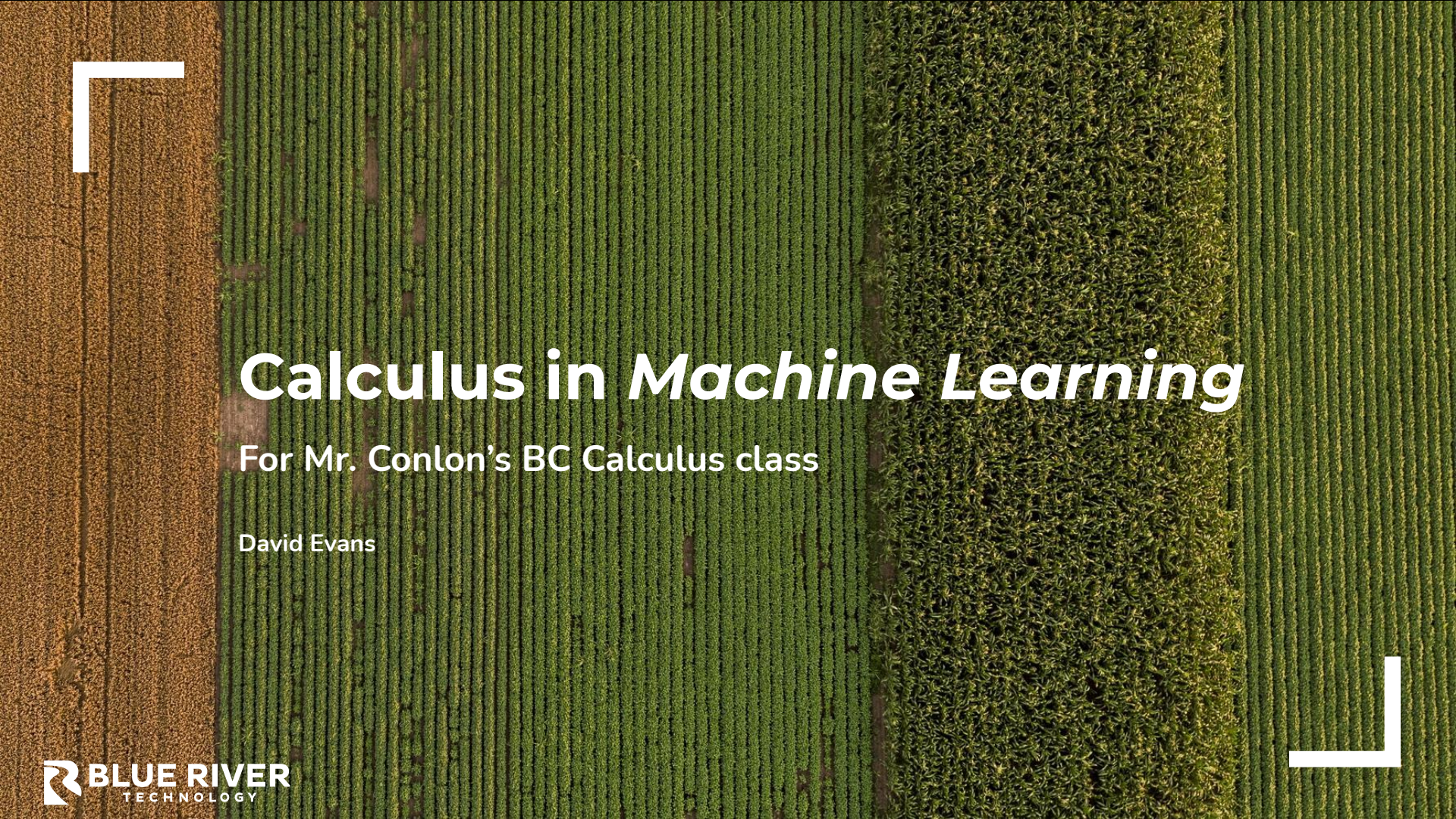


Calculus in *Machine Learning*

For Mr. Conlon's BC Calculus class

David Evans

BLUE RIVER TECHNOLOGY


mr. conlon
Groton-Dunstable Regional High School
me
ms. ordemann

My timeline so far...

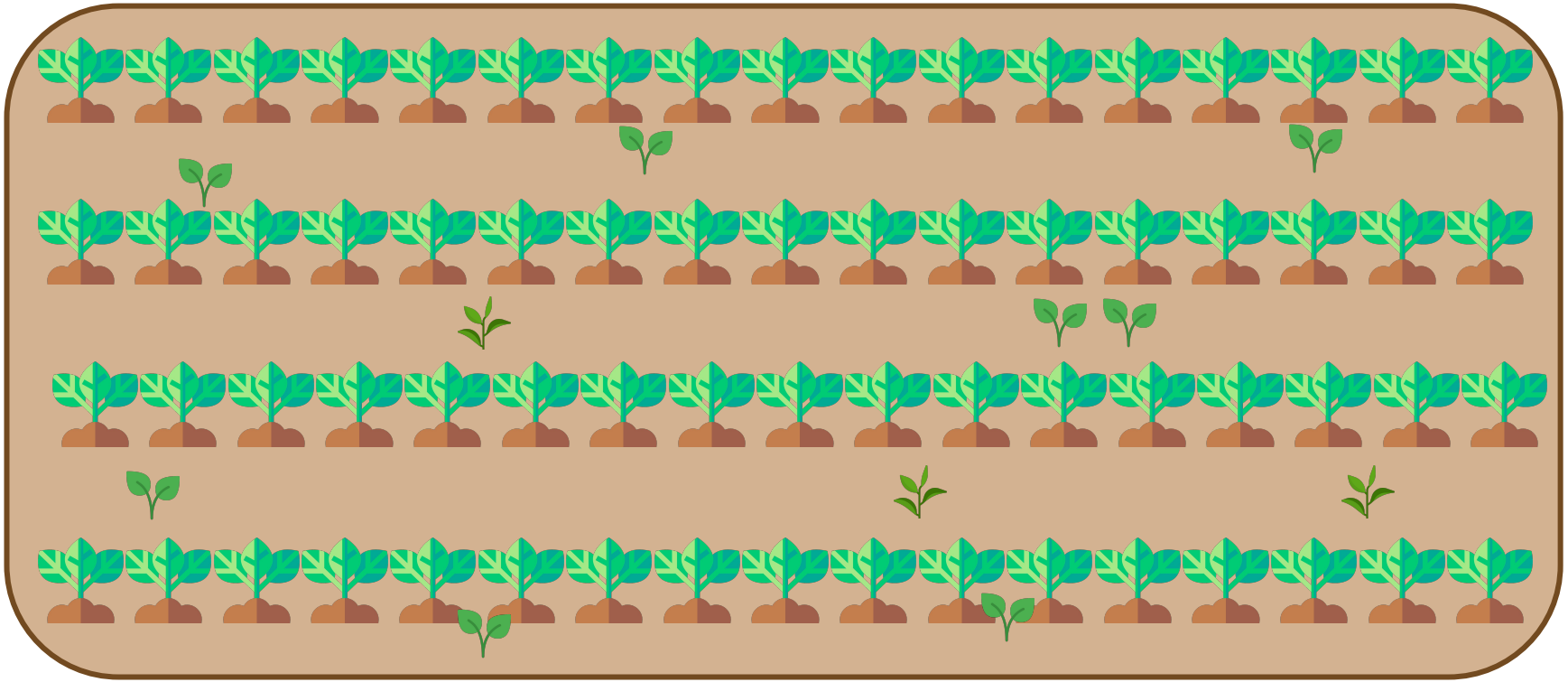
Graduated in 2013

Bachelors in Electrical Engineering

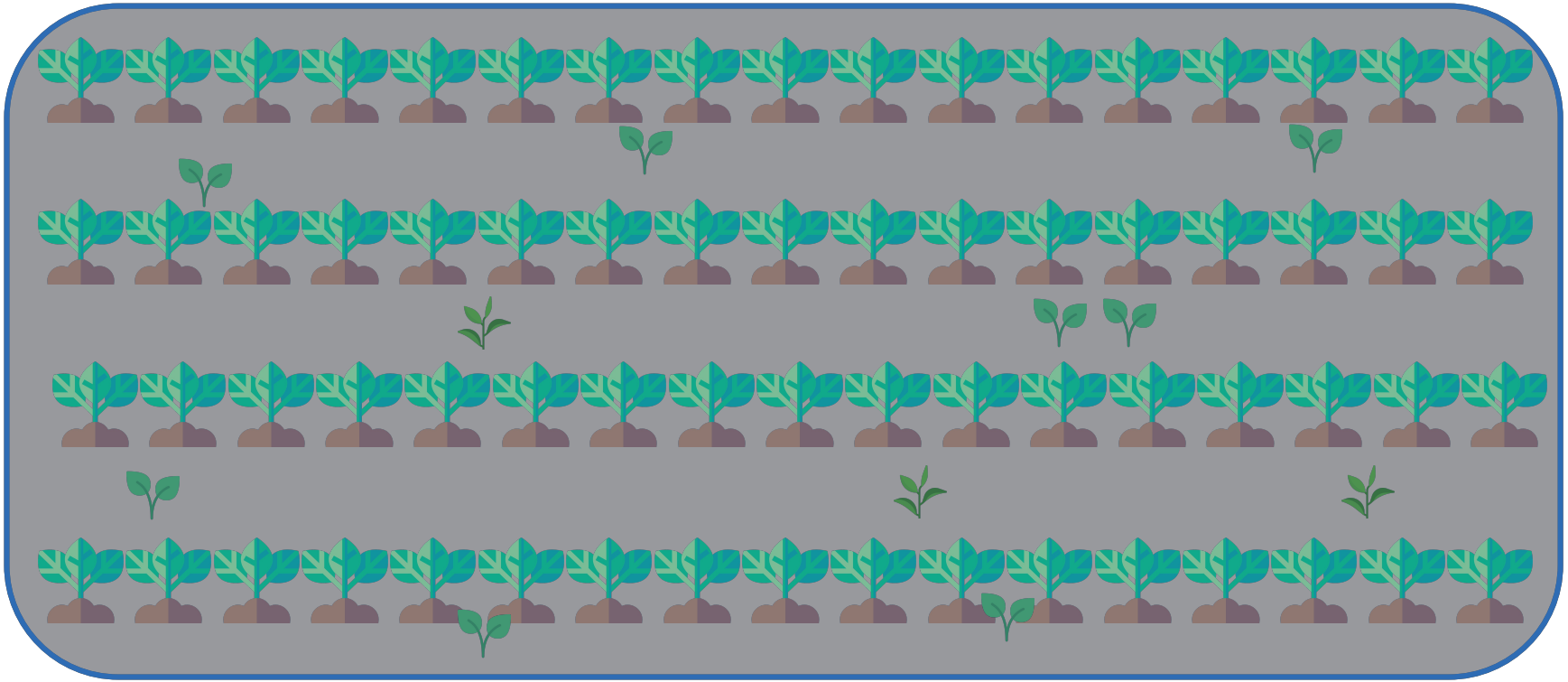
Masters in Robotics

In San Francisco, California

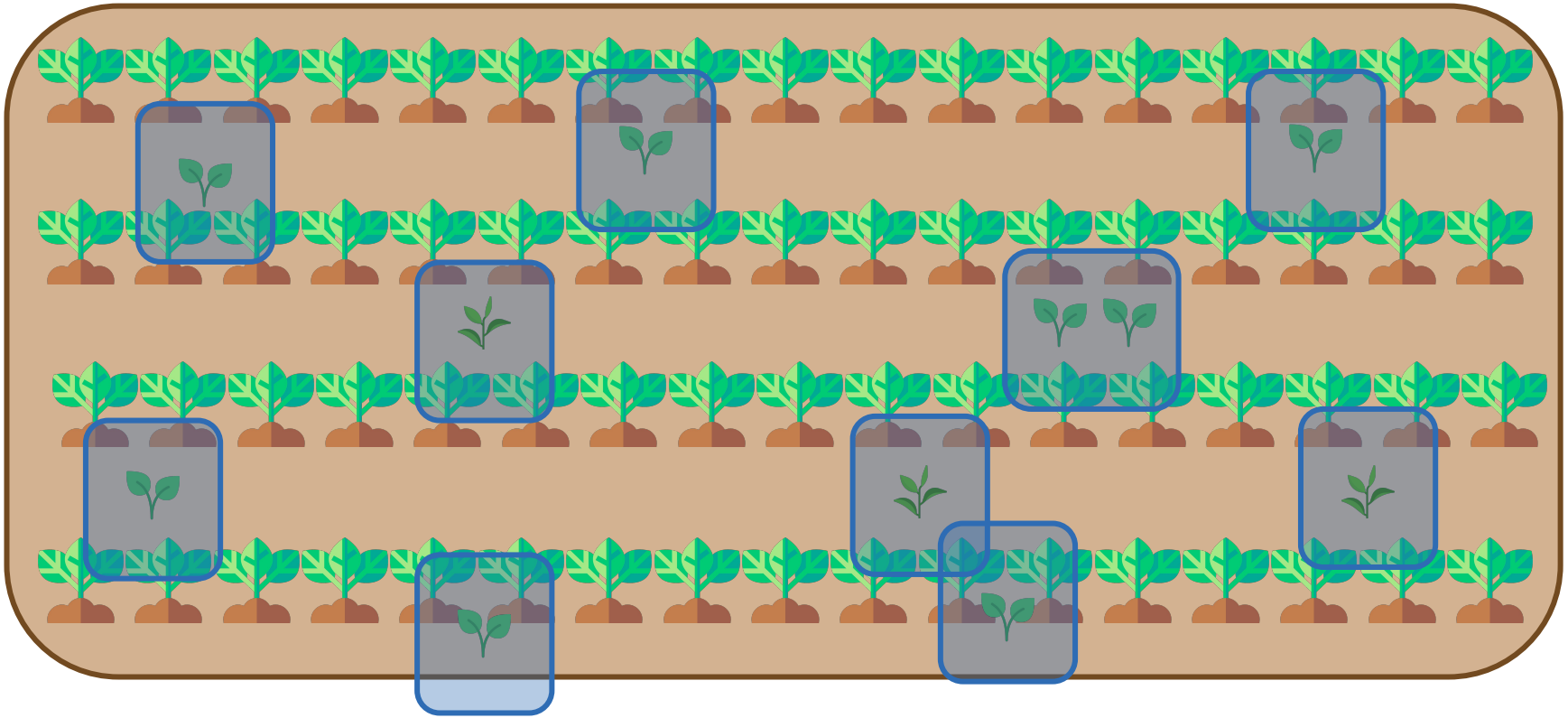
Farmers have to kill weeds in their fields



Today they broadcast their field...



What if we just sprayed the weeds?



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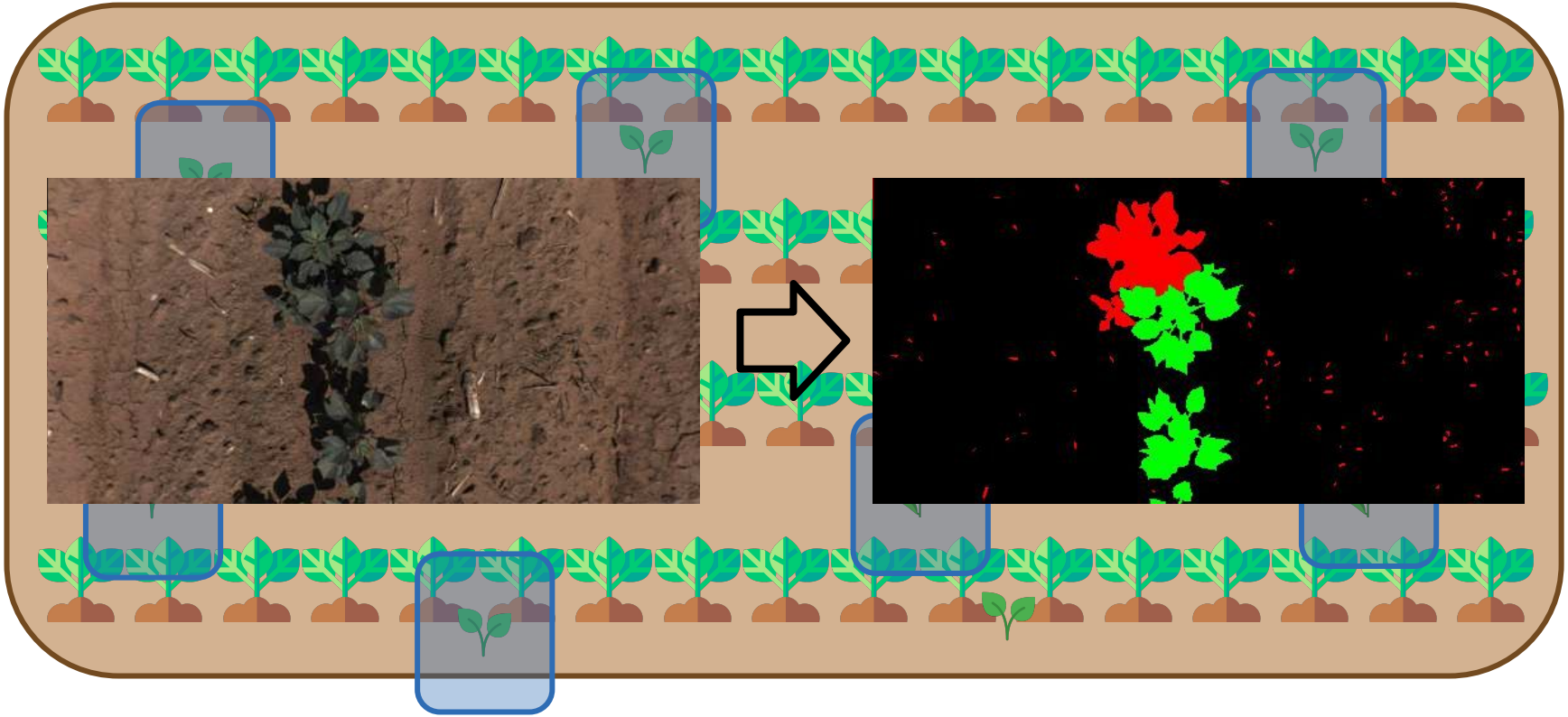
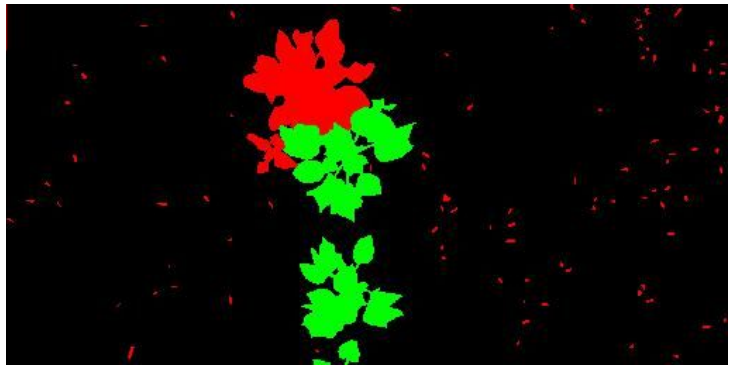


How do we do this???



How do we do this???

What is machine learning?

Machine learning: Computers using data(pattern recognition) to map an input to an output.

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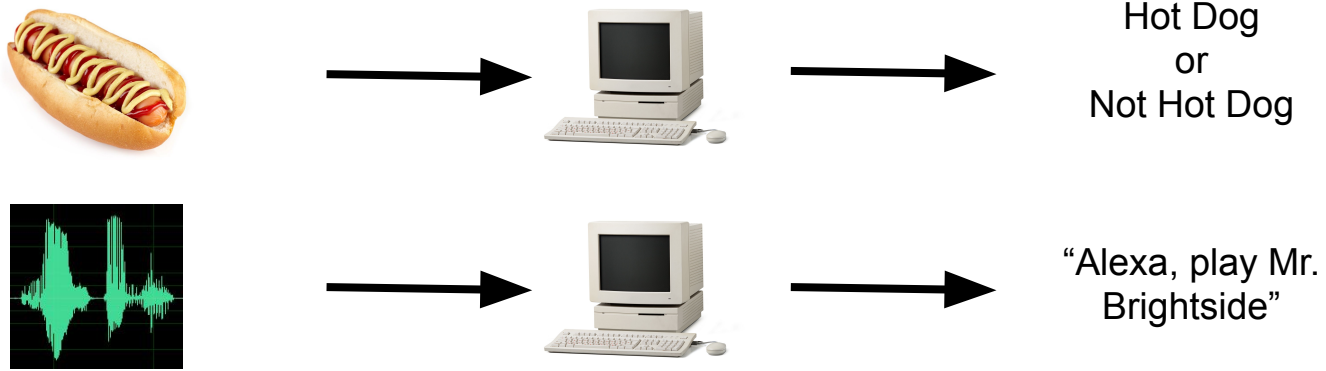

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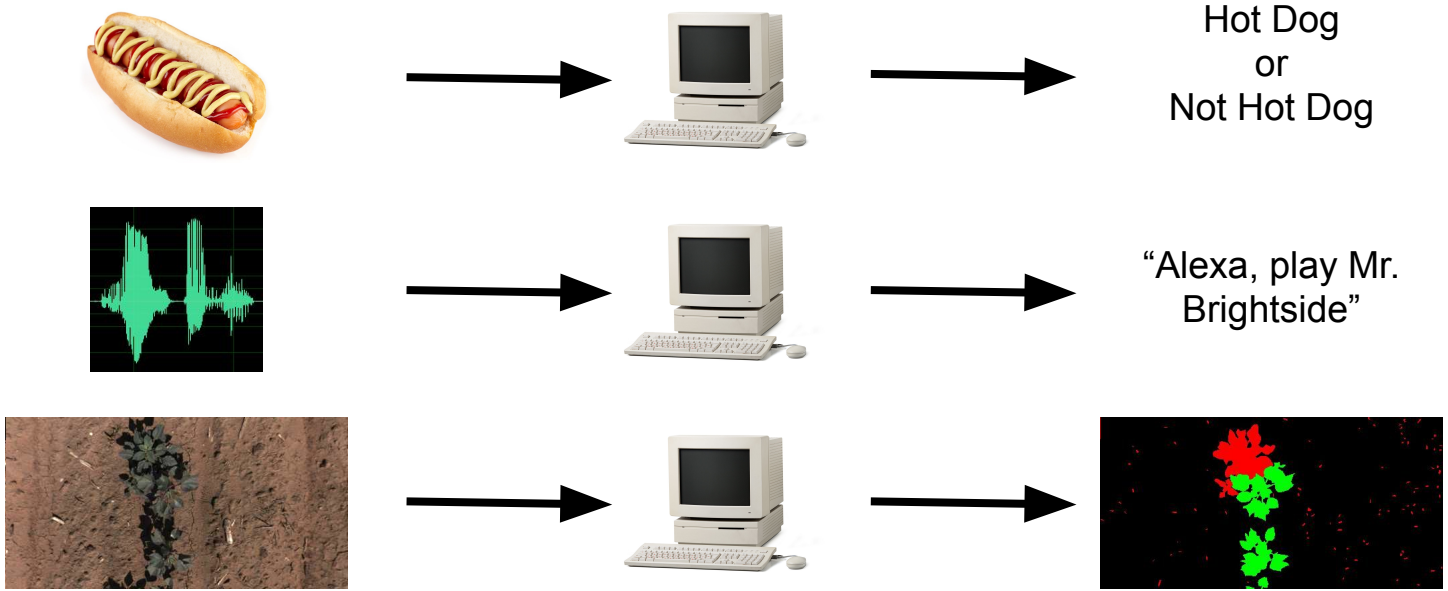
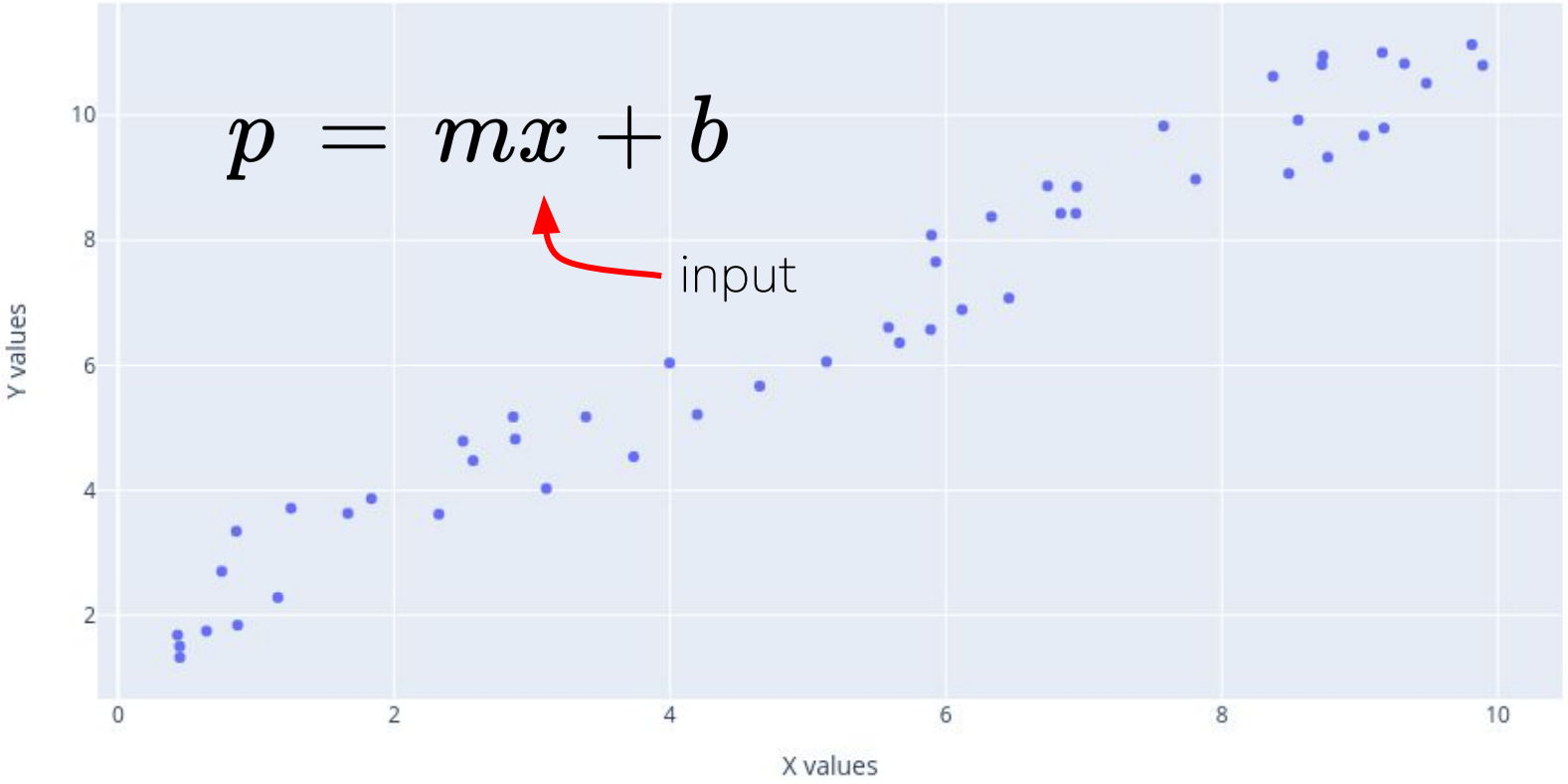
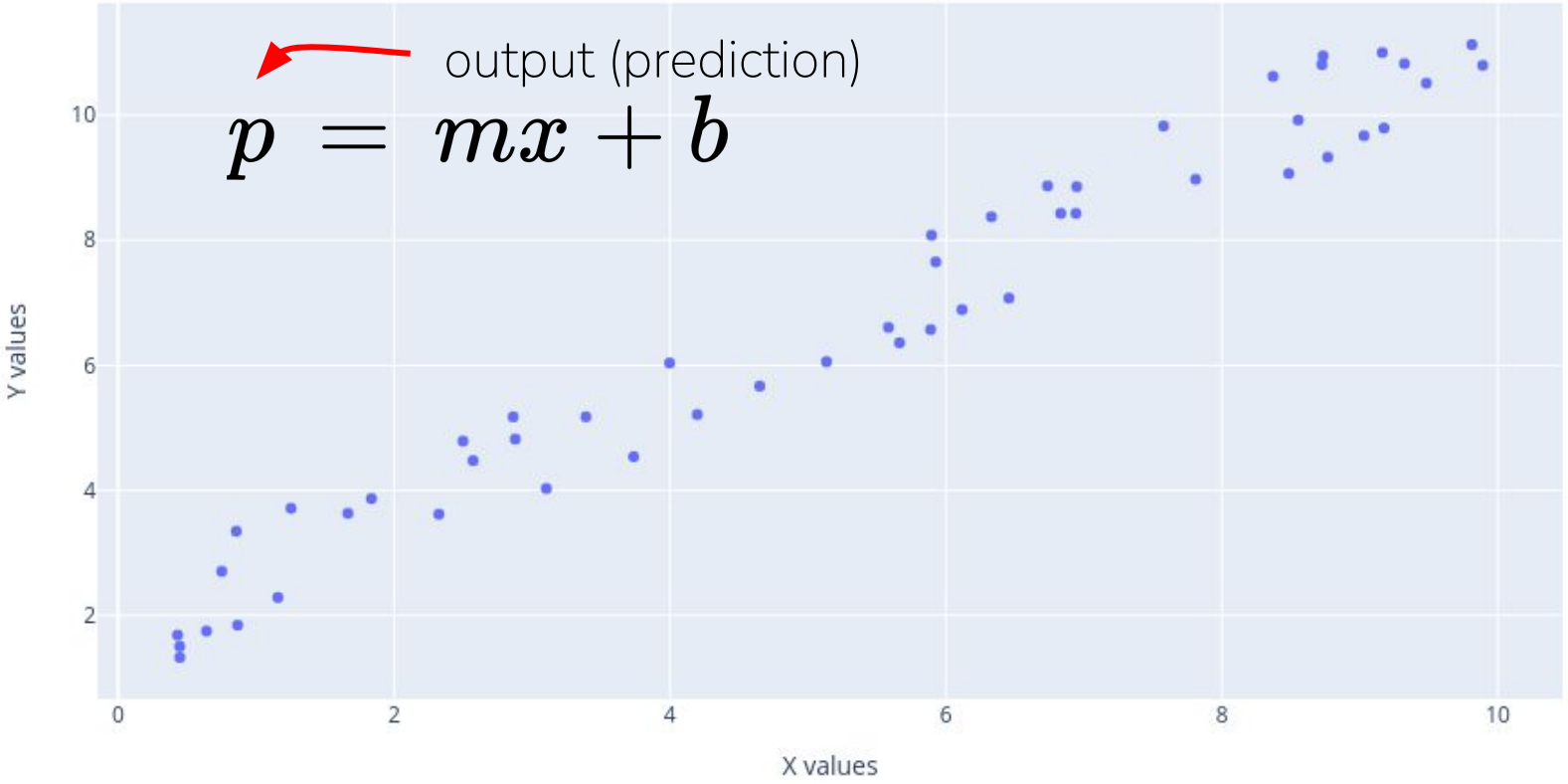


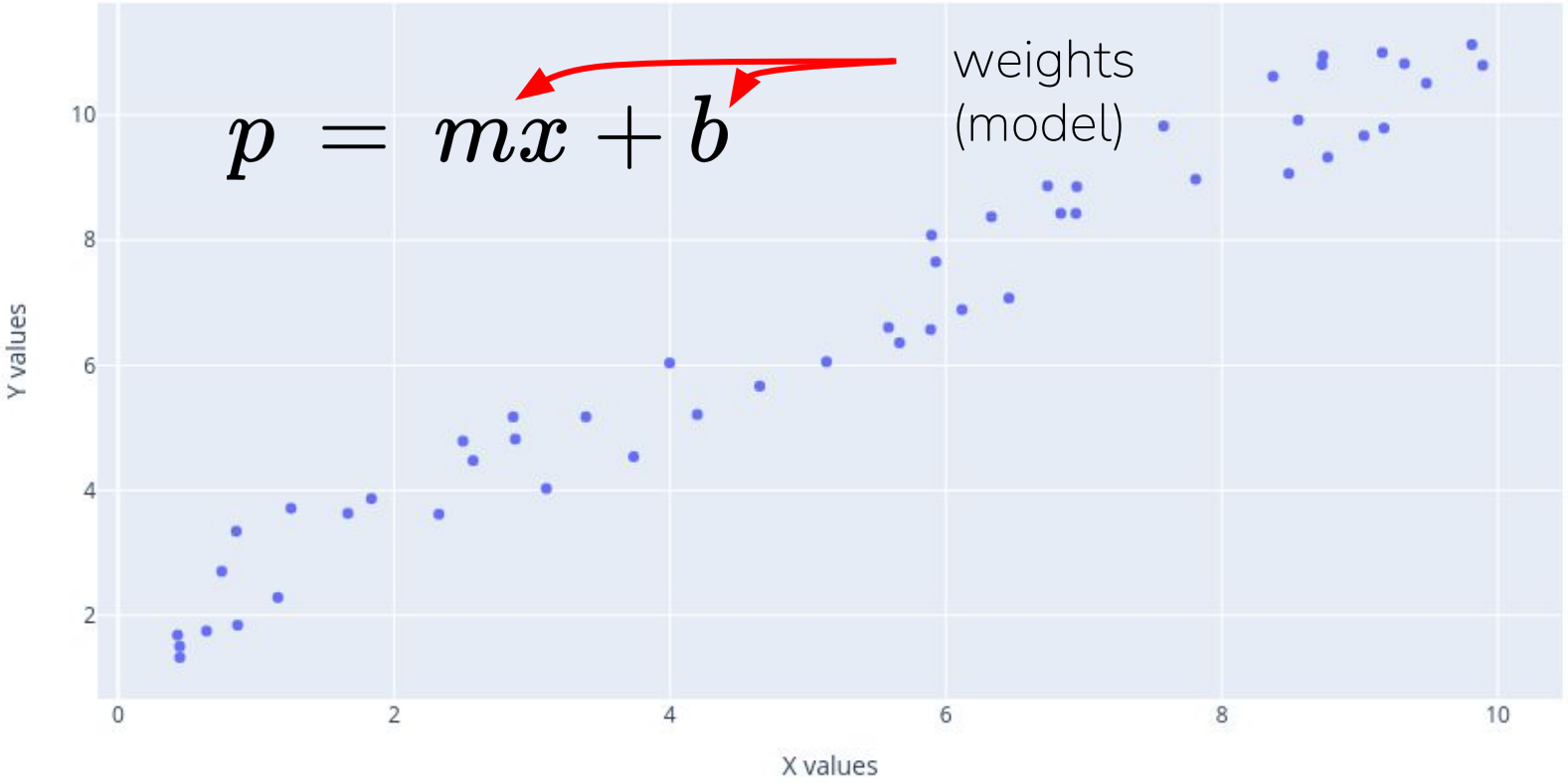
Let's **learn** a simple function



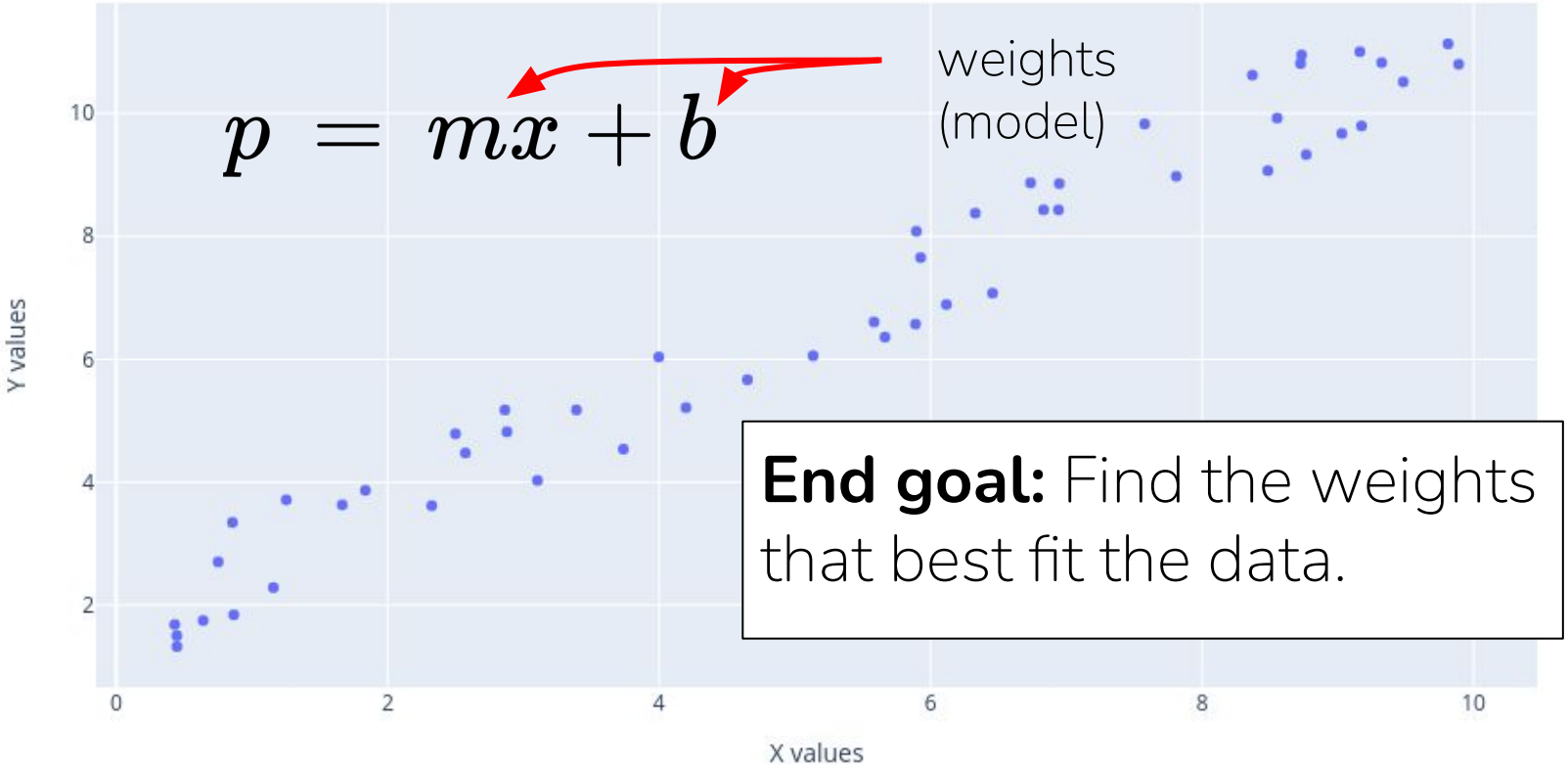
Let's **learn** a simple function



Let's **learn** a simple function



Let's **learn** a simple function

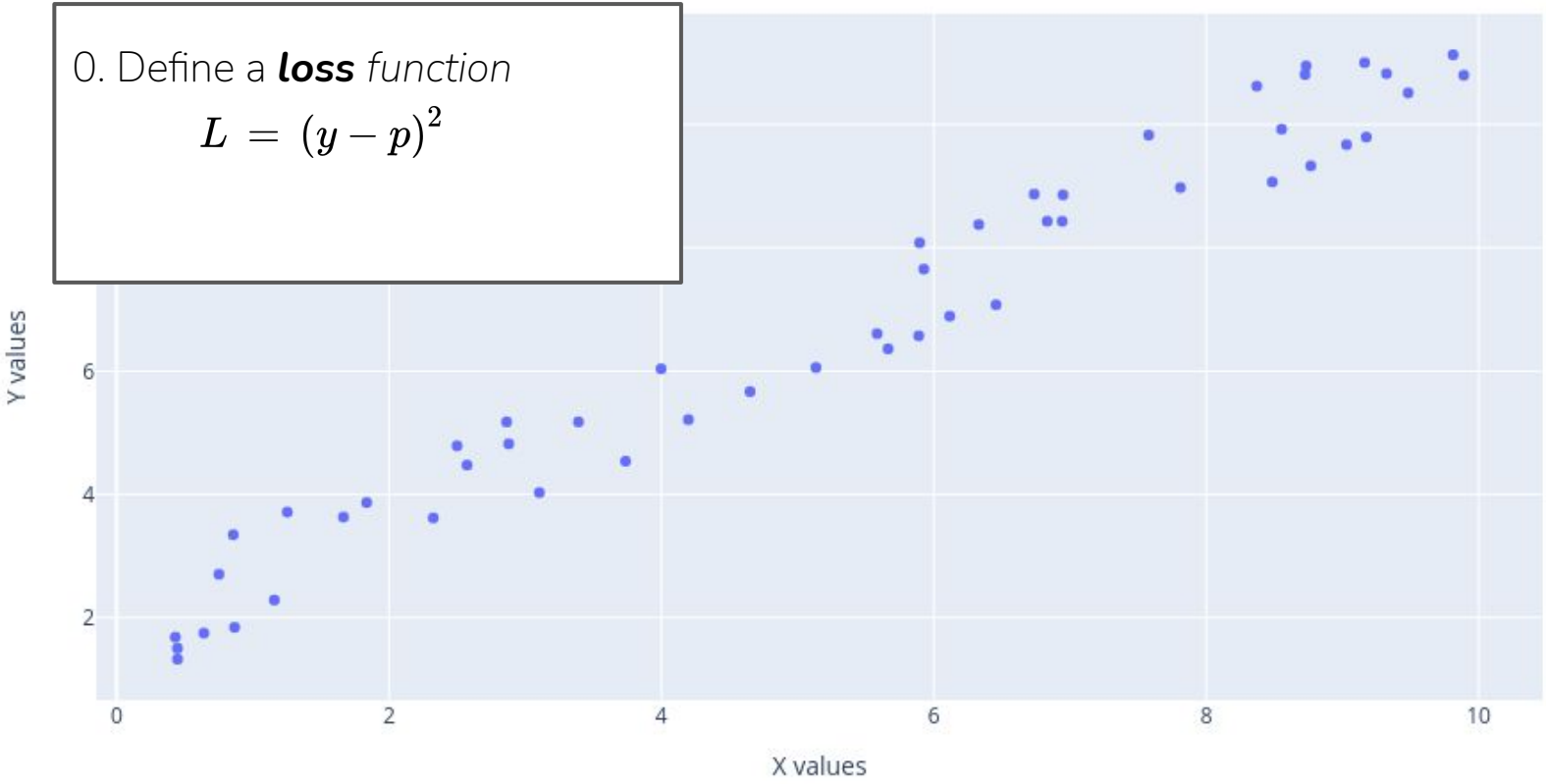


End goal: Find the weights that best fit the data.

How to train a model:

0. Define a ***loss*** *function*

$$L = (y - p)^2$$

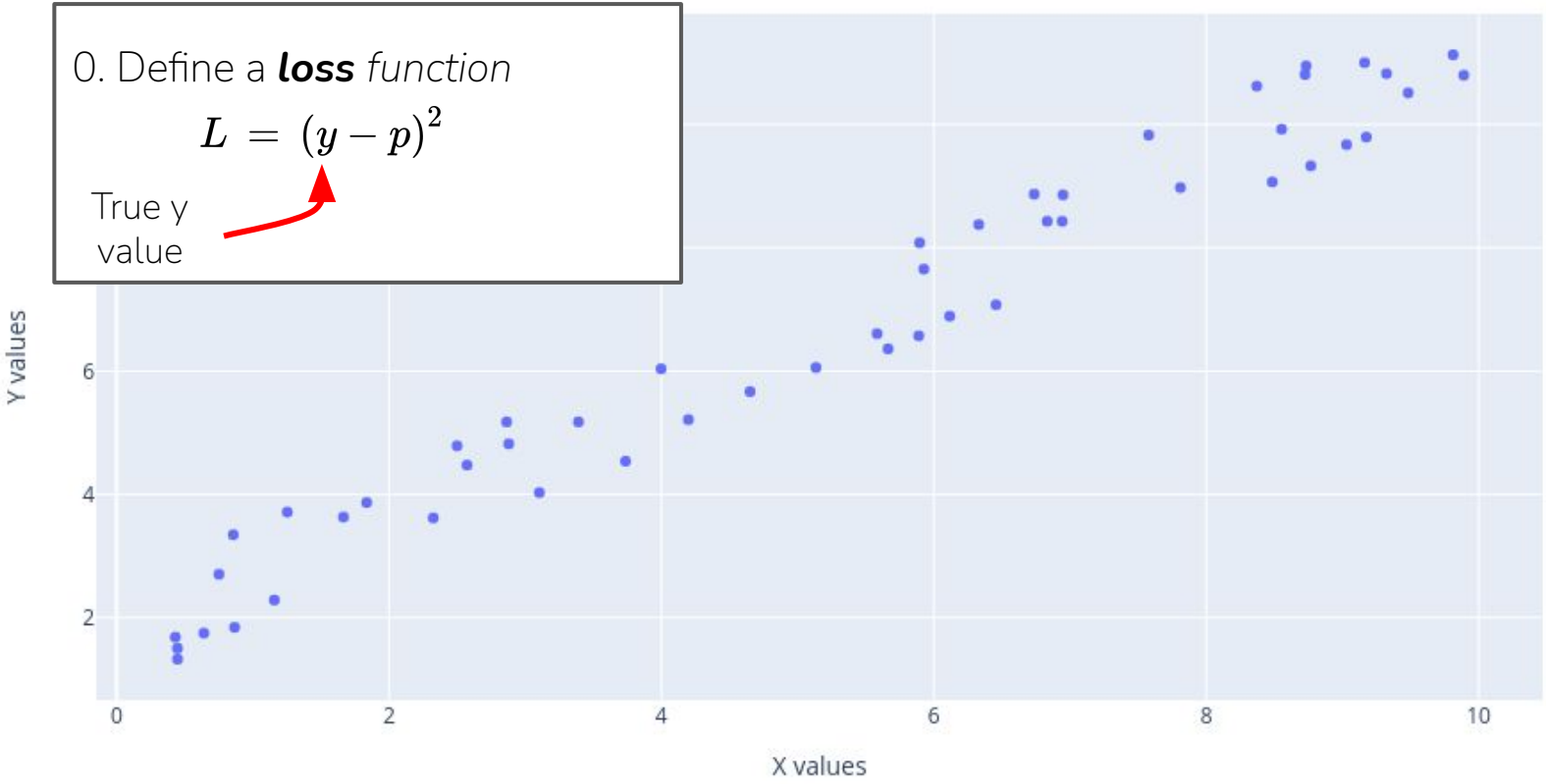


How to train a model:

0. Define a ***loss*** *function*

$$L = (y - p)^2$$

True y value

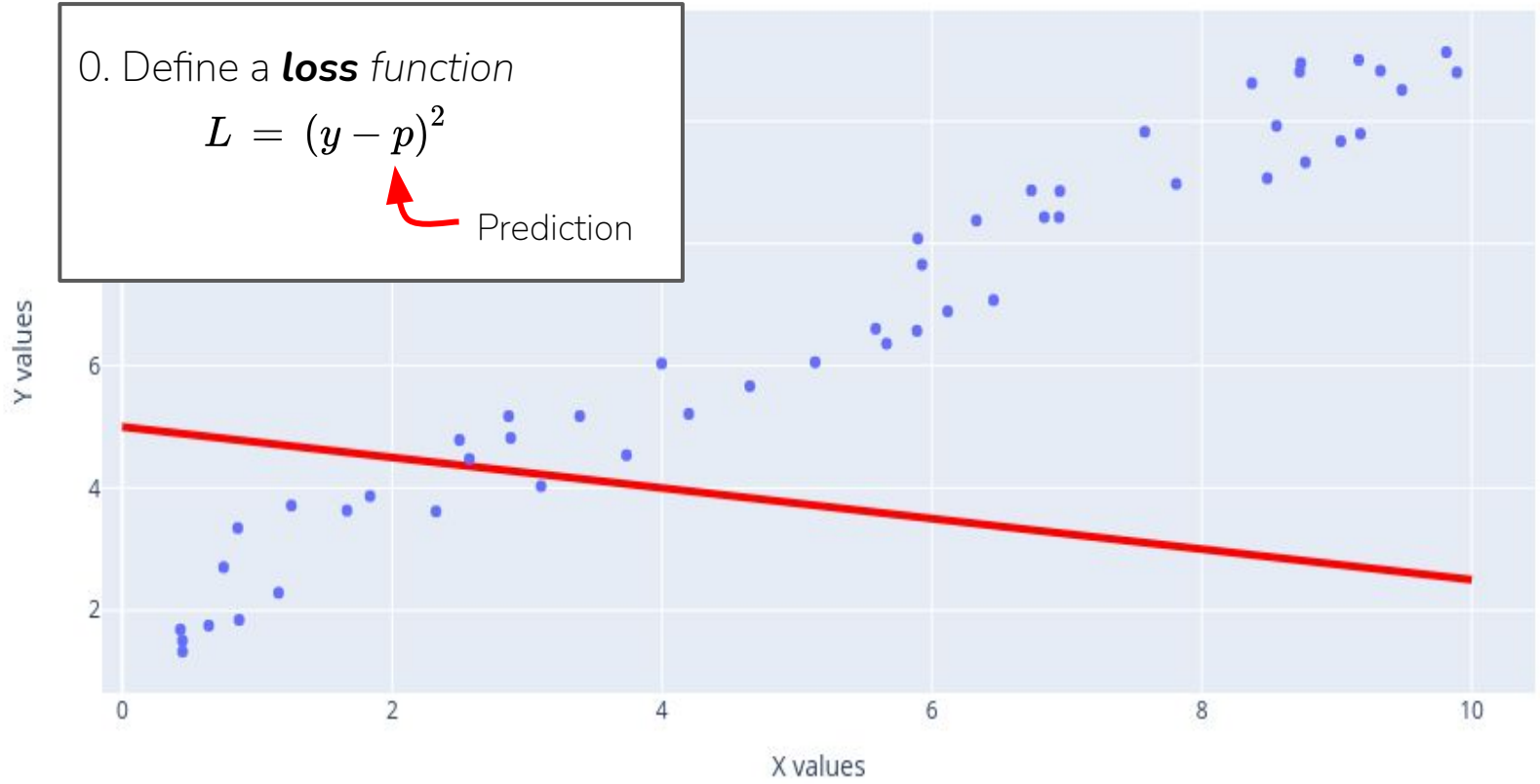


How to train a model:

0. Define a ***loss*** *function*

$$L = (y - p)^2$$

Prediction



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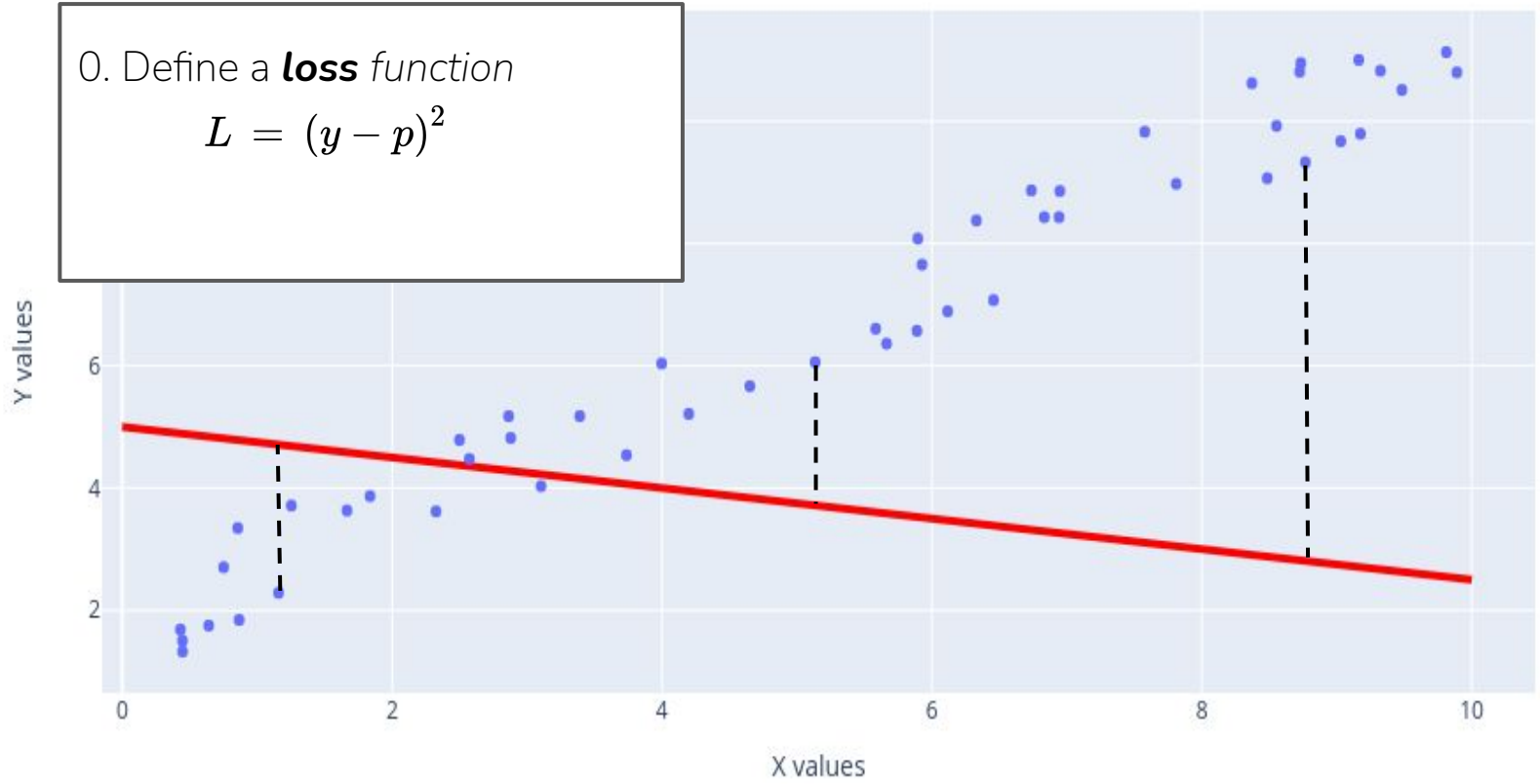
$$L = (y - p)^2$$



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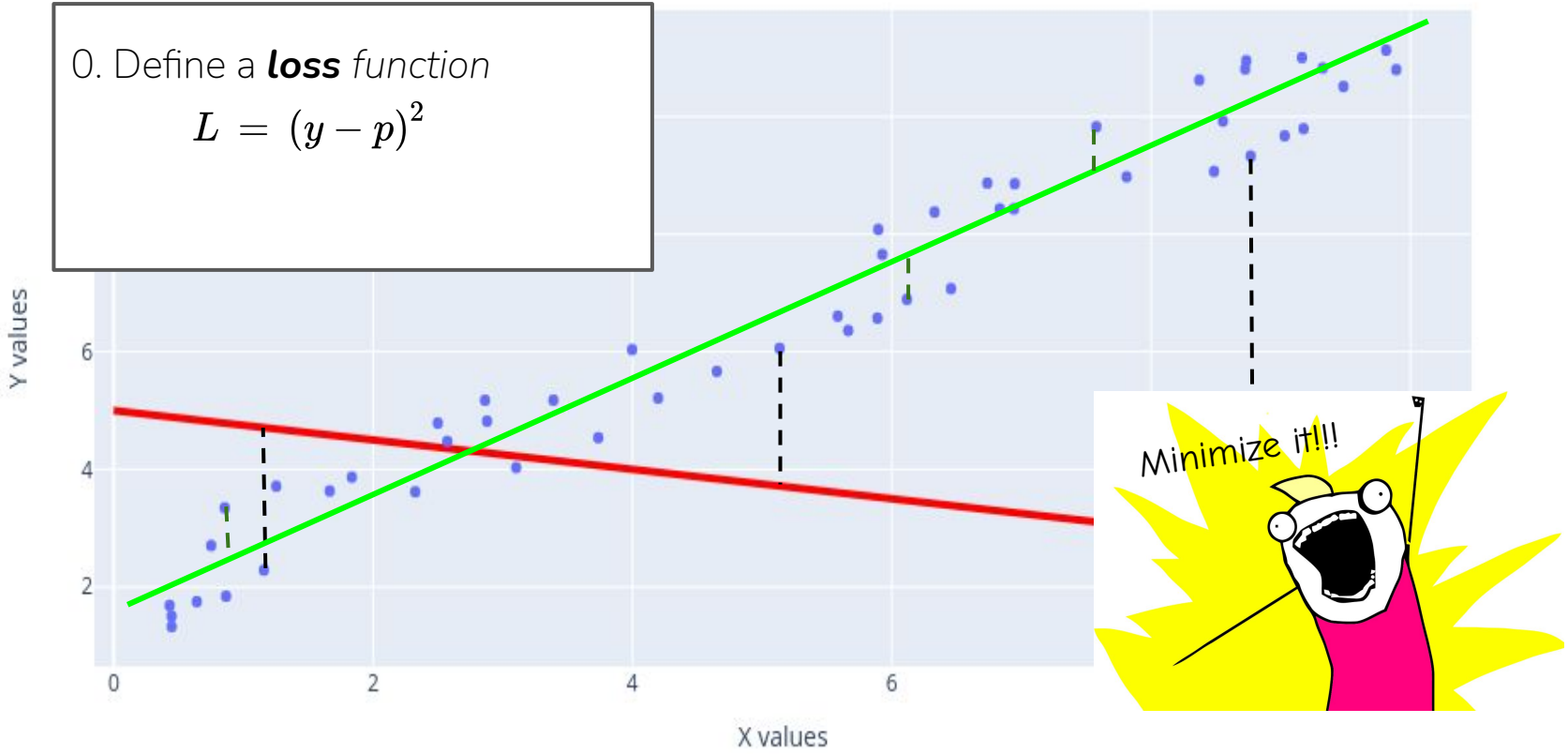


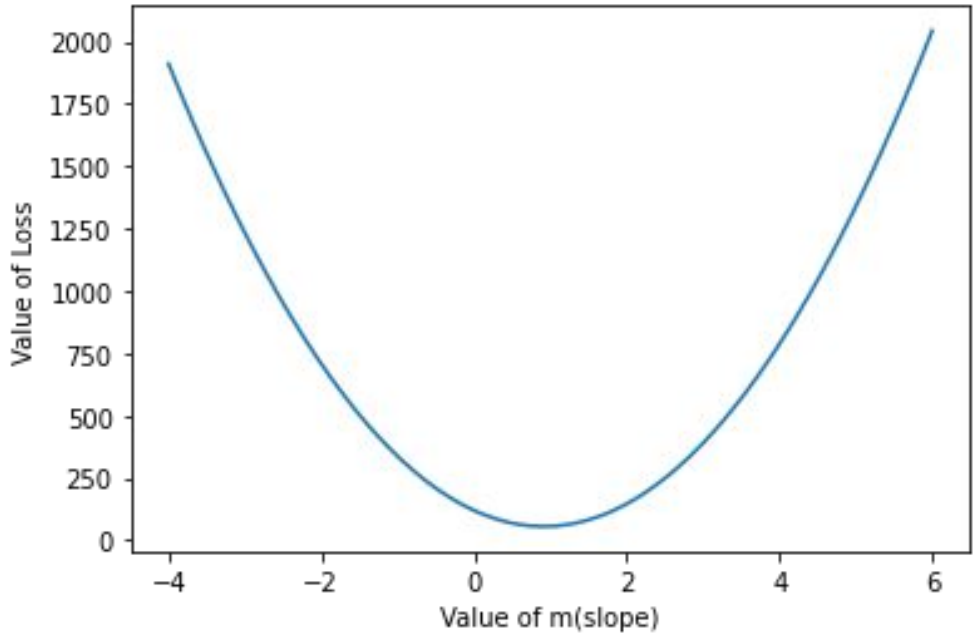
End goal: What values of **m** and **b** minimize **L**?

$$L = (y - p)^2 \qquad p = mx + b$$

Dependent variable

Independent variable

$$L = (y - (mx + b))^2$$



End goal: What values of **m** and **b** minimize **L**?

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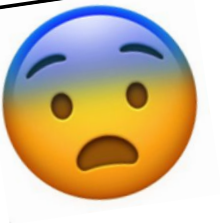
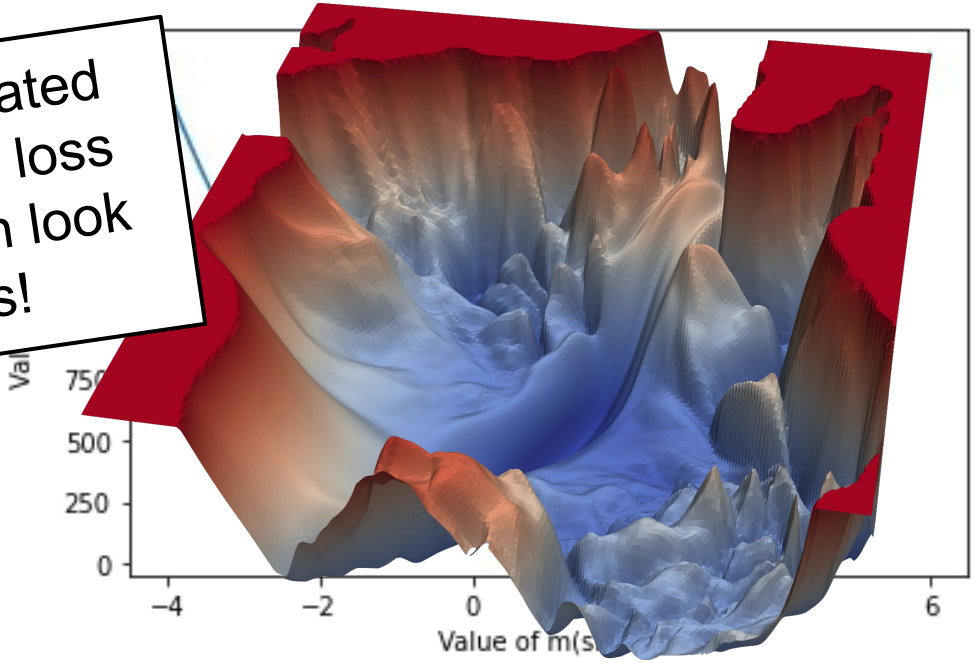
$$L = (y - (mx + b))^2$$

For complicated models, the loss function can look like this!





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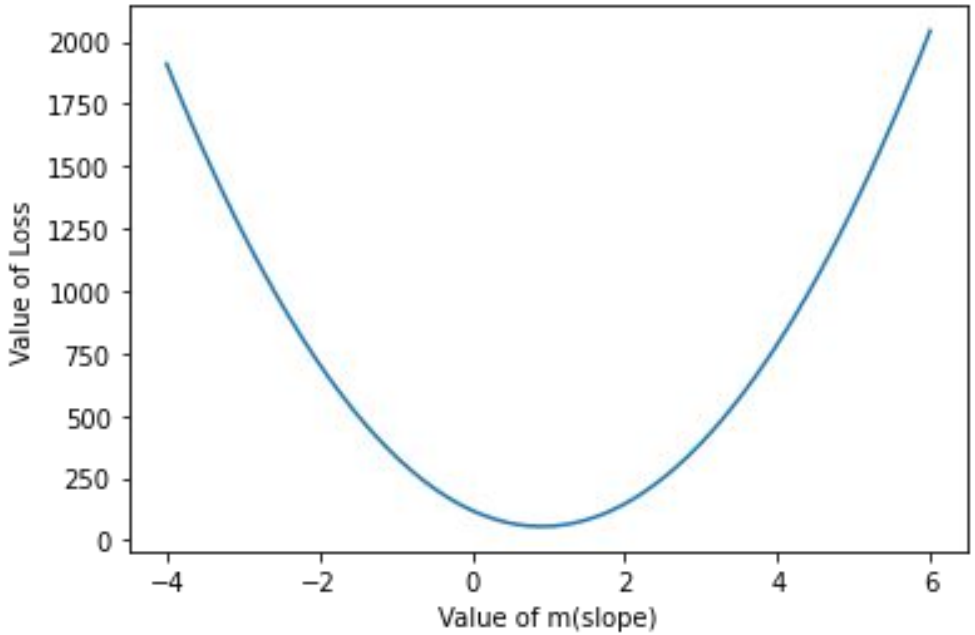

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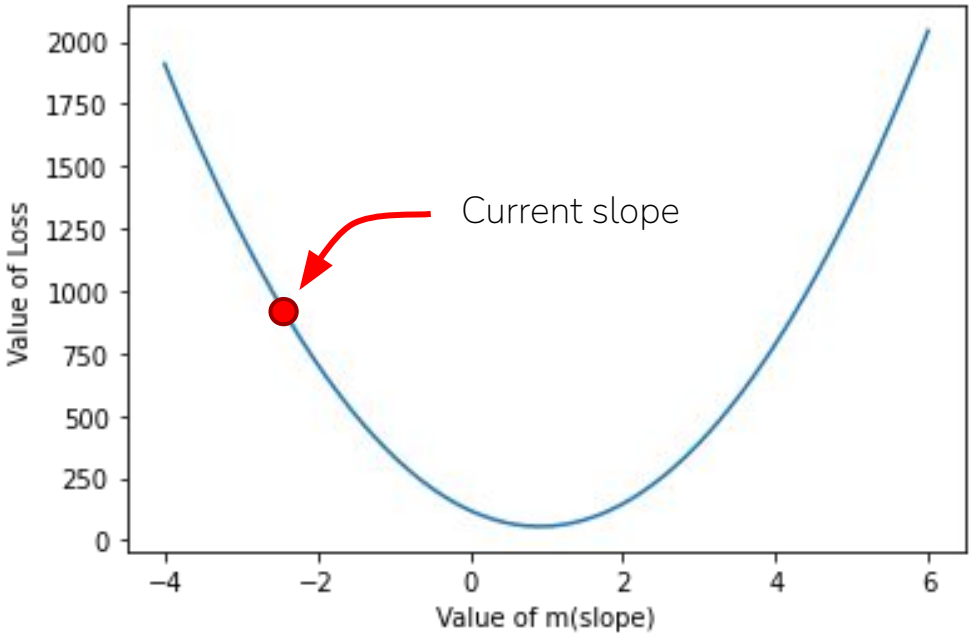

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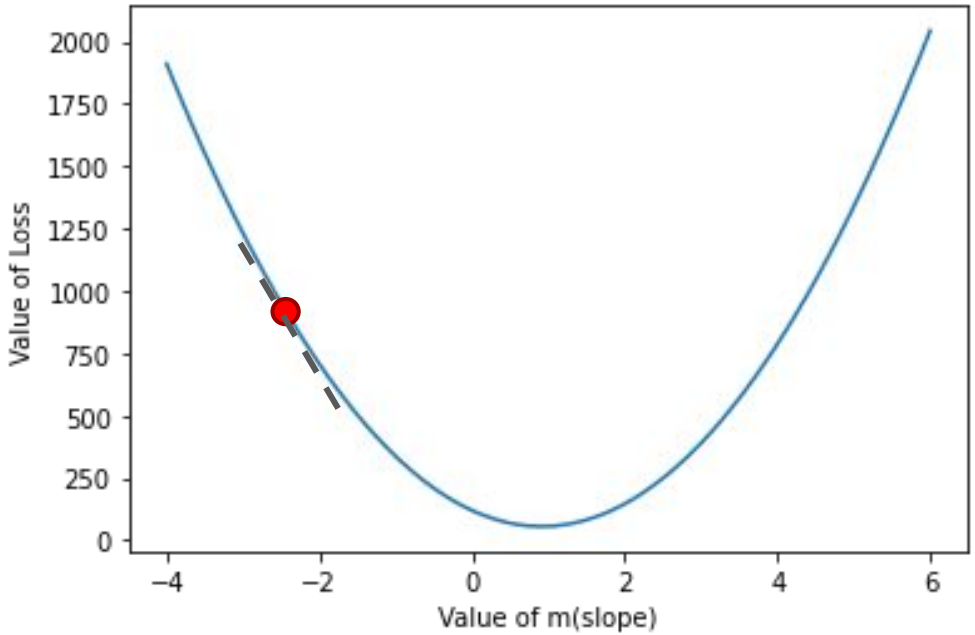

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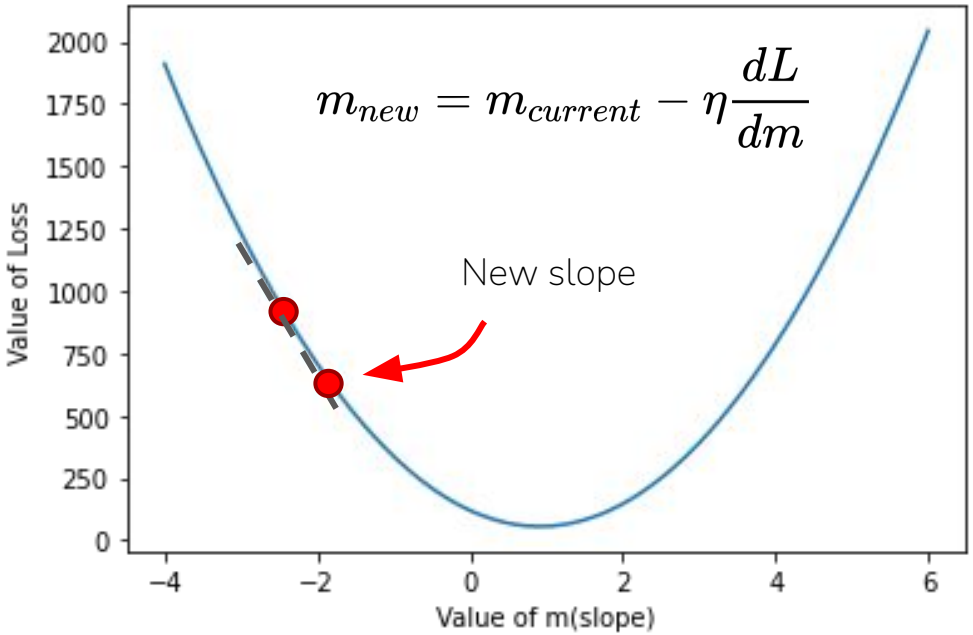

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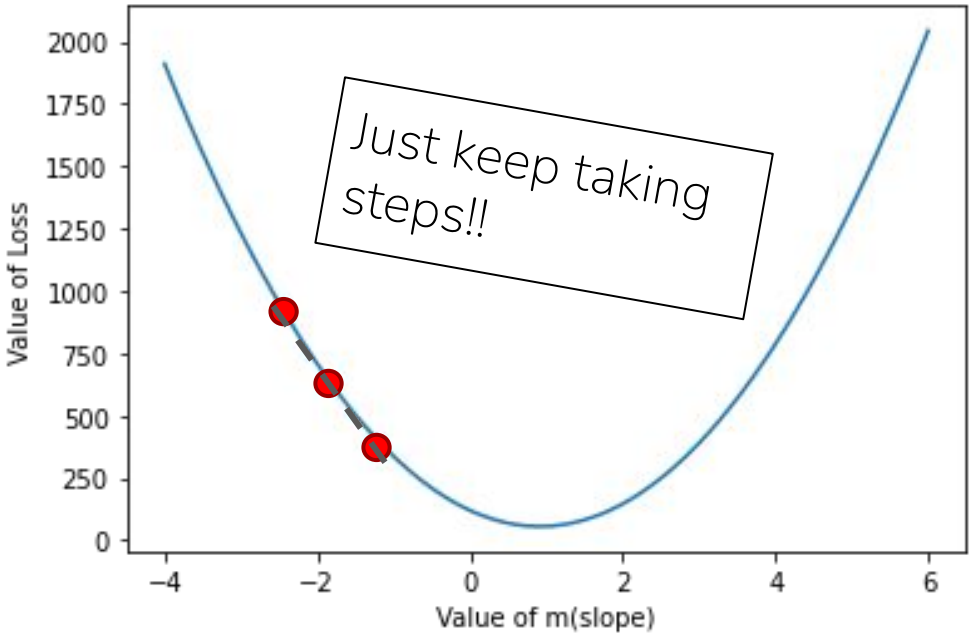

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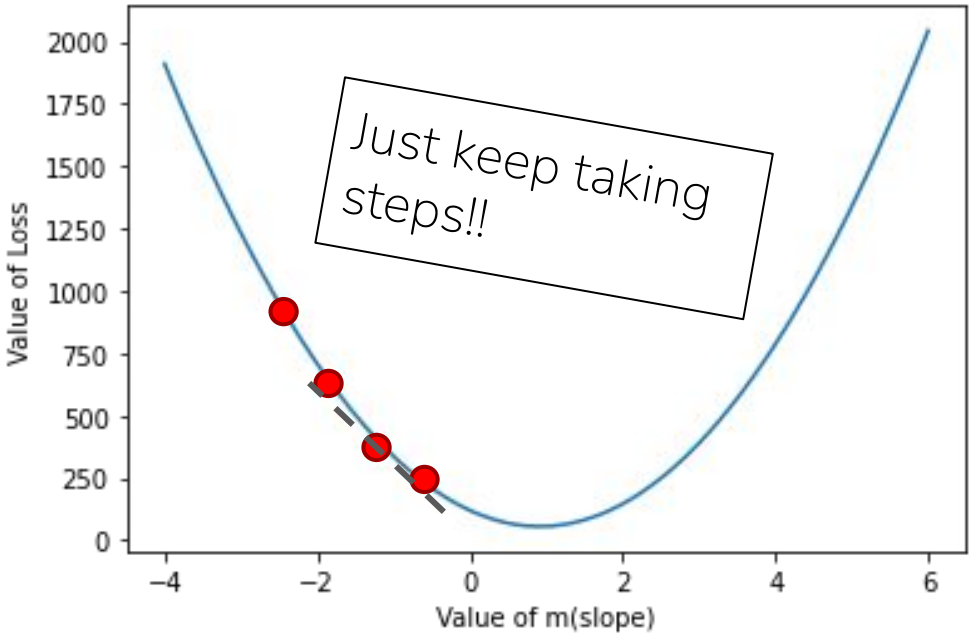

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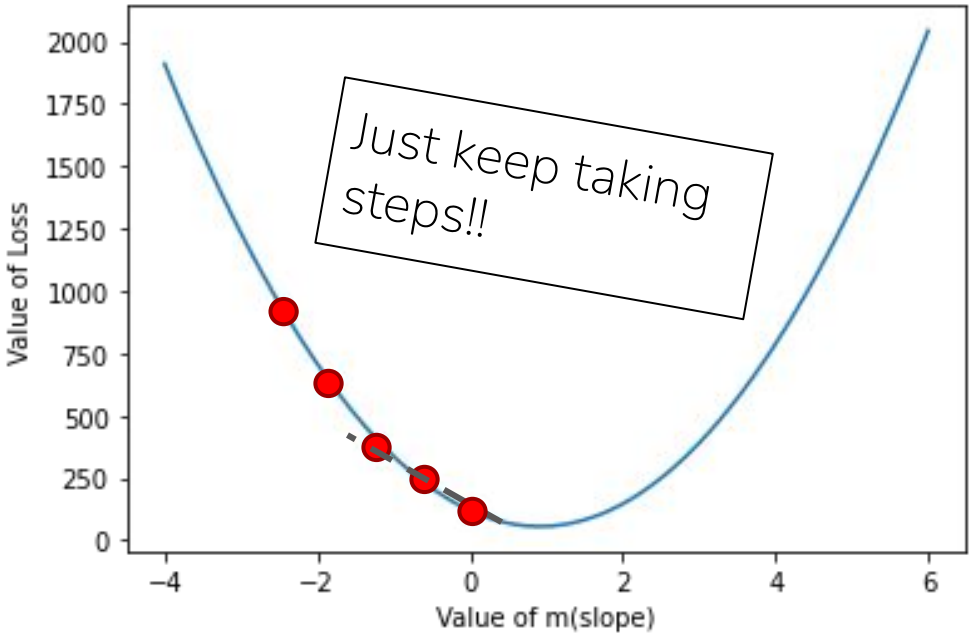

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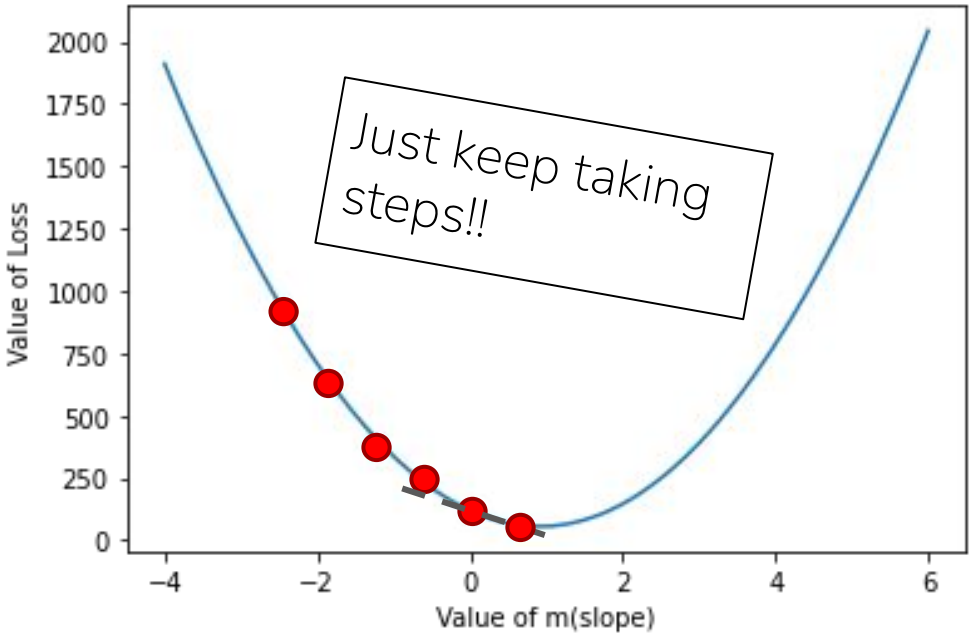

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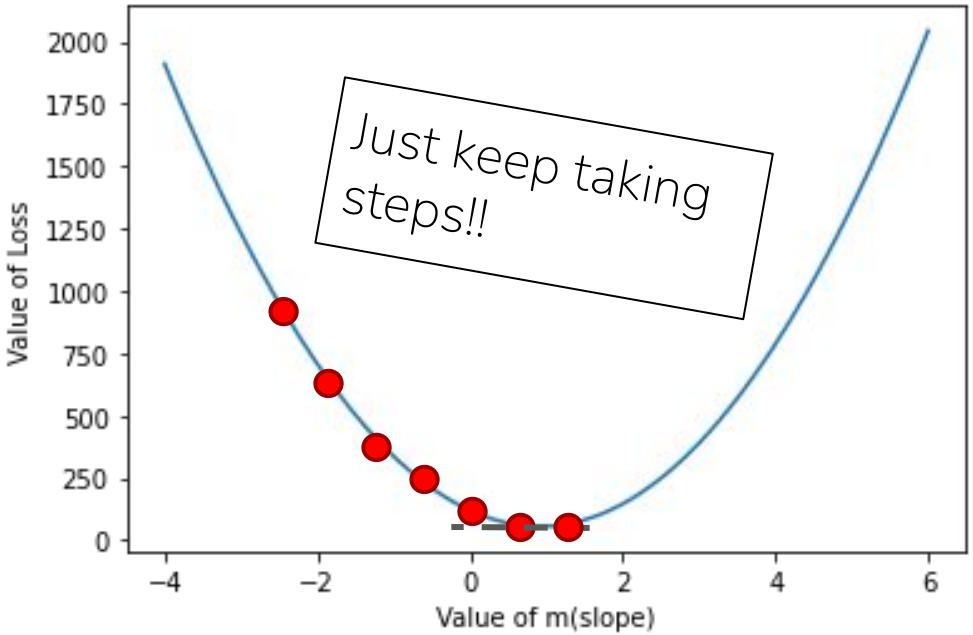
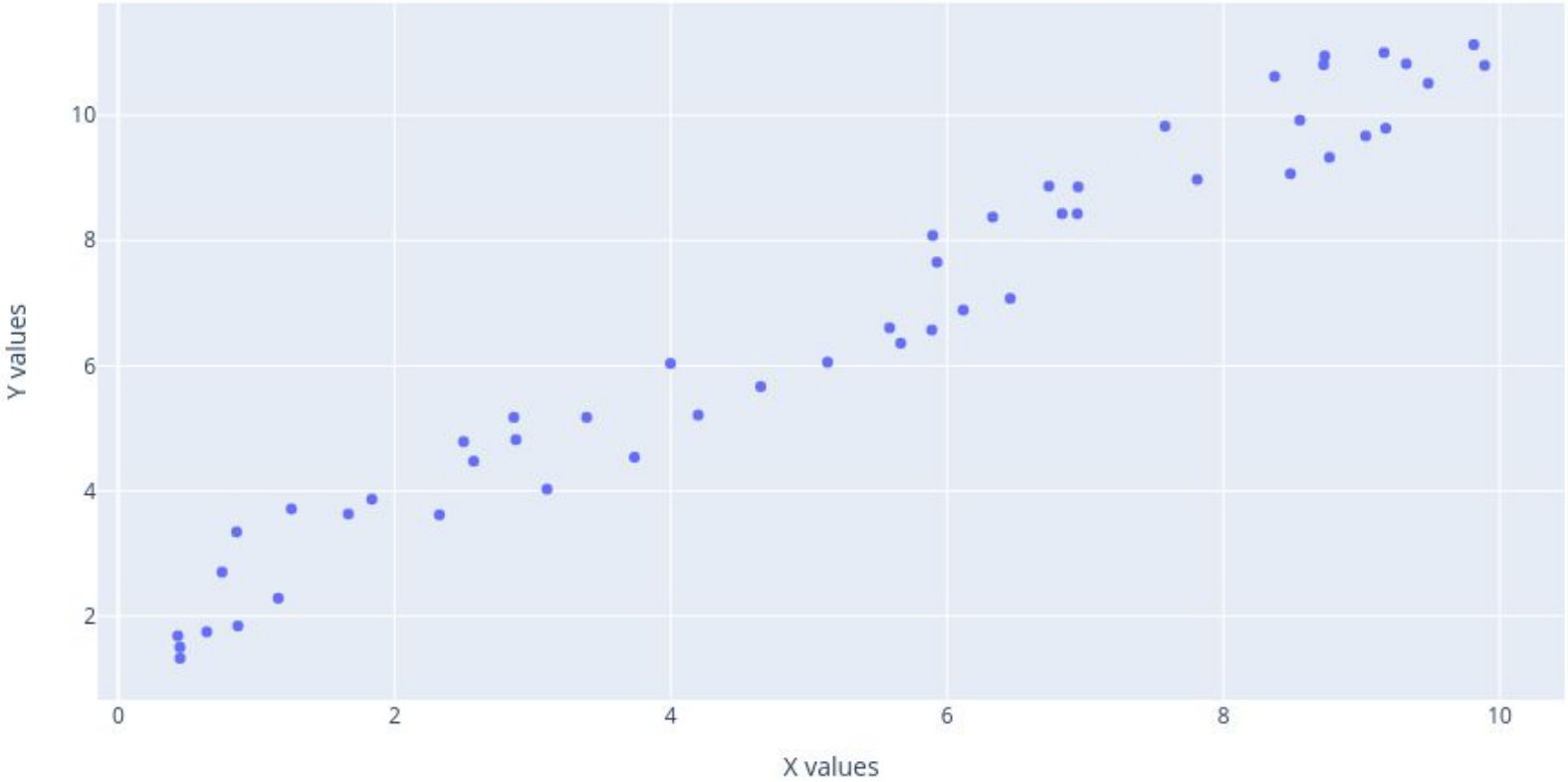


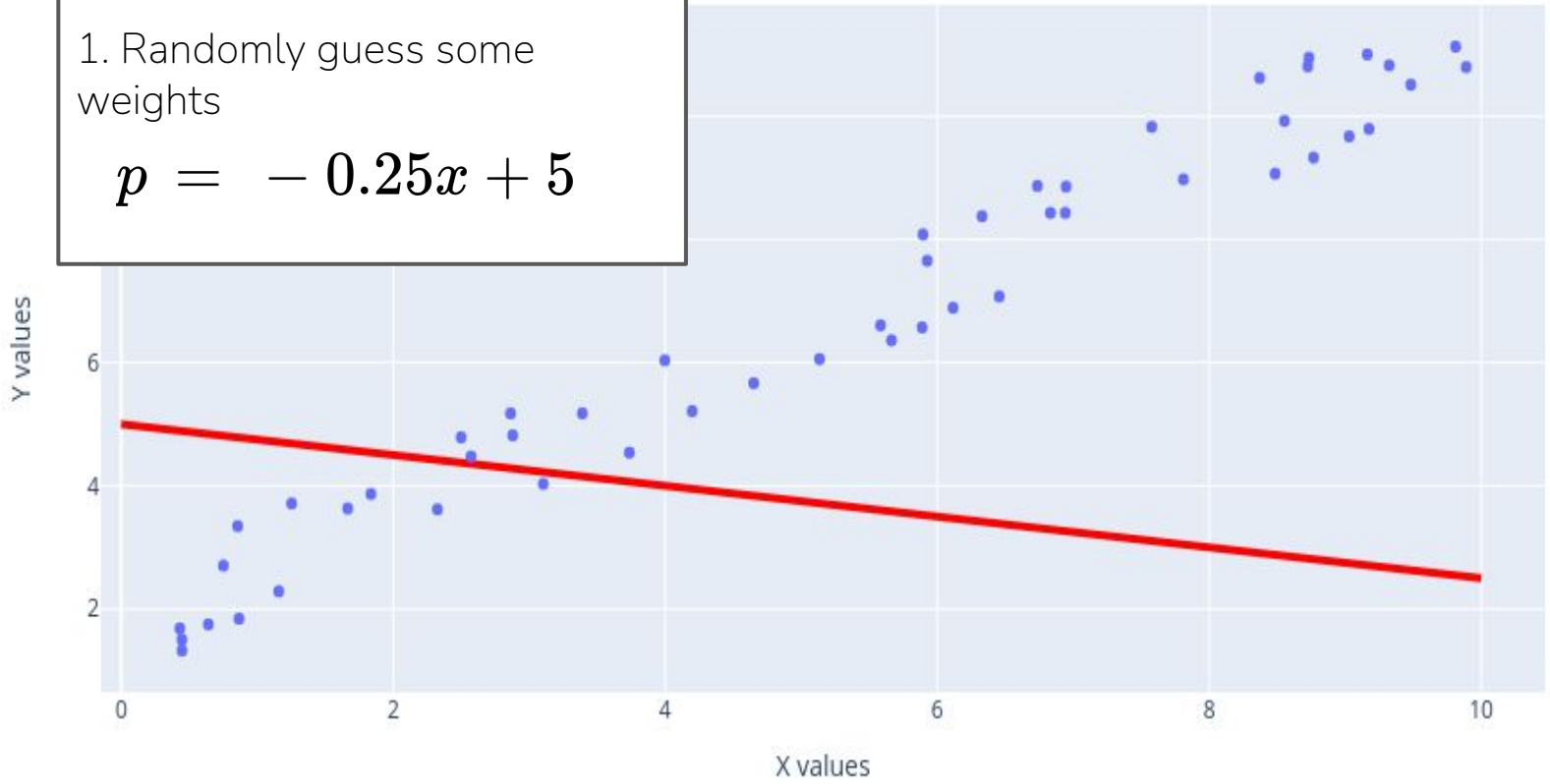
Let’s do this for our problem now!



How to train a model:

1. Randomly guess some weights

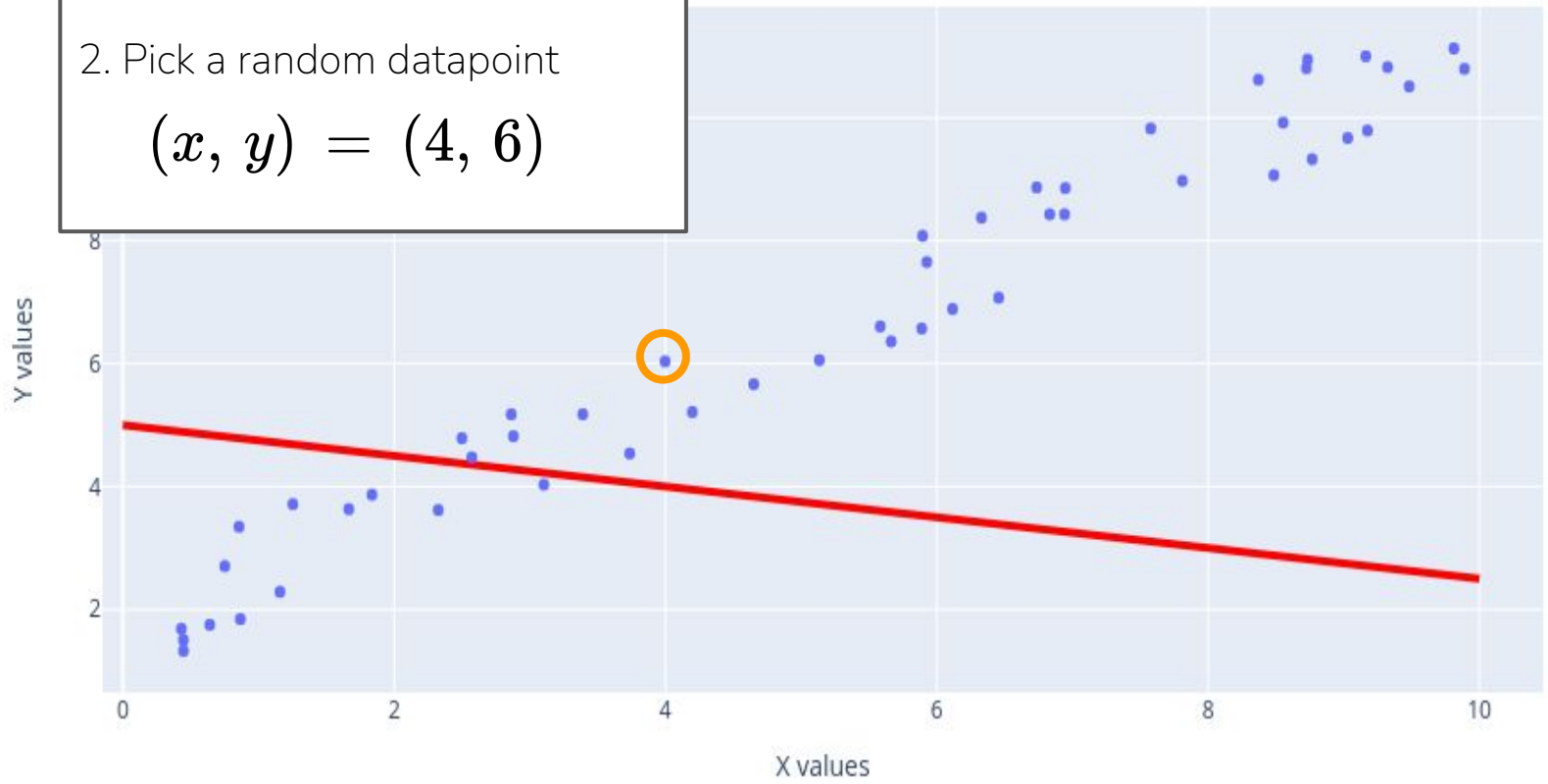
$$p = -0.25x + 5$$



How to train a model:

2. Pick a random datapoint

$$(x, y) = (4, 6)$$



How to train a model:

3. Calculate $\frac{dL}{dm}$

$$L = (y - (mx + b))^2$$

$$\frac{dL}{dm} = 2(y - (mx + b))\left(\frac{d}{dm}(-mx - b)\right)$$

$$\frac{dL}{dm} = 2(y - (mx + b))(-x)$$

$$\frac{dL}{dm} = -2yx + 2mx^2 + 2xb$$

$$\frac{dL}{dm} = -2(6)(4) + 2(-0.25)4^2 + 2(4)(5)$$

$$\frac{dL}{dm} = -8$$

Plug in our current point:

$$(x, y) = (4, 6)$$

$$(m, b) = (-0.25, 5)$$

How to train a model:

4. Do it again for $\frac{dL}{db}$!!!

$$L = (y - (mx + b))^2$$

$$\frac{dL}{db} = 2(y - (mx + b)) \left(\frac{d}{db} (-mx - b) \right)$$

$$\frac{dL}{db} = 2(y - (mx + b)) (-1)$$

$$\frac{dL}{db} = -2y + 2mx + 2b$$

$$\frac{dL}{db} = -2(6) + 2(-0.25)4 + 2(5)$$

$$\frac{dL}{db} = -4$$

Plug in our current point:

$$(x, y) = (4, 6)$$

$$(m, b) = (-0.25, 5)$$

How to train a model:

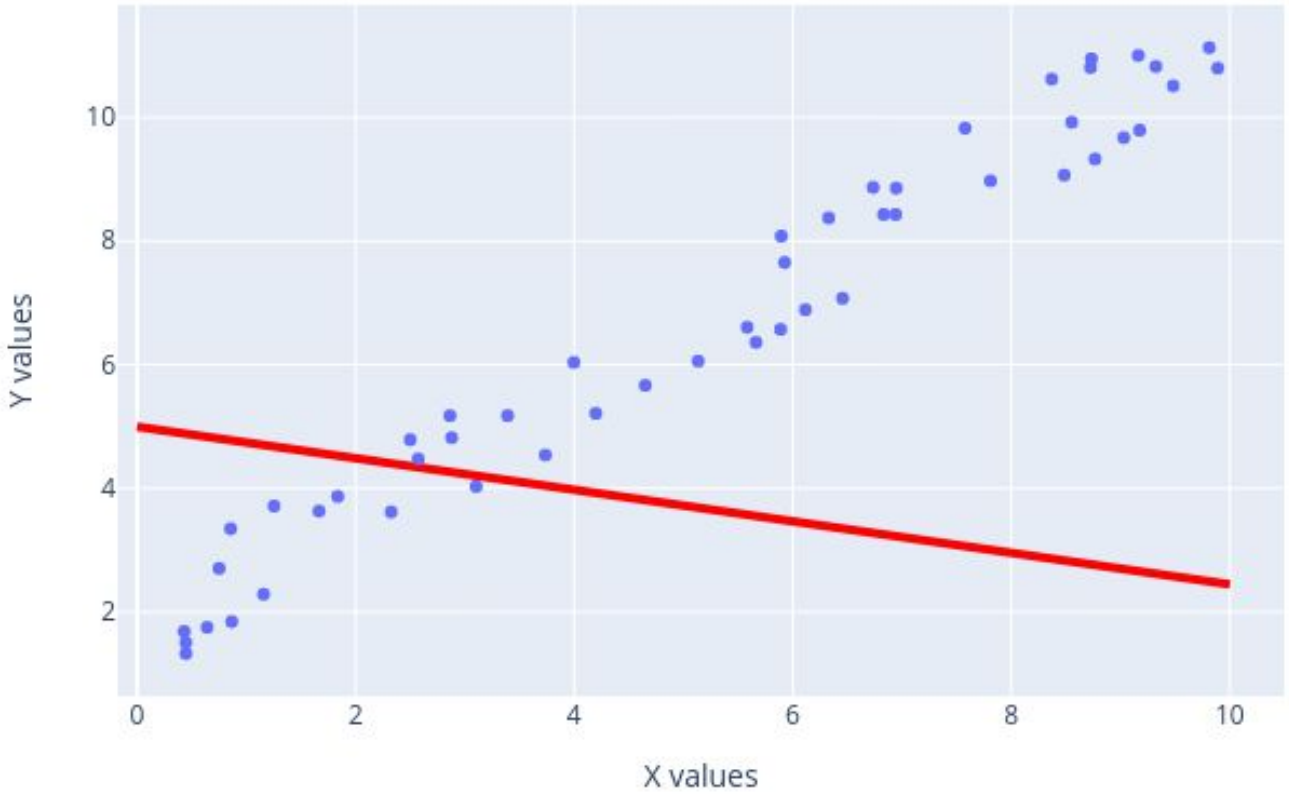
5. Update ***m*** and ***b***

$$m_{new} = m_{current} - \eta \frac{dL}{dm} \qquad b_{new} = b_{current} - \eta \frac{dL}{db}$$

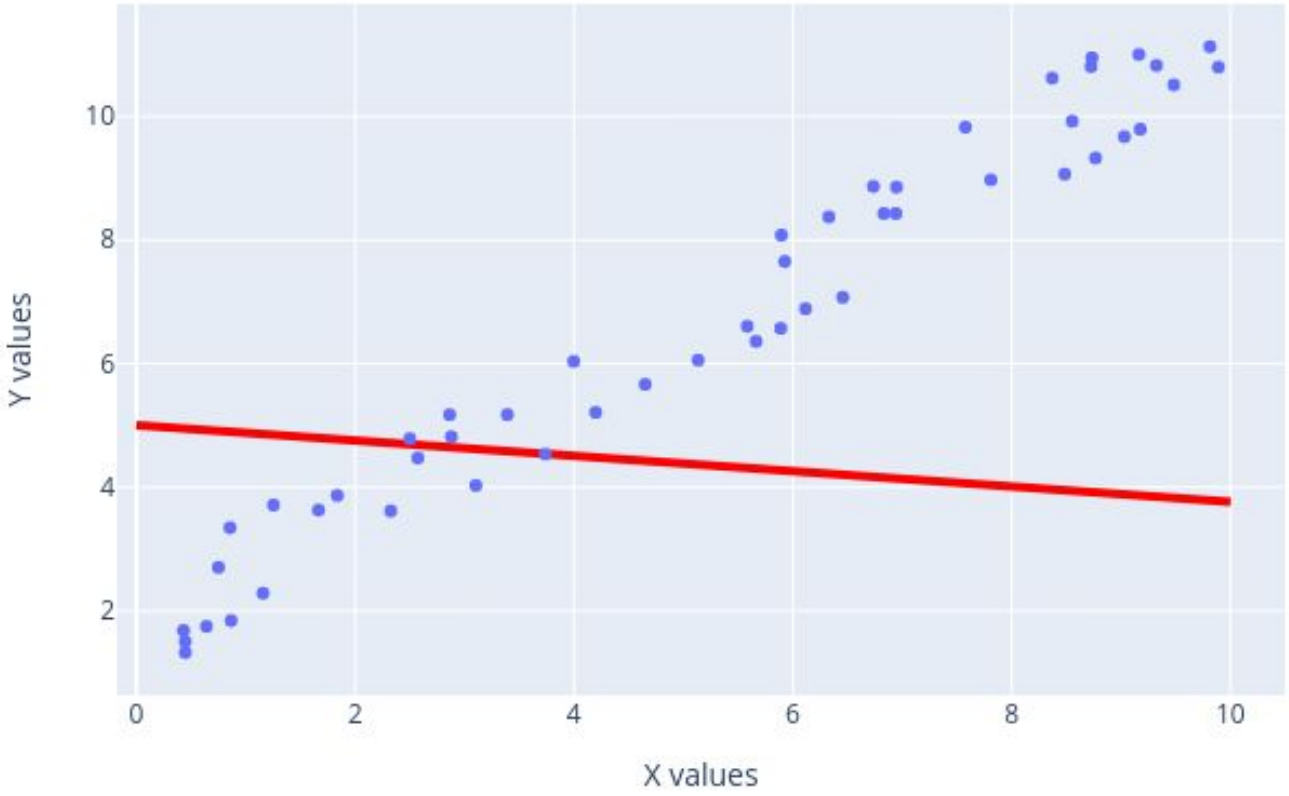
$$m_{new} = 0.25 - 0.001 \cdot (-8) \qquad b_{new} = 5 - 0.001 \cdot (-4)$$

$$m_{new} = 0.242 \qquad b_{new} = 5.004$$

Old ***m*** and ***b***:

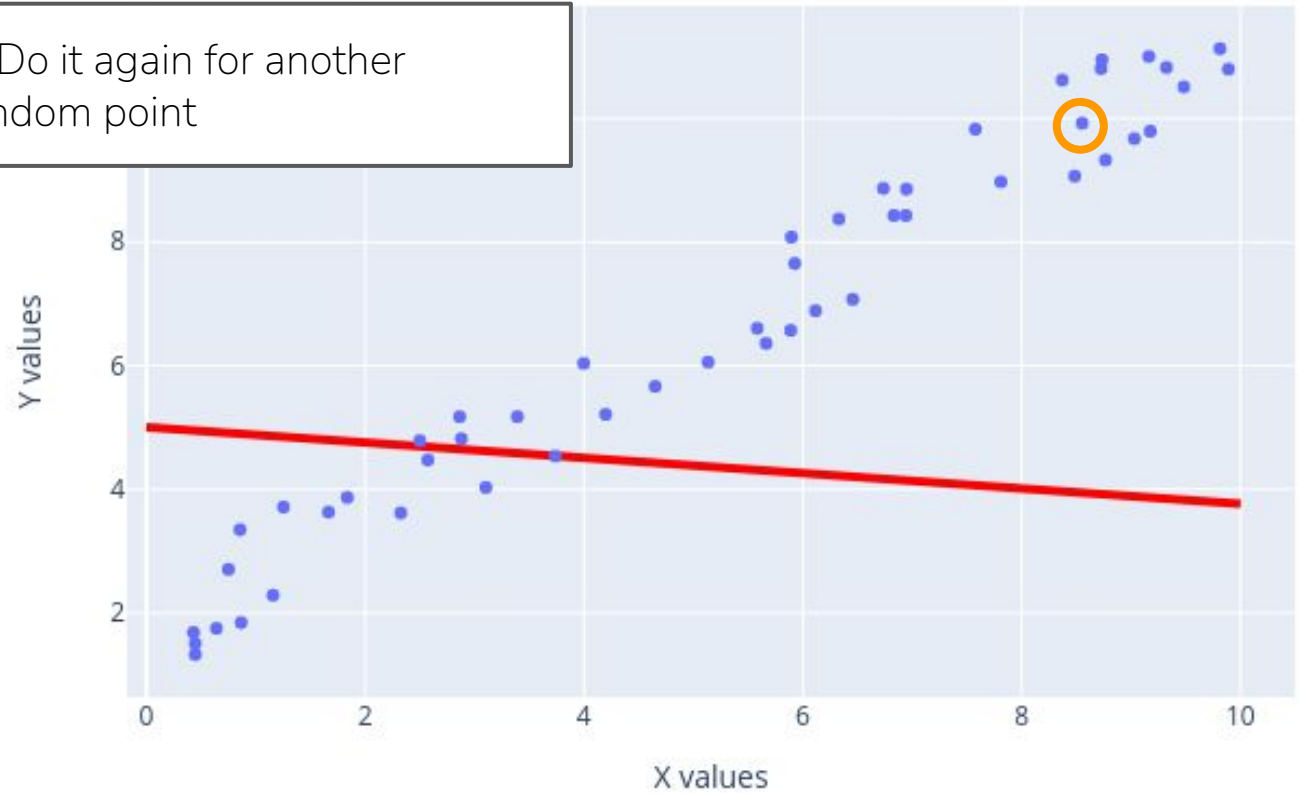


New ***m*** and ***b***:



How to train a model:

6. Do it again for another random point



How to train a model:

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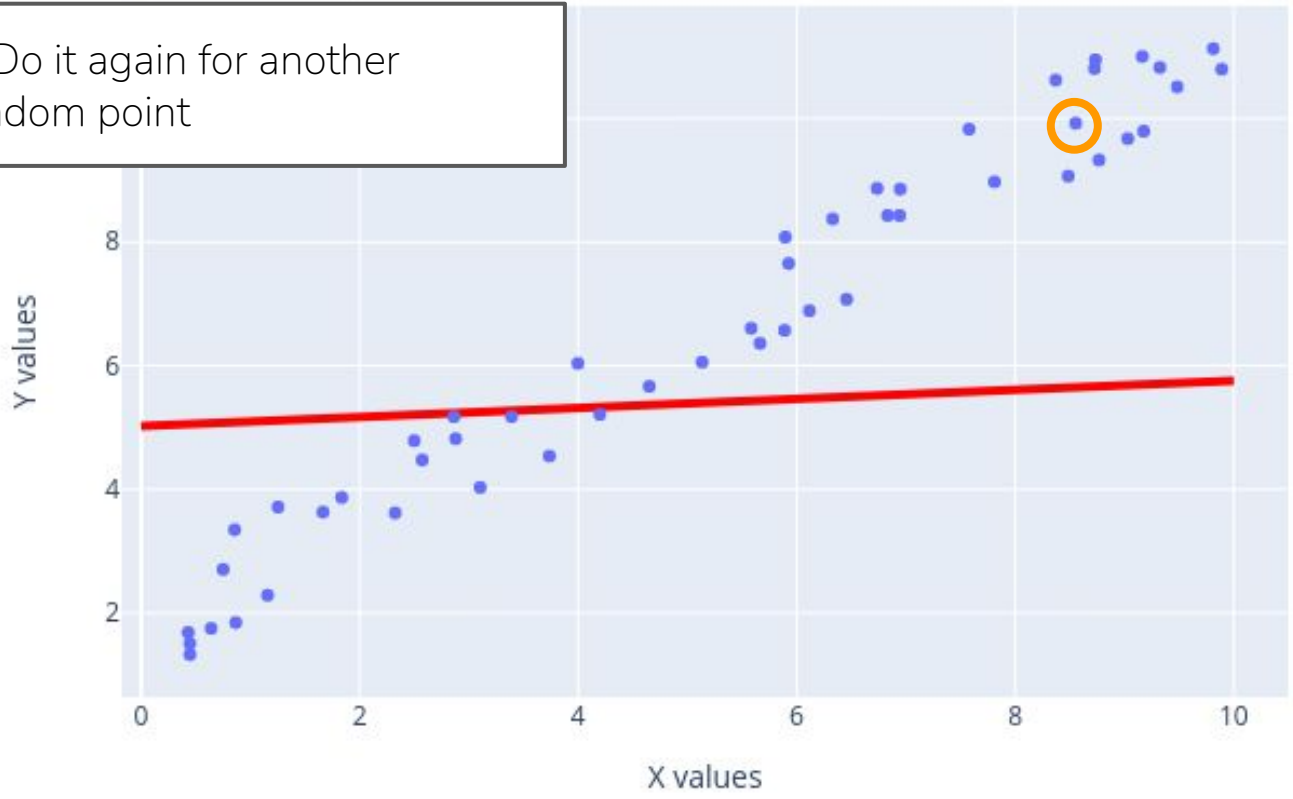
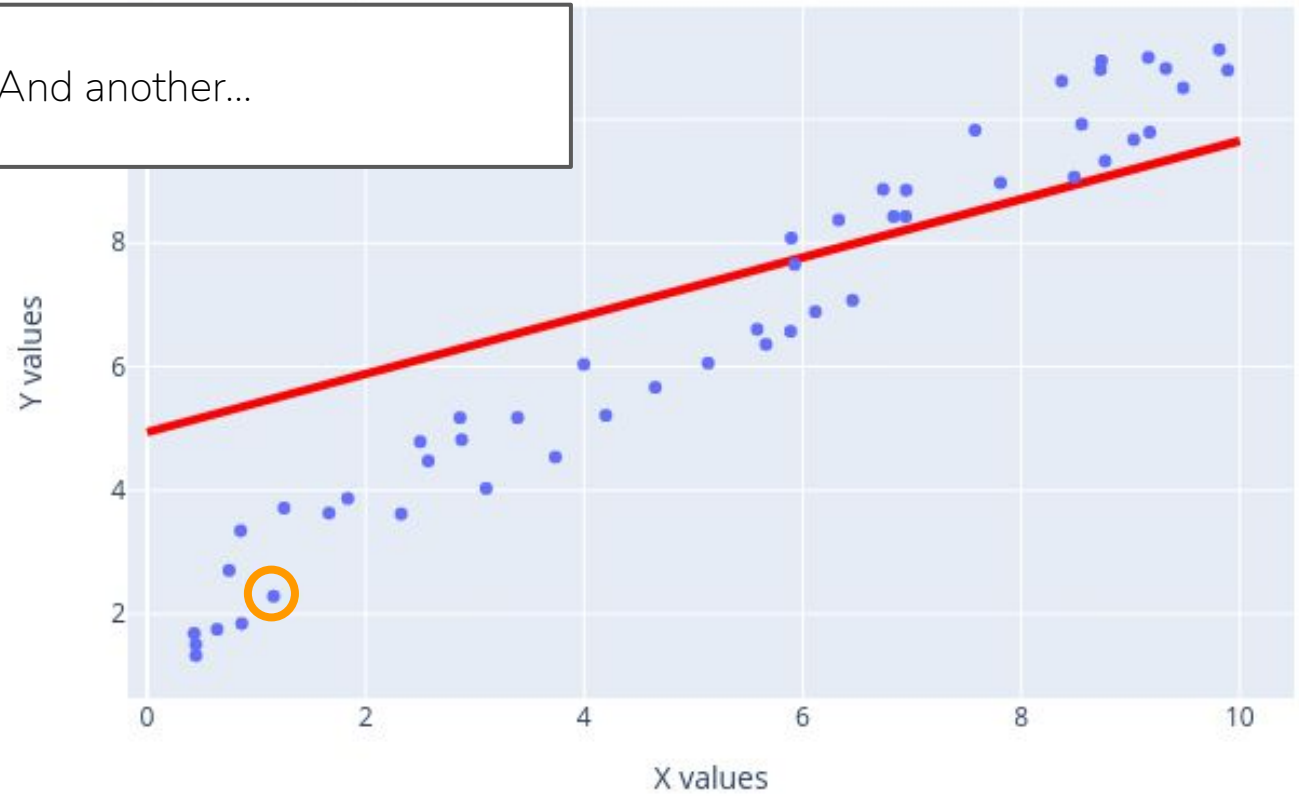


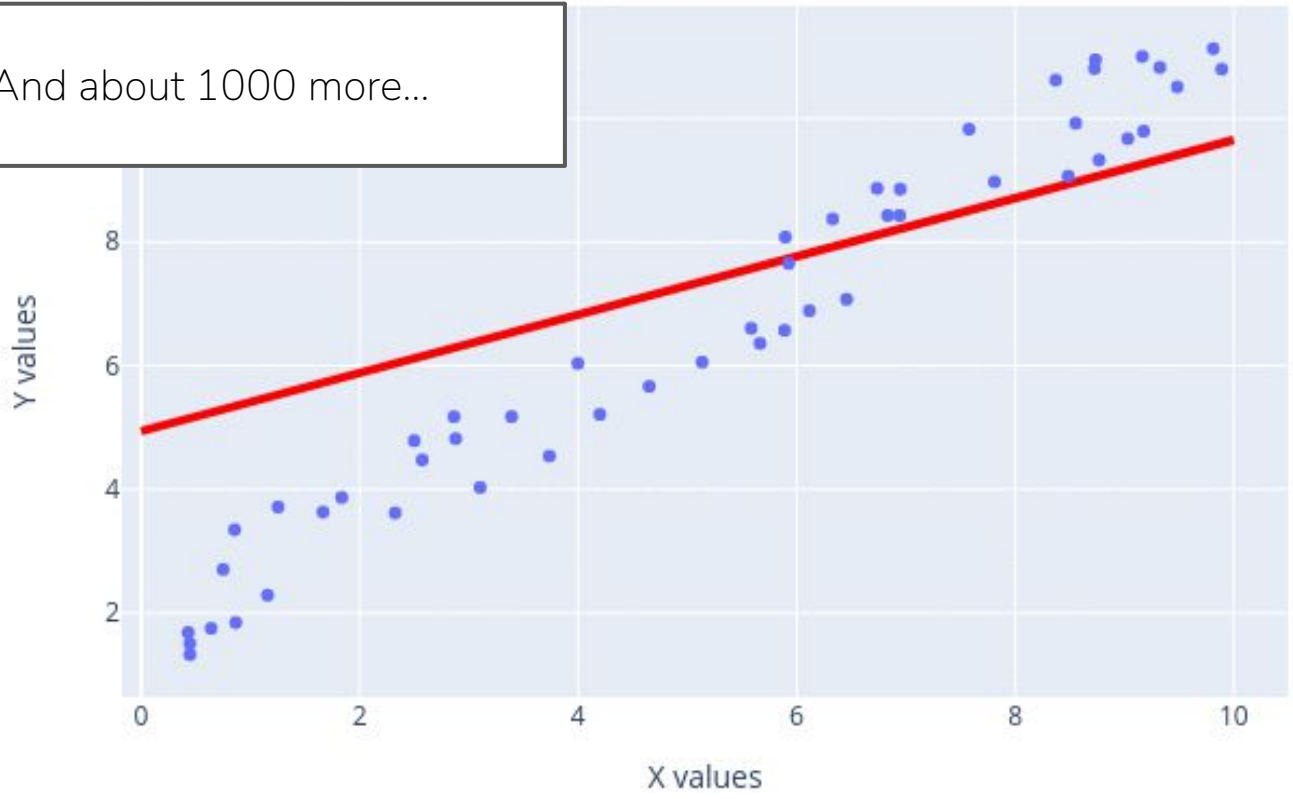
How to train a model:

7. And another...



How to train a model:

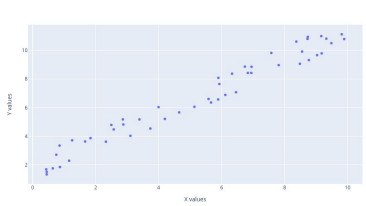
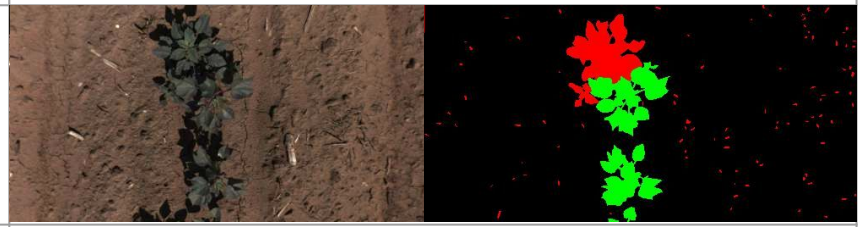
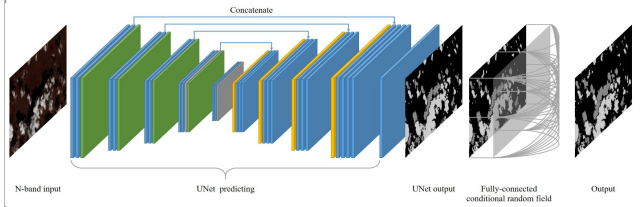
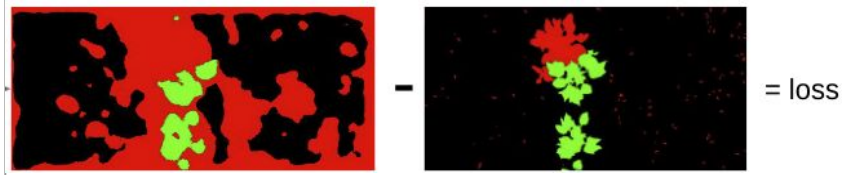
8. And about 1000 more...



How to train a model:

9. Congrats! We just trained a model!

A more complicated problem.

	Our simple problem	Blue River's problem
Data		
Model	$p = mx + b$	 Neural network
Loss	$L = (y - p)^2$	

You want more?!??!

Better look at a neural network (3blue1brown)

Want a deeper non-technical dive? (Andrew Ng)

Another pretty cool form of machine learning(CGP Grey)

The high school guide to machine learning

Code that generated these plots

My email is:
dave.evans@bluerivertech.com