

# Gradient Descent For Multiple Variables

## Gradient Descent for Multiple Variables

The gradient descent equation itself is generally the same form; we just have to repeat it for our 'n' features:

```
repeat until convergence: {
   $\theta_0 := \theta_0 - \alpha \frac{1}{m} \sum_{i=1}^m (h_{\theta}(x^{(i)}) - y^{(i)}) \cdot x_0^{(i)}$ 
   $\theta_1 := \theta_1 - \alpha \frac{1}{m} \sum_{i=1}^m (h_{\theta}(x^{(i)}) - y^{(i)}) \cdot x_1^{(i)}$ 
   $\theta_2 := \theta_2 - \alpha \frac{1}{m} \sum_{i=1}^m (h_{\theta}(x^{(i)}) - y^{(i)}) \cdot x_2^{(i)}$ 
  ...
}
```

In other words:

```
repeat until convergence: {
   $\theta_j := \theta_j - \alpha \frac{1}{m} \sum_{i=1}^m (h_{\theta}(x^{(i)}) - y^{(i)}) \cdot x_j^{(i)}$     for j := 0...n
}
```

The following image compares gradient descent with one variable to gradient descent with multiple variables:

### Gradient Descent

Previously (n=1):

Repeat {

$\theta_0 := \theta_0 - \alpha \frac{1}{m} \sum_{i=1}^m (h_{\theta}(x^{(i)}) - y^{(i)})$

$\frac{\partial}{\partial \theta_0} J(\theta)$

$\theta_1 := \theta_1 - \alpha \frac{1}{m} \sum_{i=1}^m (h_{\theta}(x^{(i)}) - y^{(i)}) x_1^{(i)}$

(simultaneously update  $\theta_0, \theta_1$ )

}

**New algorithm (n ≥ 1):**

Repeat {

$\theta_j := \theta_j - \alpha \frac{1}{m} \sum_{i=1}^m (h_{\theta}(x^{(i)}) - y^{(i)}) x_j^{(i)}$

(simultaneously update  $\theta_j$  for  $j = 0, \dots, n$ )

}

---

$\theta_0 := \theta_0 - \alpha \frac{1}{m} \sum_{i=1}^m (h_{\theta}(x^{(i)}) - y^{(i)}) x_0^{(i)}$

$\theta_1 := \theta_1 - \alpha \frac{1}{m} \sum_{i=1}^m (h_{\theta}(x^{(i)}) - y^{(i)}) x_1^{(i)}$

$\theta_2 := \theta_2 - \alpha \frac{1}{m} \sum_{i=1}^m (h_{\theta}(x^{(i)}) - y^{(i)}) x_2^{(i)}$

...

*Handwritten notes in red:*

- For the first algorithm, the first equation is labeled  $\frac{\partial}{\partial \theta_0} J(\theta)$ .
- For the second algorithm, the first equation is labeled  $\frac{\partial}{\partial \theta_j} J(\theta)$ .
- Red arrows point from the general equation to the specific ones.
- Red circles highlight  $x_0^{(i)}$  and  $x_1^{(i)}$  in the second algorithm's equations.
- A note  $x_0^{(i)} = 1$  is written next to the first equation of the second algorithm.