Track 7

Inteligencia Artificial Aplicada

2. Introduction to ML

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The Machine Learning Paradigm

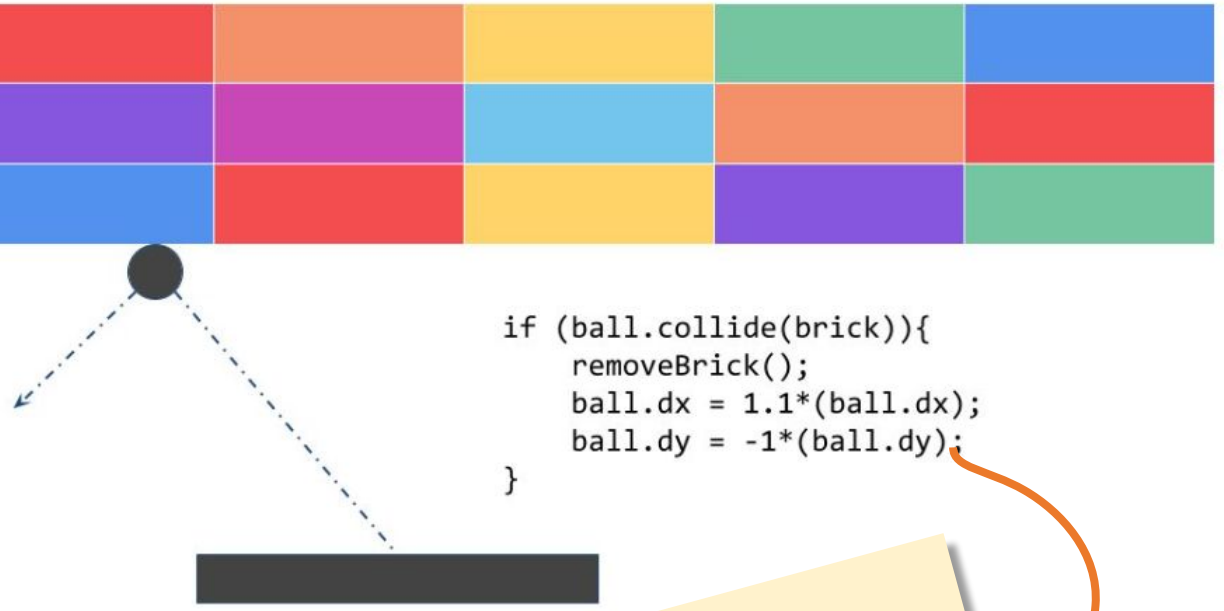
From coding to learning…

Explicit Coding

Defining rules that determine behavior of a program

Everything is pre-calculated and pre-determined by the programmer

Scenarios are limited by program complexity



Rules

- If the ball collides with the brick:
  - Remove brick
  - Change ball direction
  - Increase ball speed
- …

https://en.wikipedia.org/wiki/Breakout_(video_game)

The Traditional Programming Paradigm

Consider Activity Detection

```
if(speed<4){
    status=WALKING;
}
```

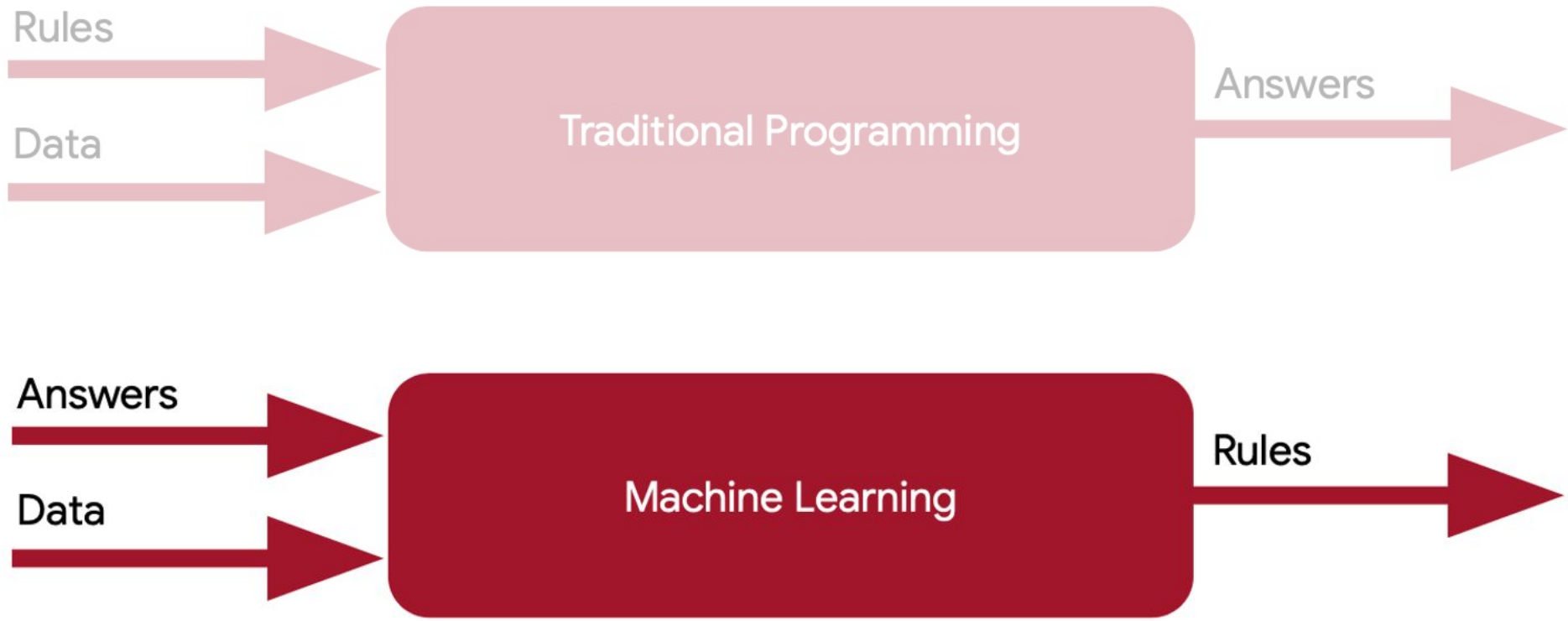
```
if(speed<4){
    status=WALKING;
} else {
    status=RUNNING;
}
```

```
if(speed<4){
    status=WALKING;
} else if(speed<12){
    status=RUNNING;
} else {
    status=BIKING;
}
```

```
// ???
```

The Traditional Programming Paradigm

The Traditional Programming Paradigm



Activity Detection with Machine Learning

```
0101001010100101010
1001010101001011101
0100101010010101001
0101001010100101010
```

Label = WALKING

```
1010100101001010101
0101010010010010001
0010011111010101111
1010100100111101011
```

Label = RUNNING

```
1001010011111010101
1101010111010101110
1010101111010101011
1111110001111010101
```

Label = BIKING

```
1111111111010011101
0011111010111110101
0101110101010101110
1010101010100111110
```

Label = GOLFING

The Machine Learning Paradigm

```
0101001010100101010
1001010101001011101
0100101010010101001
0101001010100101010
```

Label = WALKING

```
1010100101001010101
0101010010010010001
0010011111010101111
1010100100111101011
```

Label = RUNNING

```
1001010011111010101
1101010111010101110
1010101111010101011
1111110001111010101
```

Label = BIKING

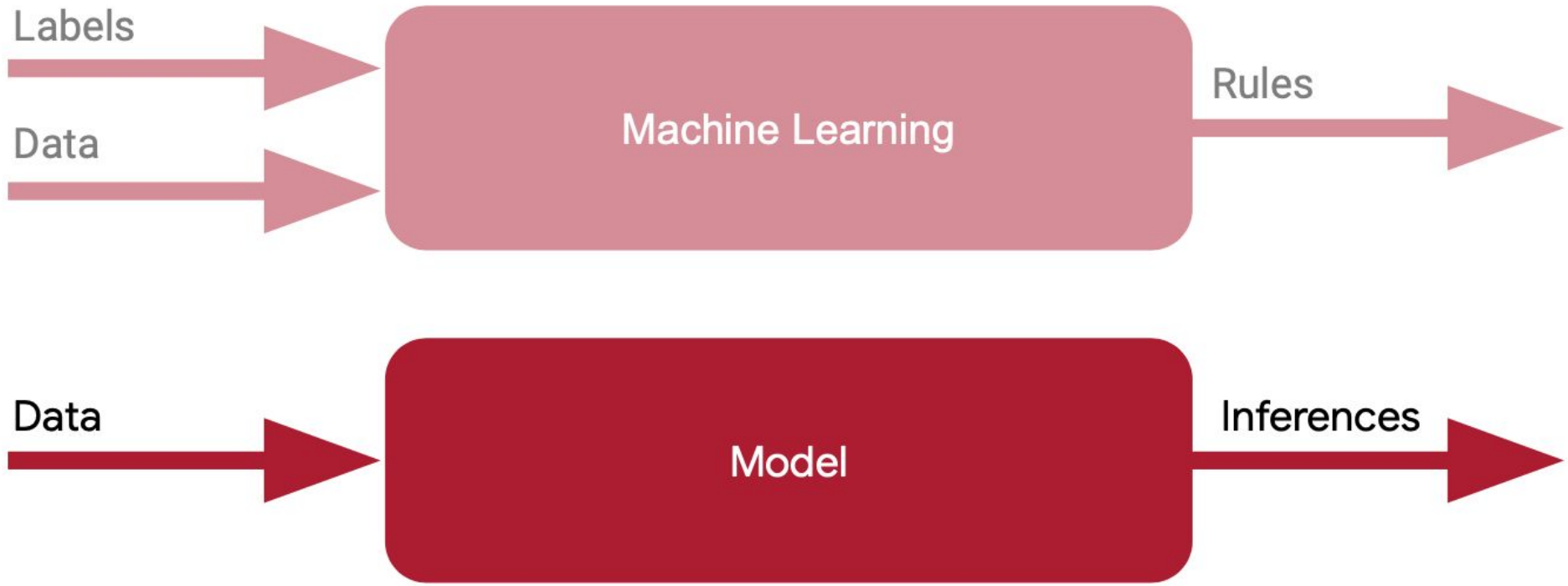
```
1111111111010011101
0011111010111110101
0101110101010101110
1010101010100111110
```

Label = GOLFING

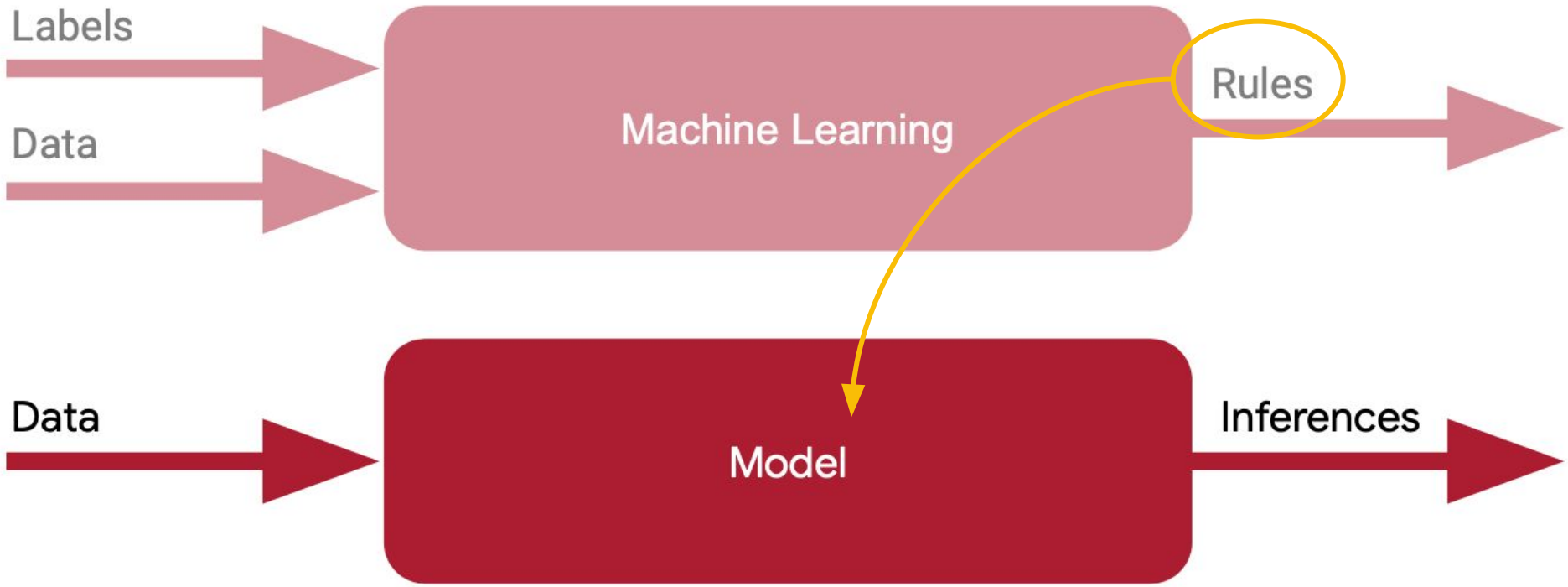
The Machine Learning Paradigm

The Machine Learning Paradigm

The Machine Learning Paradigm



The Machine Learning Paradigm



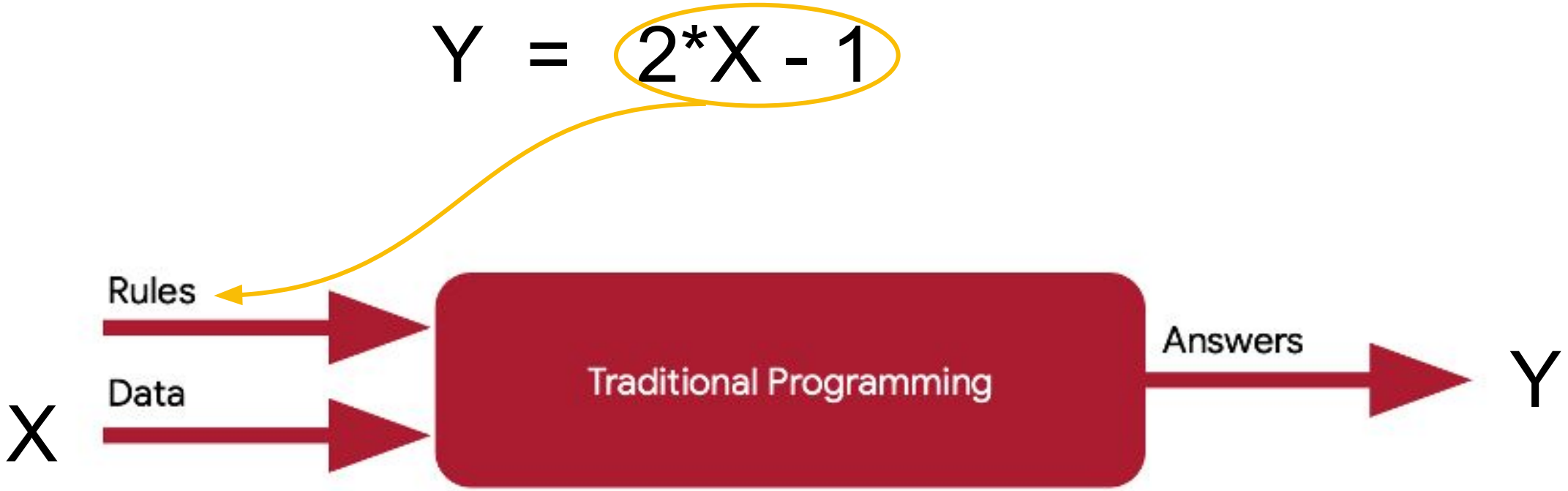
Thinking about loss…

A way to measure your accuracy

$$Y = p*X + b$$

$X = \{ -1, 0, 1, 2, 3, 4 \}$

$Y = \{?, ?, ?, ?, ?, ?\}$



X = { -1, 0, 1, 2, 3, 4 }

Y = { -3, -1, 1, 3, 5, 7 }

Matching X to Y

$X = \{ -1, 0, 1, 2, 3, 4 \}$

$Y = \{ -3, -1, 1, 3, 5, 7 \}$

Matching X to Y

$X = \{ -1, 0, 1, 2, 3, 4 \}$

$Y = \{ -3, -1, 1, 3, 5, 7 \}$

$$Y = p*X + b$$

Matching X to Y

X = { -1, 0, 1, 2, 3, 4 }

Y = { -3, -1, 1, 3, 5, 7 }

$$Y = p*X + b$$

Matching X to Y

Input

X = { -1, 0, 1, 2, 3, 4 }

Y = { -3, -1, 1, 3, 5, 7 }

Target

$Y = p*X + b$

Parameters

Make a guess!

Y = 3X - 1

p = +3
b = -1

X = { -1, 0, 1, 2, 3, 4 }

Y = { -4, -1, 2, 5, 8, 11 }

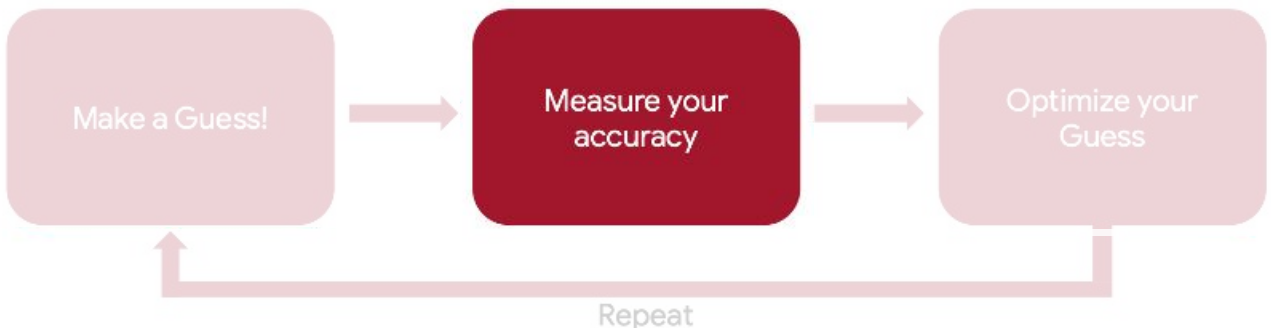
How good is the guess?

Y = 3X - 1

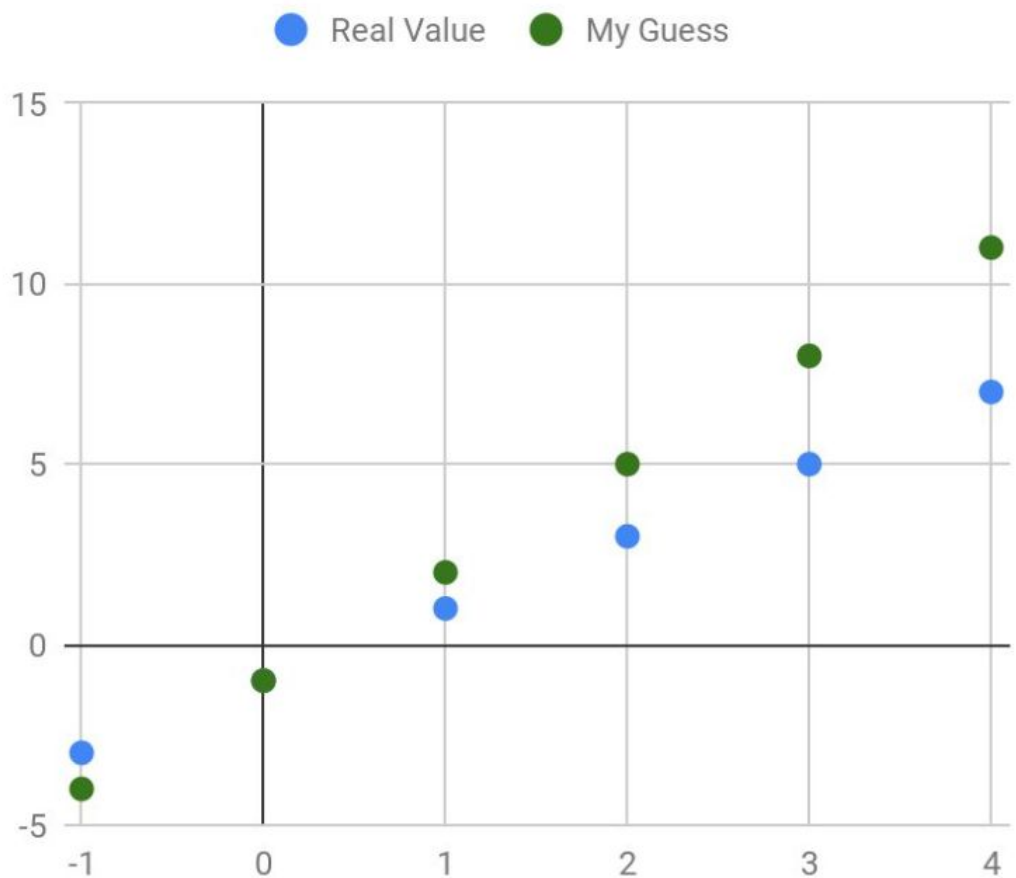
X = { -1, 0, 1, 2, 3, 4 }

My Y = { -4, -1, 2, 5, 8, 11 }

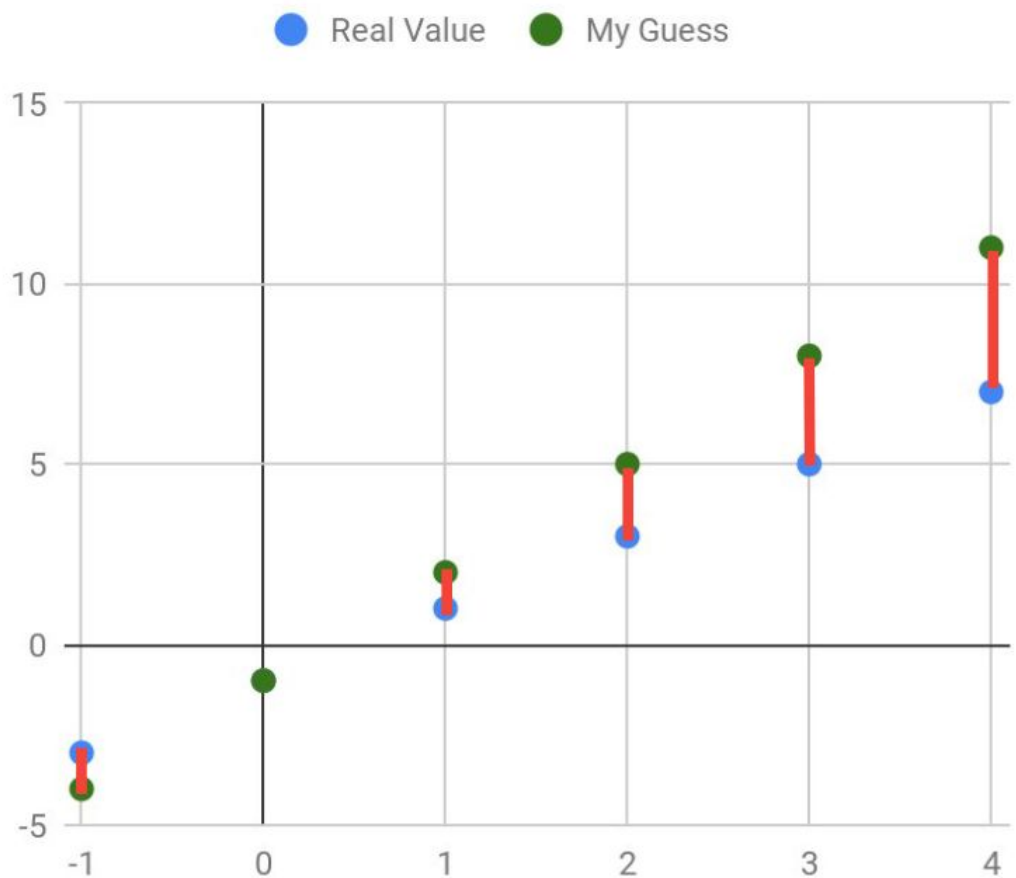
Real Y = { -3, -1, 1, 3, 5, 7 }



Let’s measure it!

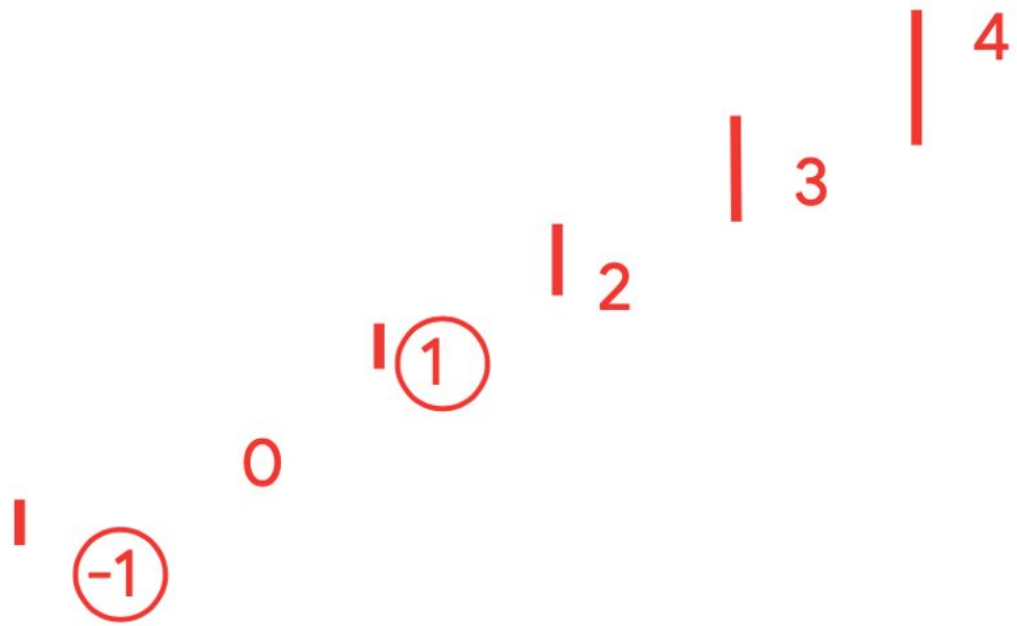


Let’s measure it!



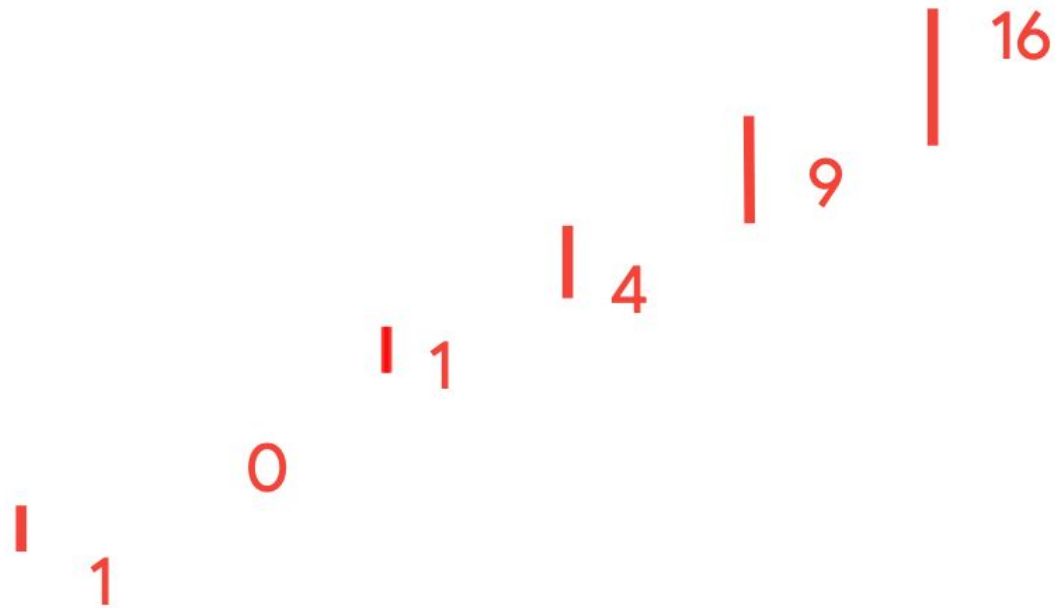
Let’s measure it!

Houston, we have a problem!



Houston, we have a problem!

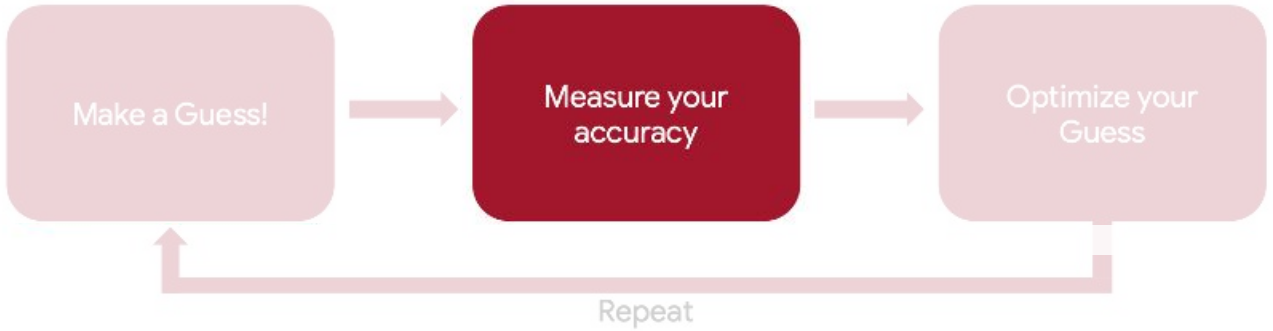
What if we **square**^{2} them?



Calculate the mean error:

= (1 + 1 + 4 + 9 + 16) / 6

= 5.17



Make another guess!

Y = 2X - 2

p = +2
b = -2

X = { -1, 0, 1, 2, 3, 4 }

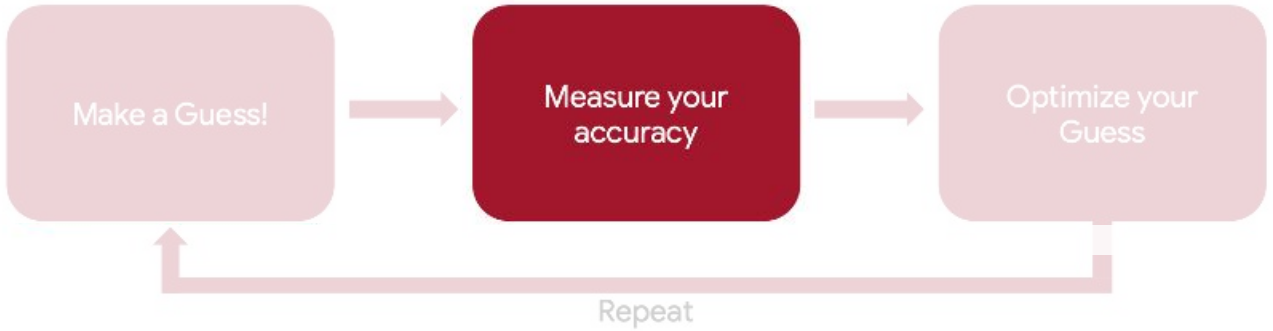
My Y = { -4, -2, 0, 2, 4, 6 }

Real Y = {-3, -1, 1, 3, 5, 7}

Diff^2 = {1, 1, 1, 1, 1, 1}

Get the same difference, repeat the same process.

= (1 + 1 + 1 + 1 + 1 + 1) / 6
= 1.00



Make another guess!

Y = 2X - 1

X = { -1, 0, 1, 2, 3, 4 }

My Y = { -3, -1, 1, 3, 5, 7 }

Real Y = {-3, -1, 1, 3, 5, 7}

Diff^2 = {0, 0, 0, 0, 0, 0}

Make another guess!

$Y = 2X - 1$

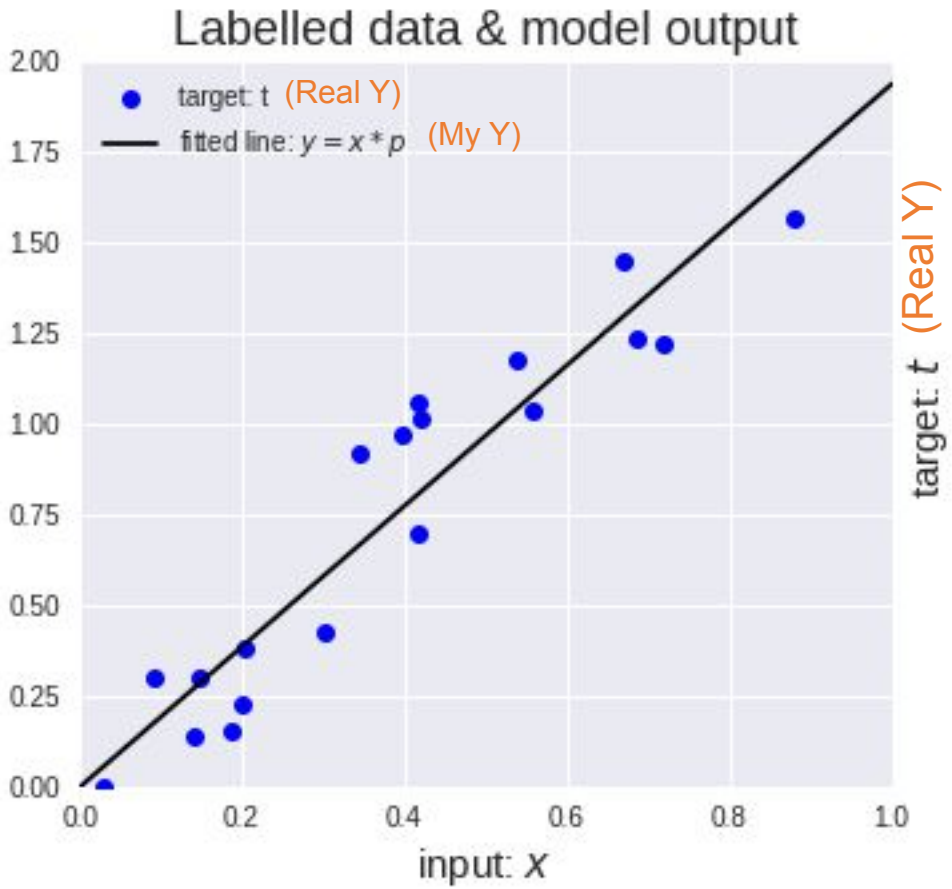
Parameters

$X = \{ -1, 0, 1, 2, 3, 4 \}$

My $Y = \{ -3, -1, 1, 3, 5, 7 \}$

Real $Y = \{-3, -1, 1, 3, 5, 7\}$

$Diff^2 = \{0, 0, 0, 0, 0, 0\}$



Make another guess!

$Y = 2X - 1$

Parameters

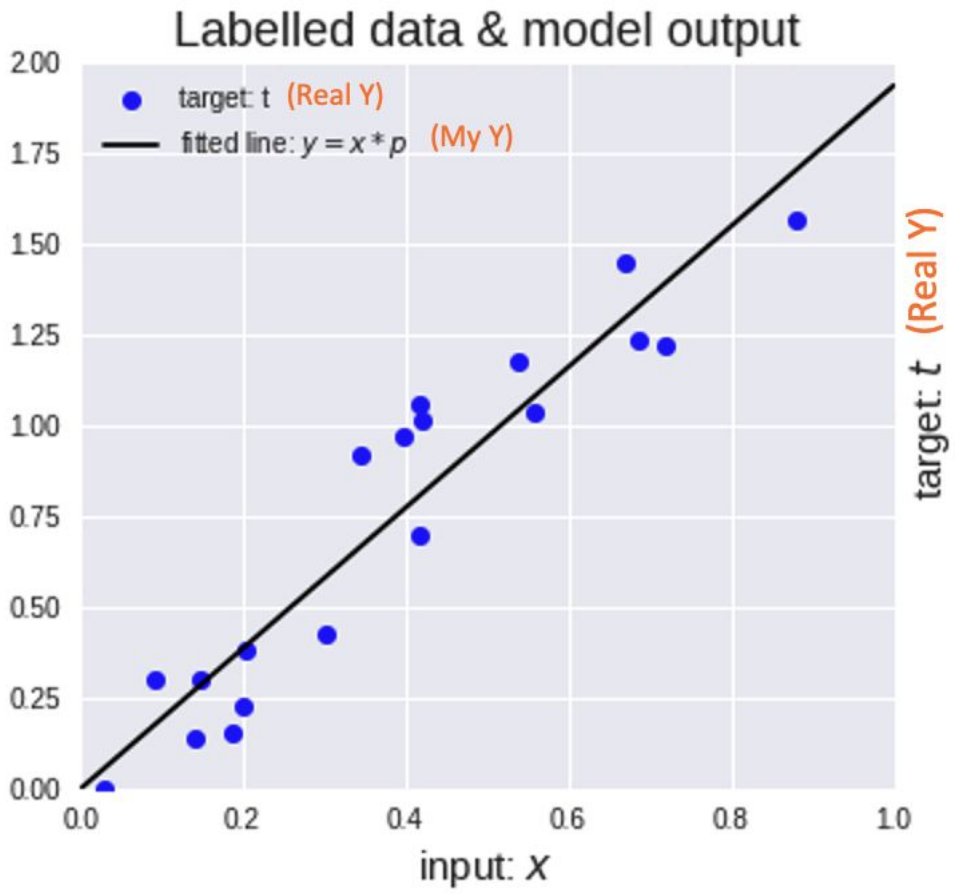
$X = \{ -1, 0, 1, 2, 3, 4 \}$

My $Y = \{ -3, -1, 1, 3, 5, 7 \}$

Real $Y = \{-3, -1, 1, 3, 5, 7\}$

MSE = {0, 0, 0, 0, 0, 0} / 6

$$\text{MSE} = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2$$



Goal is to Minimize MSE (**M**ean **S**quared **E**rror)

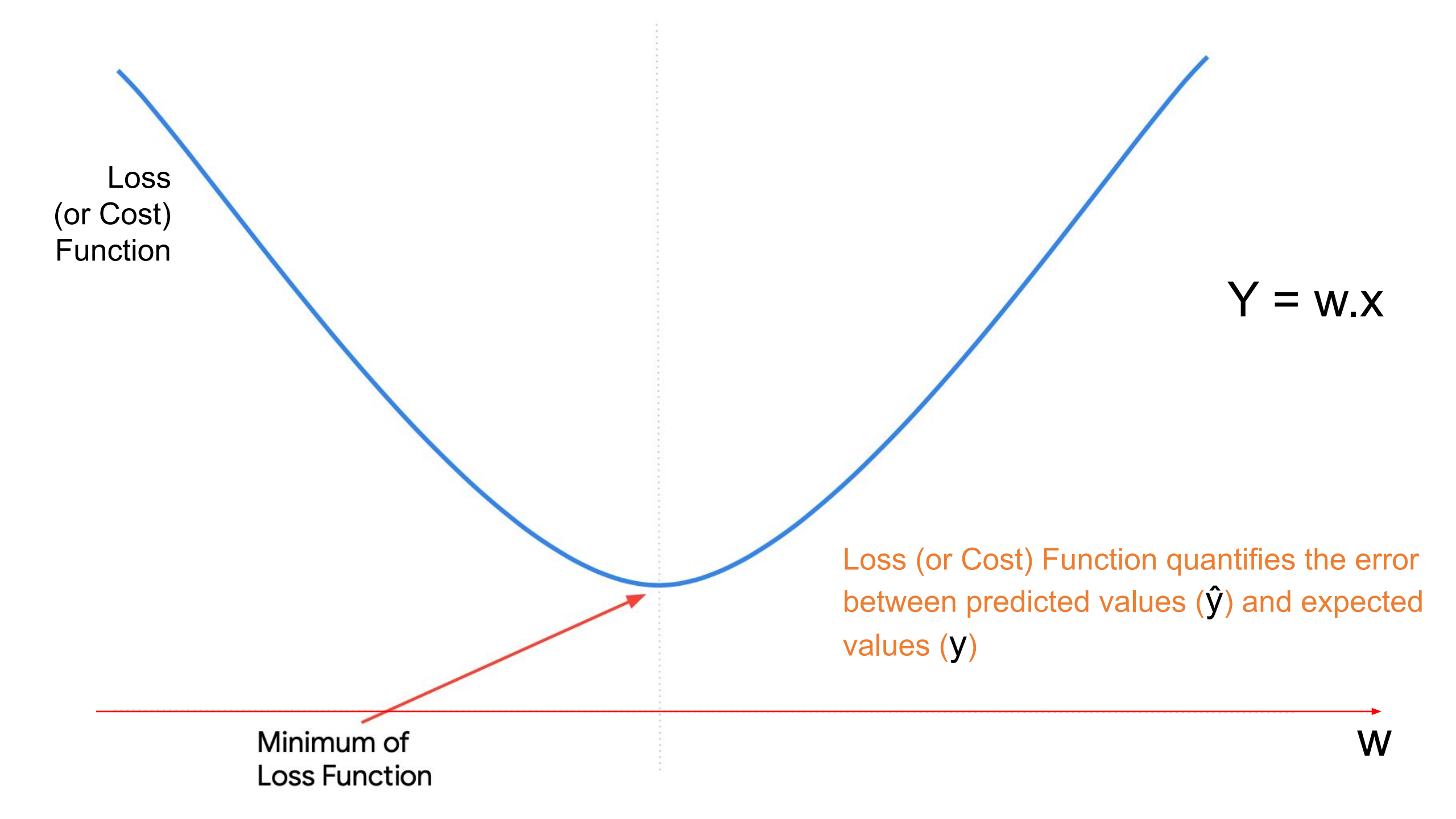
Exploring Loss and Cost Function

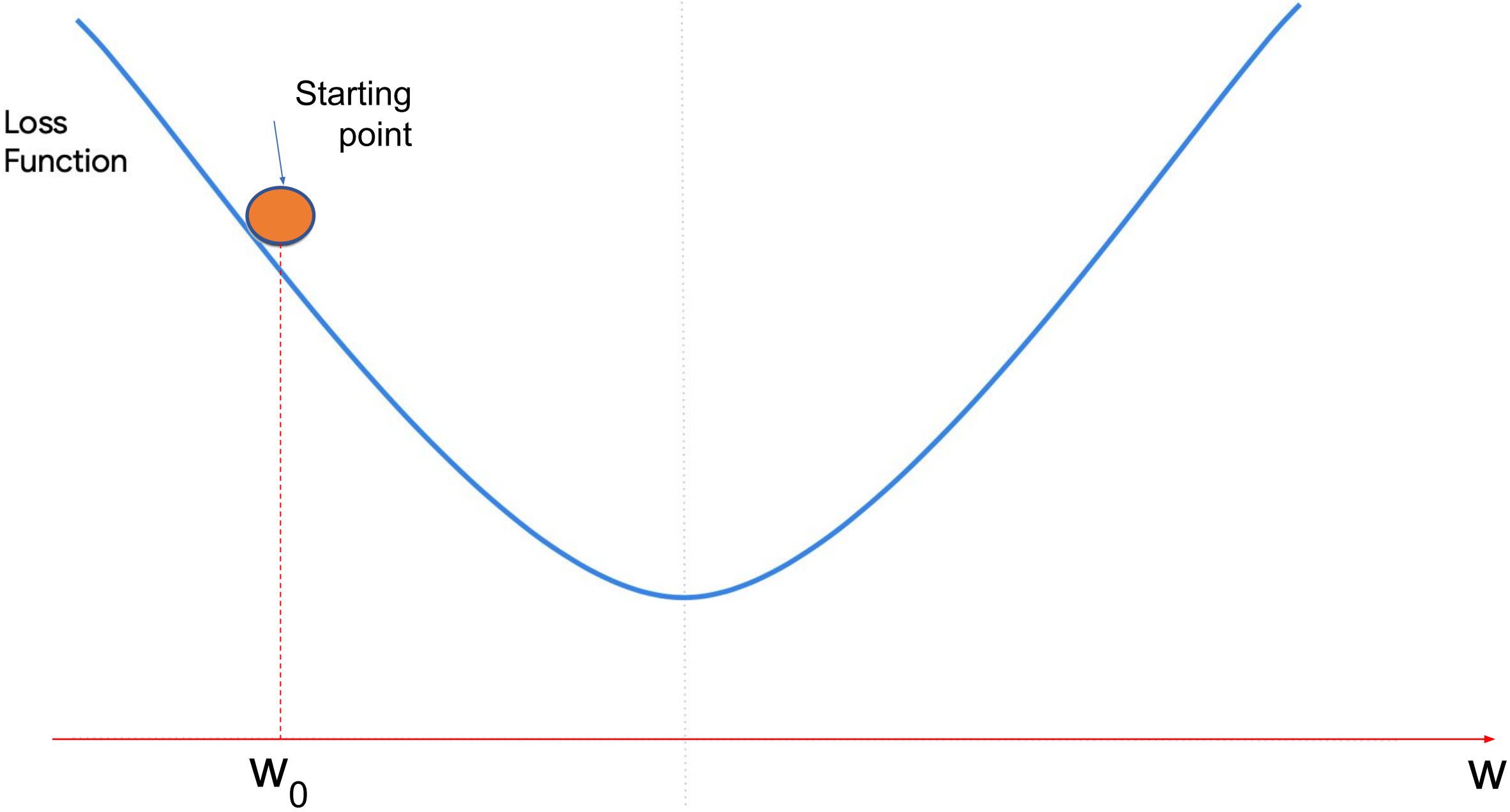
Code Time!

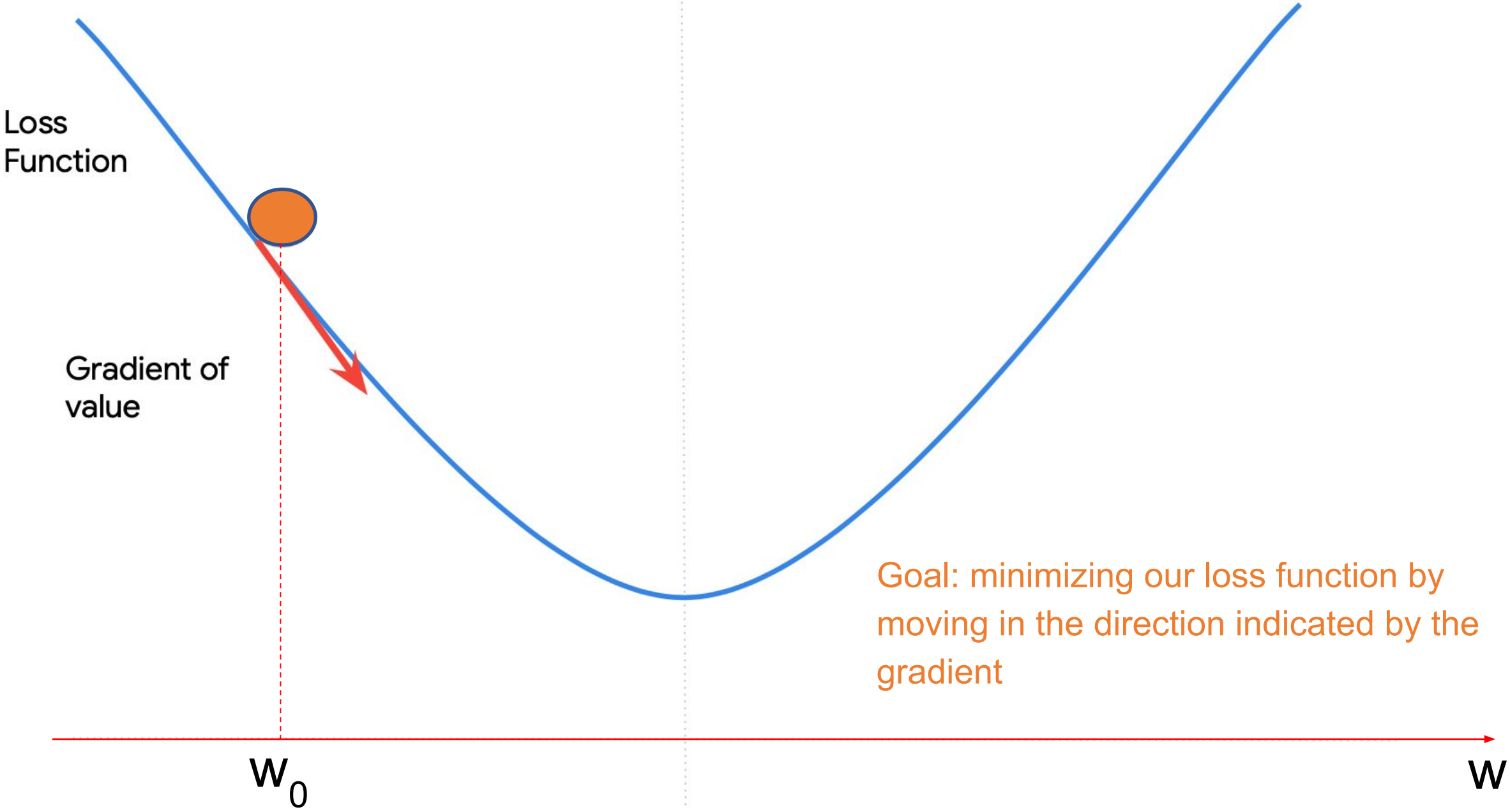
Exploring_Loss_Cost_Function.ipynb

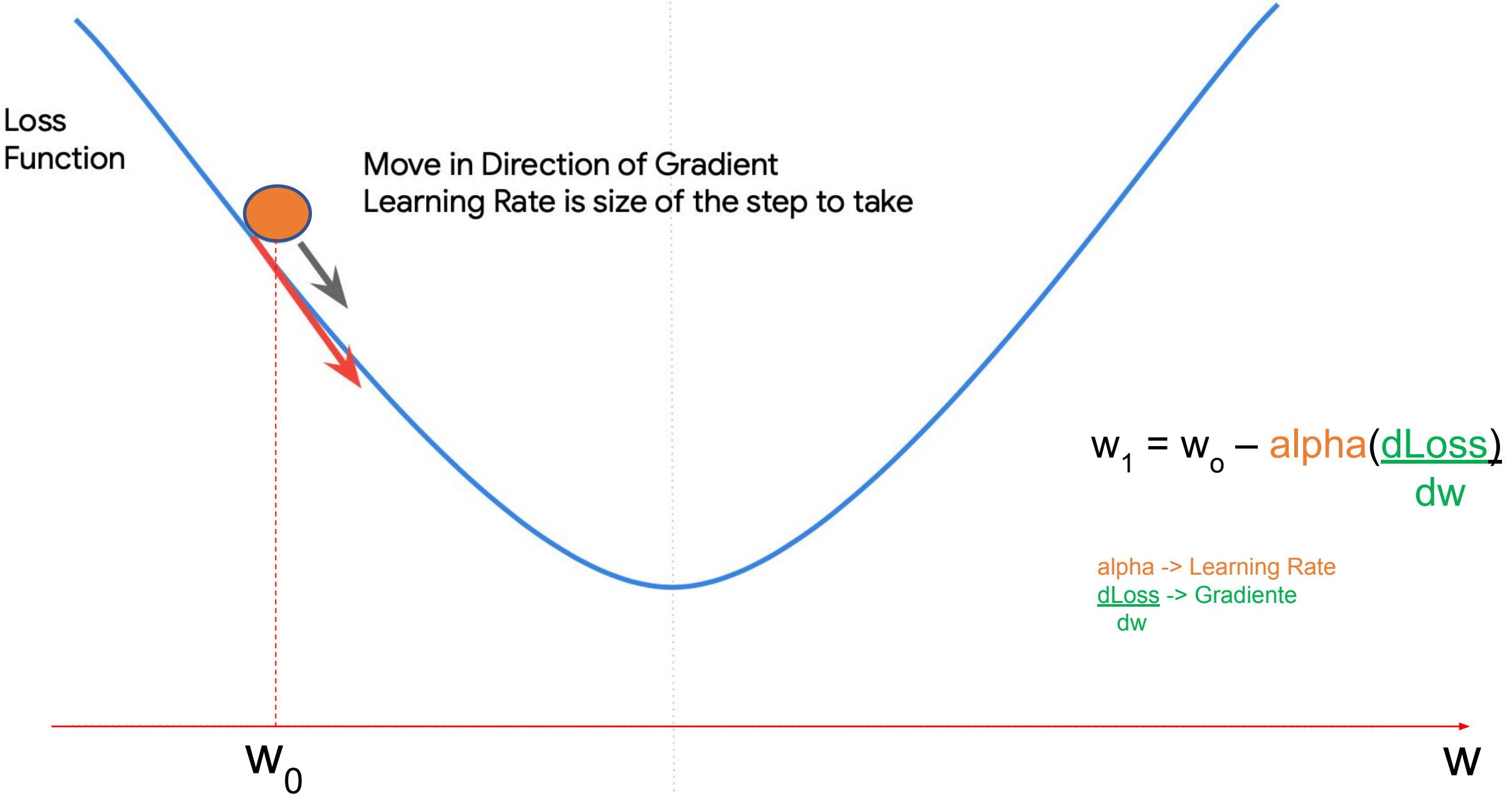
Minimizing loss…

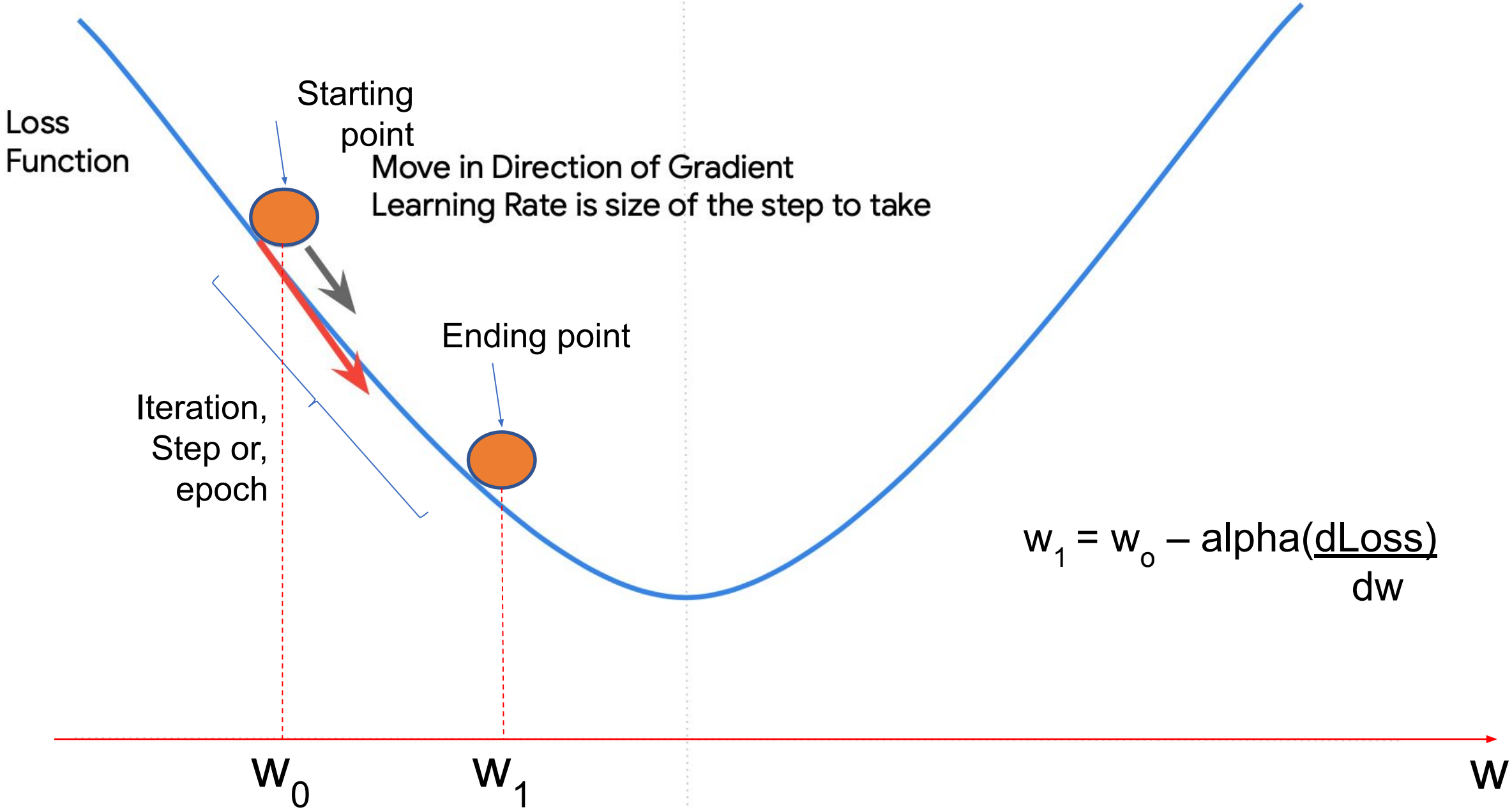
Moving down the curve…

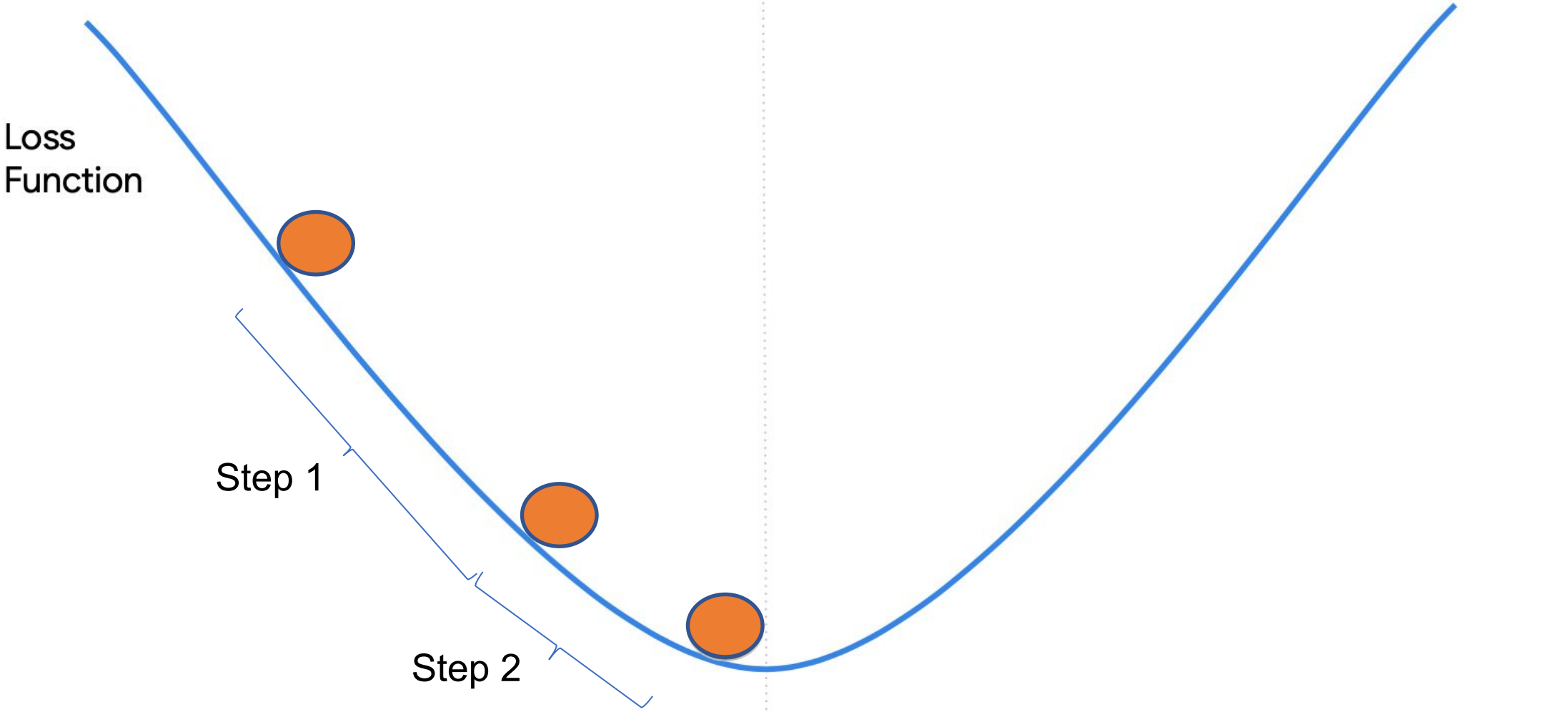

Loss
(or Cost)
Function
Y = w.x
Loss (or Cost) Function quantifies the error between predicted values (ŷ) and expected values (y)
Minimum of
Loss Function
w


Loss
Function
Starting
point
w_0
w


Loss
Function
Gradient of
value
Goal: minimizing our loss function by
moving in the direction indicated by the
gradient
w_0
w

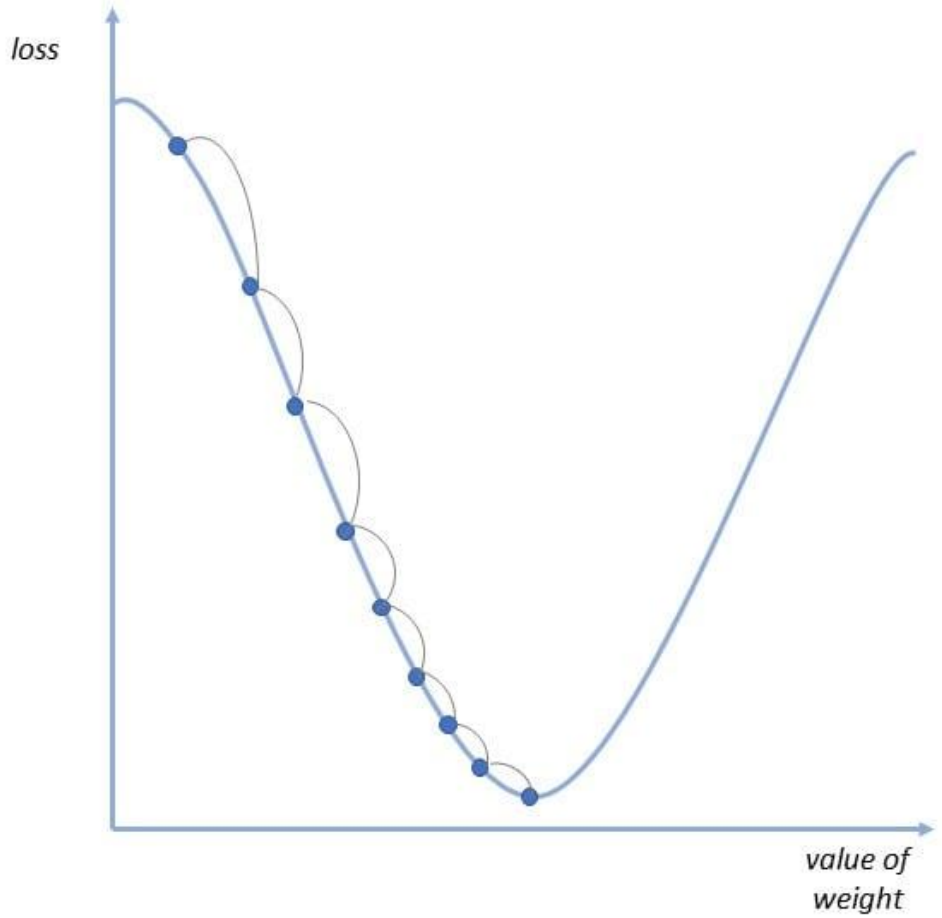

Loss
Function
Move in Direction of Gradient
Learning Rate is size of the step to take
$w_1 = w_o - \text{alpha}\left(\frac{dLoss}{dw}\right)$
alpha -> Learning Rate
dLoss -> Gradiente
dw
w_0
w


Loss Function
Starting point
Move in Direction of Gradient
Learning Rate is size of the step to take
Ending point
Iteration, Step or, epoch
$w_1 = w_o - \text{alpha}(\frac{dLoss}{dw})$
w_0
w_1
w

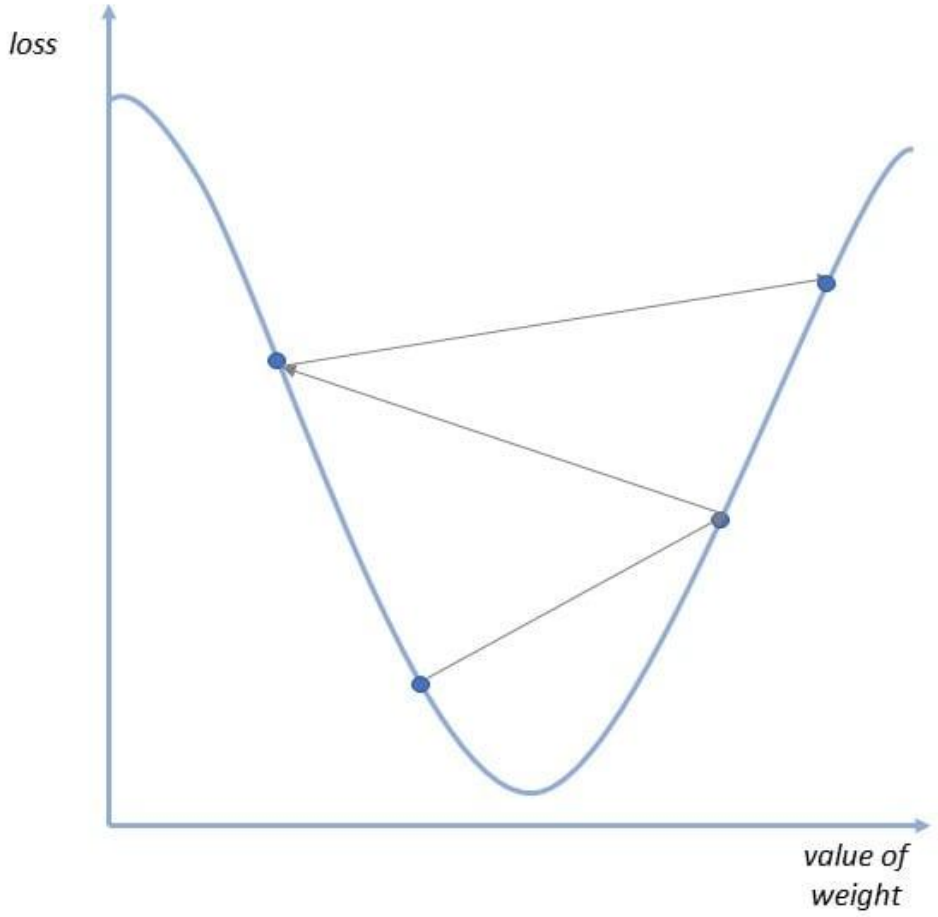

Loss
Function
Step 1
Step 2

It is important to choose the correct Learning Rate (size of the step)

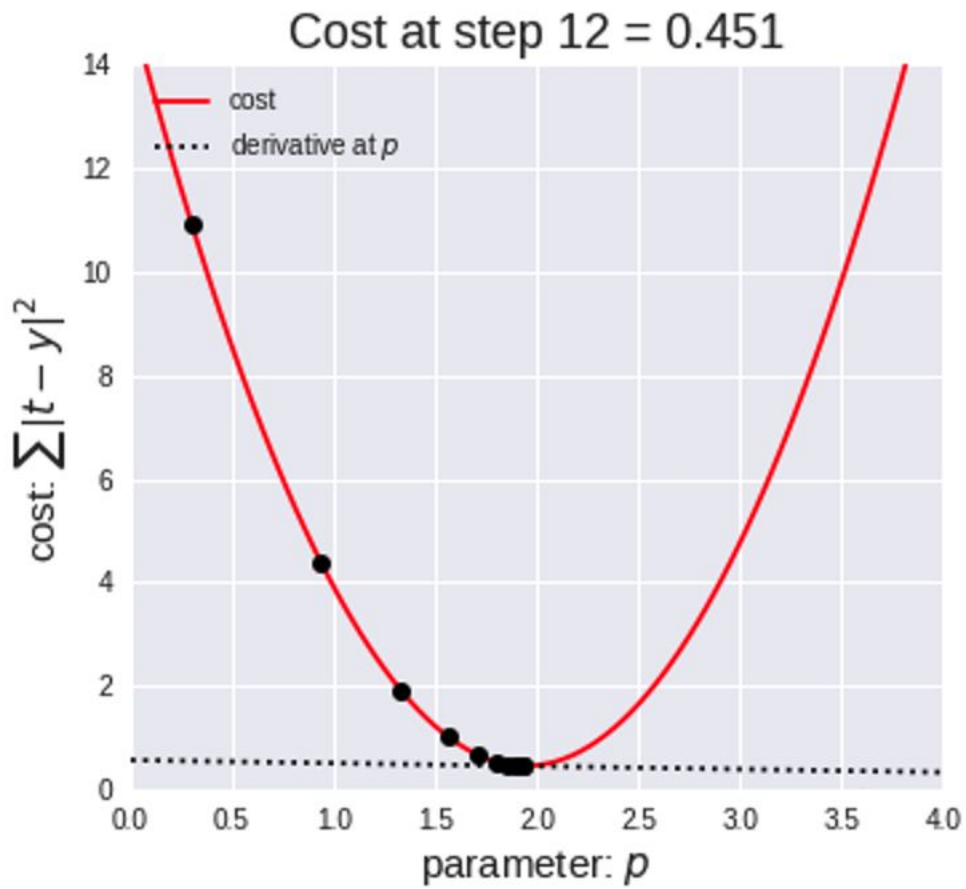
If the **Learning Rate** is too small it may take a long time to reach the minimum

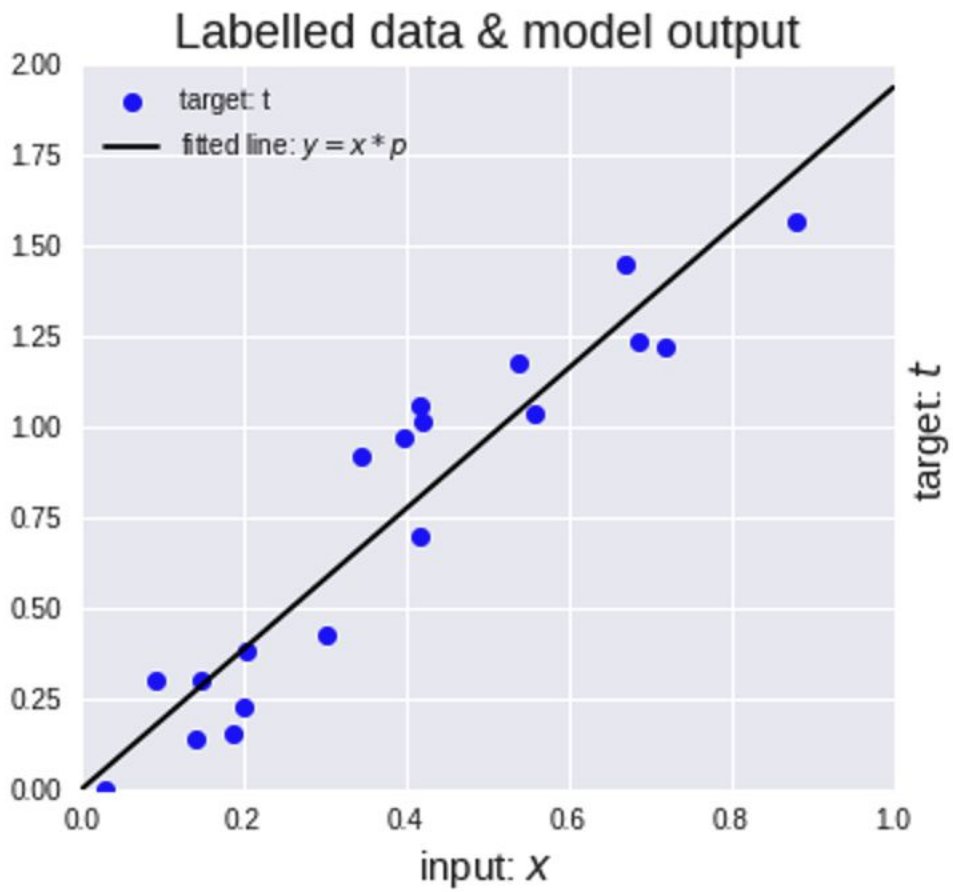


If the **Learning Rate** is too large we may never reach the minimum



Gradient Descent algorithm



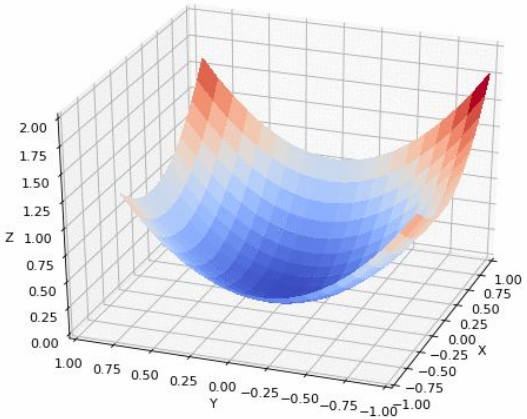


The Machine Learning Paradigm

The Machine Learning Paradigm

Epochs

(Back-Propagation)



Thanks

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