

Lecture 03

How to minimize cost

Hypothesis and Cost

$$H(x) = Wx + b$$

$$\text{cost}(W, b) = \frac{1}{m} \sum_{i=1}^m (H(x^{(i)}) - y^{(i)})^2$$

Simplified hypothesis

$$H(x) = Wx$$

$$cost(W) = \frac{1}{m} \sum_{i=1}^m (Wx^{(i)} - y^{(i)})^2$$

What cost(W) looks like?

$$\text{cost}(W) = \frac{1}{m} \sum_{i=1}^m (Wx^{(i)} - y^{(i)})^2$$

x	Y
1	1
2	2
3	3

→ $W = 1, \text{cost}(W) = ?$ **0**

$$\frac{1}{3} ((1 * 1 - 1)^2 + (1 * 2 - 2)^2 + (1 * 3 - 3)^2)$$

0 *0* *0*

What $\text{cost}(W)$ looks like?

$$\text{cost}(W) = \frac{1}{m} \sum_{i=1}^m (W x^{(i)} - y^{(i)})^2$$

x	Y
1	1
2	2
3	3

- $W=1, \text{cost}(W)=0$

$$\frac{1}{3} ((1 * 1 - 1)^2 + (1 * 2 - 2)^2 + (1 * 3 - 3)^2)$$

- $W=0, \text{cost}(W)=4.67$

$$\frac{1}{3} ((0 * 1 - 1)^2 + (0 * 2 - 2)^2 + (0 * 3 - 3)^2)$$

- $W=2, \text{cost}(W)=?$ **4.67**

$$\frac{1}{3} ((2 * 1 - 1)^2 + (2 * 2 - 2)^2 + (2 * 3 - 3)^2)$$

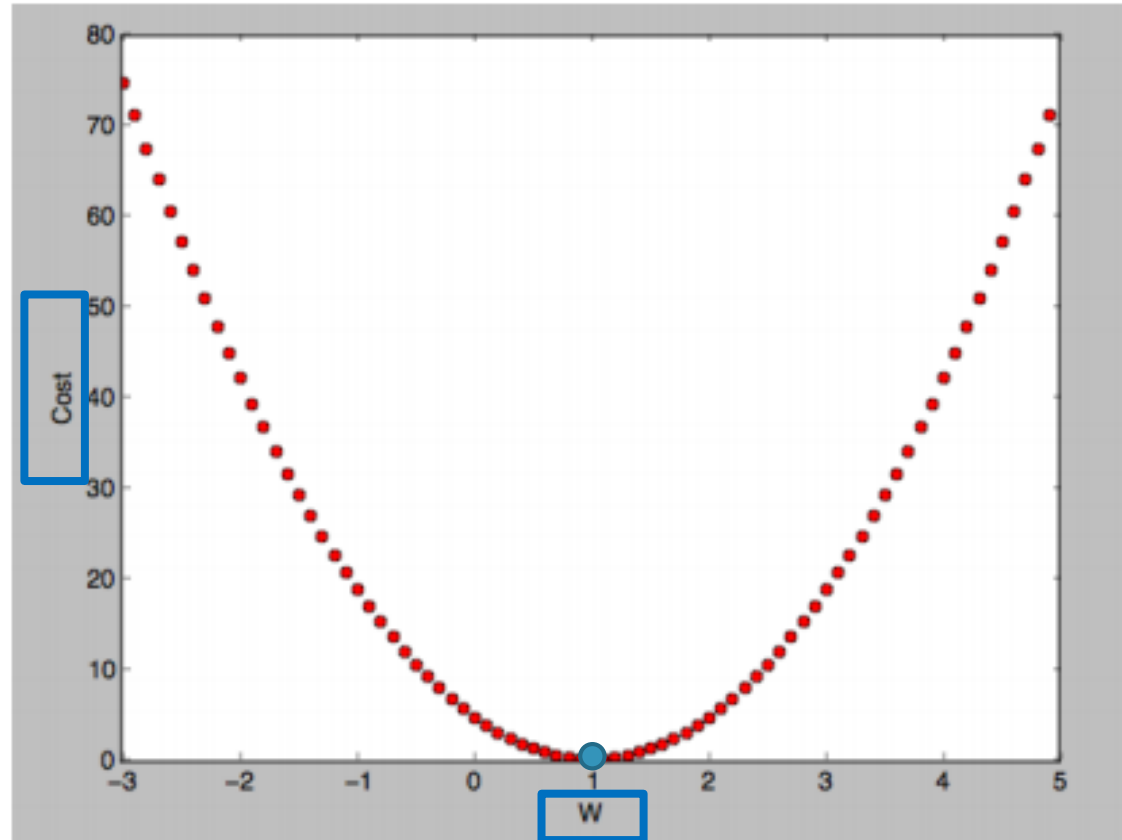
What $\text{cost}(W)$ looks like?

- $W=1, \text{cost}(W)=0$
- $W=0, \text{cost}(W)=4.67$
- $W=2, \text{cost}(W)=4.67$

What $\text{cost}(W)$ looks like?

- $W=1, \text{cost}(W)=0$
- $W=0, \text{cost}(W)=4.67$
- $W=2, \text{cost}(W)=4.67$

$$\text{cost}(W) = \frac{1}{m} \sum_{i=1}^m (Wx^{(i)} - y^{(i)})^2$$

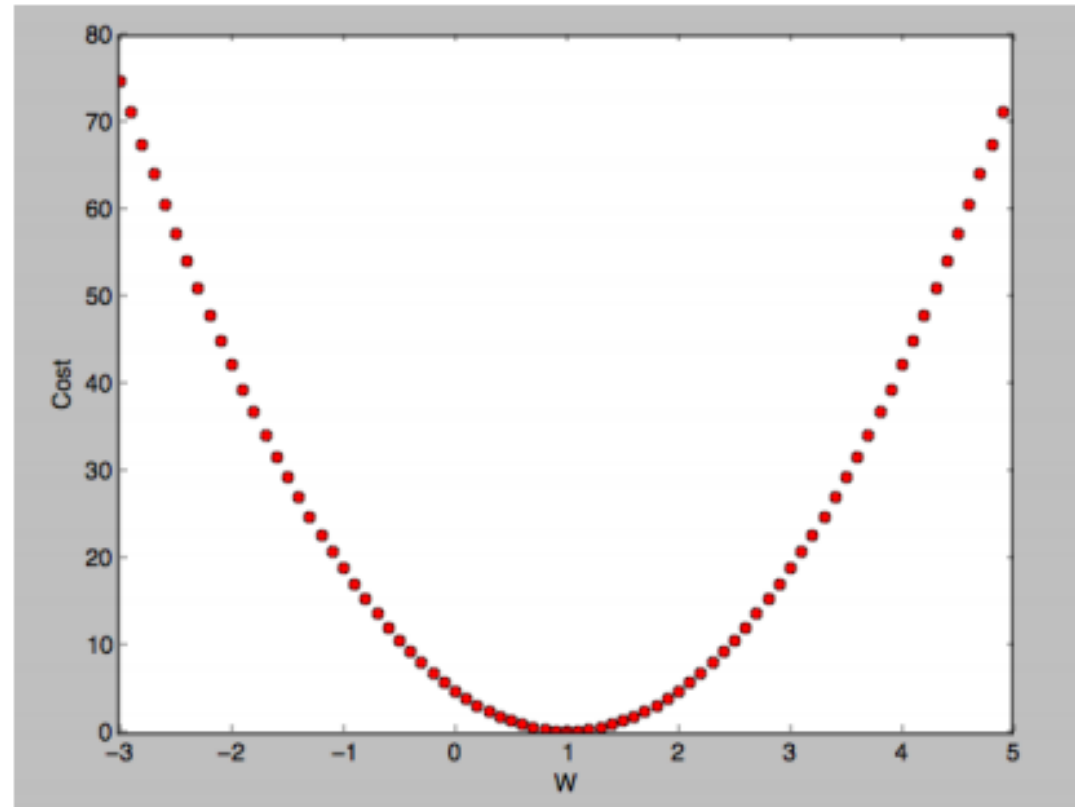


Gradient descent algorithm

- Minimize cost function
- Gradient descent is used many minimization problems
- For a given cost function, $\text{cost}(W, b)$, it will find W, b to minimize cost
- It can be applied to more general function: $\text{cost}(w_1, w_2, w_3 \dots)$

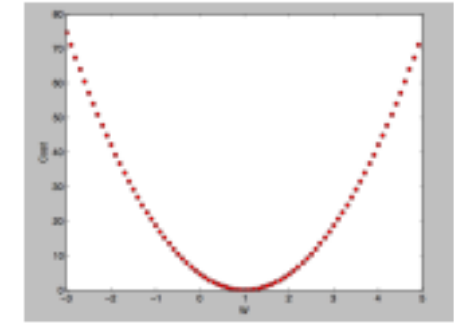
How it works?

- How would you find the lowest point?



How it works?

- Start with initial guesses
 - ▶ Start at 0,0 (or any other value)
 - ▶ Keeping changing W and b a little bit to try and reduce $\text{cost}(W, b)$
- Each time you change the parameters, you select the gradient which reduces $\text{cost}(W, b)$ the most possible
- Repeat
- Do so until you converge to a local minimum
- Has an interesting property
 - ▶ Where you start can determine which minimum you end up



gradient는 미분을
이용하여 구할 수 있다.

Formal definition

$$cost(W) = \frac{1}{m} \sum_{i=1}^m (Wx^{(i)} - y^{(i)})^2$$



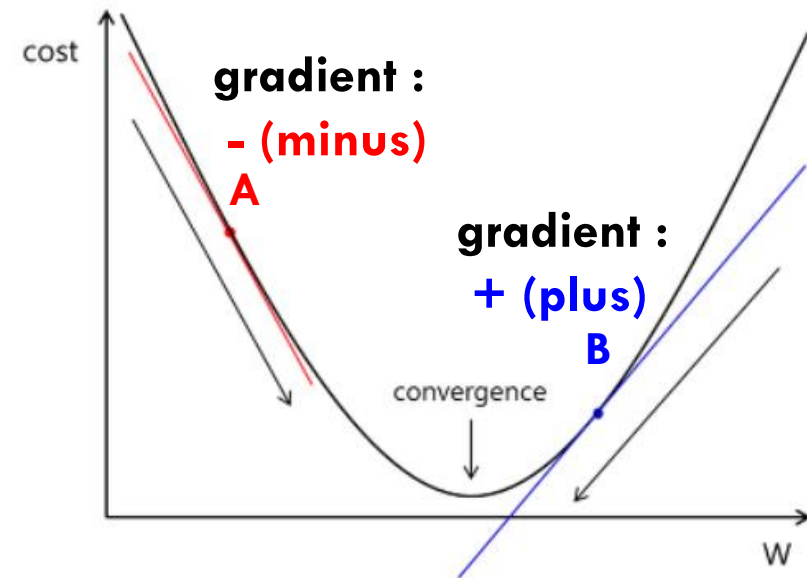
$$cost(W) = \frac{1}{2m} \sum_{i=1}^m (Wx^{(i)} - y^{(i)})^2$$

미분을 적용하기 쉽도록
분모에 2를 곱한다.

Formal definition

$$\text{cost}(W) = \frac{1}{2m} \sum_{i=1}^m (W x^{(i)} - y^{(i)})^2$$

$$W := W - \overset{\text{learning_rate}}{\alpha} \frac{\partial}{\partial W} \text{cost}(W)$$



Formal definition

$$cost(W) = \frac{1}{m} \sum_{i=1}^m (Wx^{(i)} - y^{(i)})^2$$



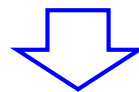
$$cost(W) = \frac{1}{2m} \sum_{i=1}^m (Wx^{(i)} - y^{(i)})^2$$



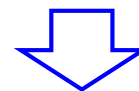
$$W := W - \alpha \frac{\partial}{\partial W} cost(W)$$



$$W := W - \alpha \frac{\partial}{\partial W} \frac{1}{2m} \sum_{i=1}^m (Wx^{(i)} - y^{(i)})^2$$



$$W := W - \alpha \frac{1}{2m} \sum_{i=1}^m 2(Wx^{(i)} - y^{(i)}) \underline{x^{(i)}}$$



$$W := W - \alpha \frac{1}{m} \sum_{i=1}^m (Wx^{(i)} - y^{(i)}) \underline{x^{(i)}}$$

Derivative Calculator

<https://www.derivative-calculator.net/>



Derivative Calculator

Calculate derivatives online — *with steps and graphing!*

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Go!

CLR + - × ÷ ^ √ ()

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This will take a few seconds.

Not what you mean? *Use parentheses!* Set differentiation variable and order in "Options".

About Help Examples Options Practice

The Derivative Calculator lets you calculate derivatives of functions online — for free!

Our calculator allows you to check your solutions to calculus exercises. It helps you practice by showing you the full working (step by step differentiation).

The Derivative Calculator supports computing first, second, ..., fifth derivatives as well as differentiating functions with many variables (partial derivatives), implicit differentiation and calculating roots/zeros. You can also check your answers! Interactive graphs/plots help visualize and better understand the functions.

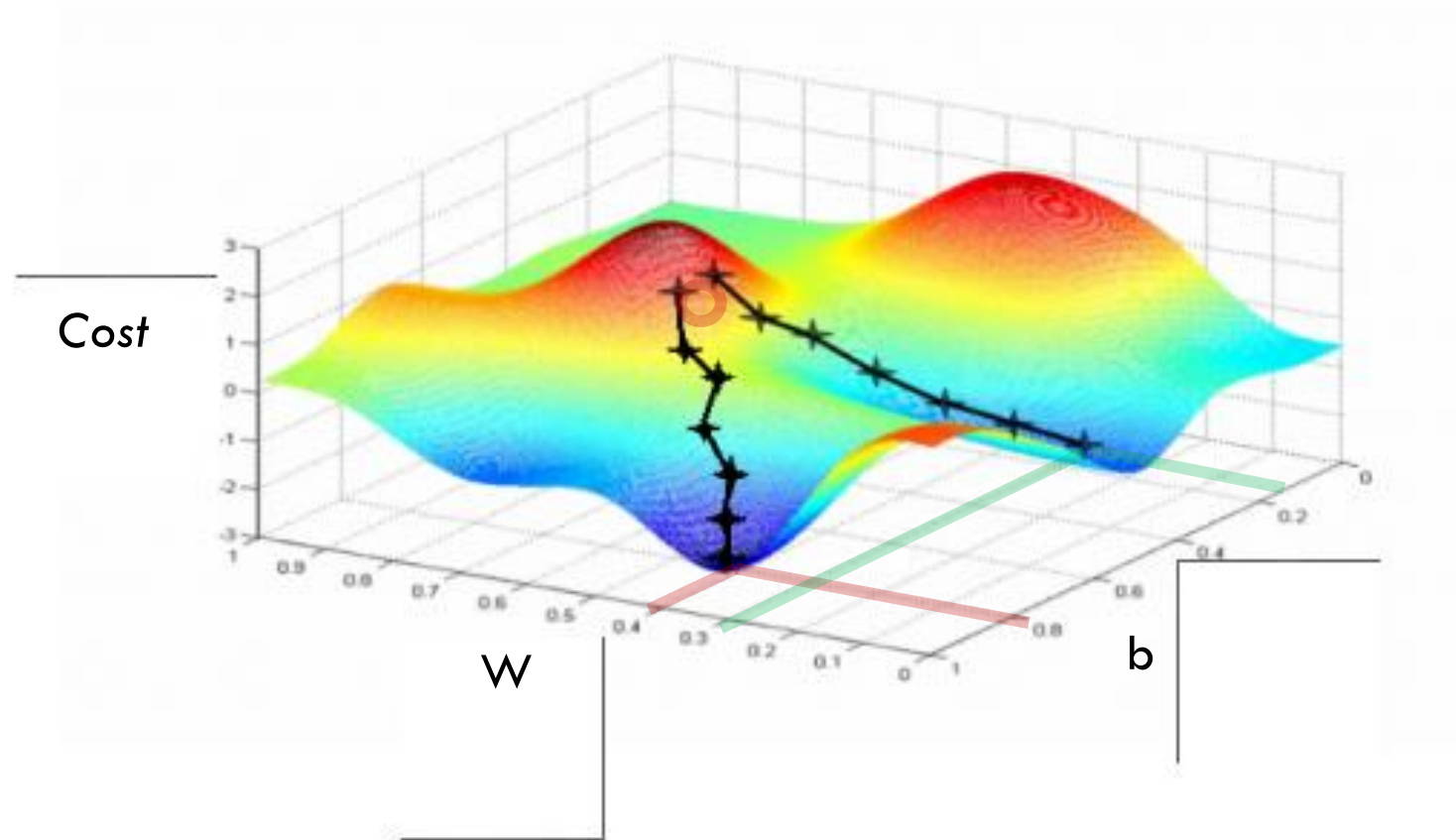
For more about how to use the Derivative Calculator, go to "*Help*" or take a look at the examples.

And now: Happy differentiating!

Gradient descent algorithm

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

Convex function



Convex function

$$cost(W, b) = \frac{1}{m} \sum_{i=1}^m (H(x^{(i)}) - y^{(i)})^2$$

