CSCI 111 Web Programming and Problem Solving
Section 1
PART III Artificial Intelligence
Weeks [12 - 15]
Week-12-lecture-3: Machine Learning. Linear Regression.
Instructor: Dr. Talgat Manglayev

CONTENT

- The problem: Predict the price of a house
- The solution: Building a regression model for housing prices
- The linear regression algorithm
- How do we measure our results? The error function

The problem: Predict the price of a house

What would be the price for a house with 4 rooms?

Rooms	Price
1	10
2	15
3	20
4	?
5	30
6	35
7	40

The problem: Predict the price of a house

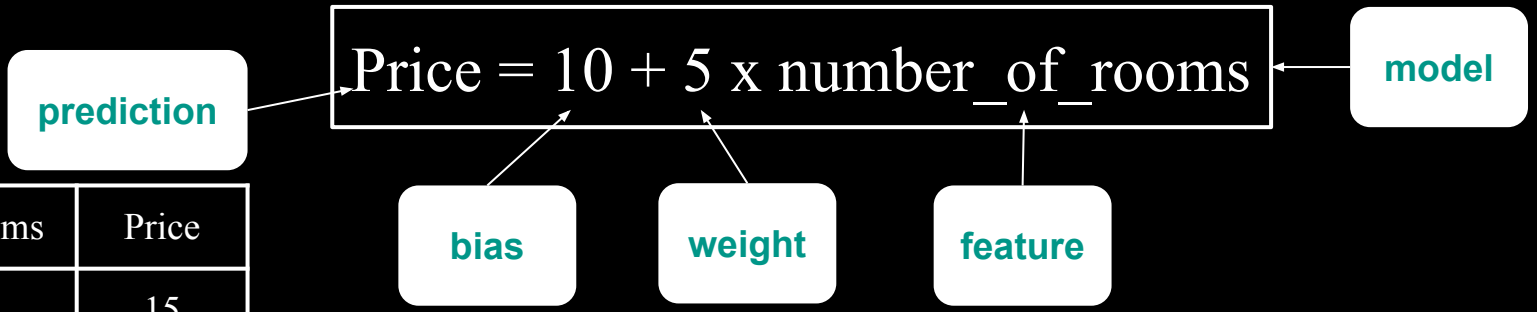
What would be the formula for price for a house?

Price = 5 + 5 x number_of_rooms

Rooms	Price
1	10
2	15
3	20
4	?
5	30
6	35
7	40

The problem: Predict the price of a house

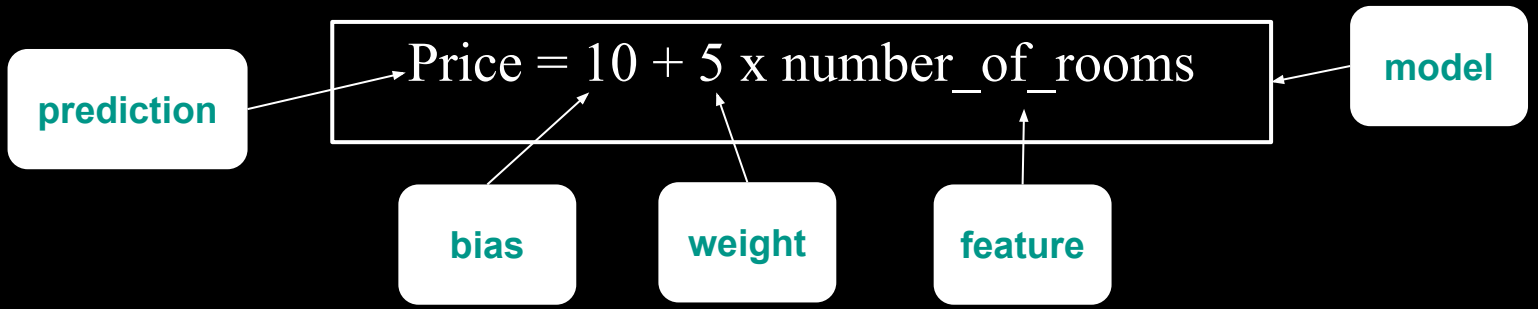
What would be the formula for price for a house?



Rooms	Price
1	15
2	20
3	25
4	?
5	35
6	40
7	45

The problem: Predict the price of a house

The model to predict price for a house



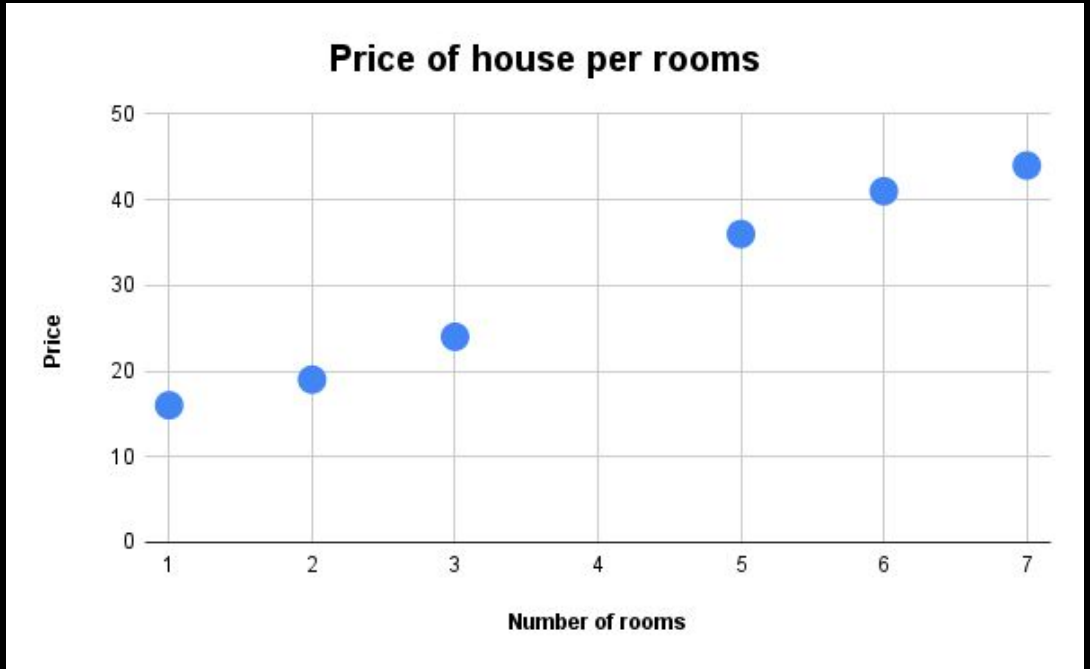
The problem: Predict the price of a house

Rooms	Price
1	16
2	19
3	24
4	?
5	36
6	41
7	44

The problem: Predict the price of a house

Price = 10 + 5 x number_of_rooms + (small_error)

Rooms	Price
1	16
2	19
3	24
4	?
5	36
6	41
7	44



The problem: Predict the price of a house

Price = 10 + 5 x number_of_rooms + (small_error)

Rooms	Price
1	16
2	19
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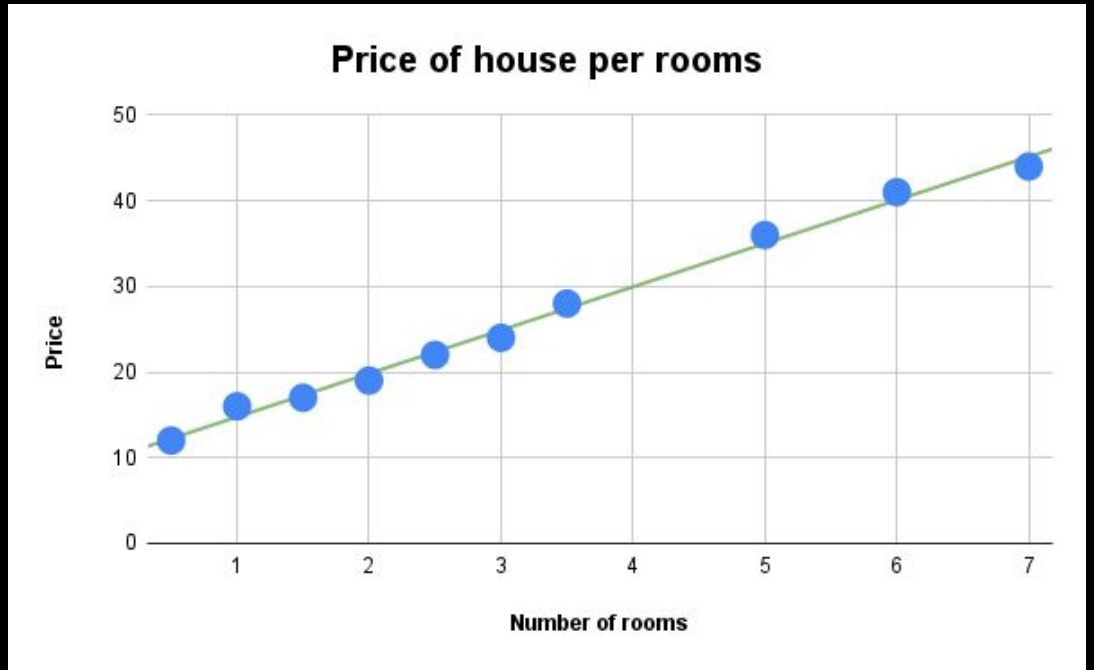
The problem: Predict the price of a house

Price = 10 + 5 x number_of_rooms + (small_error)

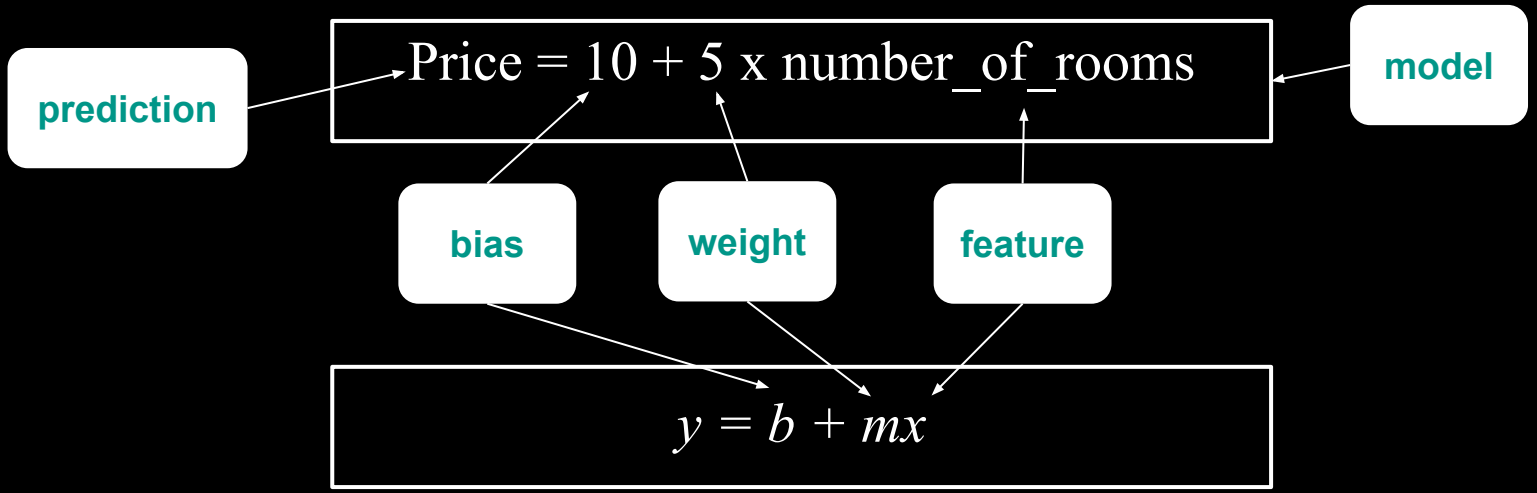
The goal of linear regression is to draw the straight line that passes as close as possible to these points.

Rooms	Price
1	16
2	19
3	24
4	30
5	36
6	41
7	44



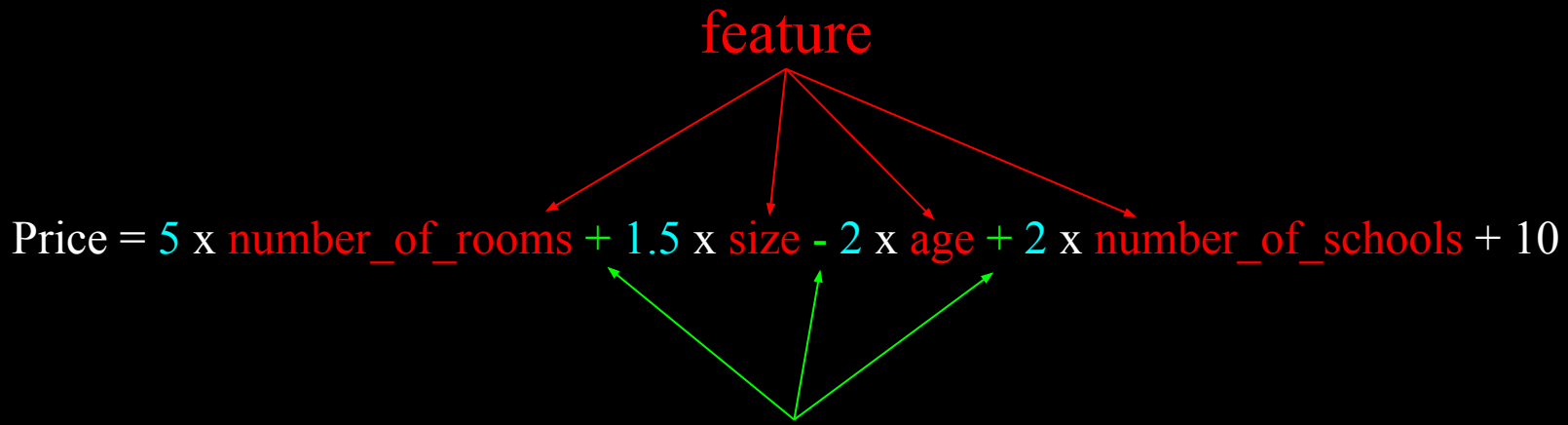
The problem: Predict the price of a house

The model to predict price for a house



Linear equation

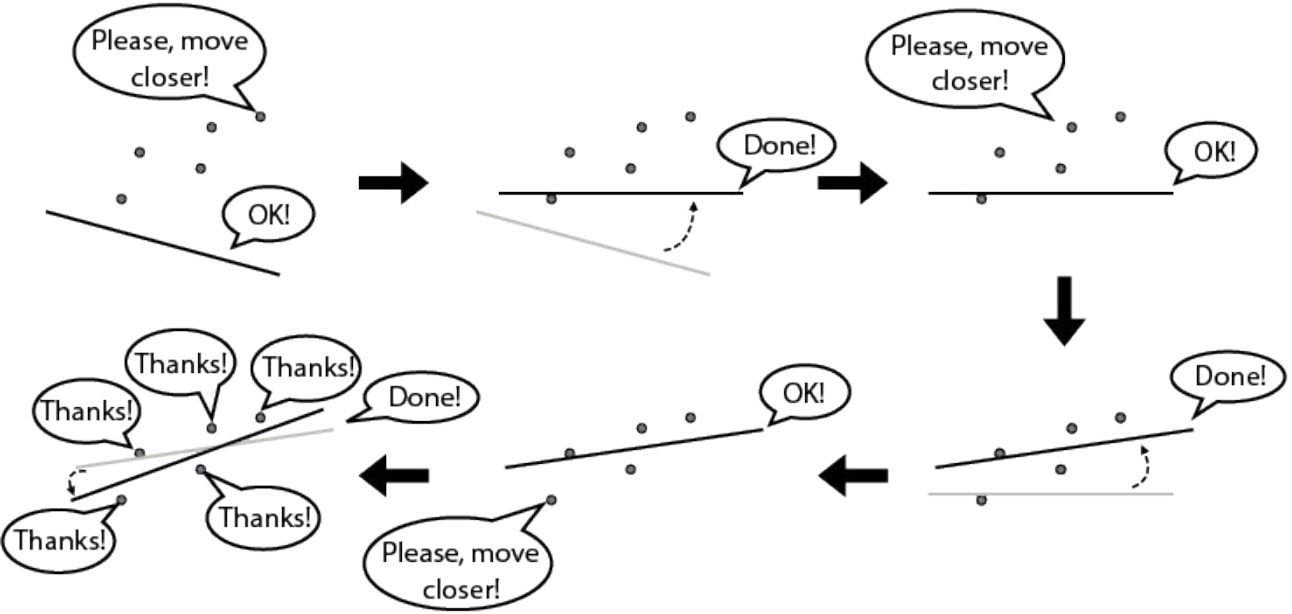
Multivariate linear regression



weight value - how important is the feature to determine the price

sign affects whether the price rises (+) or fails (-)

The linear regression algorithm



Pick a random line.

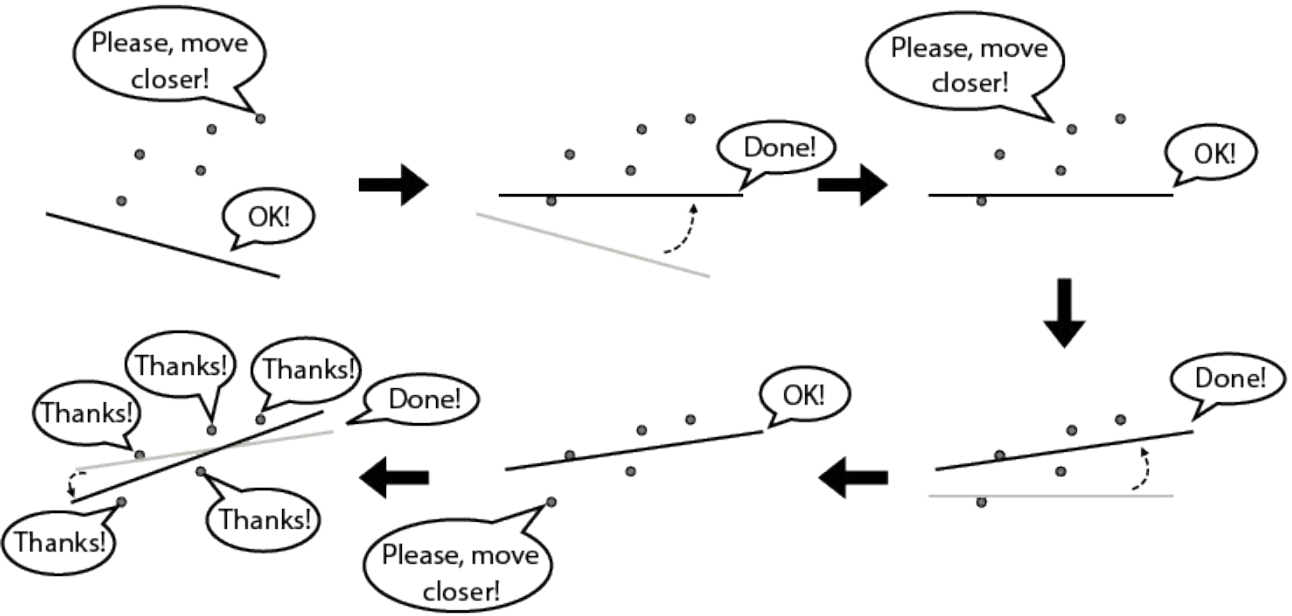
Repeat many times:

- Pick a random data point.
- Move the line a little closer to the point.

Return the line you've obtained.

Serrano, L., 2021. *Grokking machine learning*. Simon and Schuster.

The linear regression algorithm



Pick a model with random weights and a random bias.

Repeat many times:

- Pick a random data point.
- Slightly adjust the weights and bias to improve the prediction for that particular data point.

Return the model you've obtained.

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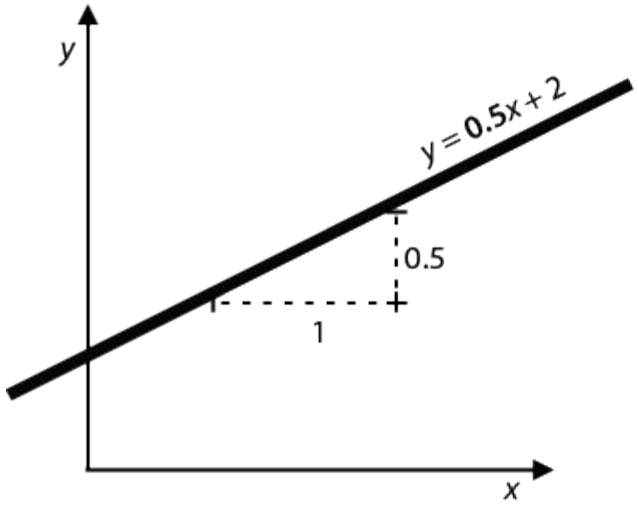
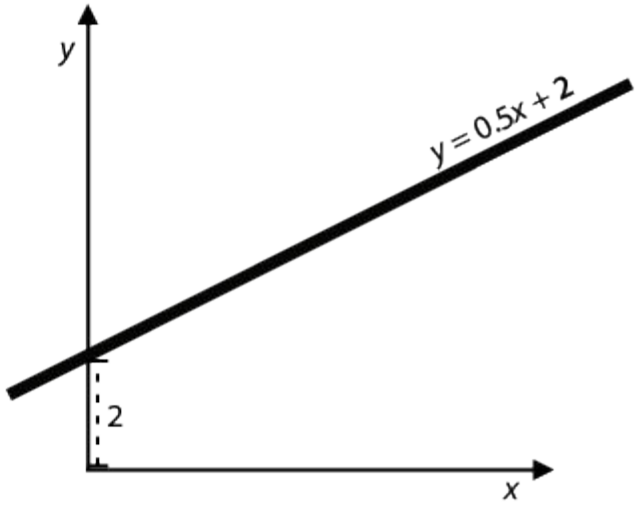
The linear regression algorithm



Slope = 0.5



y-intercept = 2

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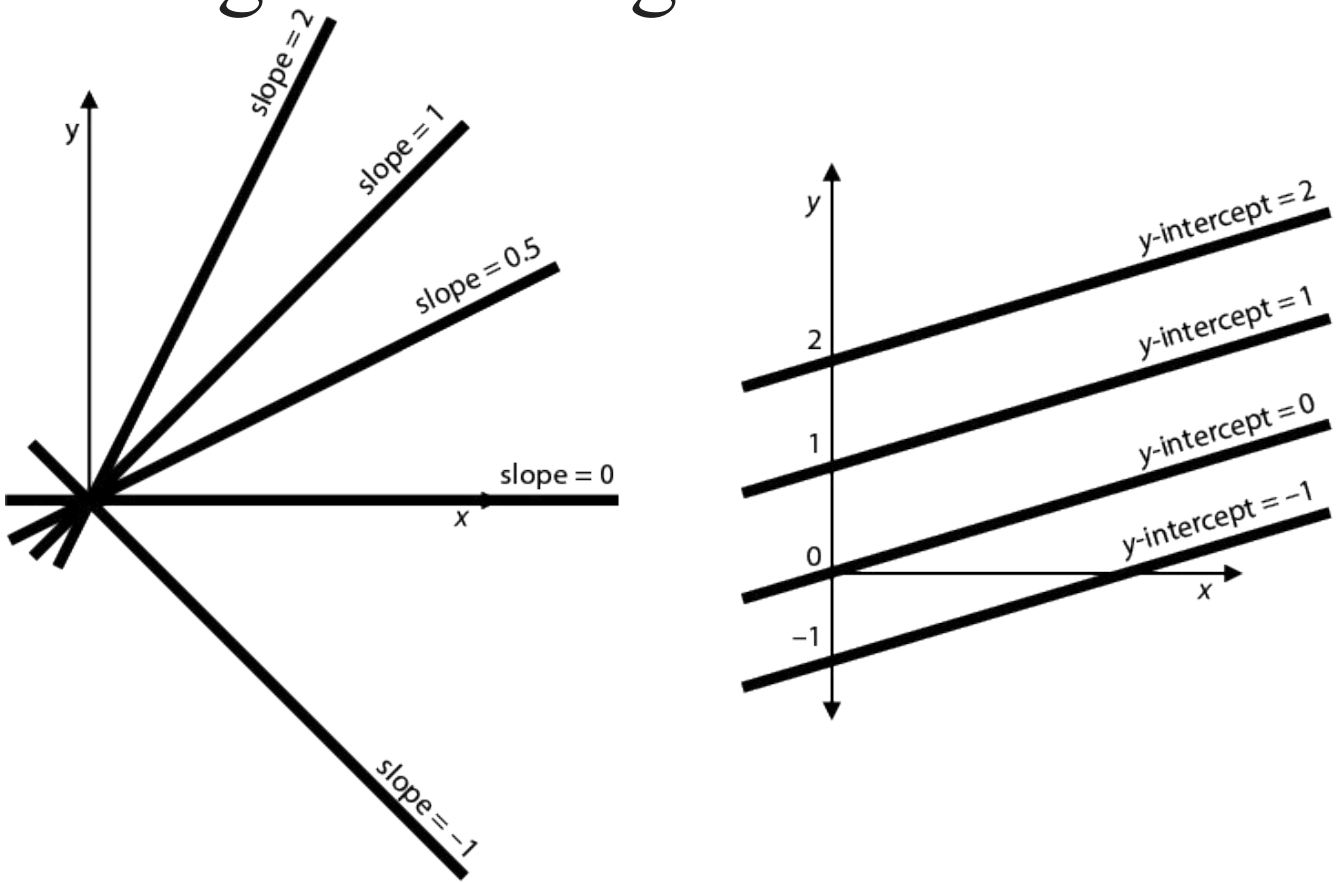
The linear regression algorithm



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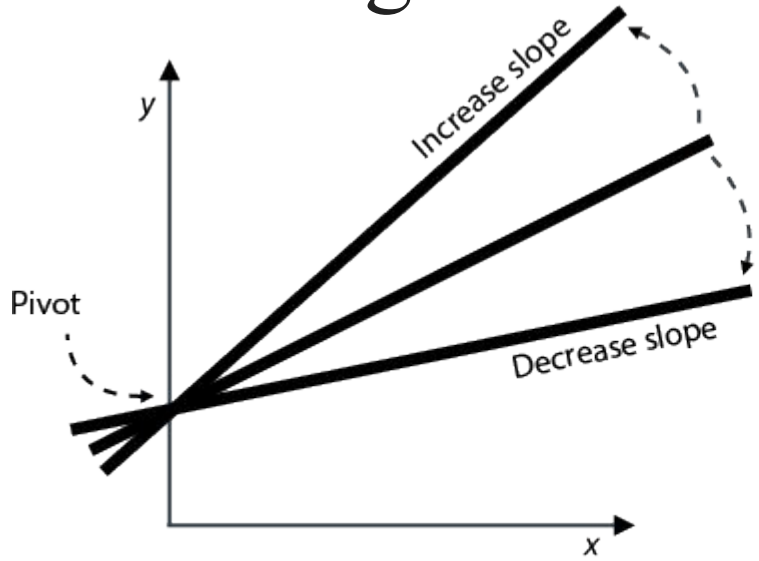
The linear regression algorithm

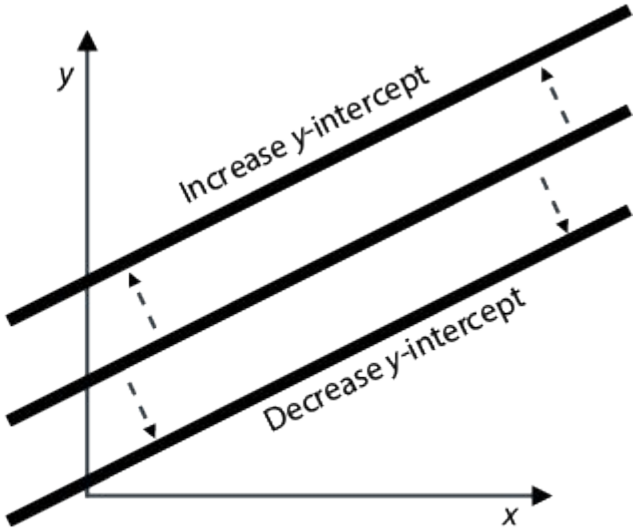


Rotate clockwise and counterclockwise

If we increase the slope of a line, the line will rotate counterclockwise.
If we decrease the slope of a line, the line will rotate clockwise.

Serrano, L., 2021. *Grokking machine learning*. Simon and Schuster.

The linear regression algorithm

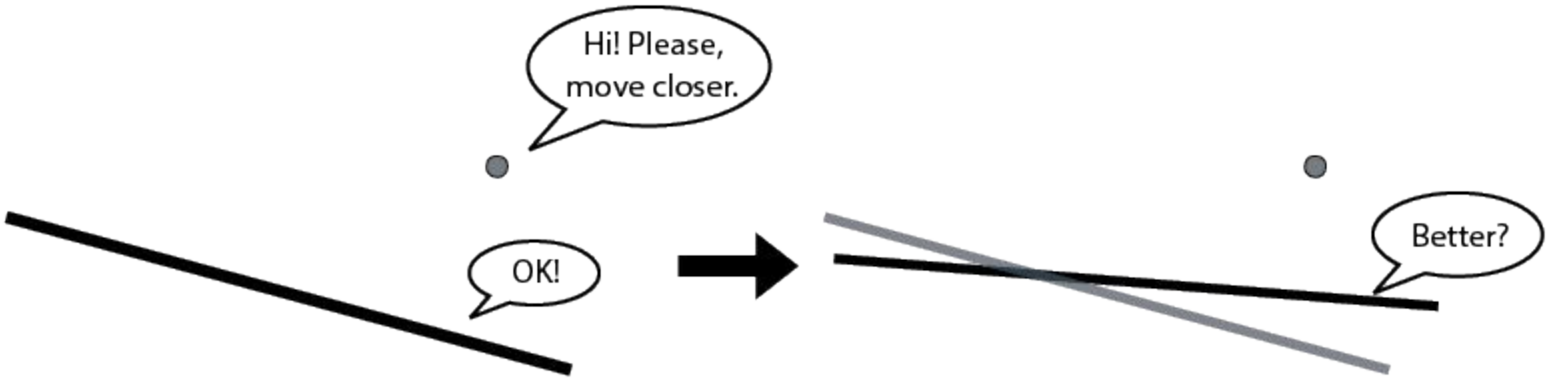


Translate up and down

If we increase the y-intercept of a line, the line is translated upward.
If we decrease the y-intercept of a line, the line is translated downward.

Serrano, L., 2021. *Grokking machine learning*. Simon and Schuster.

The linear regression algorithm



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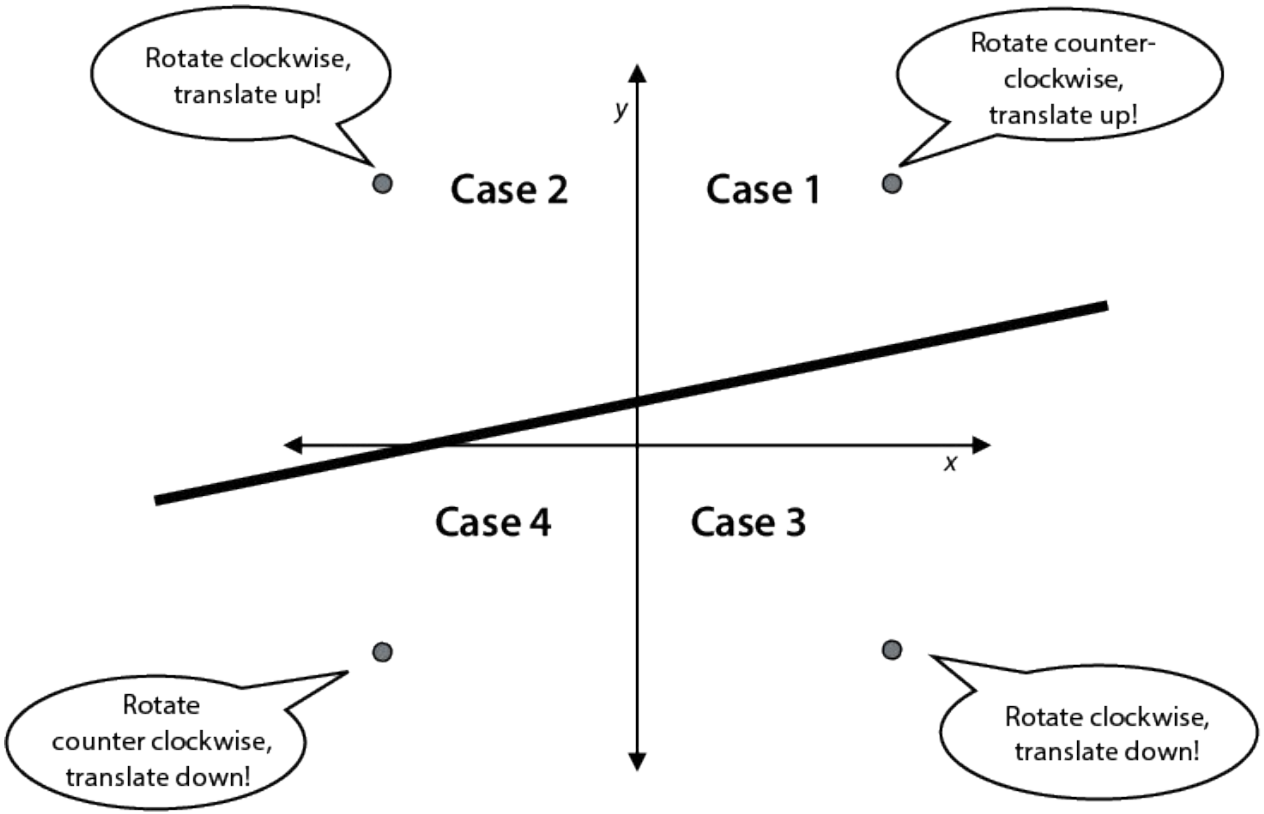
The linear regression algorithm

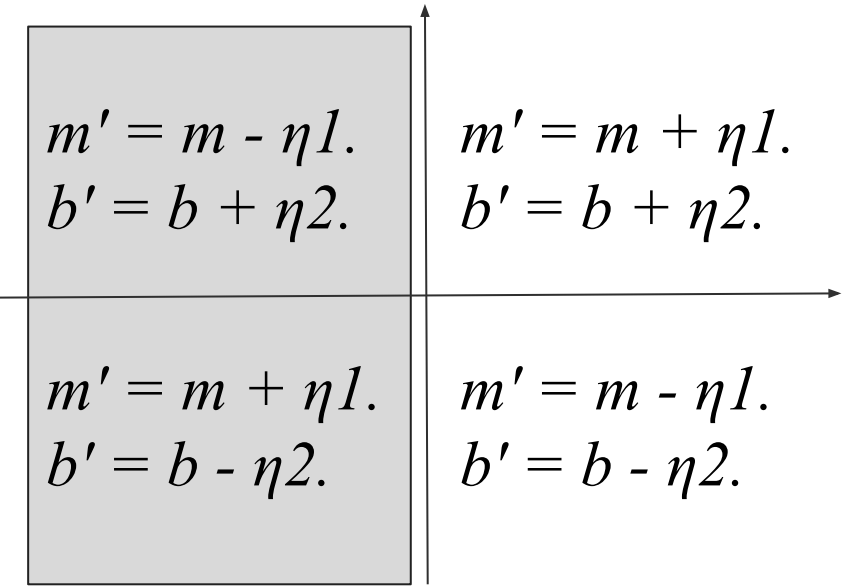


Serrano, L., 2021. *Grokking machine learning*. Simon and Schuster.

The linear regression. Simple Trick

input: $y = mx + b$, (x, y)

Pick two very small random numbers: $\eta 1$ and $\eta 2$

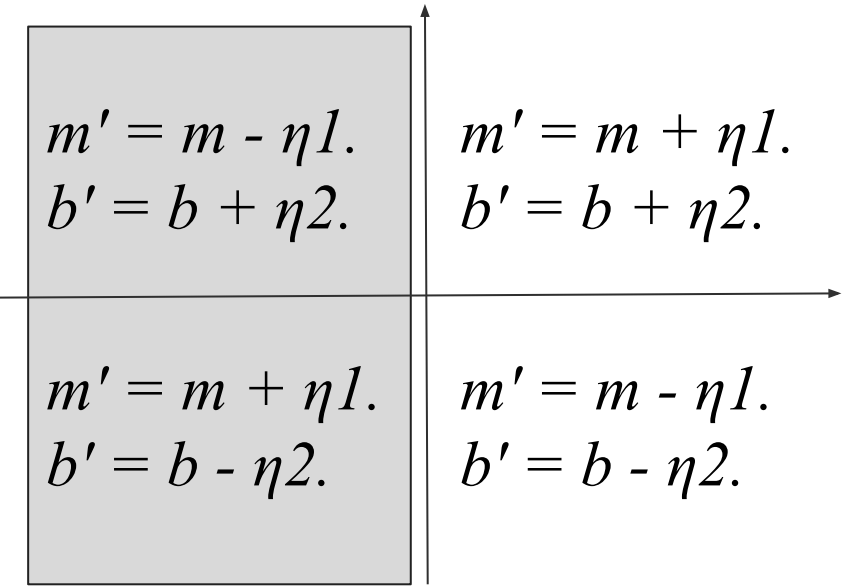


output: $y' = m'x + b'$ closer to (x, y)

The linear regression. Simple Trick

input: $y = mx + b$, (x, y)

Pick two very small random numbers: $\eta 1$ and $\eta 2$



- If the model gave us a price for the house that is lower than the actual price, add a small random amount to the price per room and to the base price of the house.
- If the model gave us a price for the house that is higher than the actual price, subtract a small random amount from the price per room and the base price of the house.

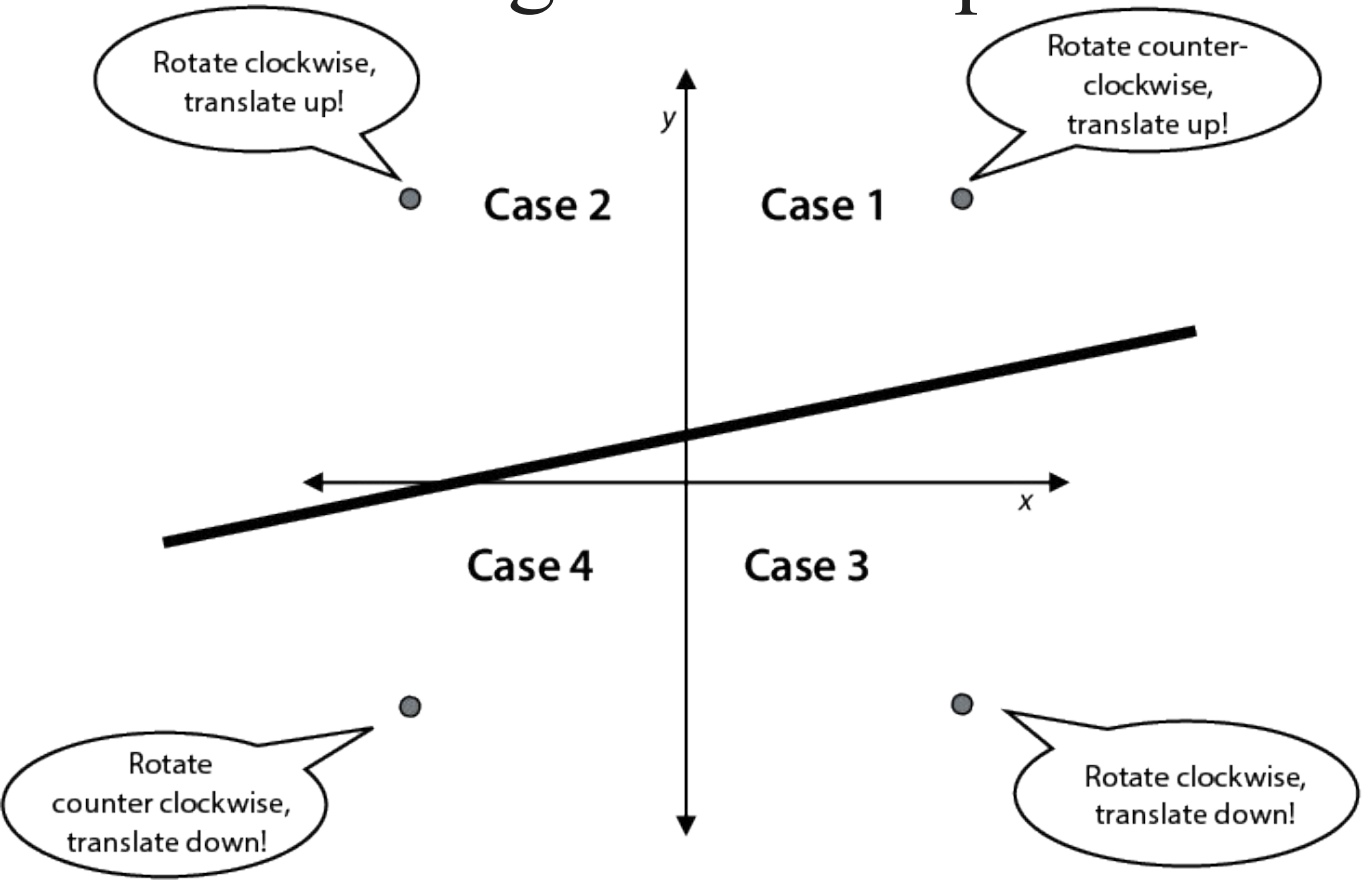
output: $y' = m'x + b'$ closer to (x, y)

The linear regression. Square trick

Move the line closer to point:

find values with the correct signs (+ or –) to add to the slope and the *y*-intercept.

The linear regression. Square trick



Observation 1: In the simple trick, when the point is above the line, we add a small amount to the *y*-intercept. When it is below the line, we subtract a small amount.

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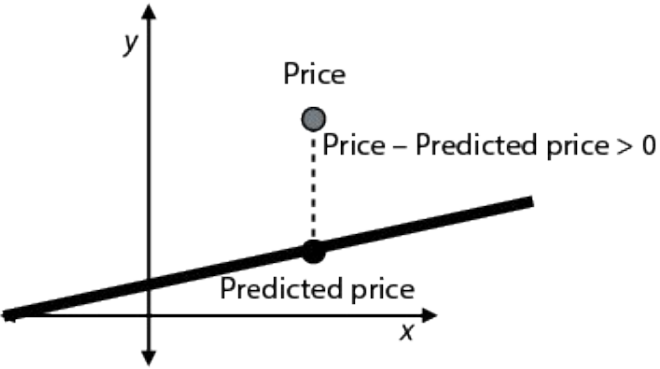
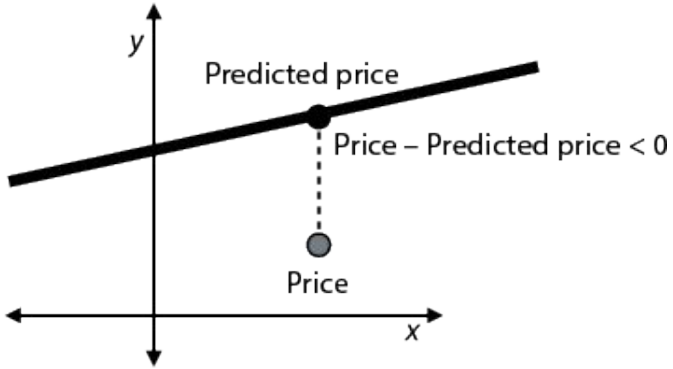
The linear regression. Square trick



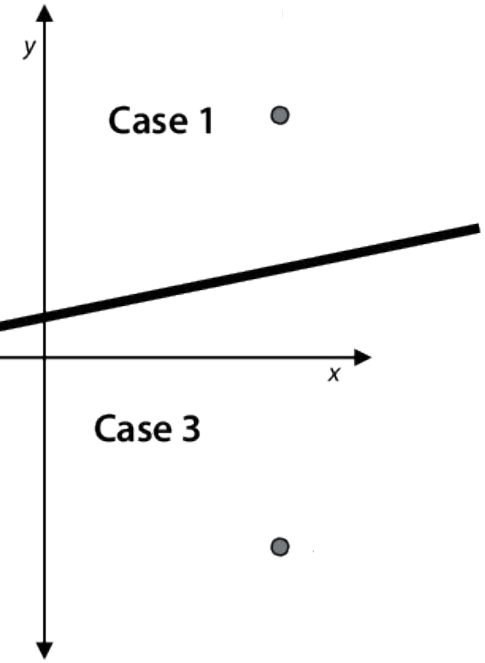


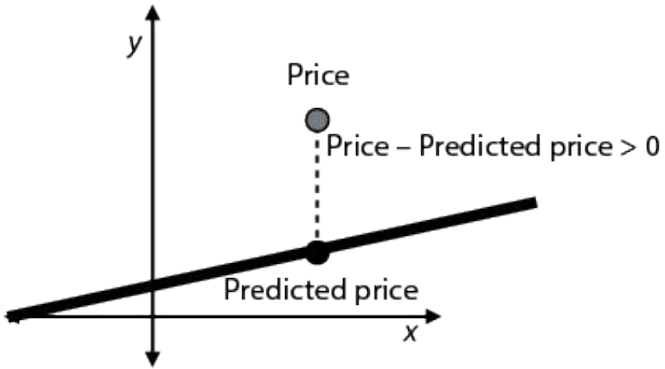
Observation 2: If a point is above the line, the value $y - y'$ (the difference between the price and the predicted price) is positive. If it is below the line, this value is negative.

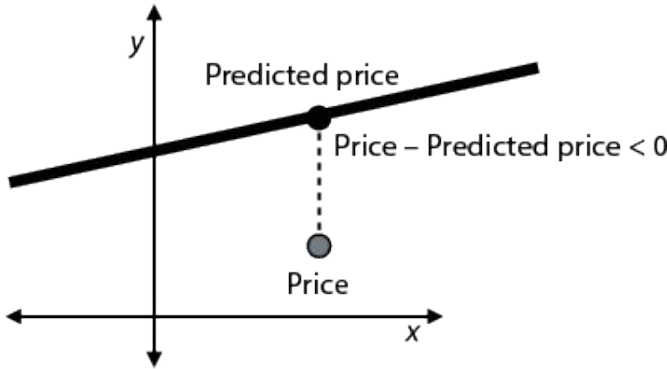
Serrano, L., 2021. *Grokking machine learning*. Simon and Schuster.

The linear regression. Square trick

if we add the difference $y - y'$ to the y-intercept, the line will always move toward the point





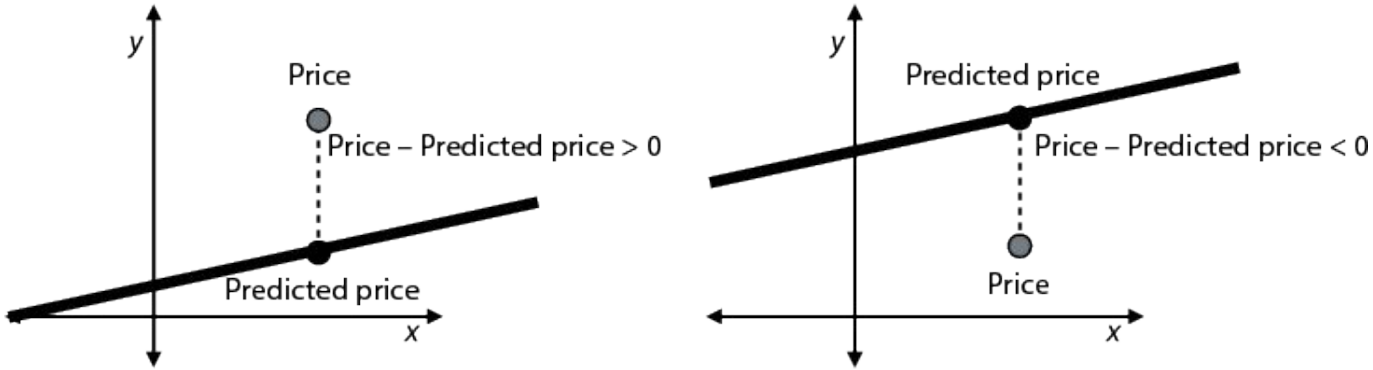


Serrano, L., 2021. *Grokking machine learning*. Simon and Schuster.

The linear regression. Square trick

if we add the difference $y - y'$ to the y-intercept, the line will always move toward the point

learning rate - A very small number η, which is set before training model to keep the changes in very small amounts by training. The value $\eta \cdot (y - y')$ is added to the y-intercept to move the line in the direction of the point.



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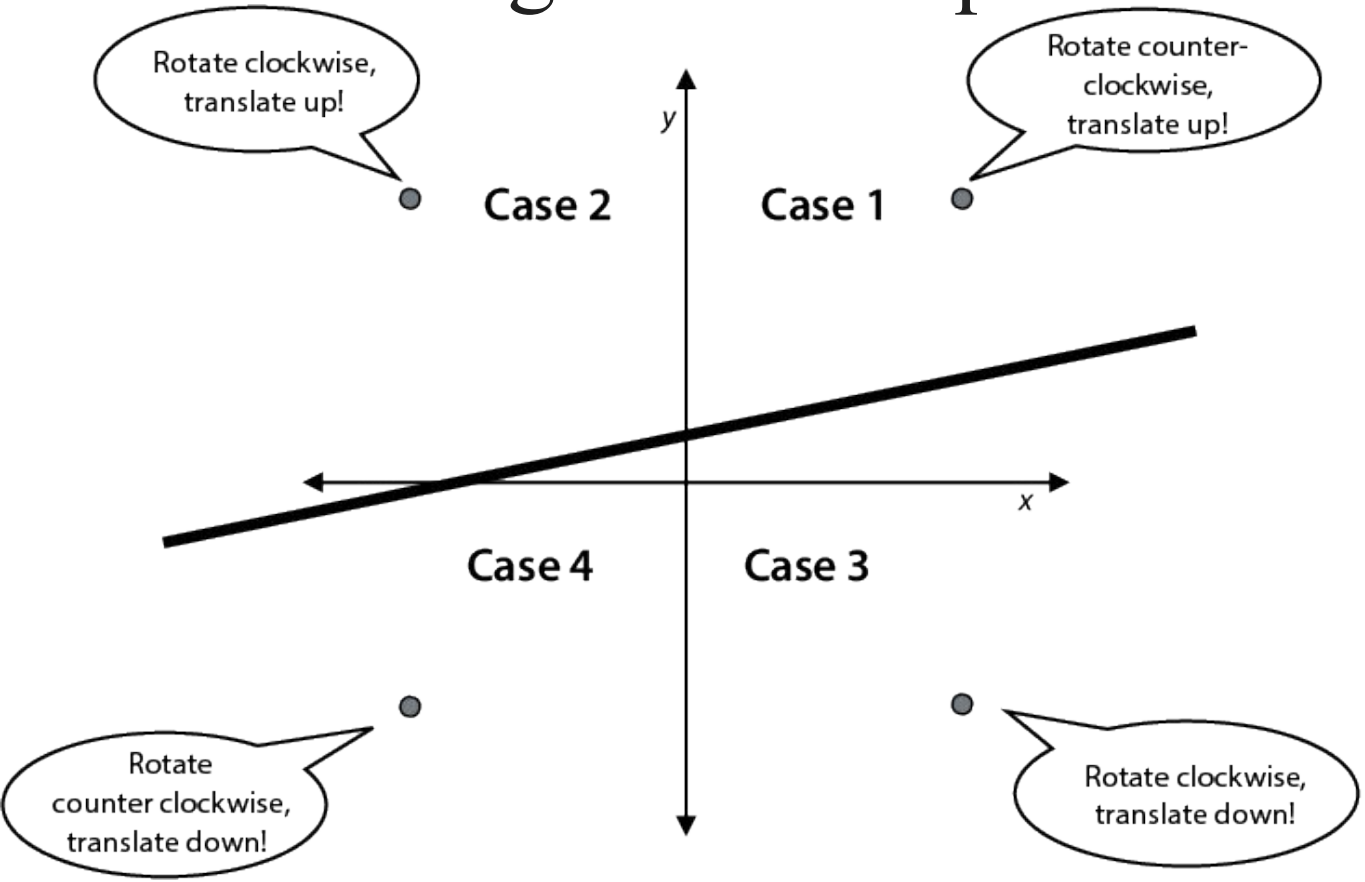
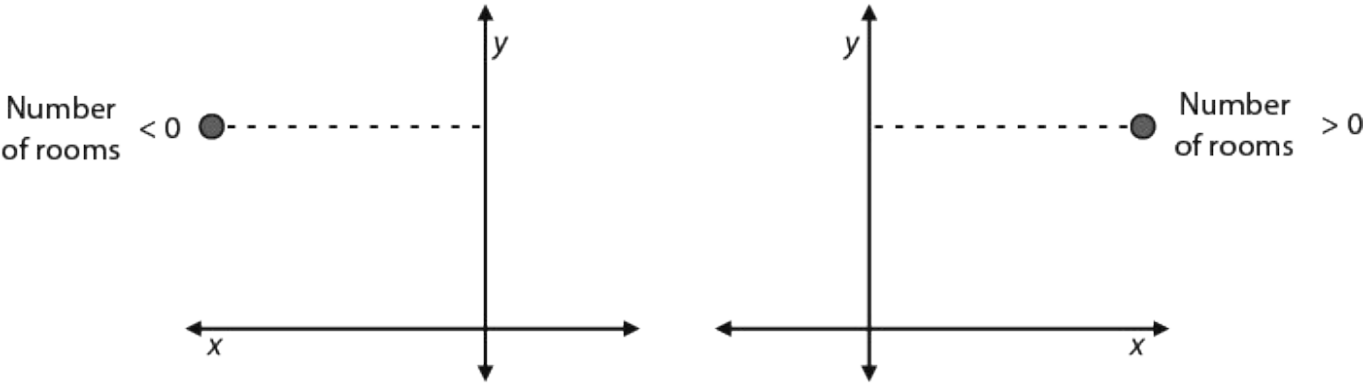
The linear regression. Square trick



Observation 3: In the simple trick, when the point is in scenario 1 or 4 (above the line and to the right of the vertical axis, or below the line and to the left of the vertical axis), we rotate the line counterclockwise.
Otherwise (scenario 2 or 3), we rotate it clockwise.

Serrano, L., 2021. *Grokking machine learning*. Simon and Schuster.

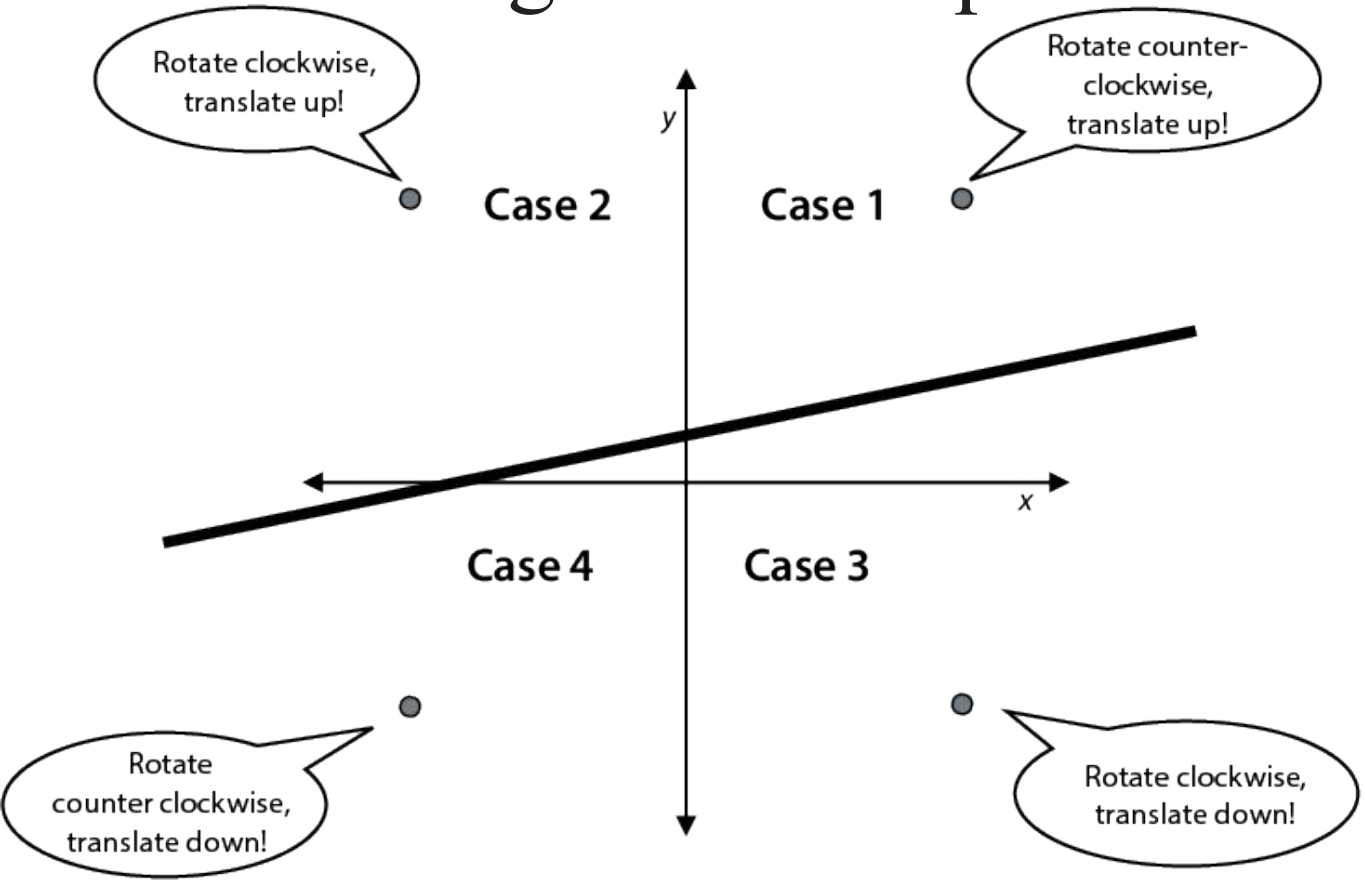
The linear regression. Square trick



Observation 4:
If a point (x, y) is to the right of the vertical axis, then x is positive.
If the point is to the left of the vertical axis, then x is negative.

Serrano, L., 2021. *Grokking machine learning*. Simon and Schuster.

The linear regression. Square trick



if

$(x > 0$ **and** $(y - y') > 0)$

or

$(x < 0$ **and** $(y - y') < 0)$

$\Rightarrow x \cdot (y - y') > 0$

$\eta \cdot x \cdot (y - y')$

- Makes the value small
- Moves the line to the direction of the point

Serrano, L., 2021. *Grokking machine learning*. Simon and Schuster.

The linear regression. Square trick

input:

$y = mx + b$, (x, y), η

steps:

$m' = m + \eta \cdot x \cdot (y - y')$ *(rotate).*

$b' = b + \eta \cdot x \cdot (y - y')$ *(translate).*

output:

price per room and base price: m', b'

example-2.html

The linear regression

Repeat the square trick many times to move the line closer to the points.

Input: a dataset of houses with number of rooms and prices

Procedure:

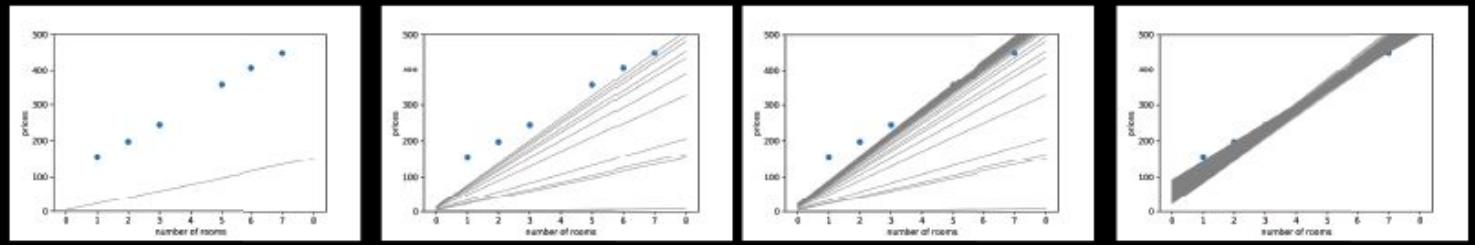
Random values for m and b.

Repeat many times:

Pick a random data point.

Update the slope and the y-intercept using the square trick.

Output: $y' = m'x + b'$



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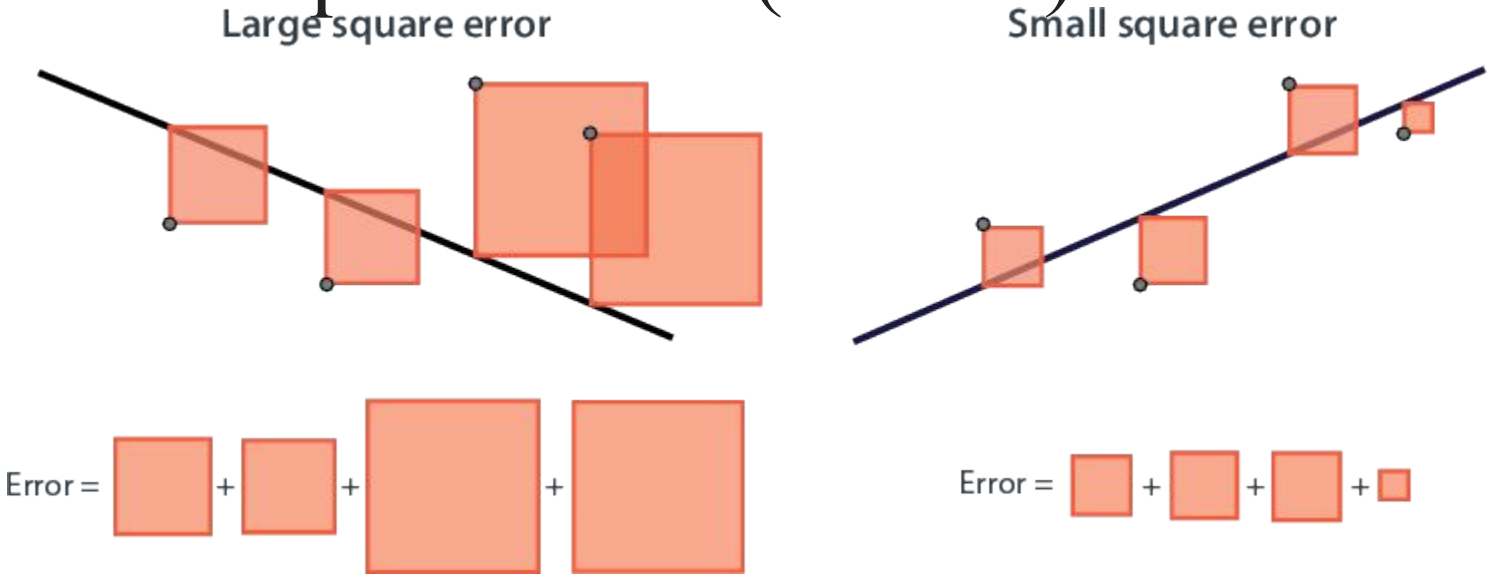
Root mean square error. (RMSE)



The model makes an error of around RMSE for any prediction we make.

Serrano, L., 2021. *Grokking machine learning*. Simon and Schuster.

Self study

General case: The linear regression. Square trick.

RMSE.

Serrano, L., 2021. Grokking machine learning. Simon and Schuster., Chapter 3

Gradient descent

Summary