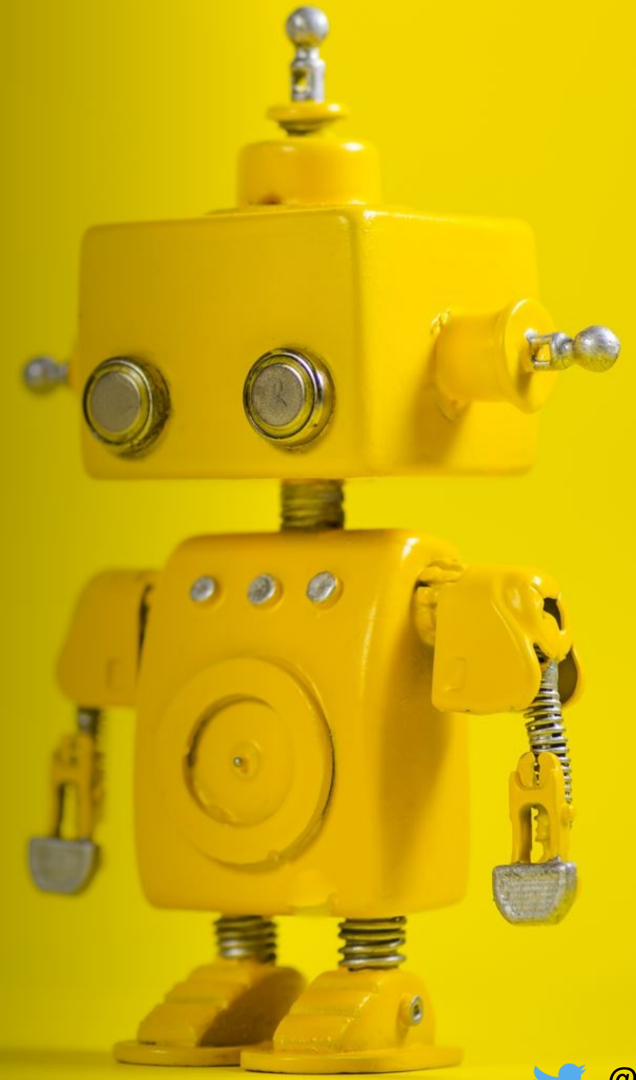
FruitPunch AI Bootcamp

Session 1– Linear Regression

15.11.2020

M. Alican Noyan

FruitPunch AI & Ipsumio



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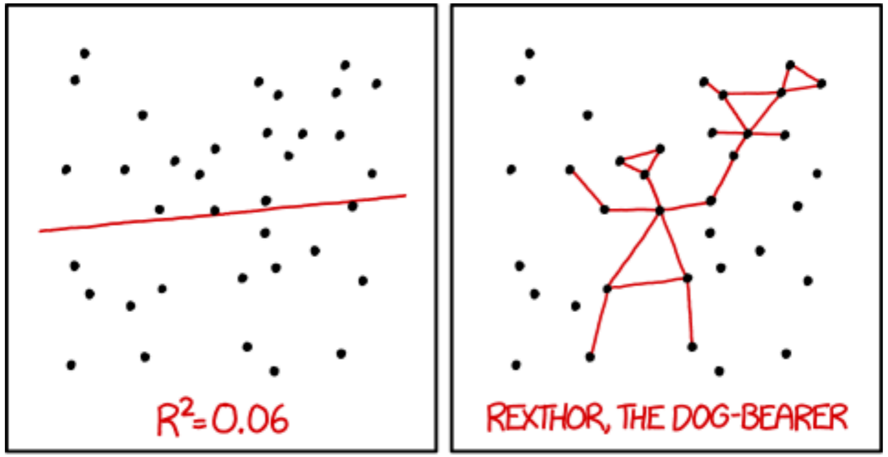


What is Machine Learning?

Challenge 1
Linear regression

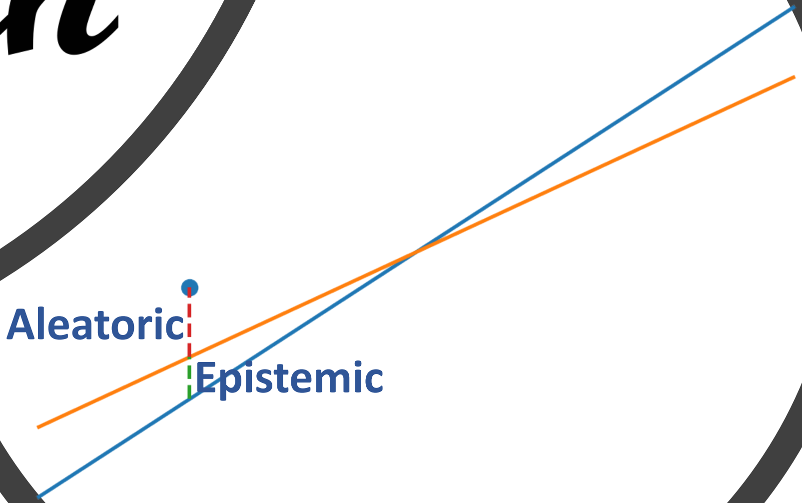
45 min

3 hours

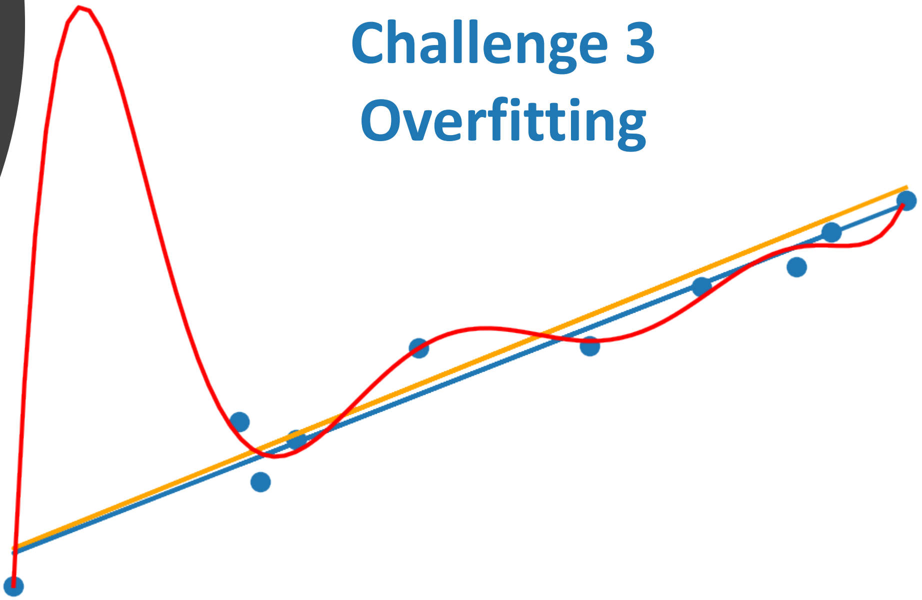
Challenge 4
Implement Linear regression

$$\theta_j = \theta_j - \alpha \frac{\partial J}{\partial \theta_j}$$

Challenge 2



Challenge 3
Overfitting



Any ML experience?	50/50
Any ML course?	None/All of them
Stats?	Low/High
Software?	Low/High

Mehmet Alican Noyan
B.Sc. Metallurgy and Materials Engineering (ODTÜ - Ankara)
M.Sc. Materials Science and Nanotechnology (Bilkent - Ankara)
Ph.D. Photonics (ICFO - Barcelona)

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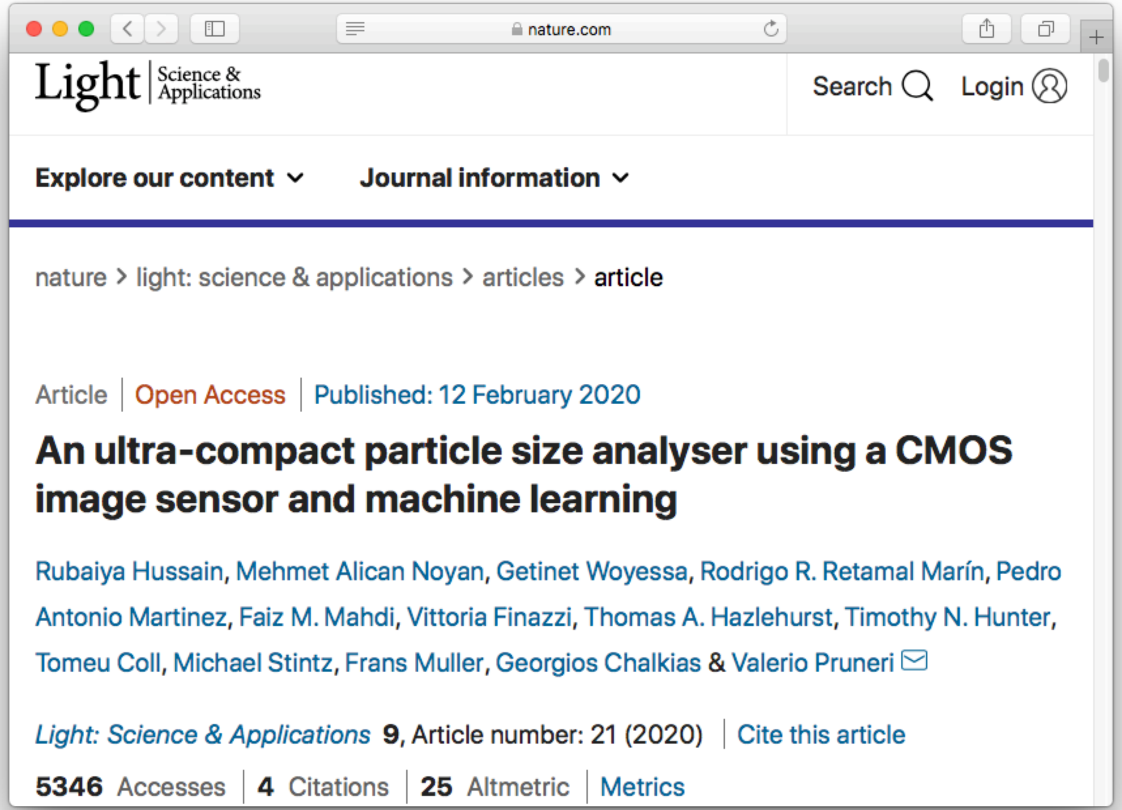

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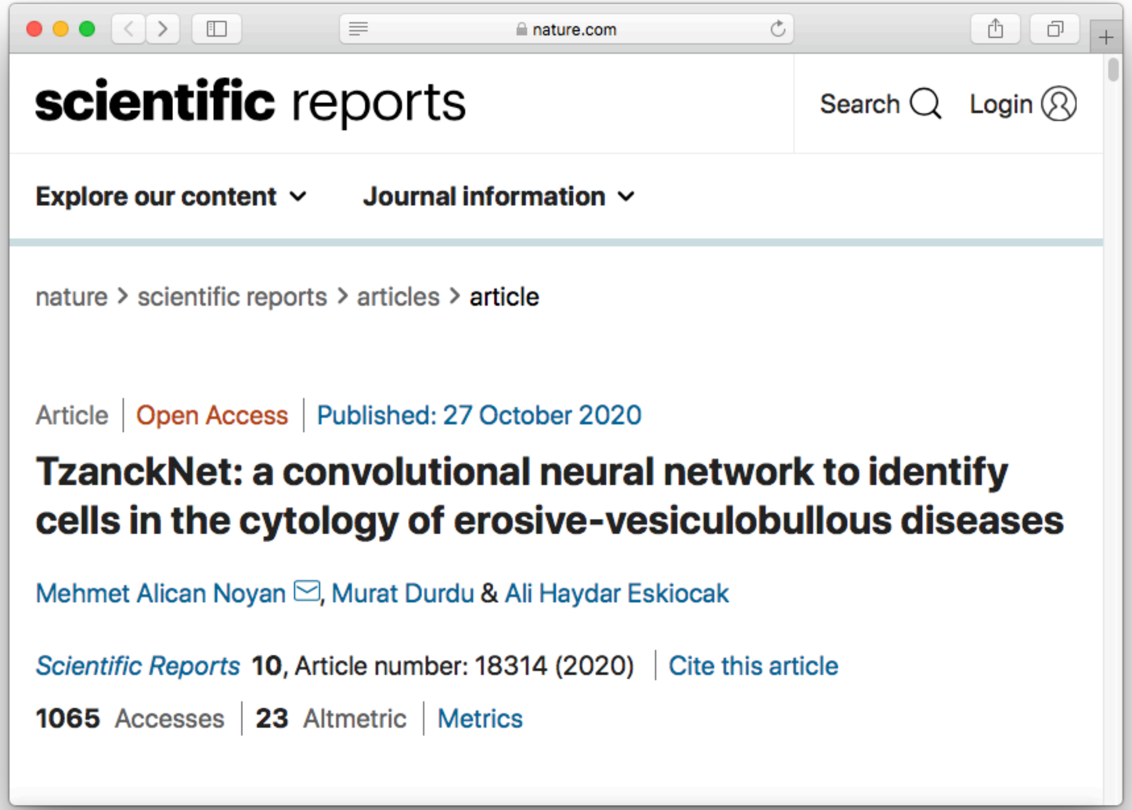

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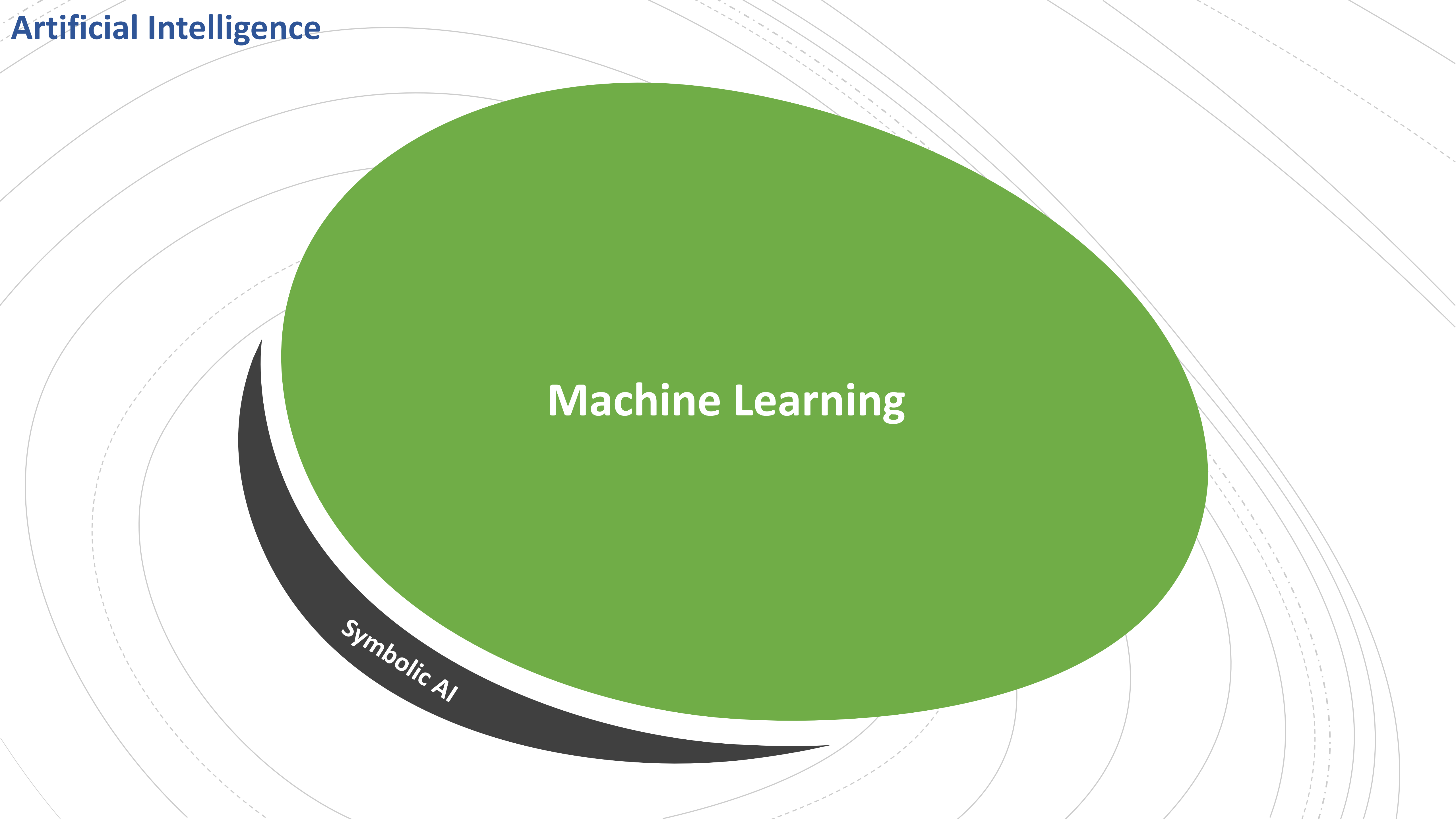
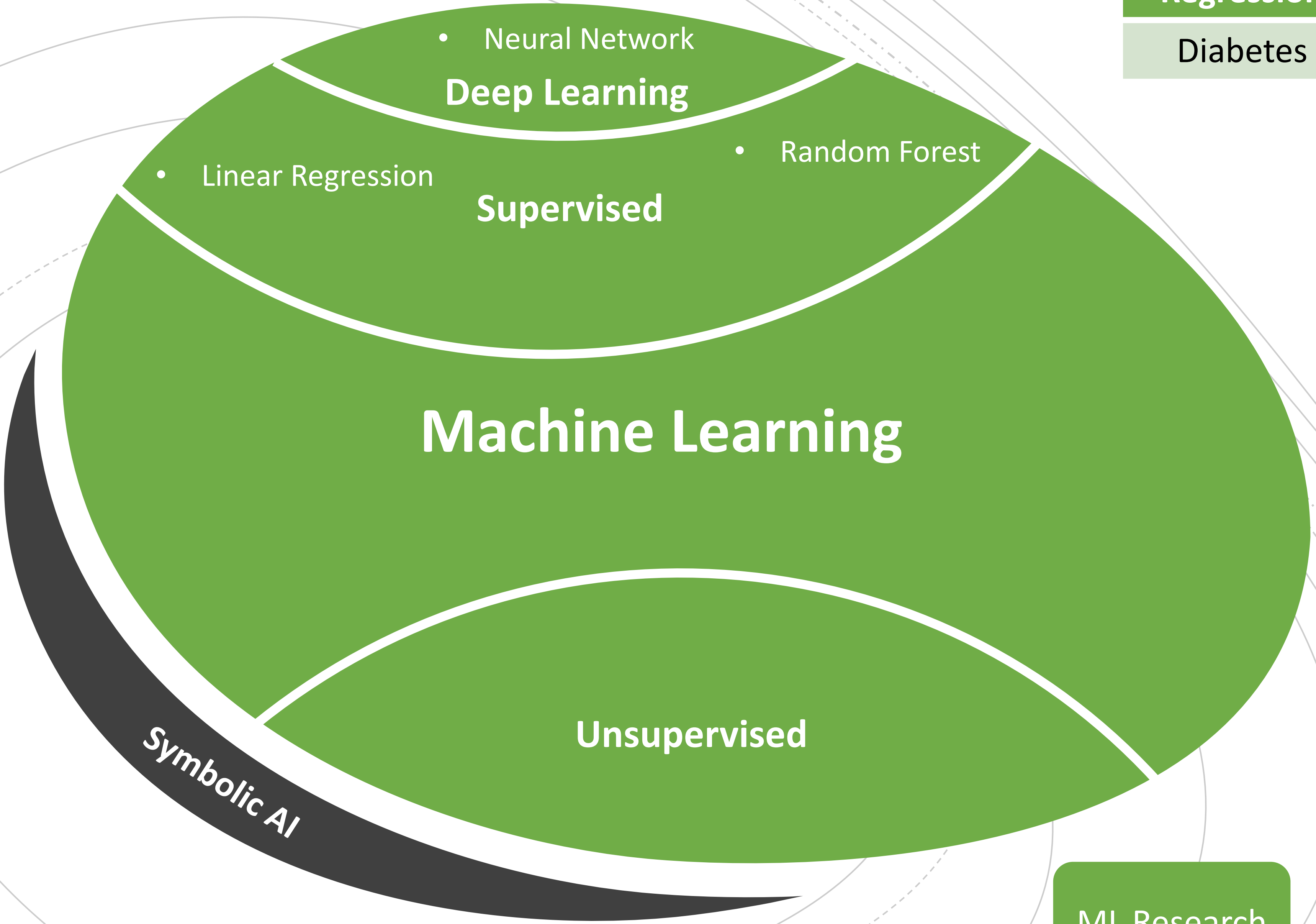

Artificial Intelligence
Machine Learning
Symbolic AI

Artificial Intelligence



Regression	Classification
Diabetes	Digits

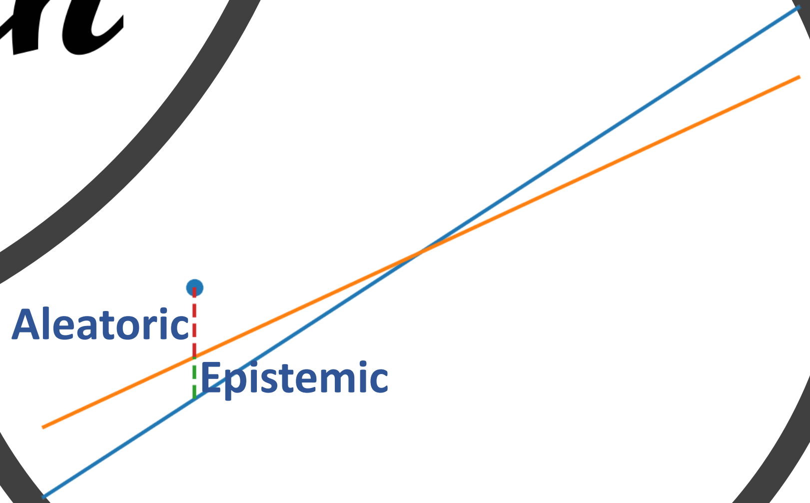
ML Research

Applied ML

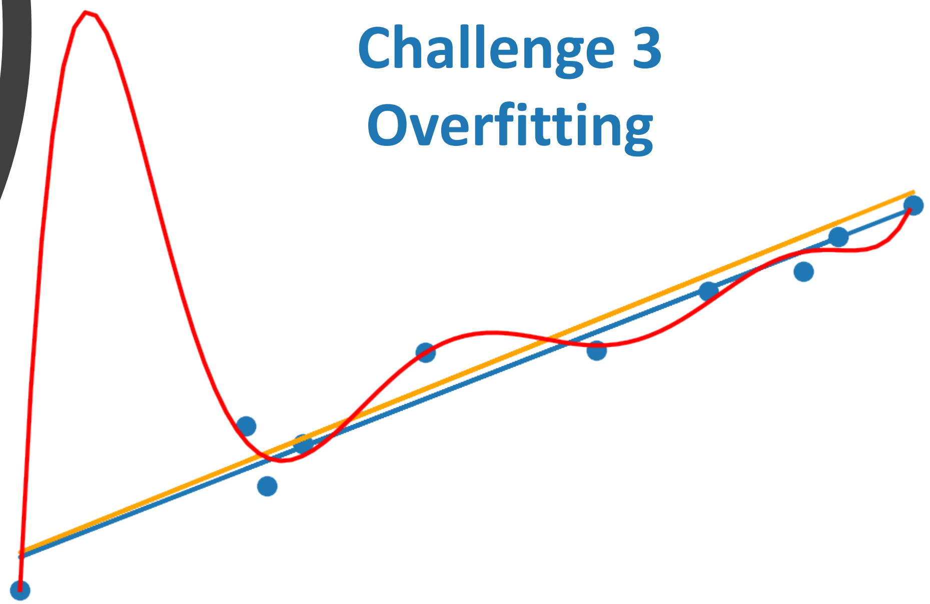
Data = Signal + Noise

Challenge 1
Linear regression

Challenge 2



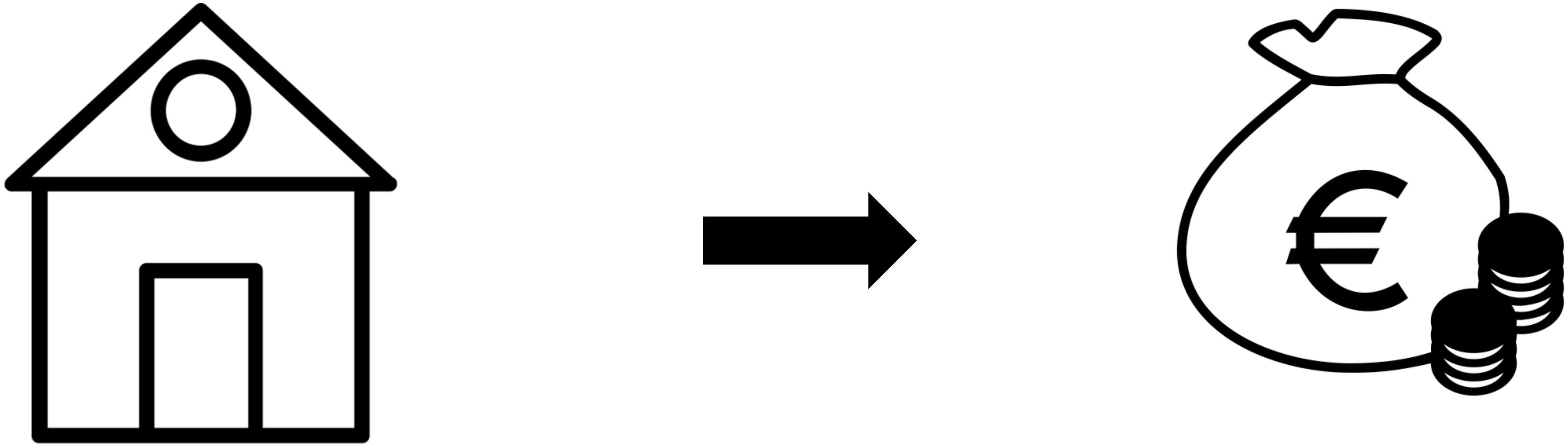
Challenge 3
Overfitting



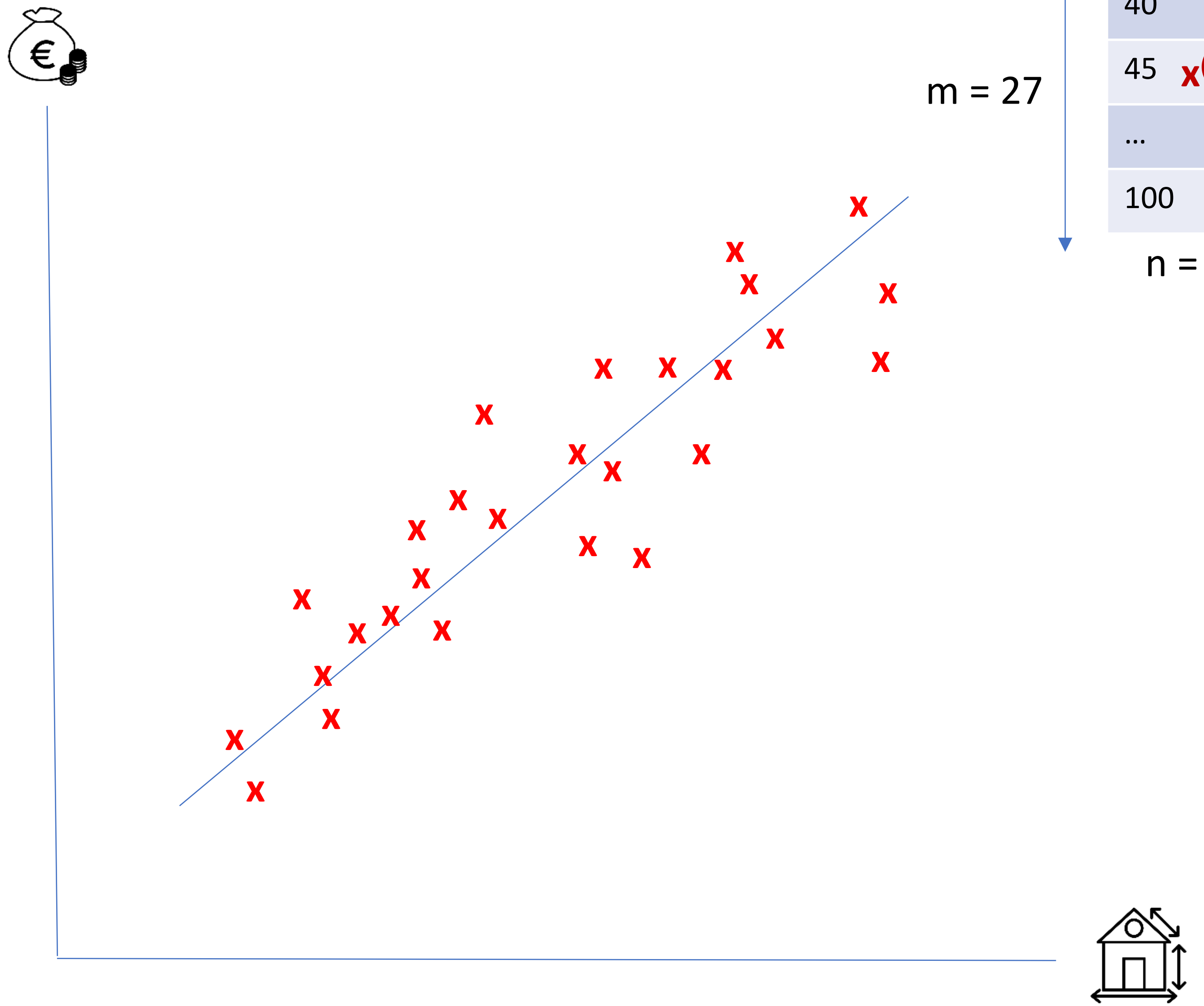
Challenge 4
Implement Linear regression

$$\theta_j = \theta_j - \alpha \frac{\partial J}{\partial \theta_j}$$

House price prediction



House price prediction



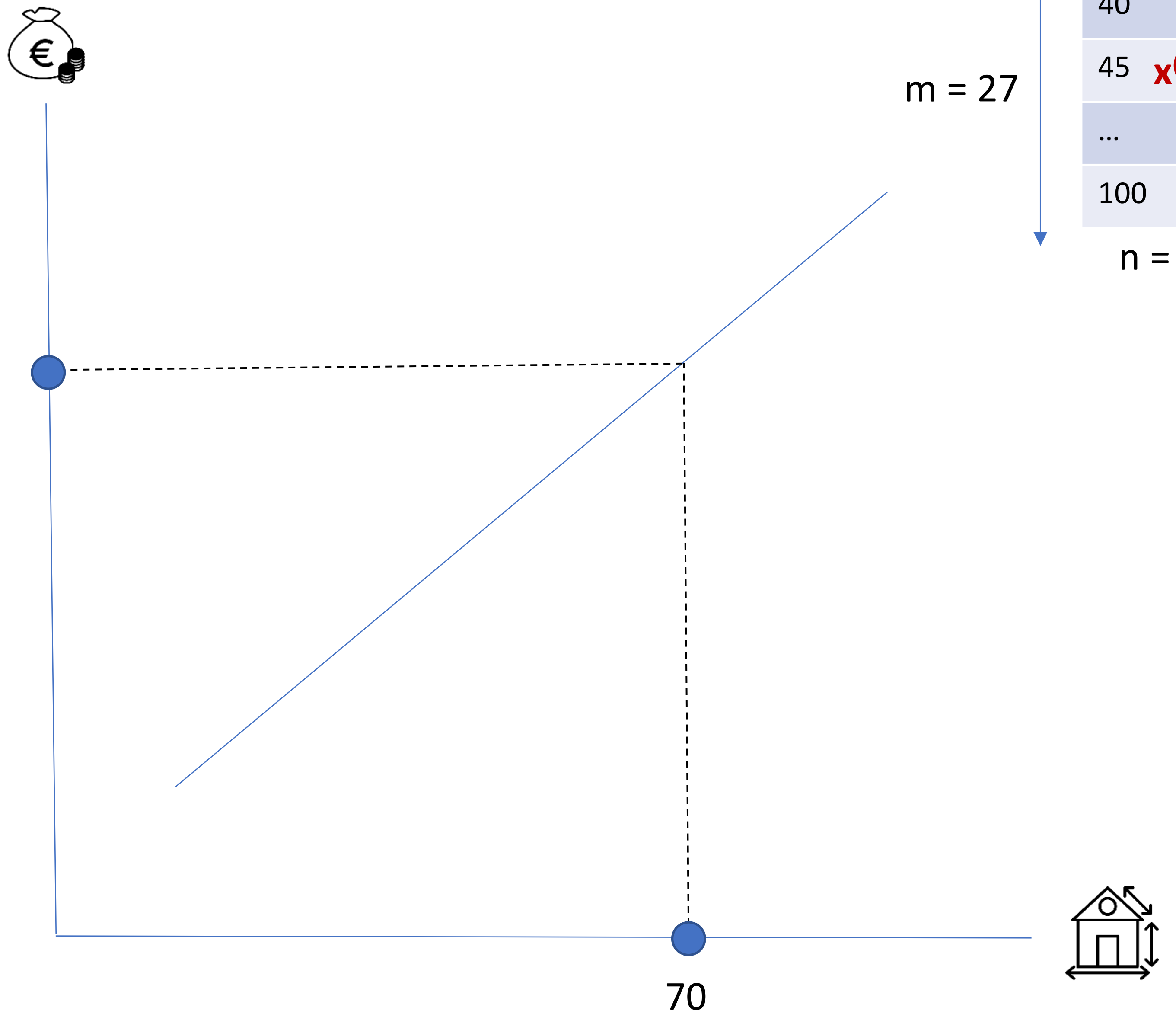
m = 27

Size (m^2)	Price (€)
40	150,000
45 $x^{(2)}$	170,000 $y^{(2)}$
…	
100	310,000

n = 1

$(x^{(i)}, y^{(i)})$

House price prediction



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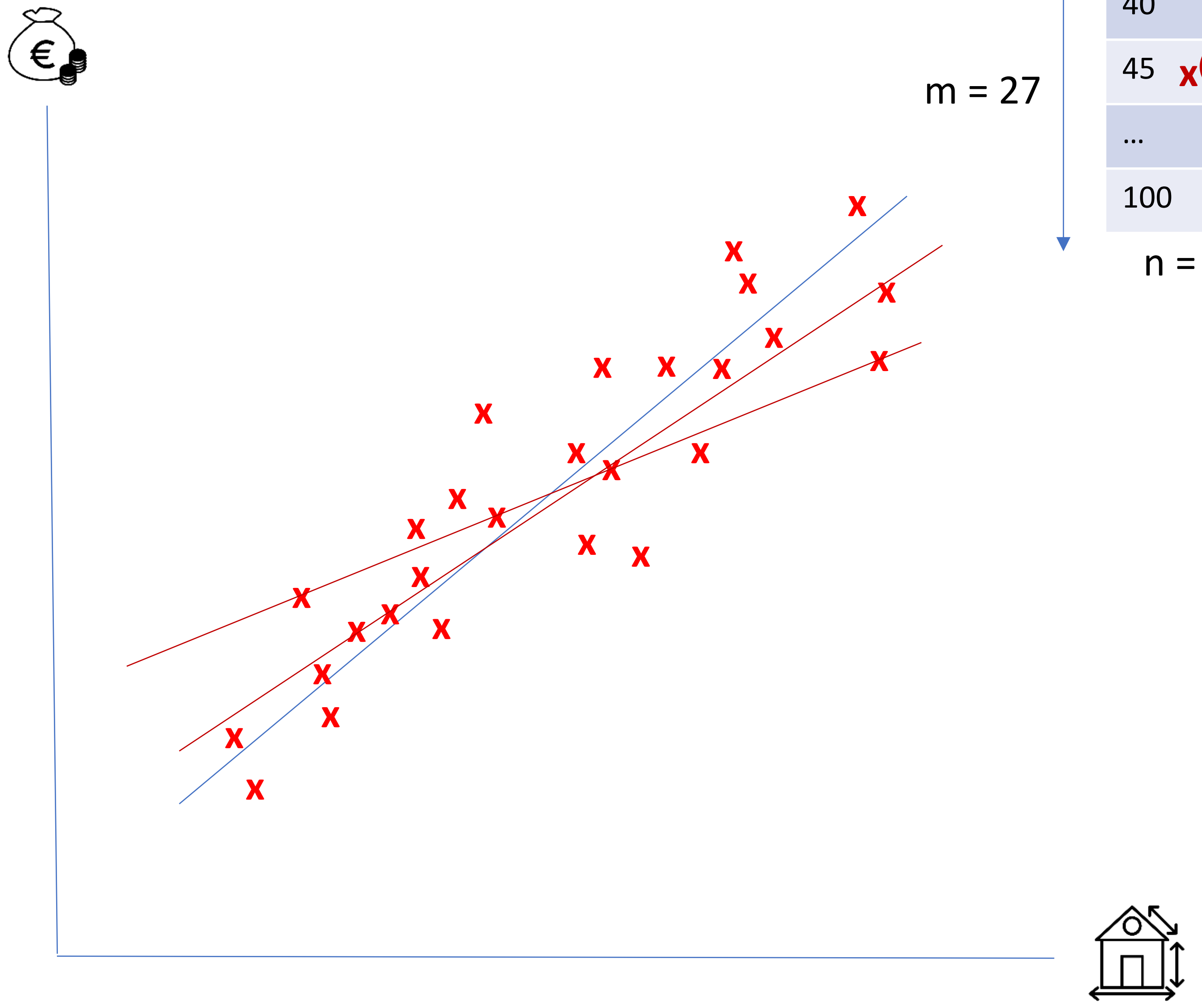
$(x^{(i)}, y^{(i)})$

$$y = \theta_0 + \theta_1 \times x$$

House price prediction



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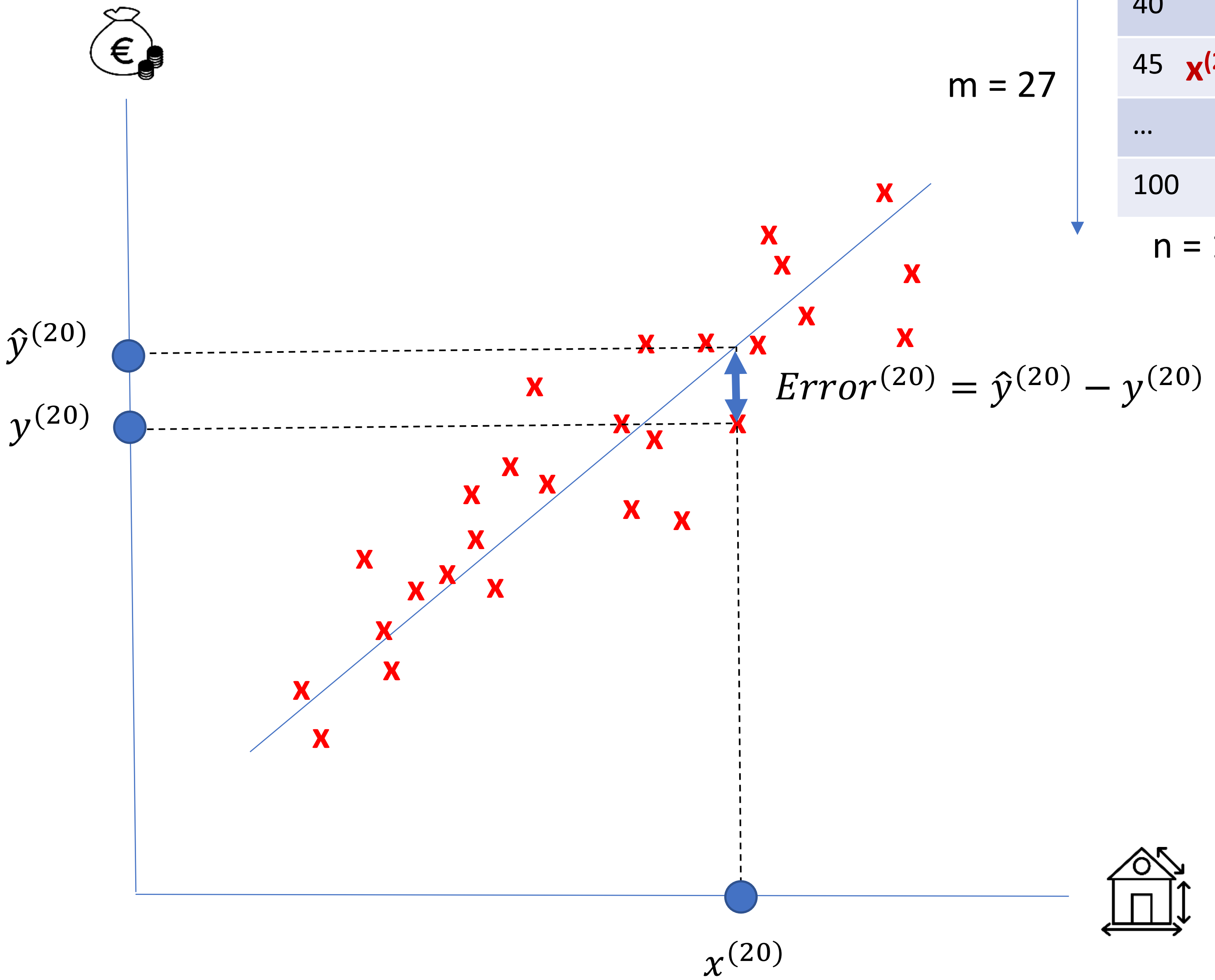


$y = \theta_0 + \theta_1 \times x$

$$\sum_{i=1}^{m} (\hat{y}^{(i)} - y^{(i)})$$

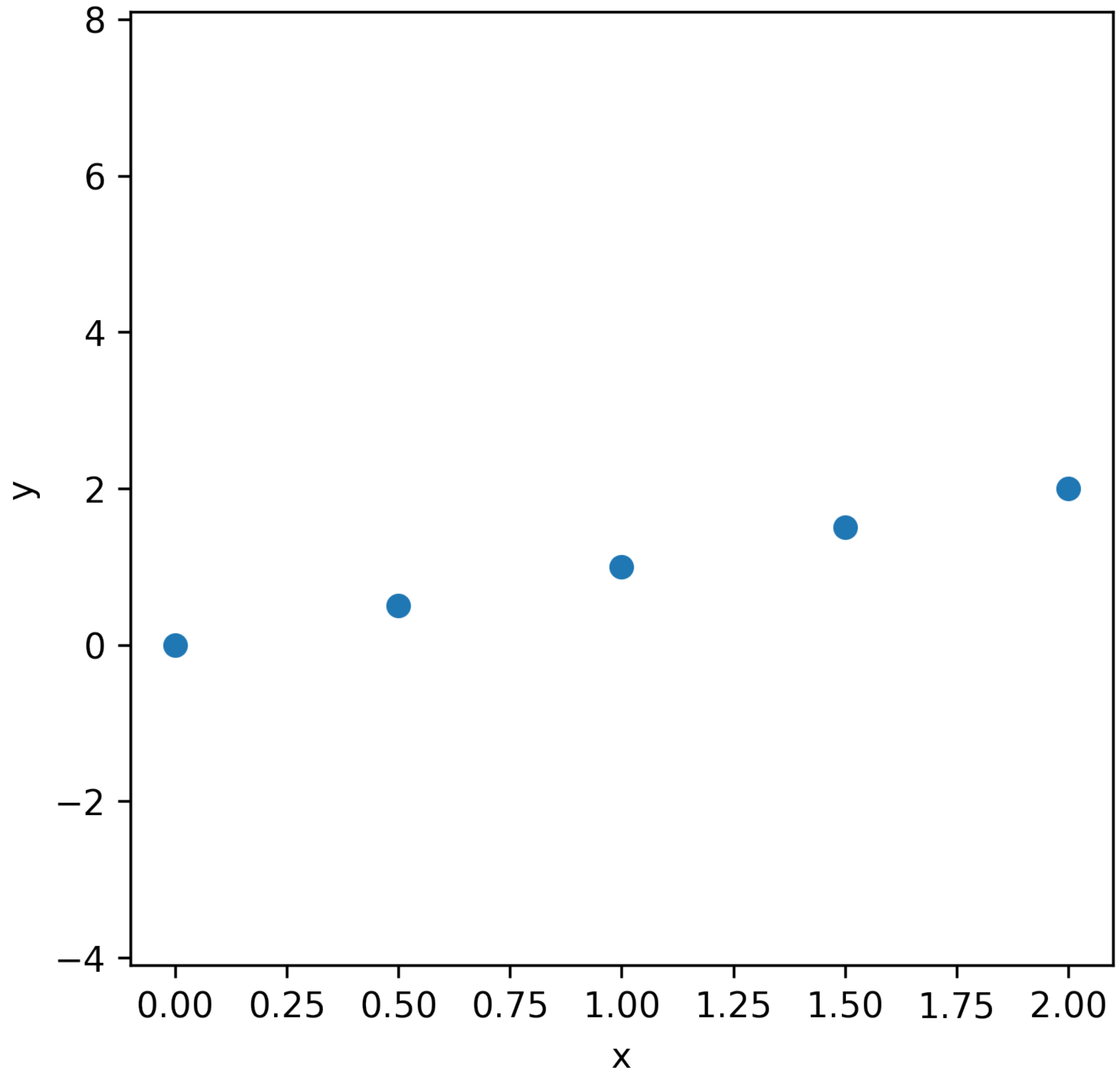
$$\sum_{i=1}^{m} (\hat{y}^{(i)} - y^{(i)})^2$$

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

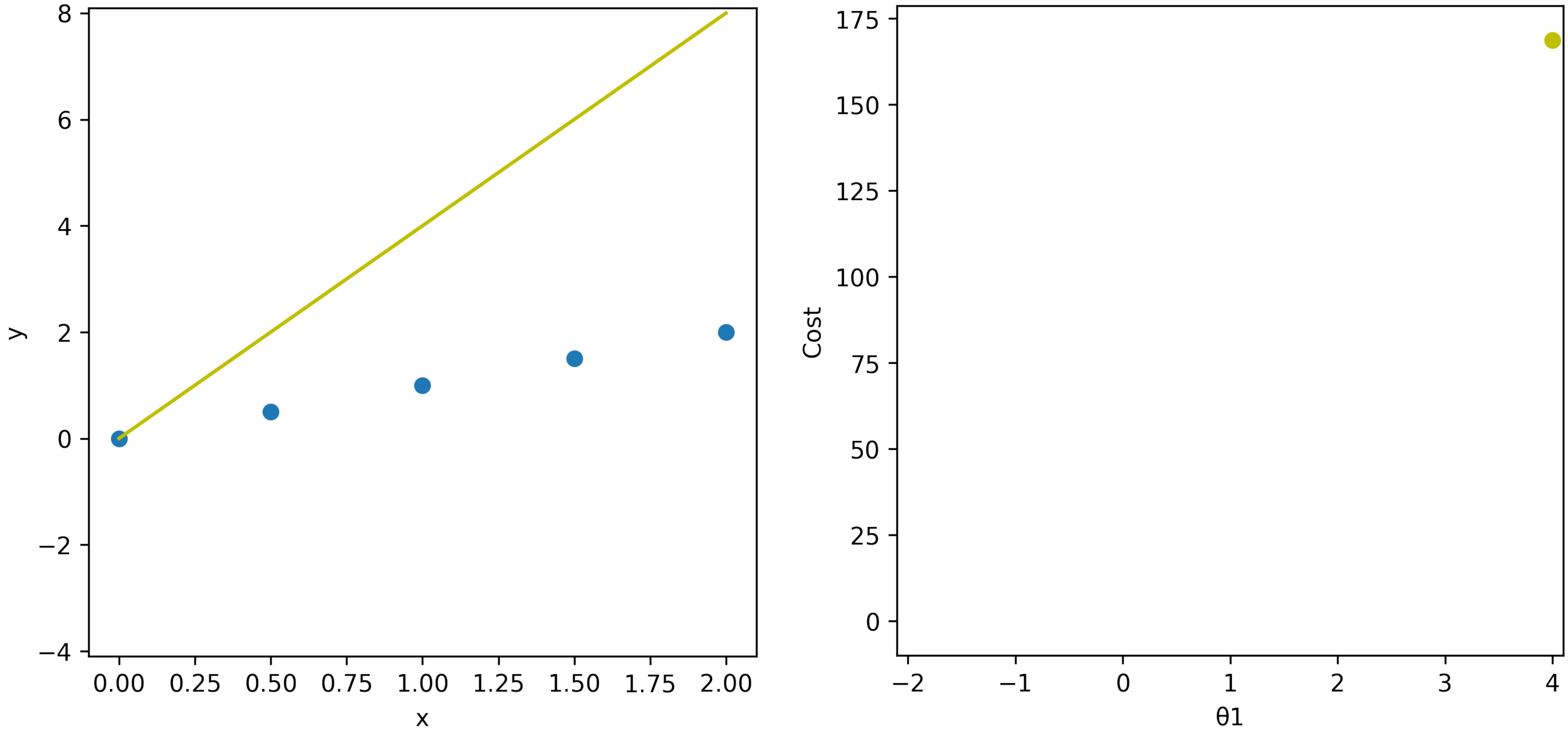
$$\frac{1}{2m}\sum_{i=1}^{m} (\hat{y}^{(i)} - y^{(i)})^2$$

$$J(\theta_0, \theta_1) = \frac{1}{2m}\sum_{i=1}^{m} (\theta_0 + \theta_1 x^{(i)} - y^{(i)})^2$$

Minimize a simplified J

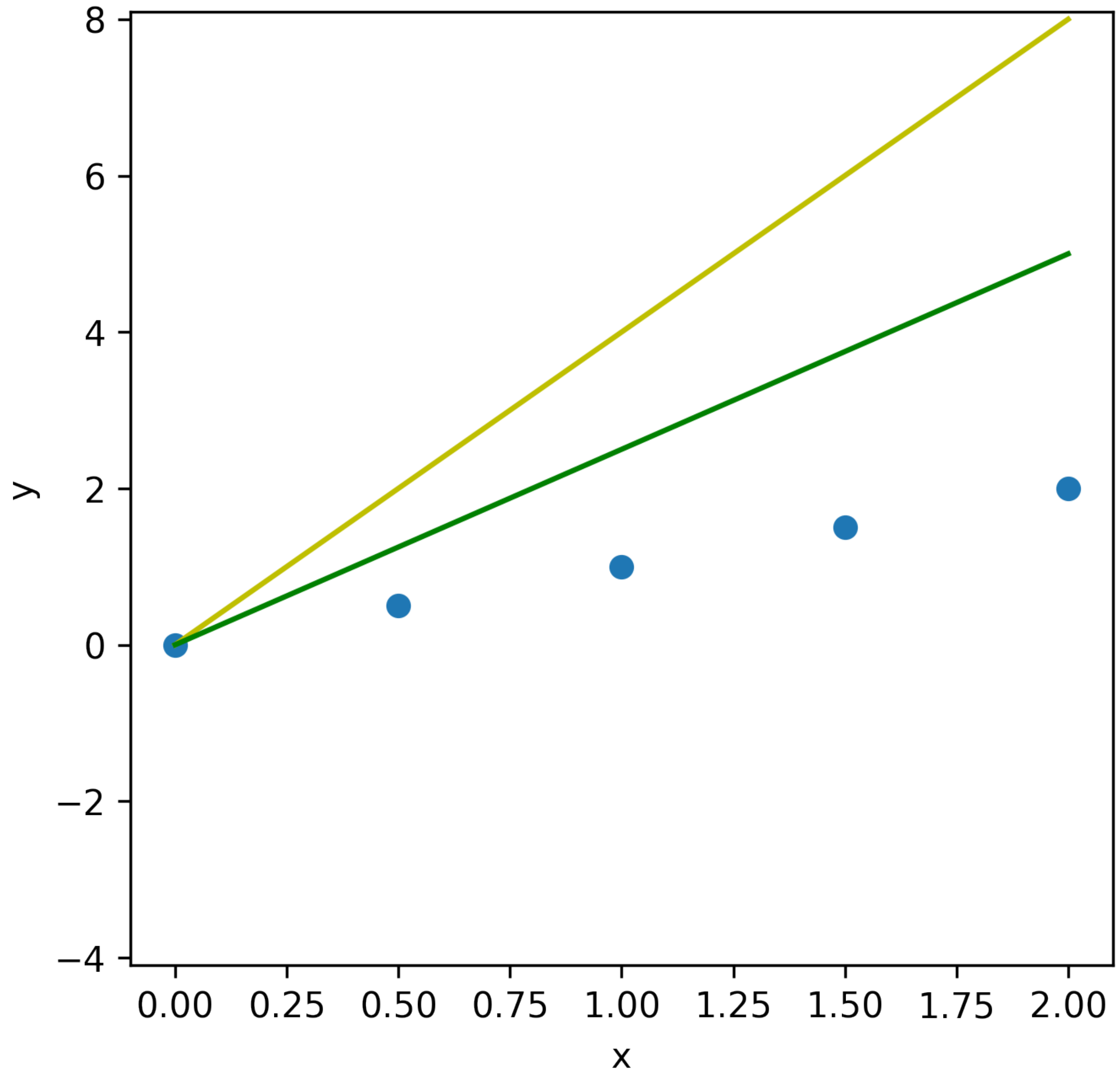


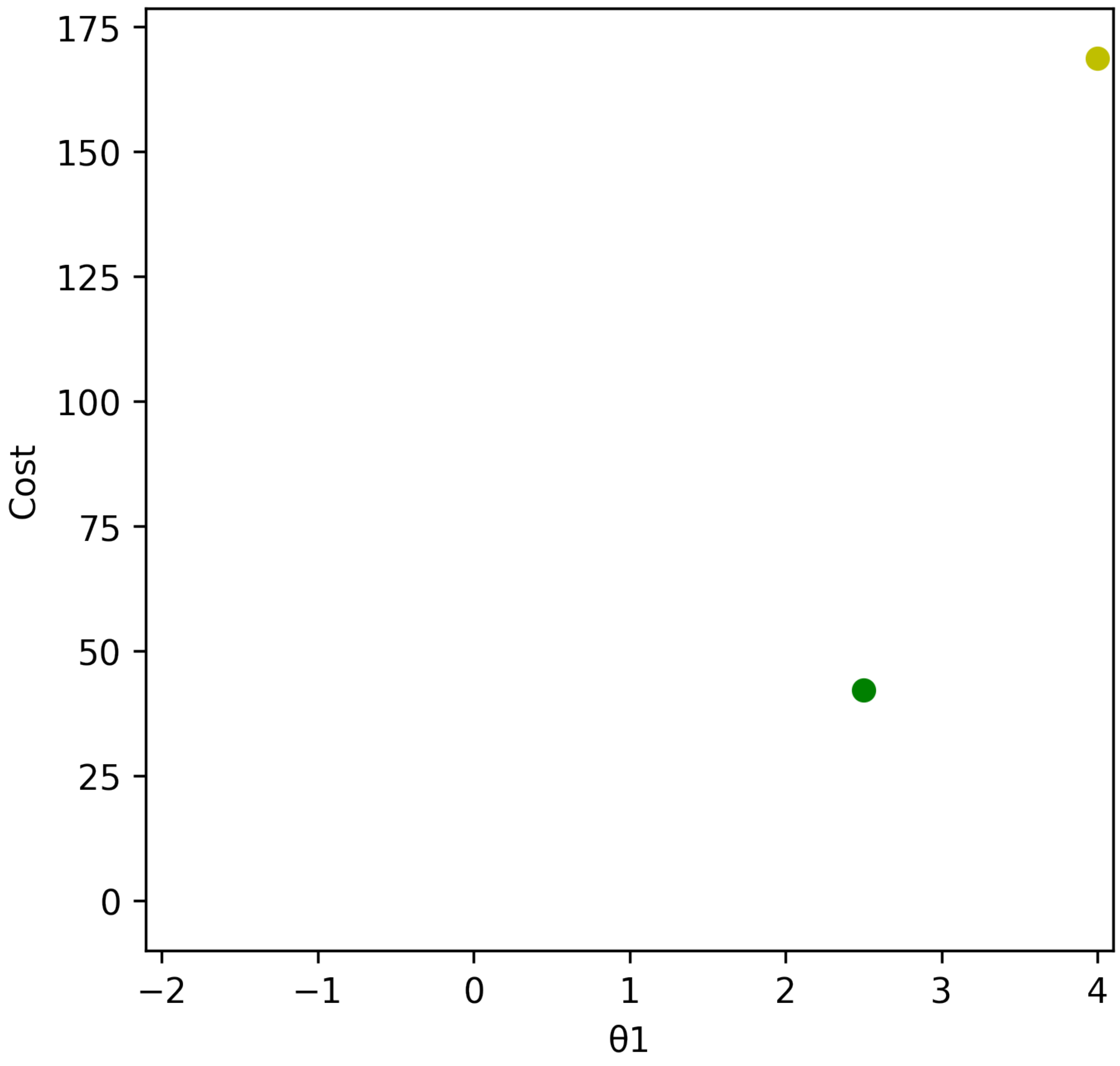
Minimize a simplified J



$$J(0, \theta_1) = \frac{1}{2m} \sum_{i=1}^{m} (0 + \theta_1 x^{(i)} - y^{(i)})^2$$

Minimize a simplified J





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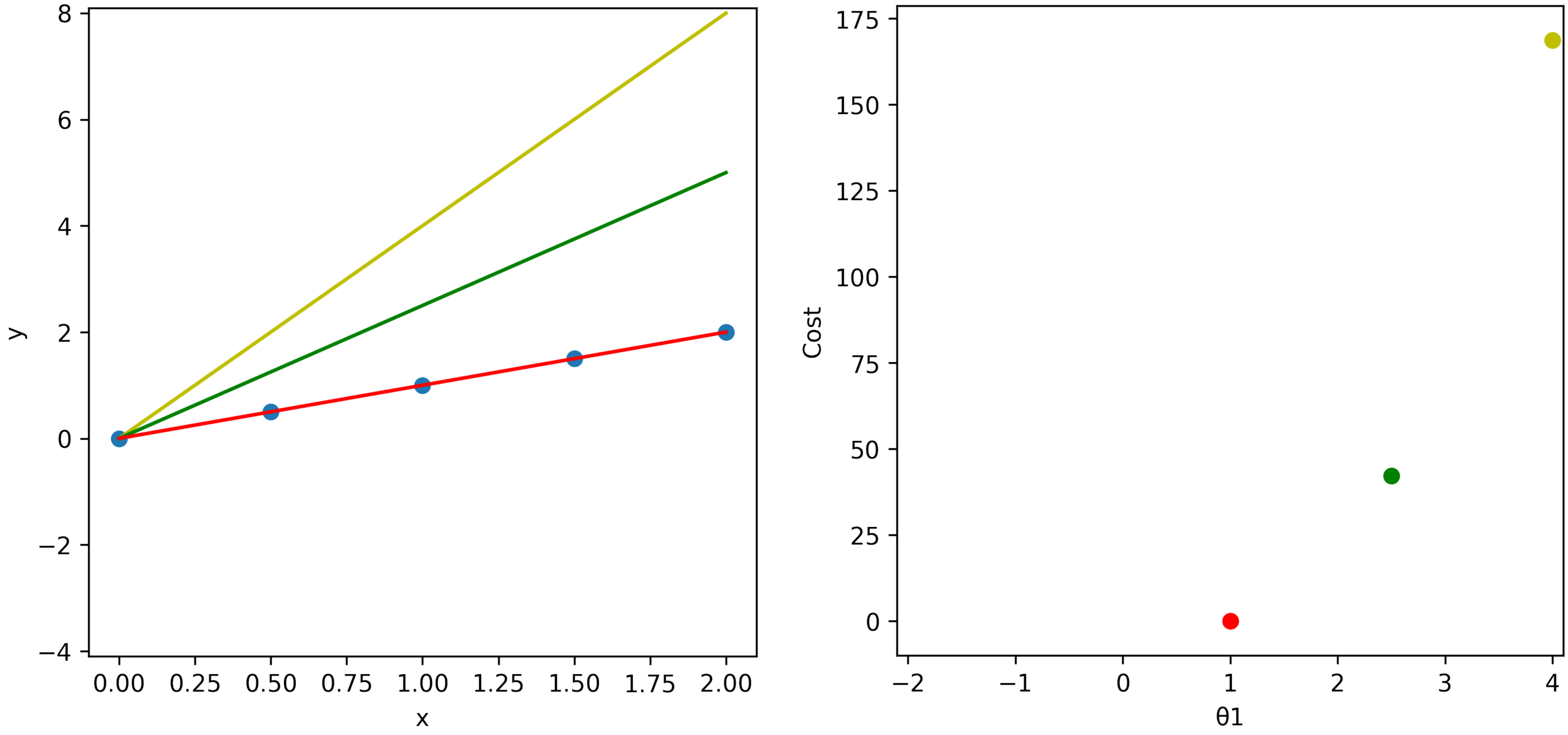
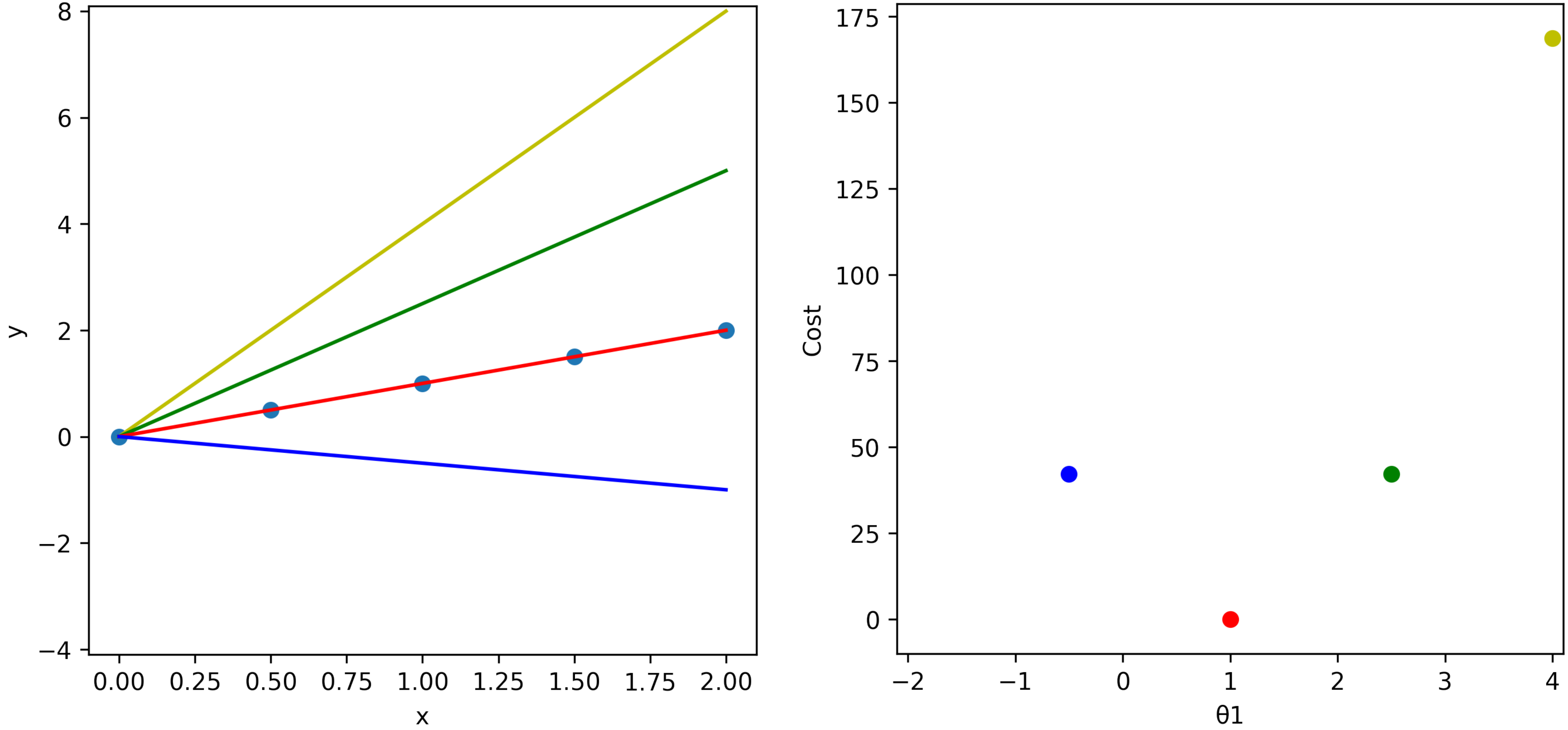


$$J(0,\theta_1) = \frac{1}{2m}\sum_{i=1}^{m}(0+\theta_1 x^{(i)} - y^{(i)})^2$$

Minimize a simplified J



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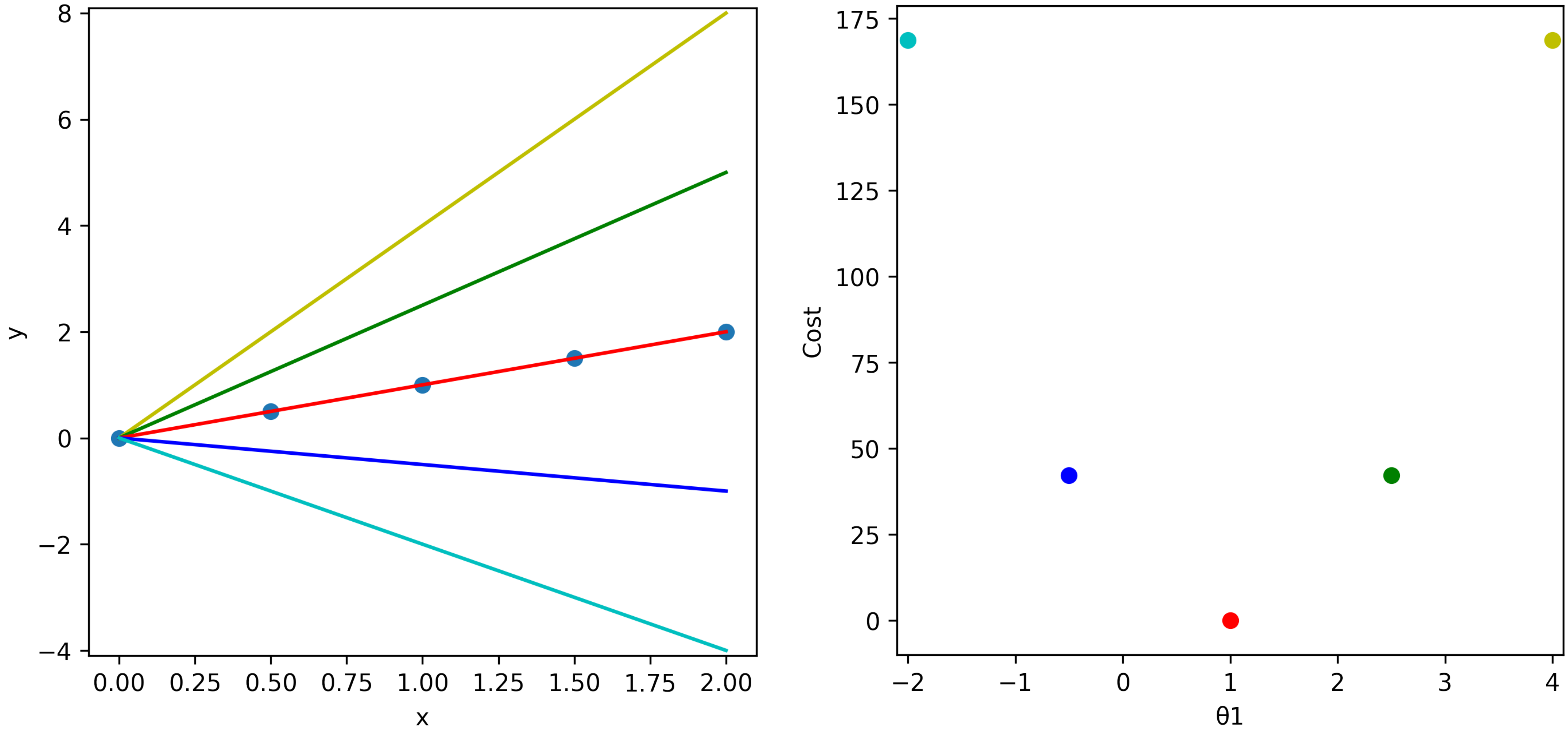
Minimize a simplified J



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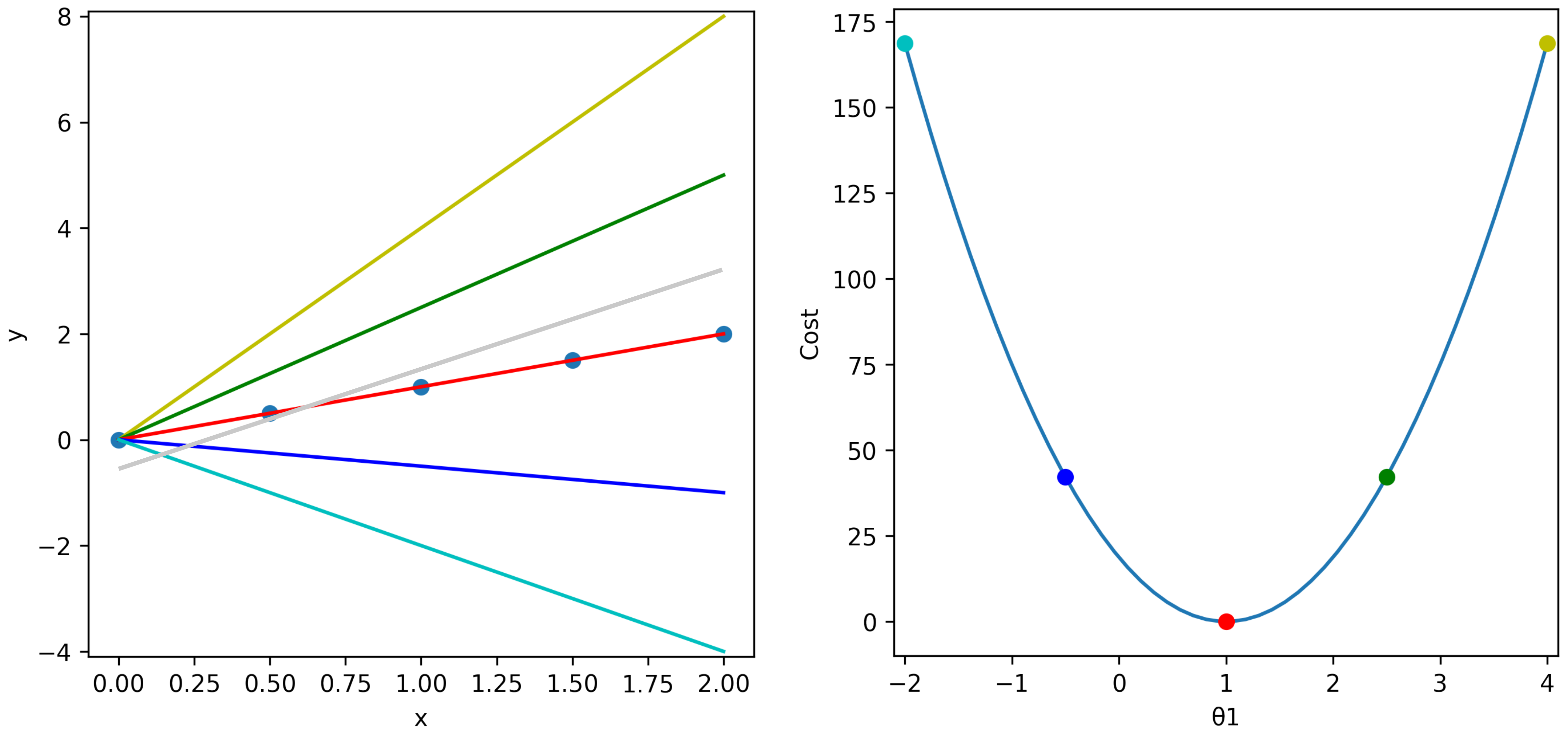
Minimize a simplified J



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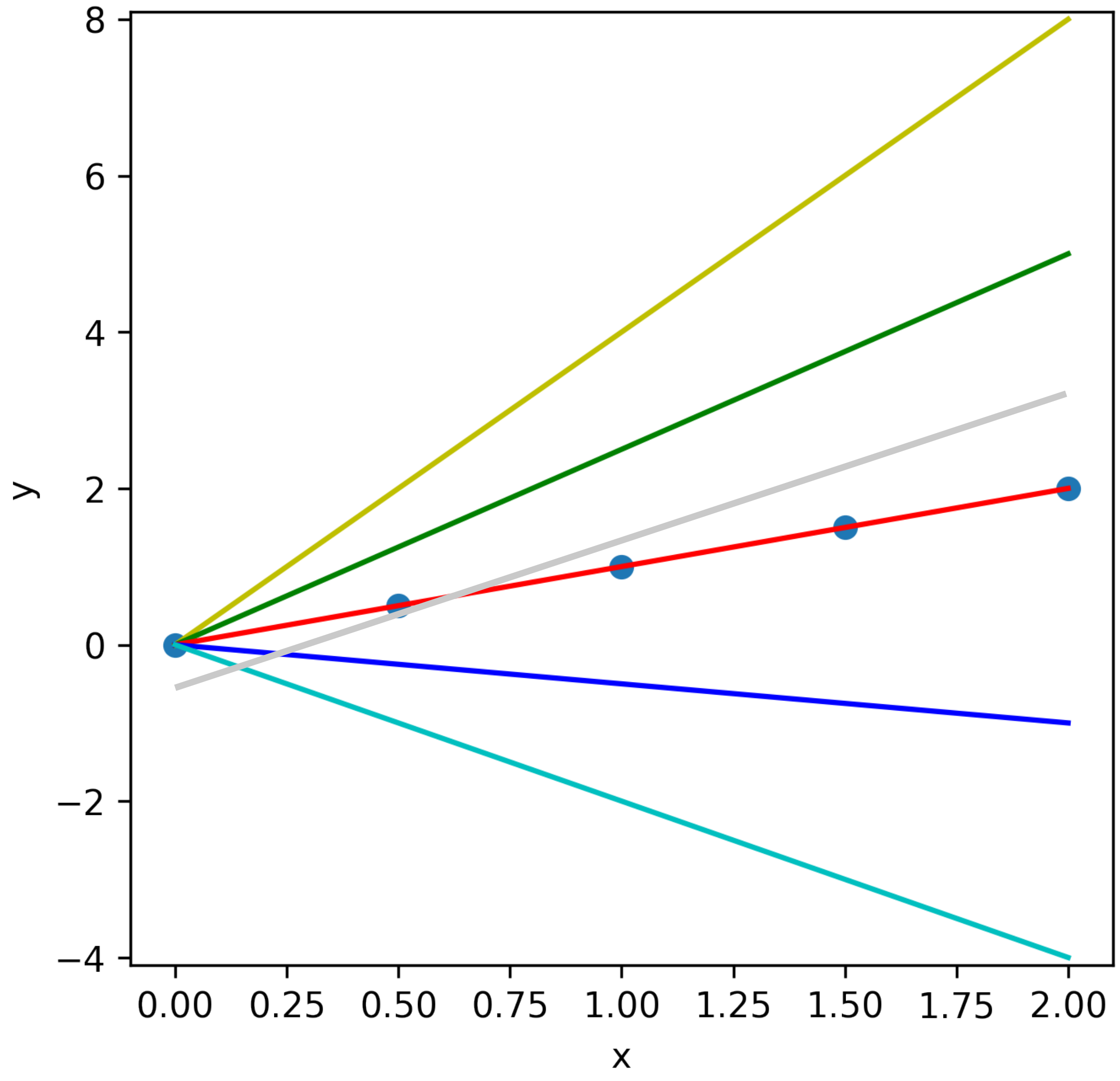
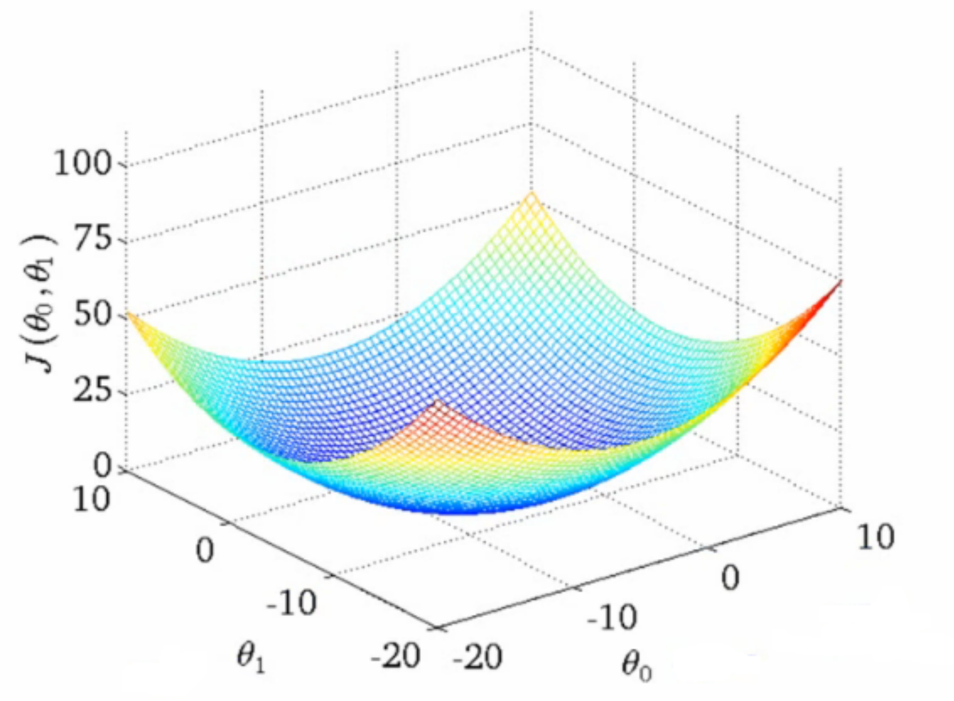
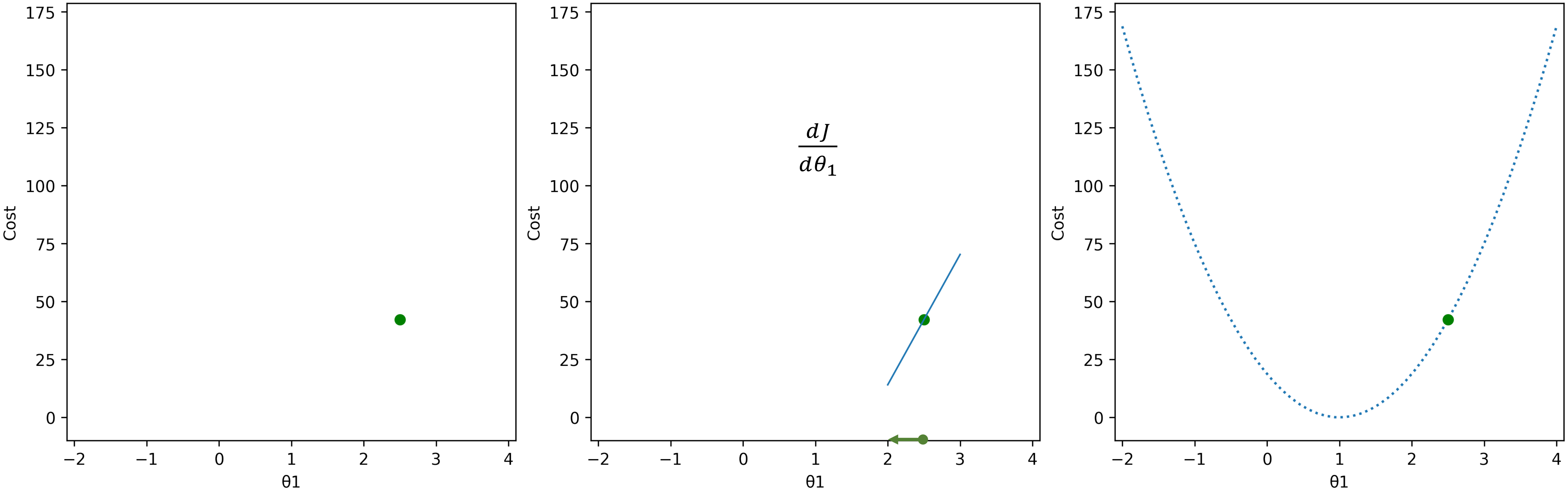
Minimize a simplified J



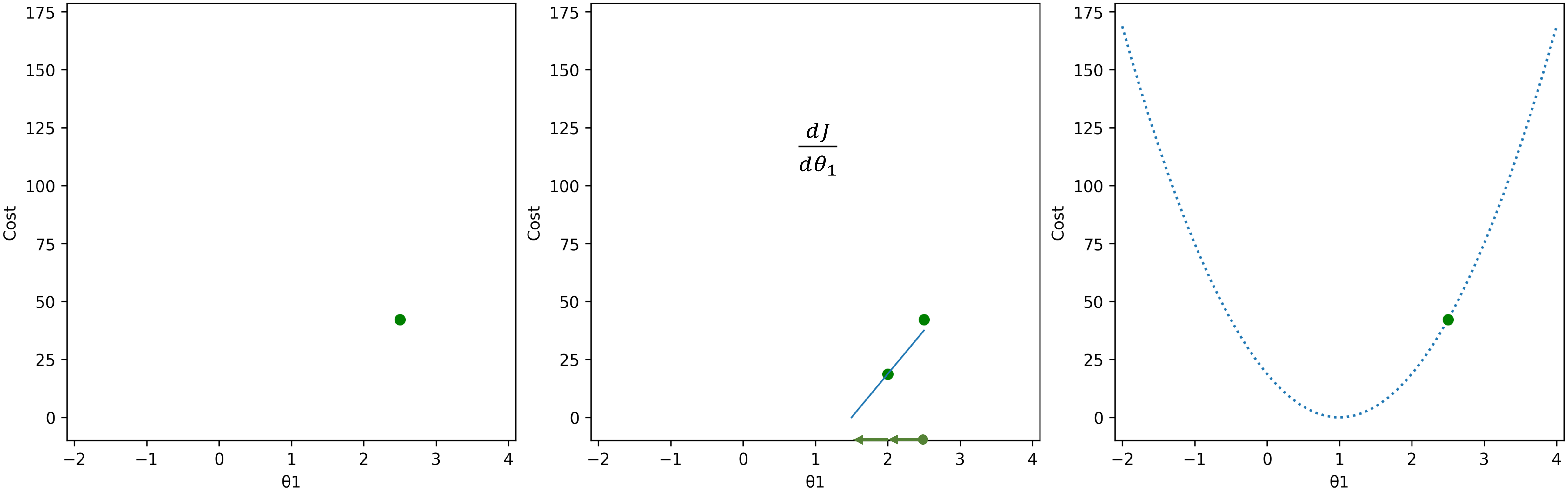


Gradient Descent



$$2 = 2.5 - 0.5$$

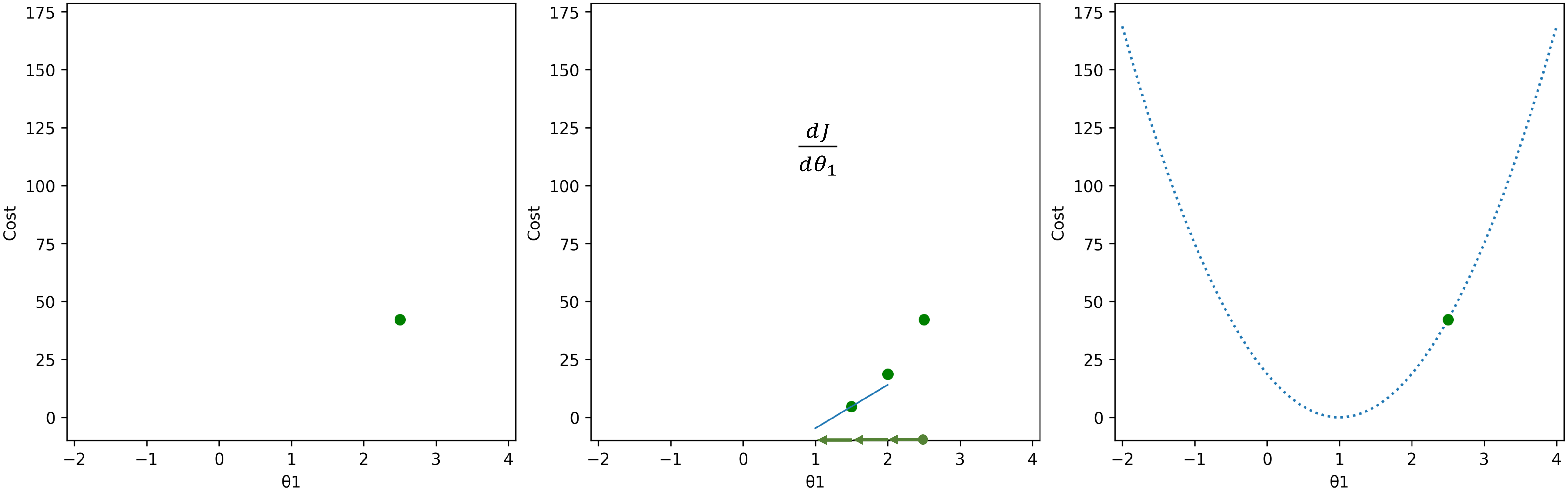
Gradient Descent



$$2 = 2.5 - 0.5$$

$$1.5 = 2 - 0.5$$

Gradient Descent

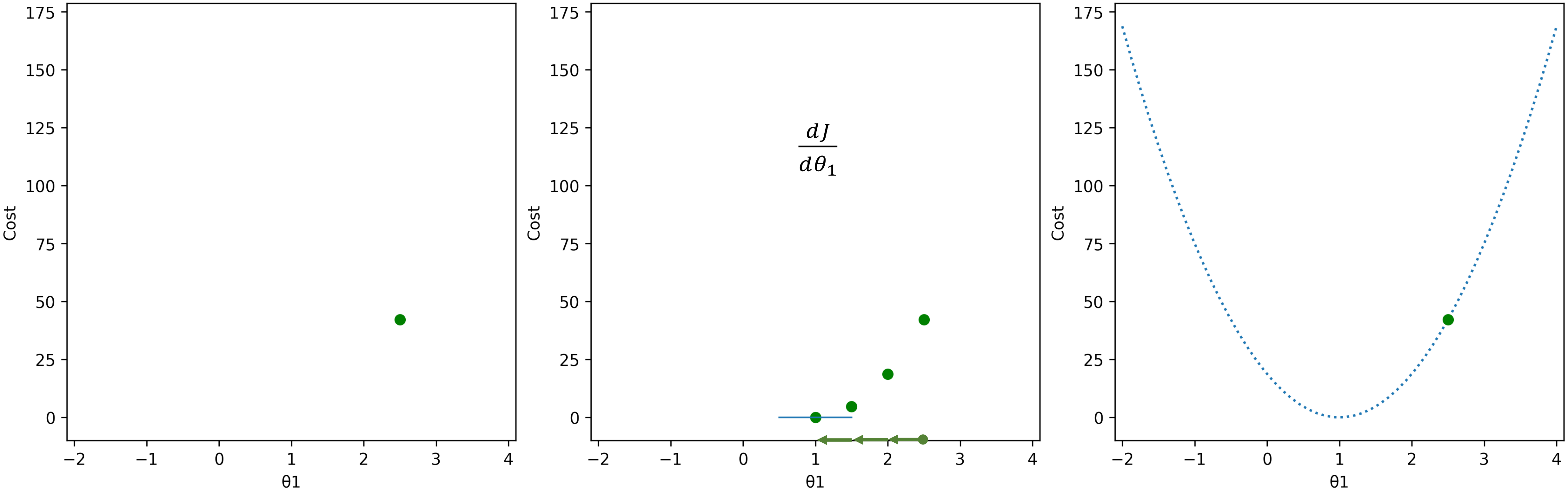


$$2 = 2.5 - 0.5$$

$$1.5 = 2 - 0.5$$

$$1 = 1.5 - 0.5$$

Gradient Descent



Repeat until slope = 0

$$\theta_1 = \theta_1 - 0.5$$

$$2 = 2.5 - 0.5$$

$$1.5 = 2 - 0.5$$

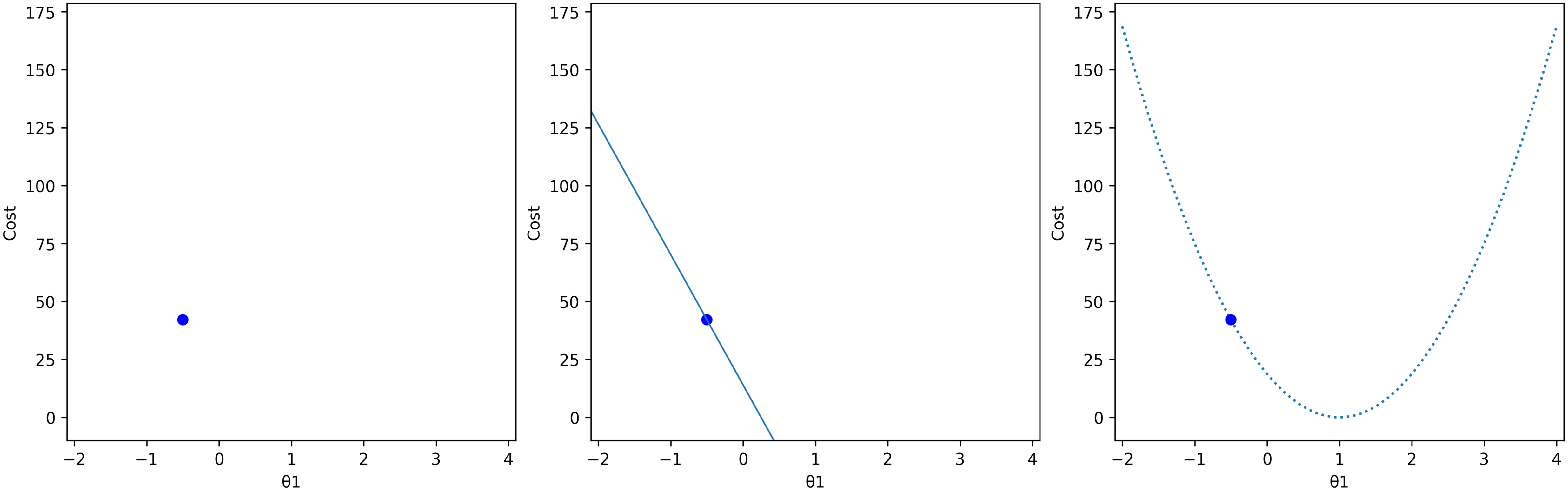
$$1 = 1.5 - 0.5$$

Repeat until convergence

$$\theta_1 = \theta_1 - \alpha \frac{dJ}{d\theta_1}$$

Learning rate (lr)

Gradient Descent



Repeat until convergence

$$\theta_1 = \theta_1 - \alpha \frac{dJ}{d\theta_1}$$

Gradient Descent

$$\theta_0 = \theta_0 - \alpha \frac{\partial J}{\partial \theta_0}$$

$$\theta_1 = \theta_1 - \alpha \frac{\partial J}{\partial \theta_1}$$

$$\theta_2 = \theta_2 - \alpha \frac{\partial J}{\partial \theta_2}$$

Repeat until convergence

$$\theta_j = \theta_j - \alpha \frac{\partial J}{\partial \theta_j}$$ j = 0,1,2…

$$J(\theta_0, \theta_1) = \frac{1}{2m} \sum_{i=1}^{m} (\theta_0 + \theta_1 x^{(i)} - y^{(i)})^2$$

$$\frac{\partial J}{\partial \theta_0} = \frac{1}{m} \sum_{i=1}^{m} \left(\theta_0 + \theta_1 x^{(i)} - y^{(i)}\right) * 1$$

$$\frac{\partial J}{\partial \theta_1} = \frac{1}{m} \sum_{i=1}^{m} \left(\theta_0 + \theta_1 x^{(i)} - y^{(i)}\right) * x^{(i)}$$

$$\theta_0 = \theta_0 - \frac{\alpha}{m} \sum_{i=1}^{m} \left(\theta_0 + \theta_1 x^{(i)} - y^{(i)}\right)$$

$$\theta_1 = \theta_1 - \frac{\alpha}{m} \sum_{i=1}^{m} \left(\theta_0 + \theta_1 x^{(i)} - y^{(i)}\right) * x^{(i)}$$

Dot product

x	y ?
-1	-3
0	-1
1	1
3	5
4	7

$$\theta_0 + \theta_1 * x = y$$

$$\theta_0 = -1$$
$$\theta_1 = 2$$

$$X \cdot \theta = y$$

```
X
```

```
array([[ 1., -1.],
       [ 1.,  0.],
       [ 1.,  1.],
       [ 1.,  3.],
       [ 1.,  4.]])
```

```
theta
```

```
array([[-1],
       [ 2]])
```

```
np.dot(X, theta)
```

```
array([[-3.],
       [-1.],
       [ 1.],
       [ 5.],
       [ 7.]])
```

```
X.shape
```

```
(5, 2)
```

```
theta.shape
```

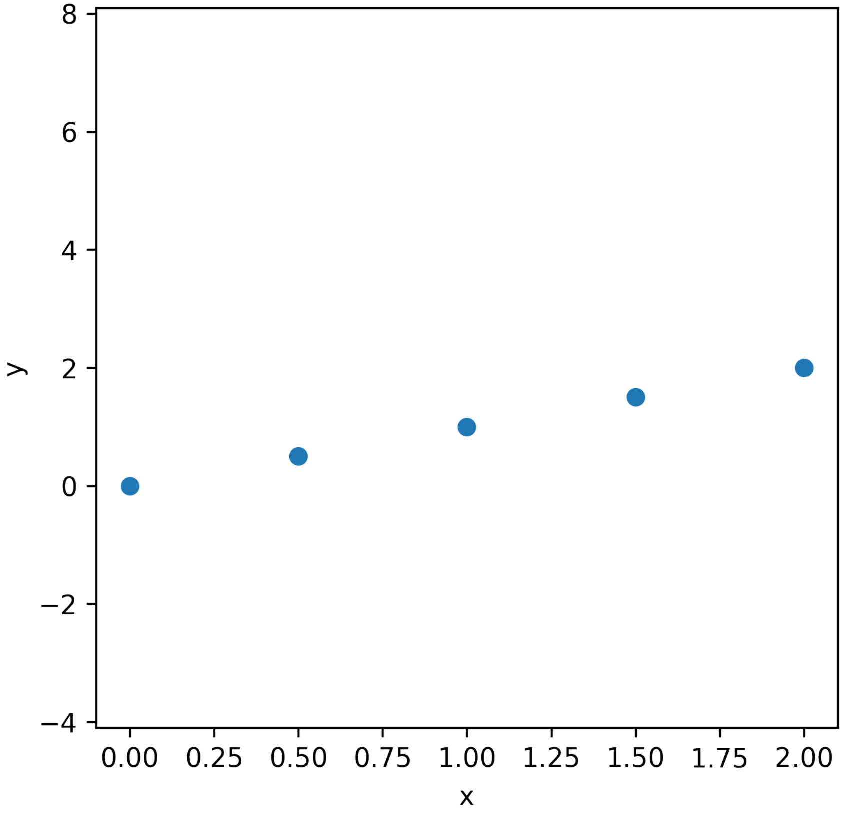
```
(2, 1)
```

```
theta.shape
```

```
(2,)
```

np.reshape()
np.newaxis

The Challenge




```
def cost_function(X, y, theta):
```

$$J(\theta_0, \theta_1) = \frac{1}{2m}\sum_{i=1}^{m}\left(\theta_0 + \theta_1 x^{(i)} - y^{(i)}\right)^2$$

```
def GD_one_step(X, y, theta, lr):
```

$$\theta_0 = \theta_0 - \frac{\alpha}{m}\sum_{i=1}^{m}\left(\theta_0 + \theta_1 x^{(i)} - y^{(i)}\right)$$

$$\theta_1 = \theta_1 - \frac{\alpha}{m}\sum_{i=1}^{m}\left(\theta_0 + \theta_1 x^{(i)} - y^{(i)}\right) * x^{(i)}$$

```
def GD(X, y, lr, epoch):
```

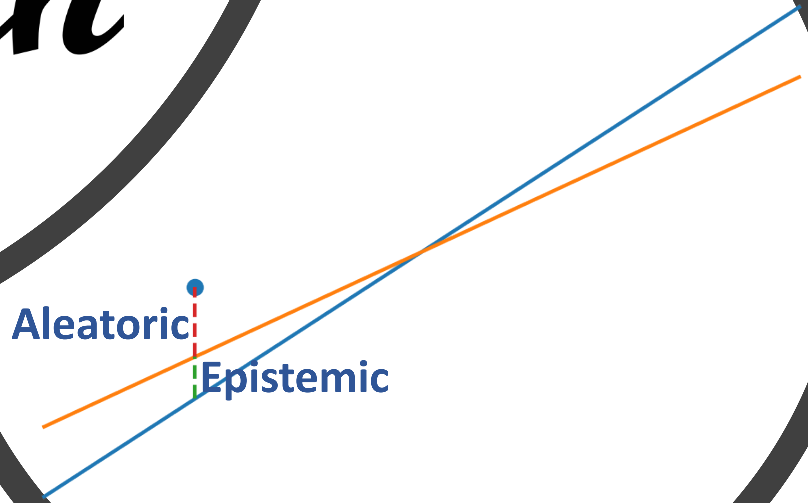
Repeat until convergence

Challenge 1
Linear regression

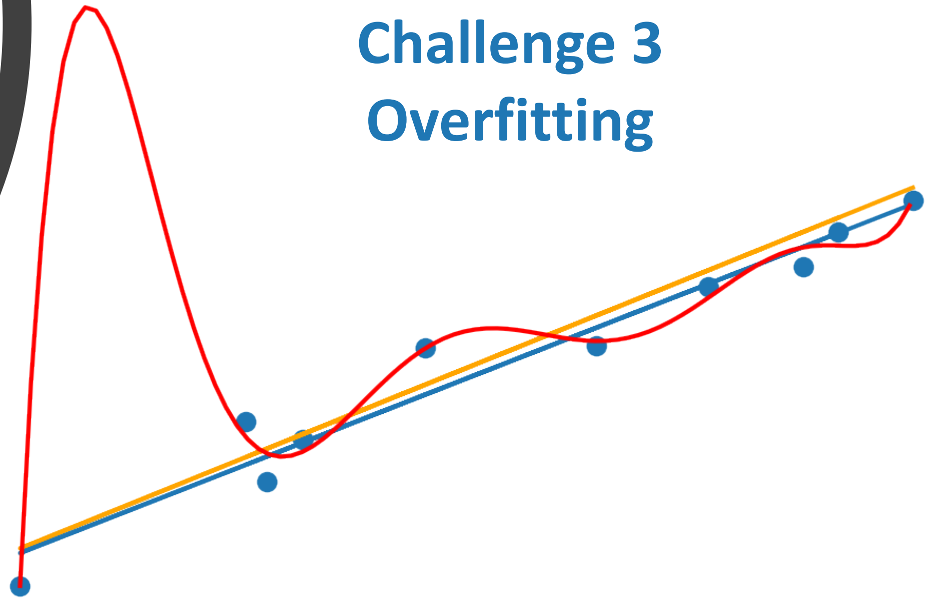
Challenge 4
Implement Linear regression

$$\theta_j = \theta_j - \alpha \frac{\partial J}{\partial \theta_j}$$

Challenge 2



Challenge 3
Overfitting



Good luck!

@malicannoyan