * x[:, 1])
    w3 = w3 - alpha * (1 / len(data)) * sum((x[:, 0]*w1+x[:, 1]*w2+x[:, 2]*w3 + b - y) * x[:, 2])
    b = b - alpha * (1/len(data)) * sum(x[:, 0]*w1+x[:, 1]*w2+x[:, 2]*w3 + b - y)
print("w1 = %f, w2 = %f, w3 = %f, b = %f" % (w1, w2, w3, b))
```

# Multiple LR

Answer is

$w_1 = 0.5, \; w_2 = 1.0, \; w_3 = 2.0, \; b = 0.0$

# Much Better

```python
# multivariable_lr_gd_matrix.py
import numpy as np

data = np.array([[3.9,2.1,7.5,19.05],
                 [2.1,3.2,4.5,13.25],
                 [4.7,4.1,7.8,22.05],
                 [8.5,5.4,1.2,12.05],
                 [1.9,3.4,6.2,16.75],
                 [6.3,4.3,7.7,22.85],
                 [8.9,4.4,3.3,15.45]])
x = data[:, :-1]
y = data[:, -1]

# initialization
w = np.array([0, 0, 0])
b = 0
# learning rate
alpha = 0.01
# GD
for i in range(50000):
    w = w - alpha * (1 / len(data)) * np.dot(np.transpose(np.dot(x, w)+b - y), x)
    b = b - alpha * (1 / len(data)) * sum(np.dot(x, w)+b - y)
print(w, b)
```

# Lab 10

Train a linear model (estimate optimal $w_1$, $w_2$, $w_3$, $b$) given the data below.
The answer is $w_1 = 1.0$, $w_2 = 2.0$, $w_3 = 3.0$, $b = 1.0$.
Submit both source codes and screenshots in the blackboard.

| $x_1$ | $x_2$ | $x_3$ | y |
|---|---|---|---|
| 3.5 | 4.7 | 2.3 | 20.8 |
| 4.4 | 5.7 | 4.1 | 29.1 |
| 2.5 | 7.3 | 1.2 | 21.7 |
| 8.5 | 3.3 | 4.8 | 30.5 |
| 4.9 | 6.4 | 5.7 | 35.8 |
| 7.2 | 7.1 | 7.4 | 44.6 |
| 5.6 | 8.2 | 6.5 | 42.5 |