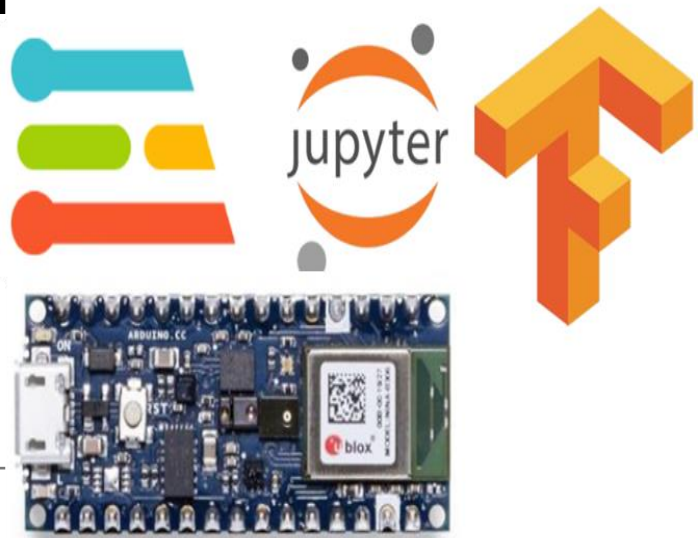
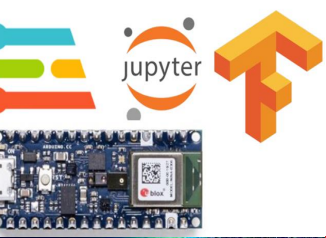
Advanced Microprocessors

THE MACHINE LEARNING PARADIGM

Dennis A. N. Gookyi





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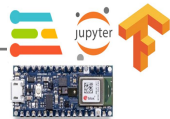
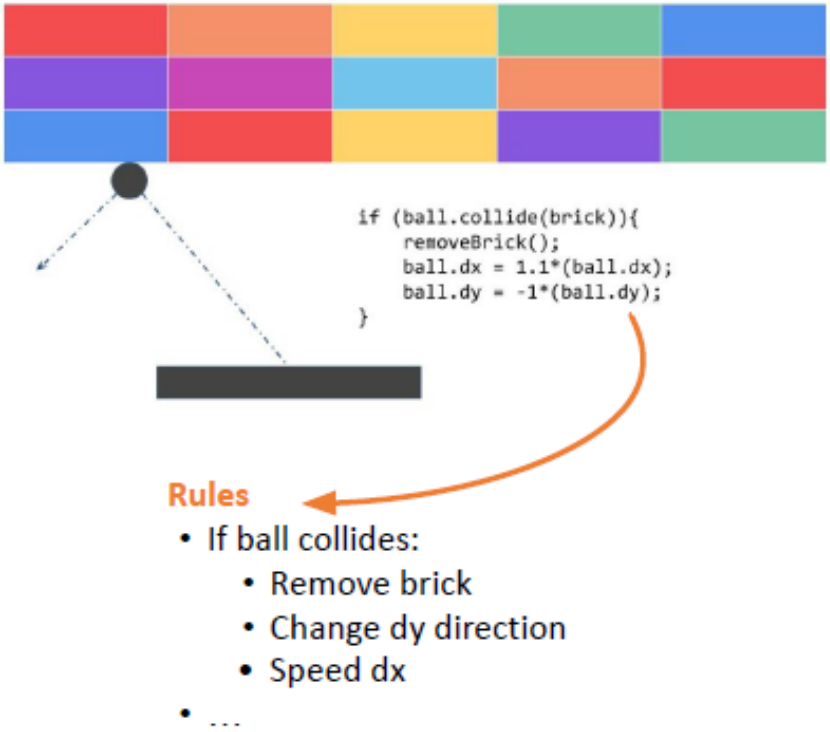
- The Machine Learning Paradigm



THE MACHINE LEARNING PARADIGM

- 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



THE MACHINE LEARNING PARADIGM

- The traditional programming paradigm

THE MACHINE LEARNING PARADIGM

- The traditional programming paradigm
  - Consider activity detection

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

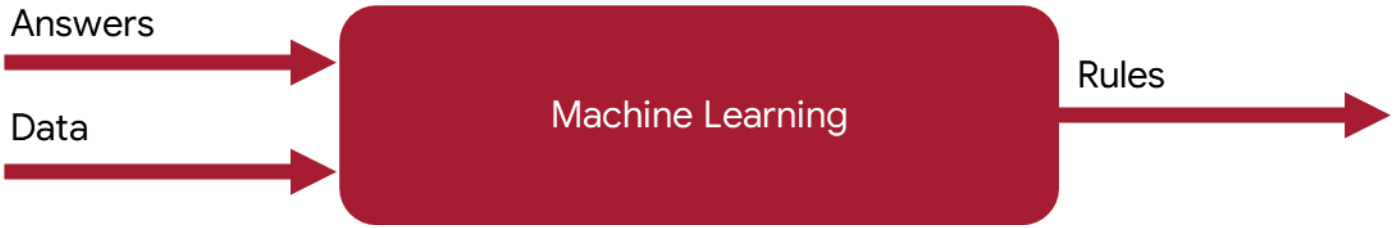
```
if(speed<4){
    status=WALKING;
} else {
    status=RUNNING;
}
```

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

```
// ???
```

THE MACHINE LEARNING PARADIGM

- The machine learning paradigm



THE MACHINE LEARNING PARADIGM

- The machine learning paradigm
  - Activity detection with machine learning

```
01010010101001010101
10010101010010111101
01001010100101010010
01010010101001010101
```

Label = WALKING

```
10101001010010101010
01010100100100100001
00100111111010101111
10101001001111010111
```

Label = RUNNING

```
10010100111110101010
11010101110101011110
10101011110101010111
11111110001111010101
```

Label = BIKING

```
11111111110100111010
00111111010111110101
01011101010101011110
10101010100111110
```

Label = GOLFING

THE MACHINE LEARNING PARADIGM

- The machine learning 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
```

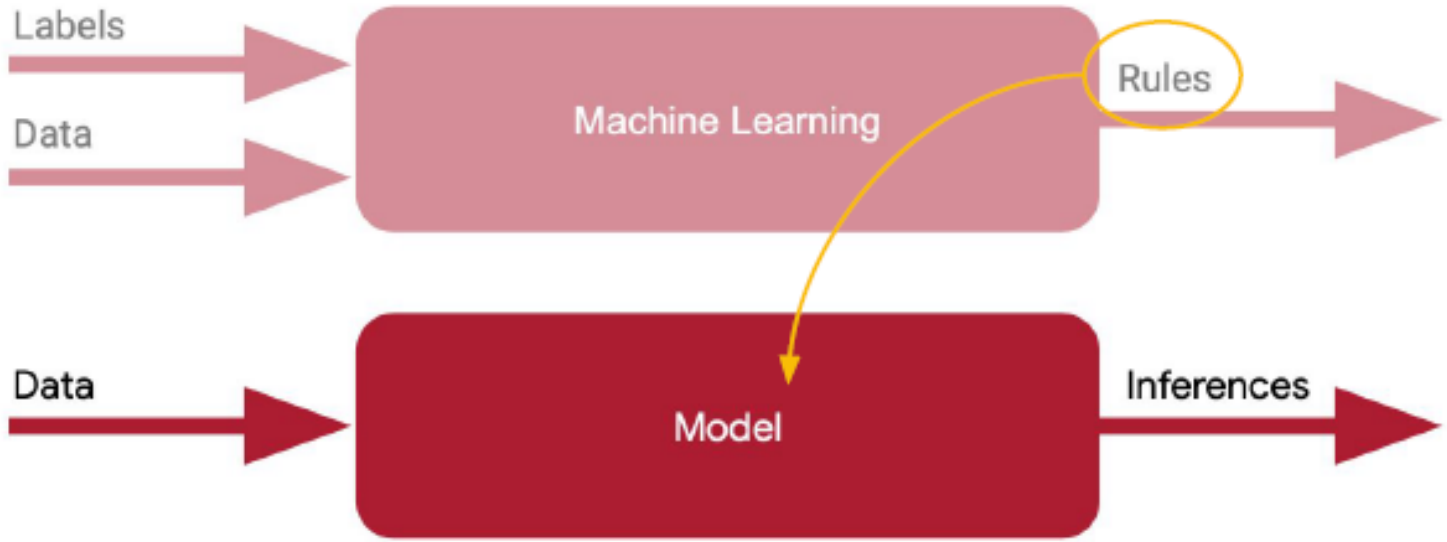
Label = GOLFING

THE MACHINE LEARNING PARADIGM

- The machine learning paradigm

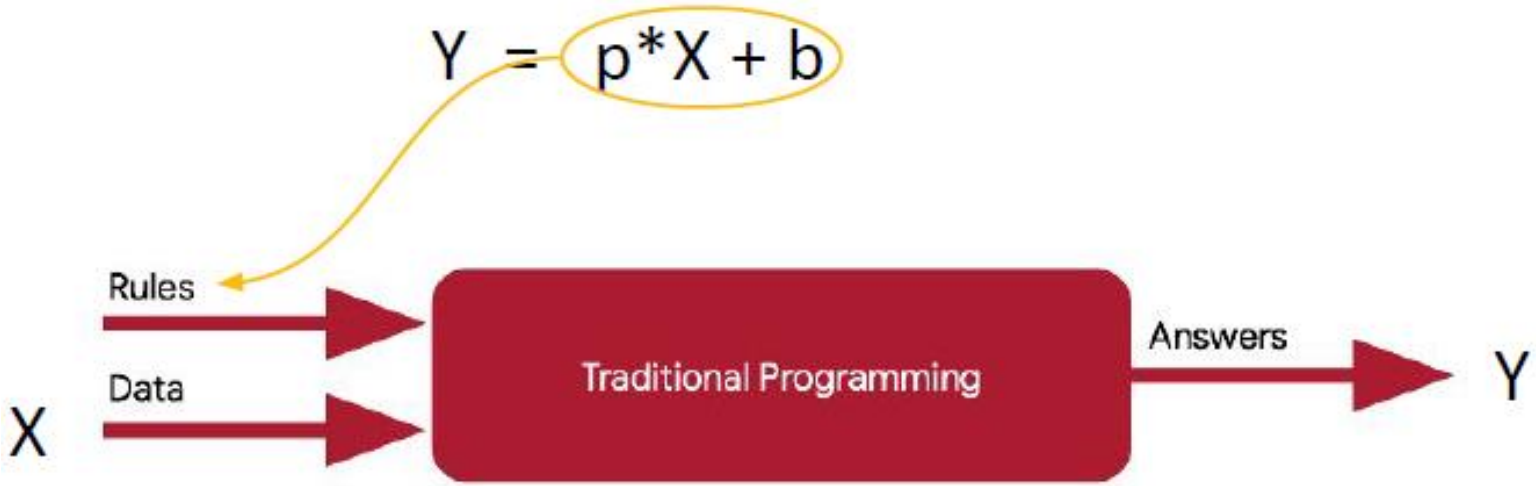
THE MACHINE LEARNING PARADIGM

- The machine learning paradigm



THE MACHINE LEARNING PARADIGM

- Loss
  - A way to measure your accuracy

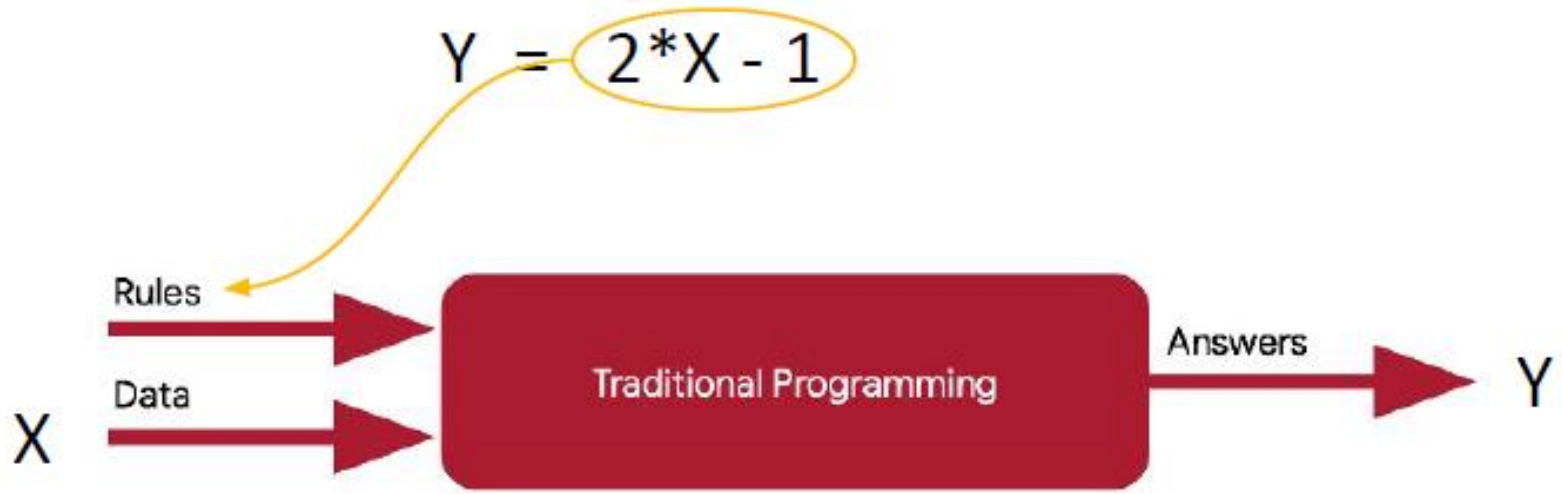


X = { -1, 0, 1, 2, 3, 4 }

Y = {?, ?, ? ,?, ?, ?}

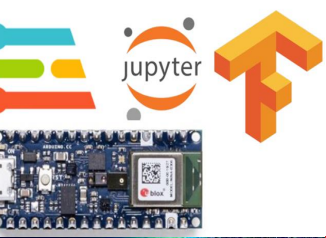
THE MACHINE LEARNING PARADIGM

- Loss
  - A way to measure your accuracy



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

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

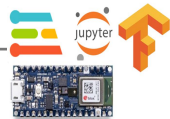


THE MACHINE LEARNING PARADIGM

- Loss
  - A way to measure your accuracy

Matching X to Y

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



THE MACHINE LEARNING PARADIGM

- Loss
  - A way to measure your accuracy

Matching X to Y

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

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

$Y = p*X + b$

THE MACHINE LEARNING PARADIGM

- Loss
  - A way to measure your accuracy

Matching X to Y

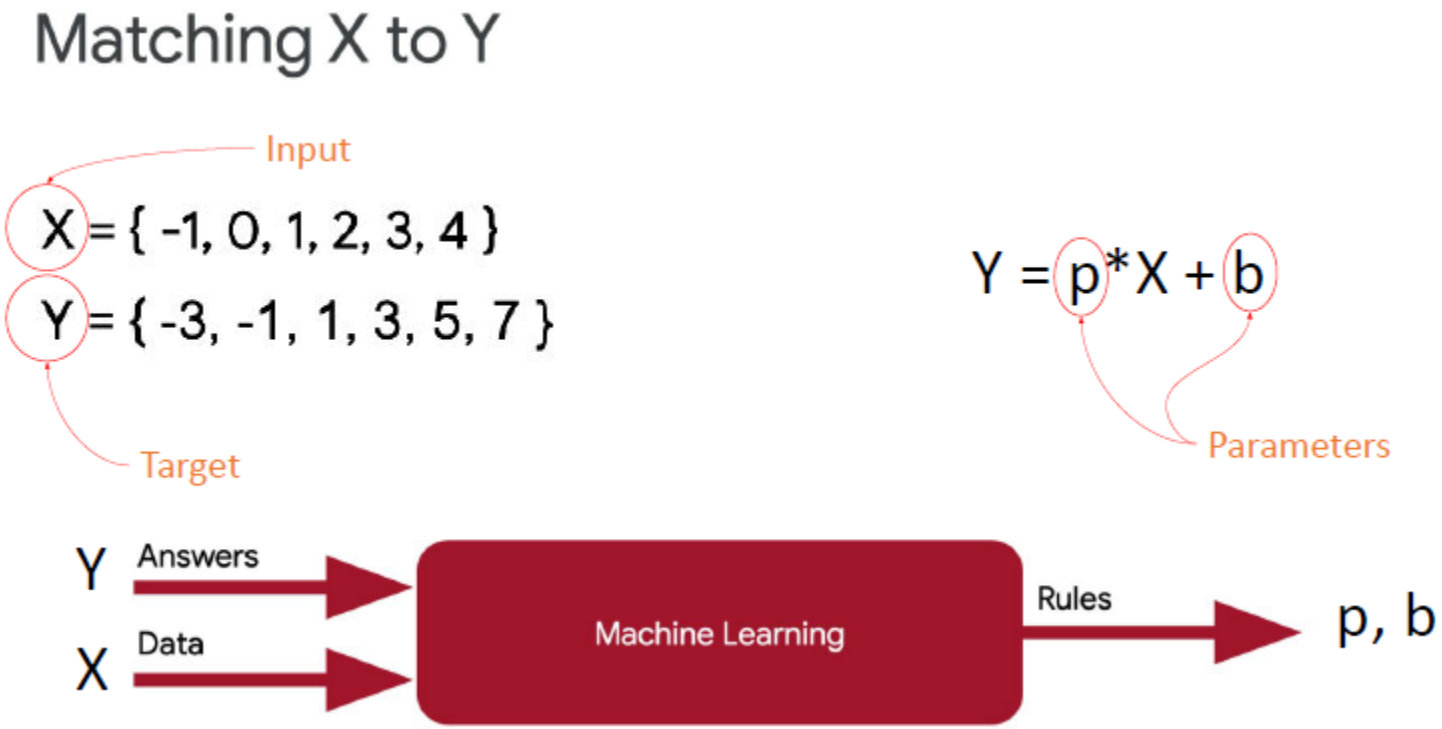
X = { -1, 0, 1, 2, 3, 4 }

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

$Y = p*X + b$

THE MACHINE LEARNING PARADIGM

- Loss
  - A way to measure your accuracy



THE MACHINE LEARNING PARADIGM

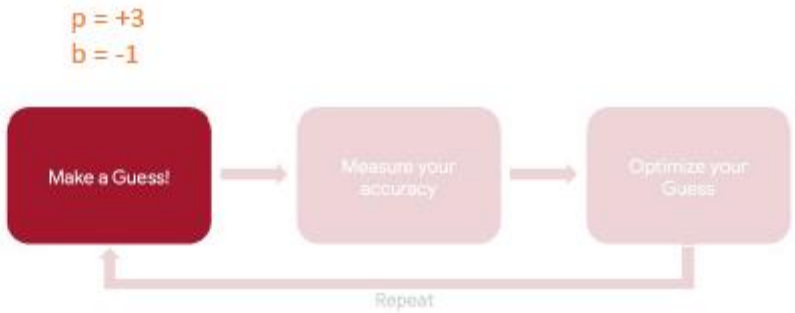
- Loss
  - A way to measure your accuracy

Make a guess! ("parameters' initialization")

Y = 3X - 1

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

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



THE MACHINE LEARNING PARADIGM

- Loss
  - A way to measure your accuracy

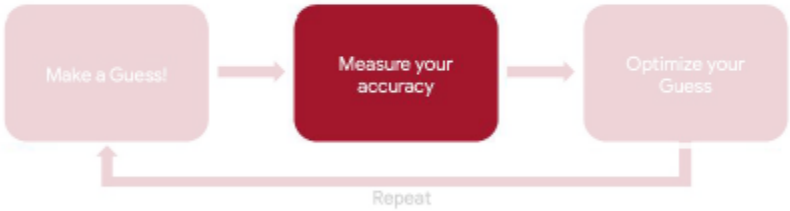
How good is the guess?

Y = 3X - 1

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

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

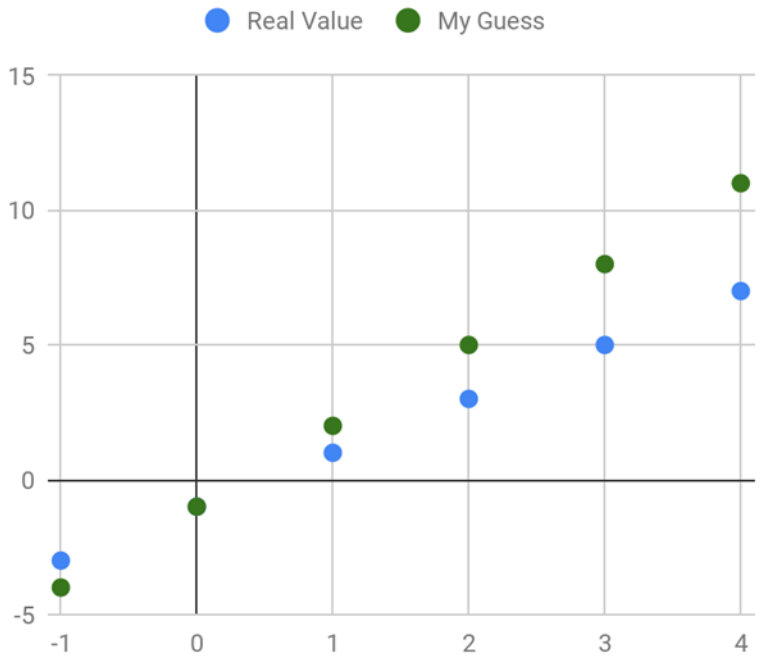
Real Y = { -3, -1, 1, 3, 5, 7 }



THE MACHINE LEARNING PARADIGM

- Loss
  - A way to measure your accuracy

Let's measure it!



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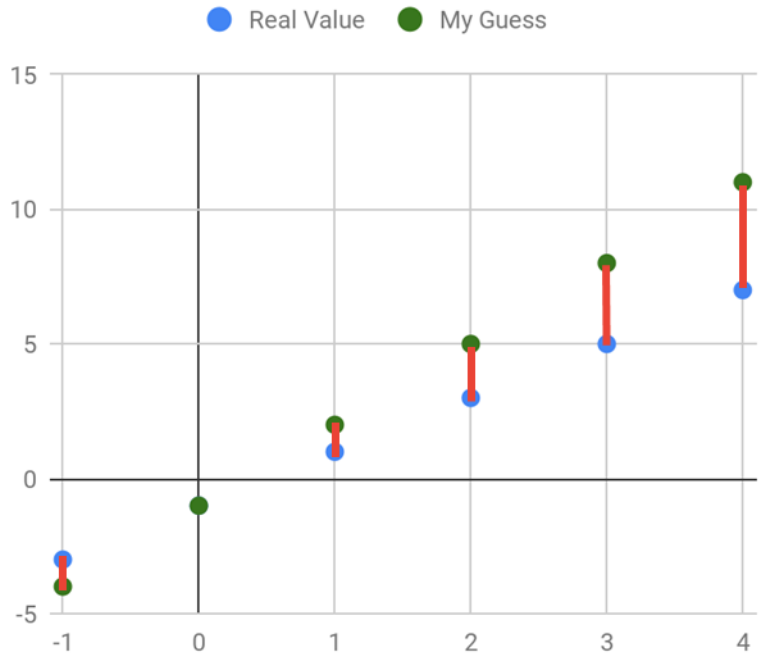

THE MACHINE LEARNING PARADIGM

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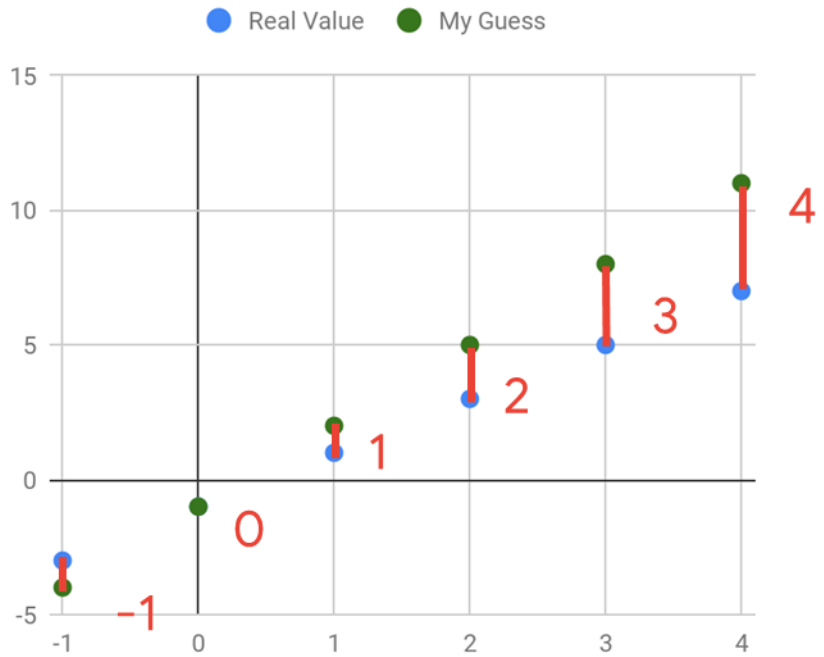
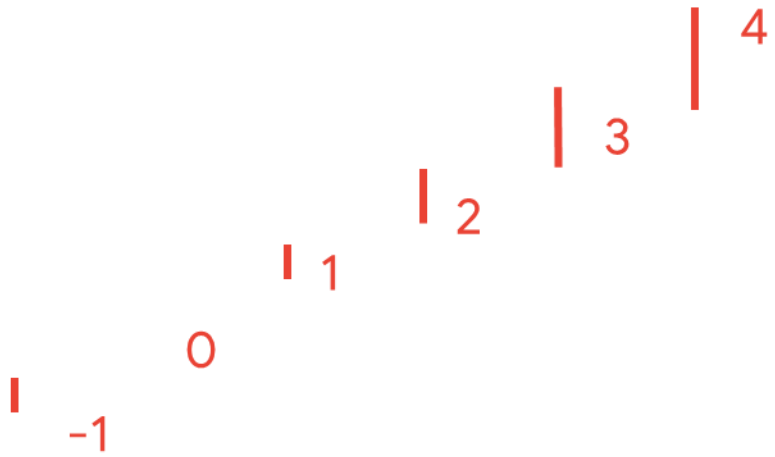


THE MACHINE LEARNING PARADIGM

- Loss
  - A way to measure your accuracy

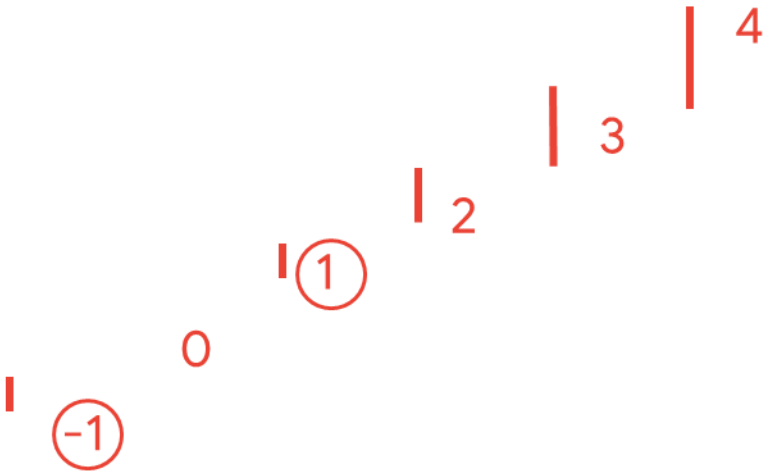
Let's measure it!



THE MACHINE LEARNING PARADIGM

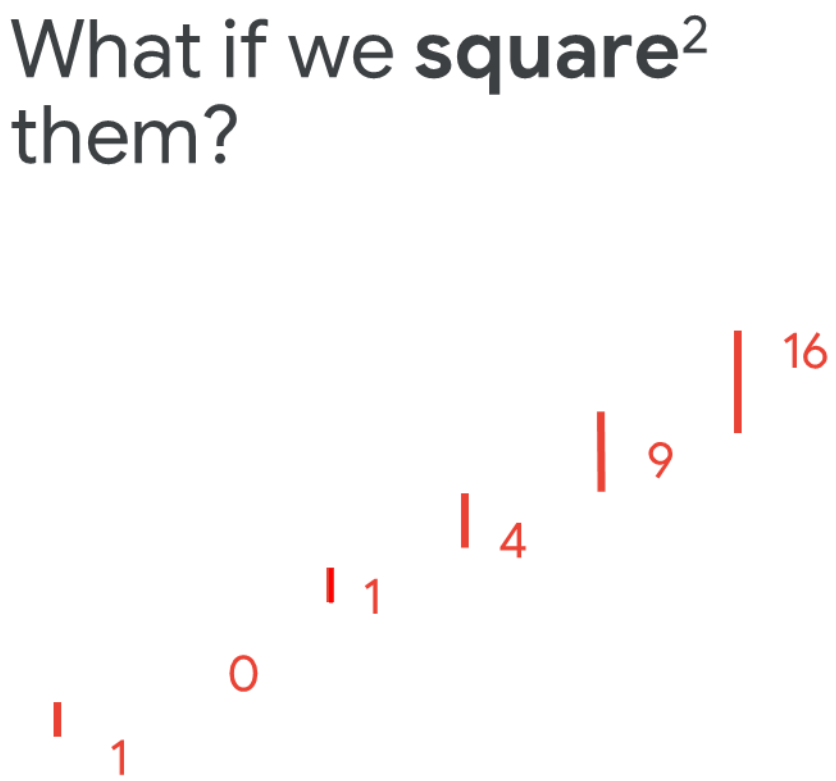
- Loss
  - A way to measure your accuracy

We have a problem!



THE MACHINE LEARNING PARADIGM

- Loss
  - A way to measure your accuracy



THE MACHINE LEARNING PARADIGM

- Loss
  - A way to measure your accuracy

Calculate de mean error:

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

= 5.17

THE MACHINE LEARNING PARADIGM

- Loss
  - A way to measure your accuracy

Make another guess!

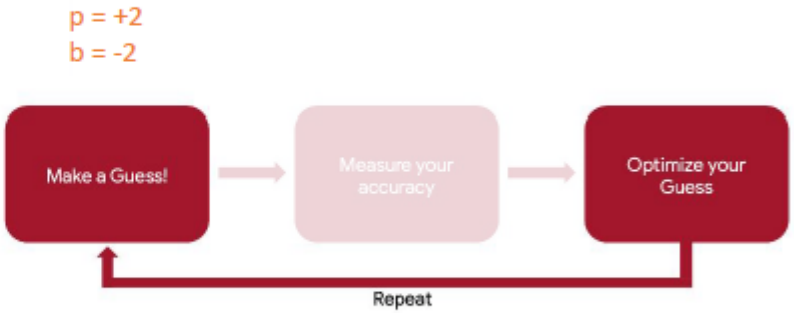
Y = 2X - 2

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}

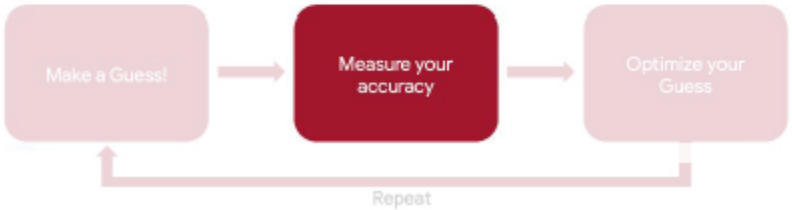


THE MACHINE LEARNING PARADIGM

- Loss
  - A way to measure your accuracy

Get the same difference, repeat the same process.

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



THE MACHINE LEARNING PARADIGM

- Loss
  - A way to measure your accuracy

Make another guess!

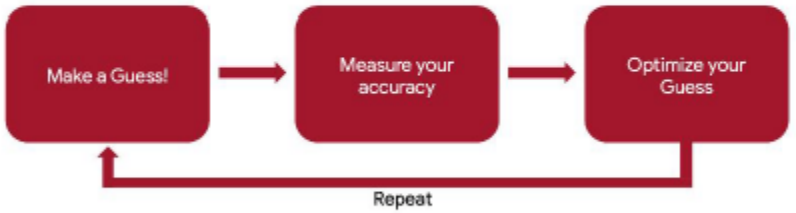
Y = 2X - 1

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}



THE MACHINE LEARNING PARADIGM

- Loss
  - A way to measure your accuracy

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}

THE MACHINE LEARNING PARADIGM

- Loss
  - A way to measure your accuracy

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

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

Mean Squared Error: Goal: Minimum as possible!

THE MACHINE LEARNING PARADIGM

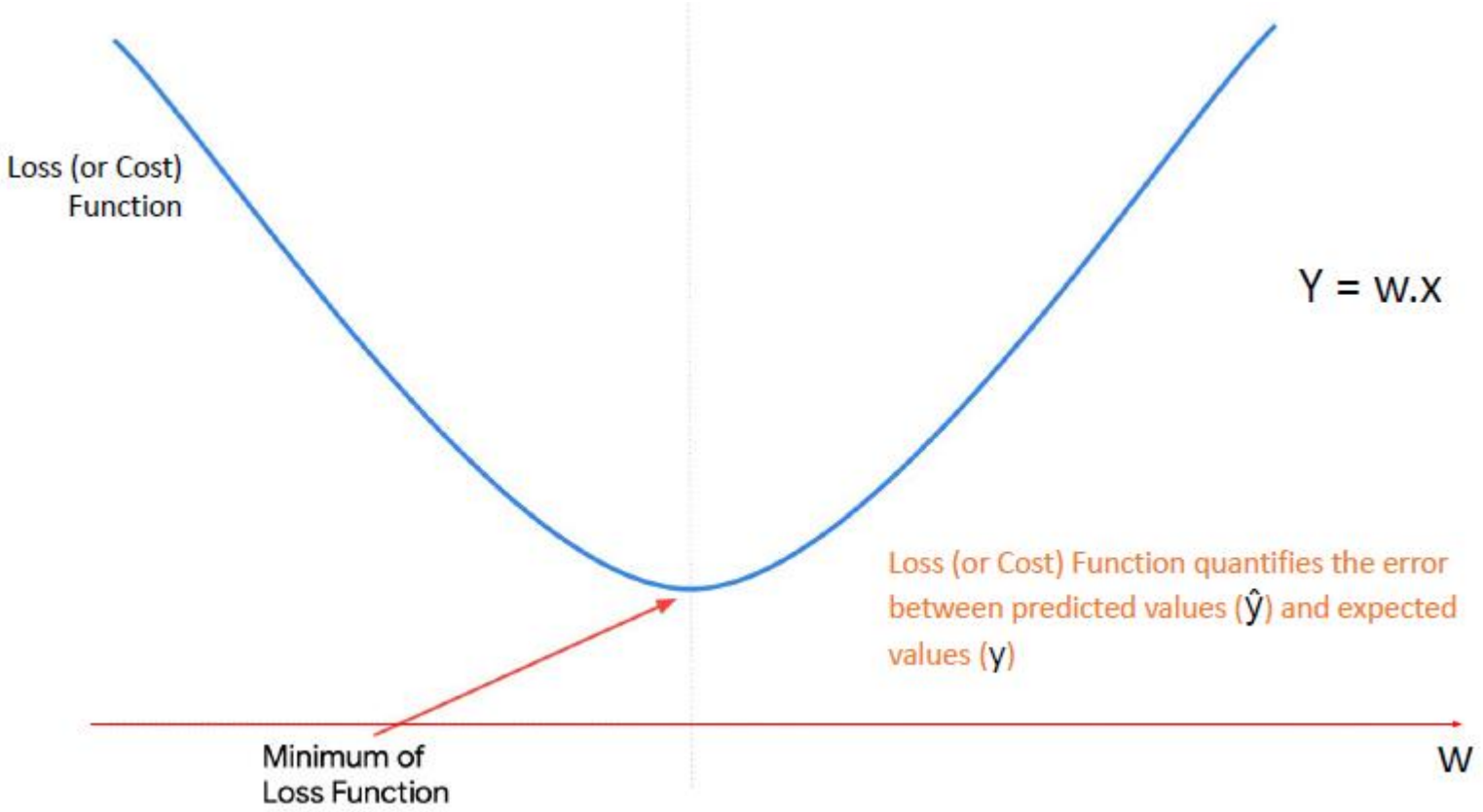
- Loss
  - A way to measure your accuracy

Exploring Loss and Cost Function

Code Time!

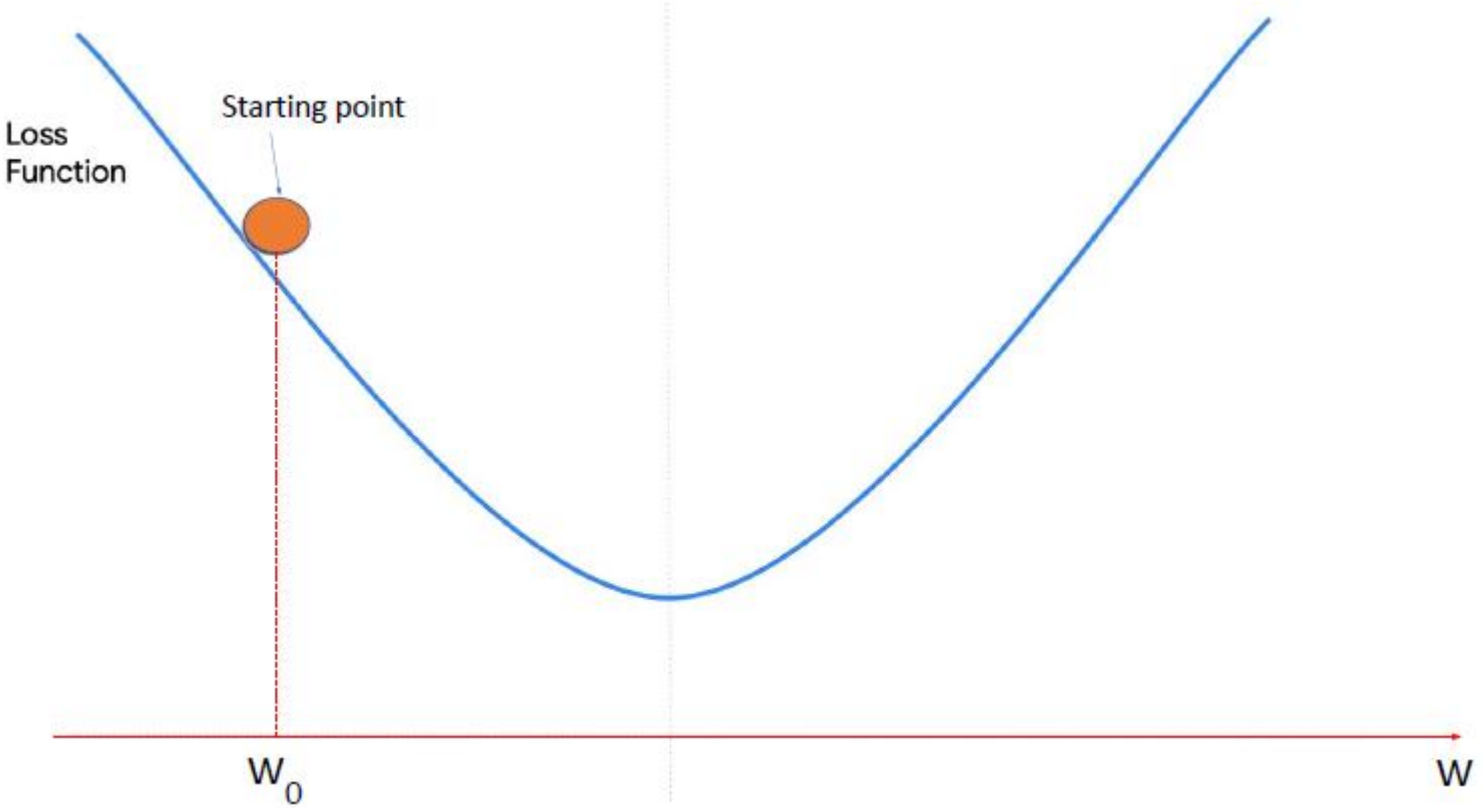
THE MACHINE LEARNING PARADIGM

- Minimizing loss



THE MACHINE LEARNING PARADIGM

- Minimizing loss



THE MACHINE LEARNING PARADIGM

- Minimizing loss

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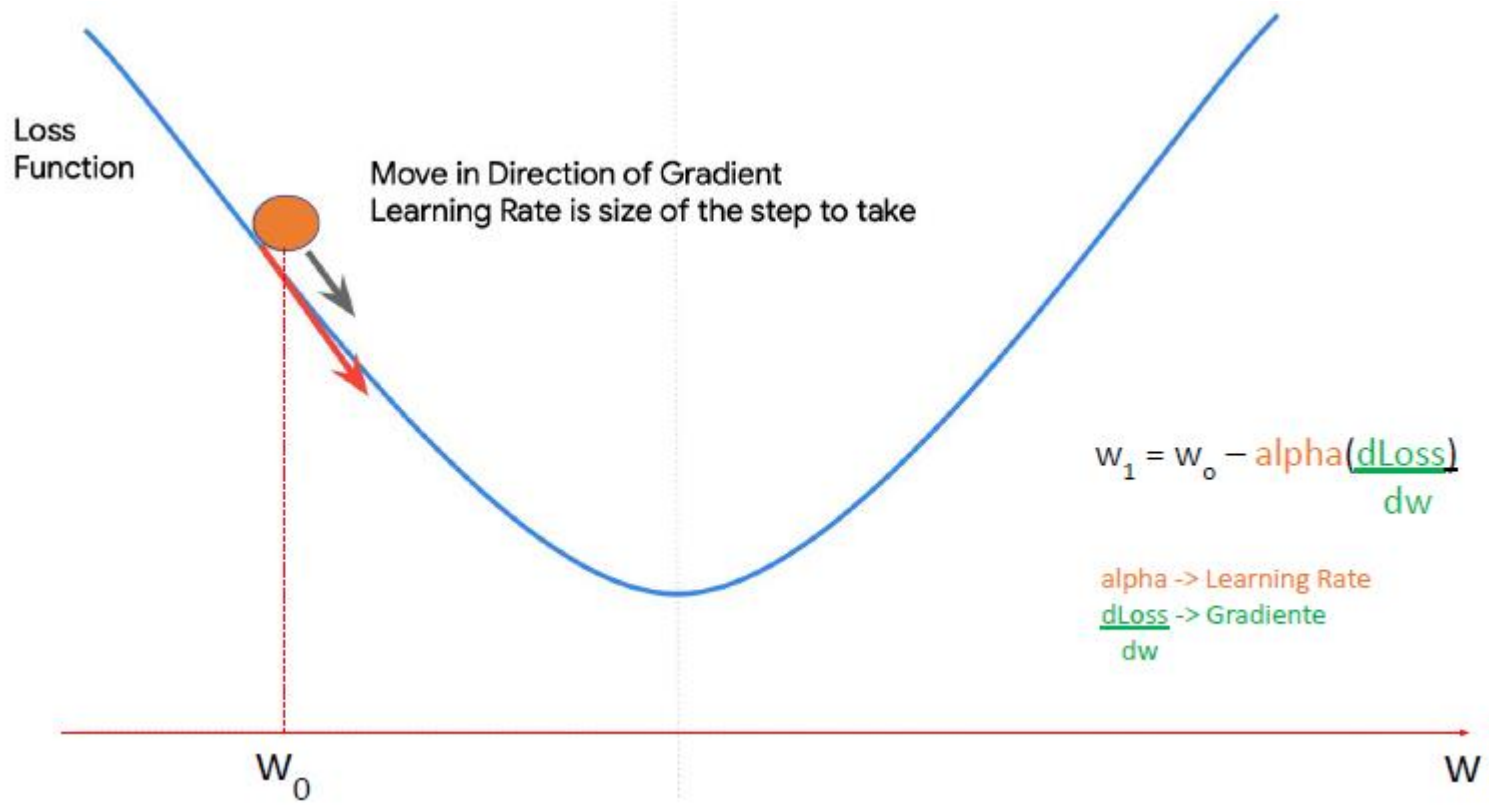
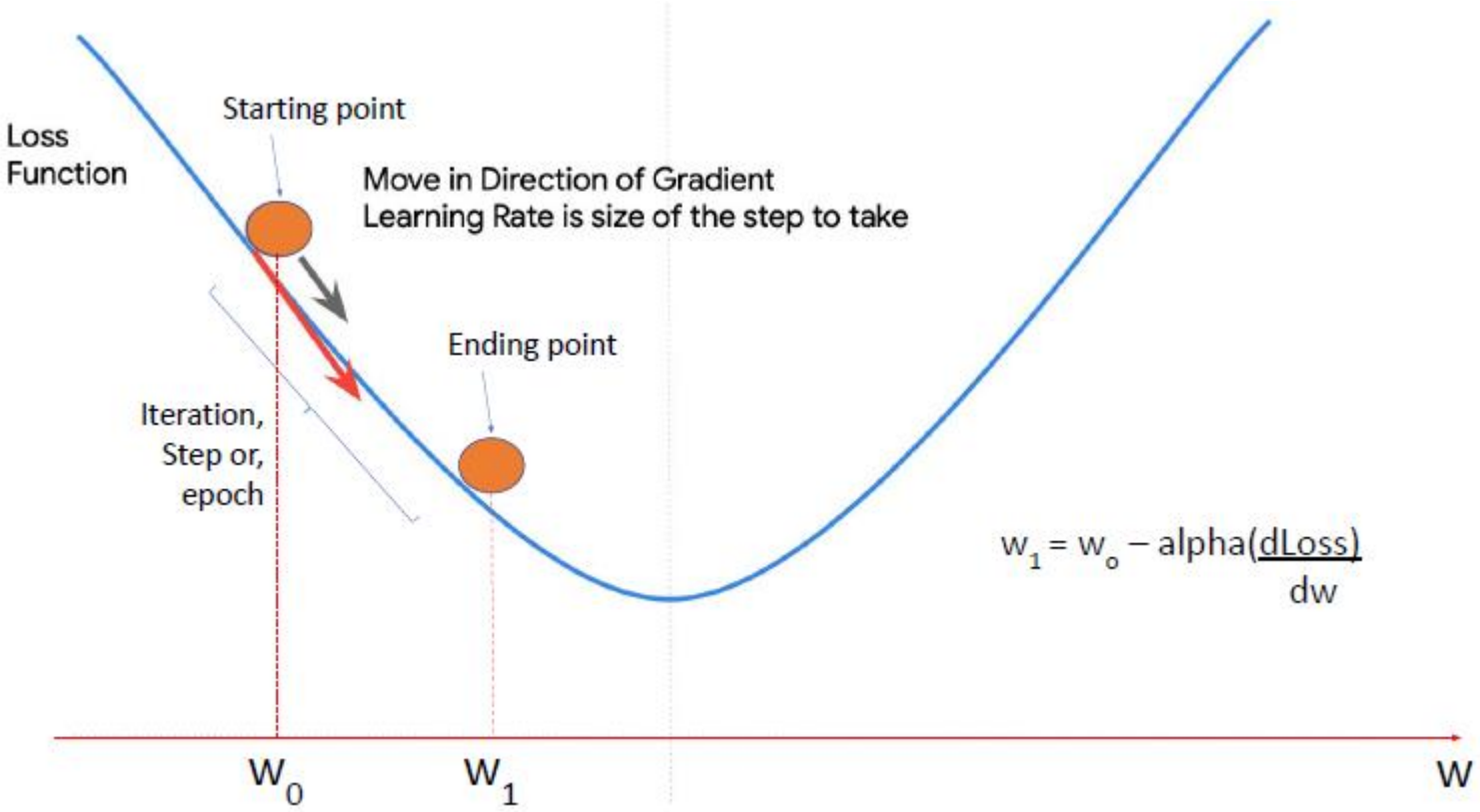
- Minimizing loss



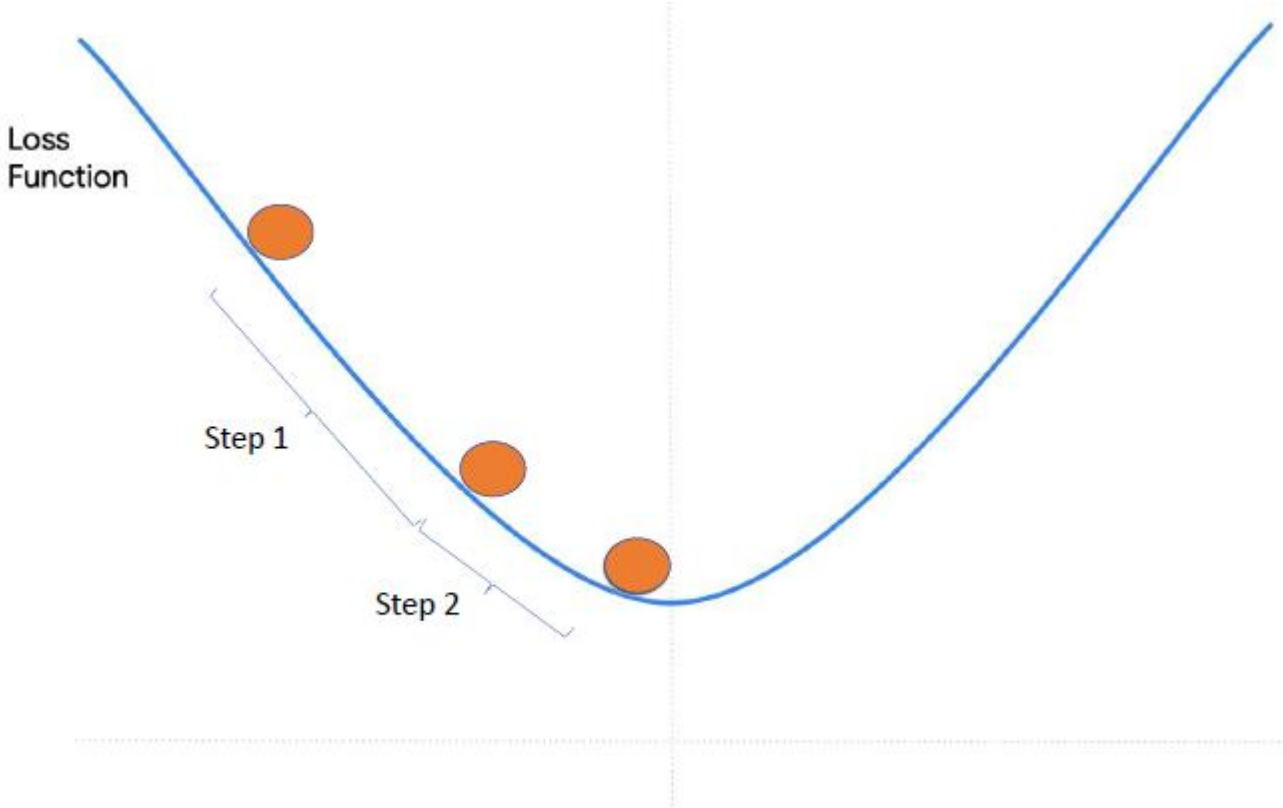
THE MACHINE LEARNING PARADIGM

- Minimizing loss



THE MACHINE LEARNING PARADIGM

- Minimizing loss

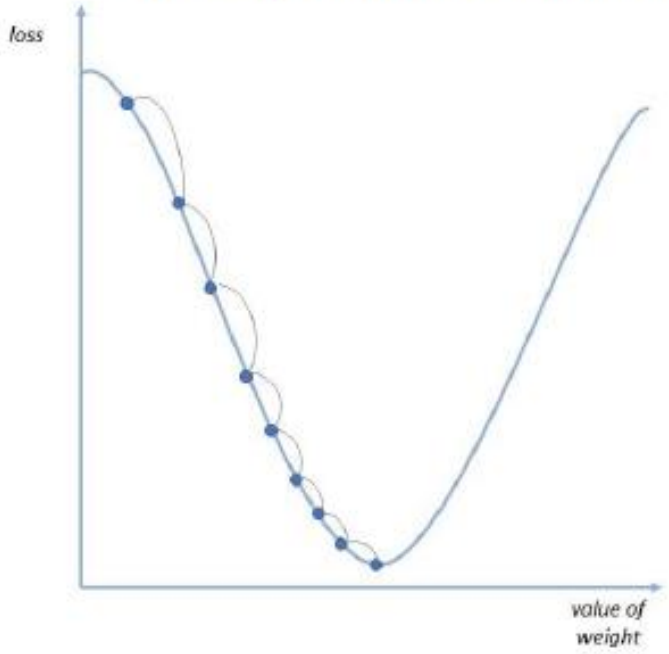


THE MACHINE LEARNING PARADIGM

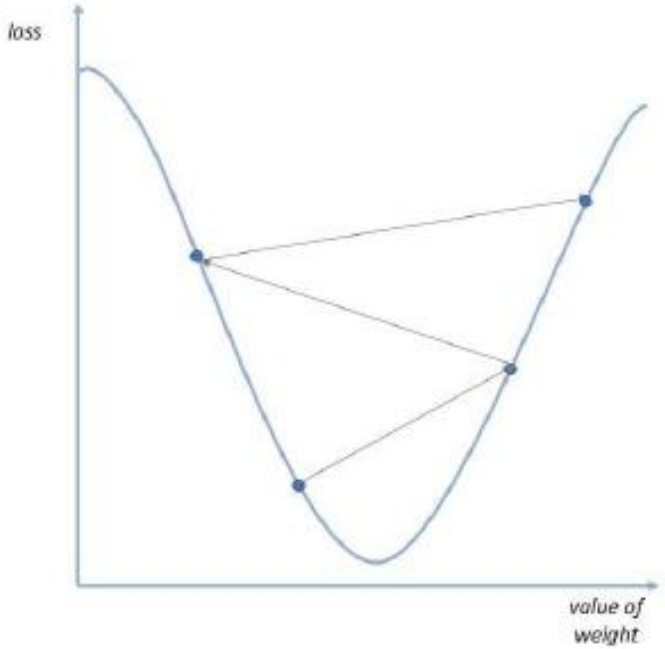
- Minimizing loss

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



THE MACHINE LEARNING PARADIGM

- The machine learning paradigm

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- The machine learning paradigm