Universitat de Girona

Artificial intelligence and Machine learning

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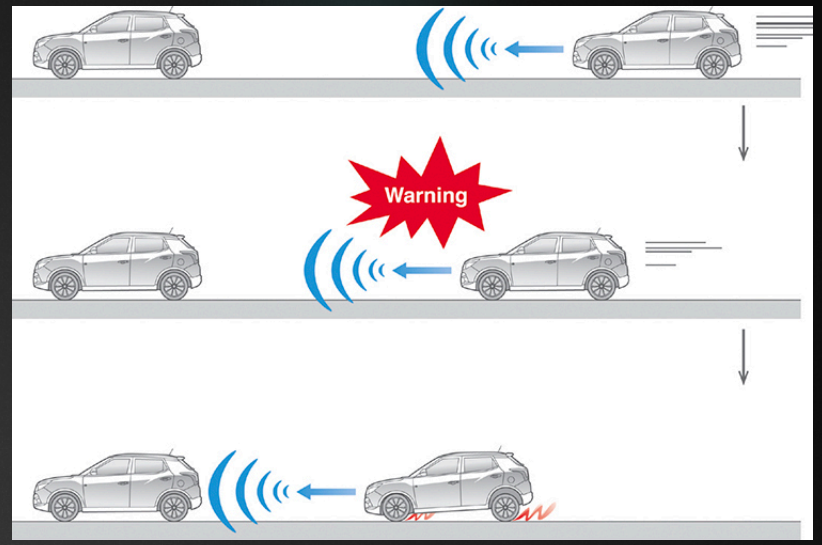
coatingAI

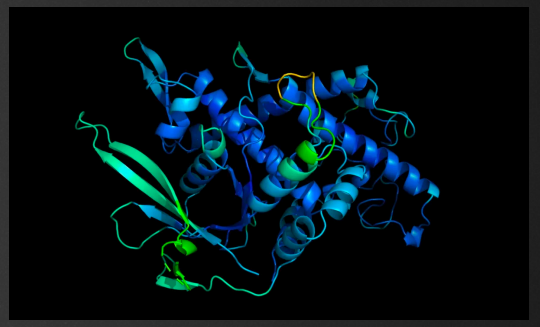
Intelligence

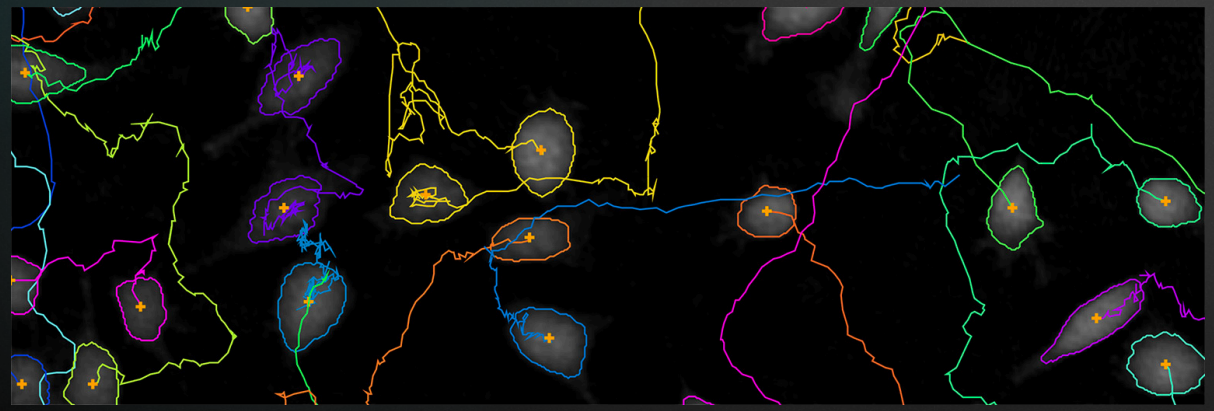
- ChatGPT: “Intelligence is a complex and multifaceted concept that refers to the ability of an individual or system to acquire and apply knowledge, reason, solve problems, make decisions, adapt to new situations, learn from experience, and exhibit general cognitive skills”
- Natural intelligence: displayed by animals and some humans

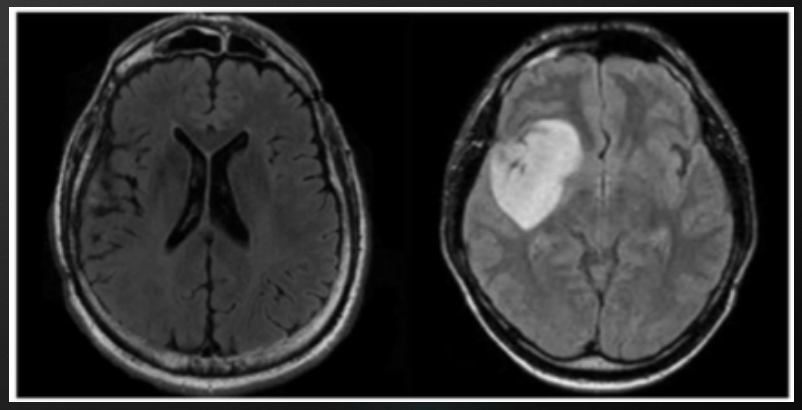
Artificial Intelligence

- Intelligence displayed by machines
- Able to mimic human actions and behavior
- Computer vision, natural language processing, robotics, recommendation systems, healthcare…







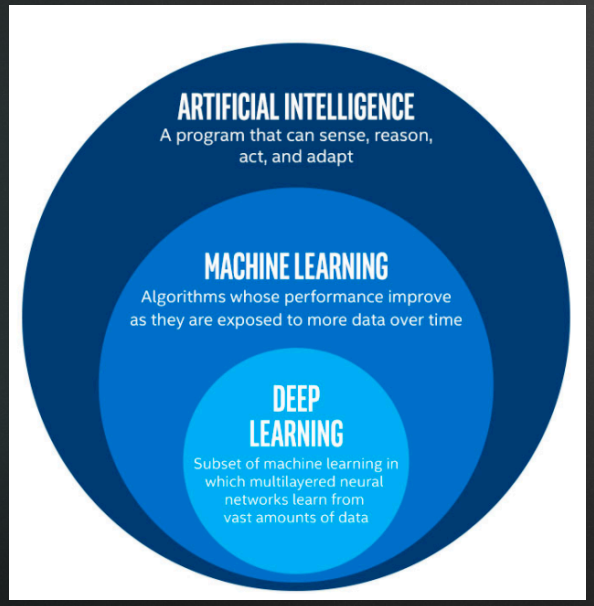


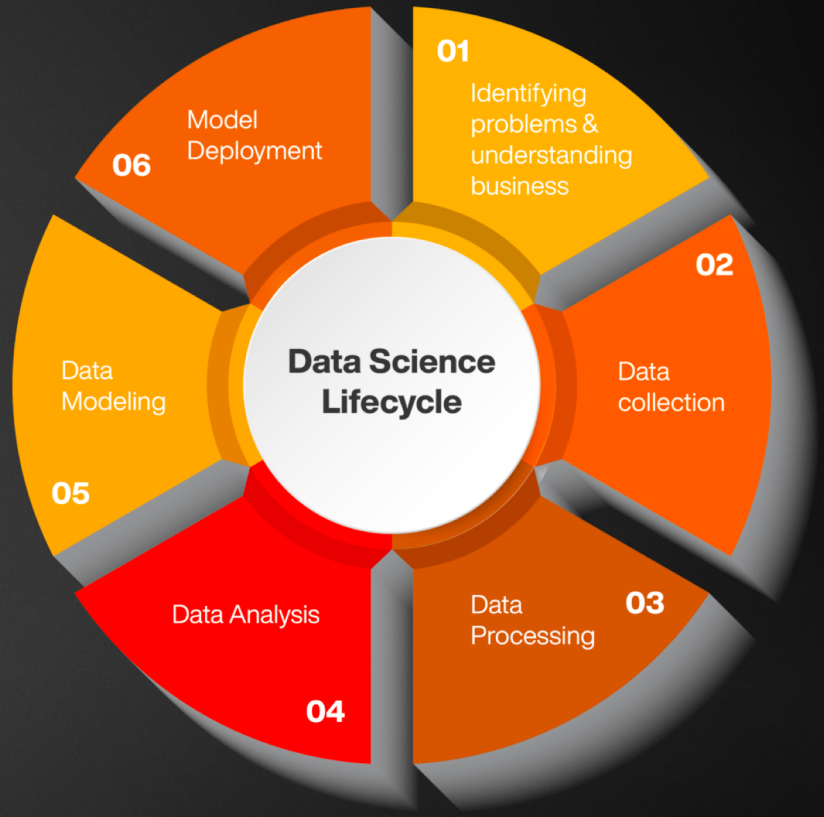
Machine learning

- "Field of study that gives computers the ability to learn without being explicitly programmed" – Arthur Samuel 1959
- Minimax algorithm with alpha-beta pruning
- "A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks in T, as measured by P, improves with experience E " – Tom Mitchell 1997

Data science

- Machine learning can be considered a subfield of data science
- What defines machine learning is the algorithm that we use to develop a model

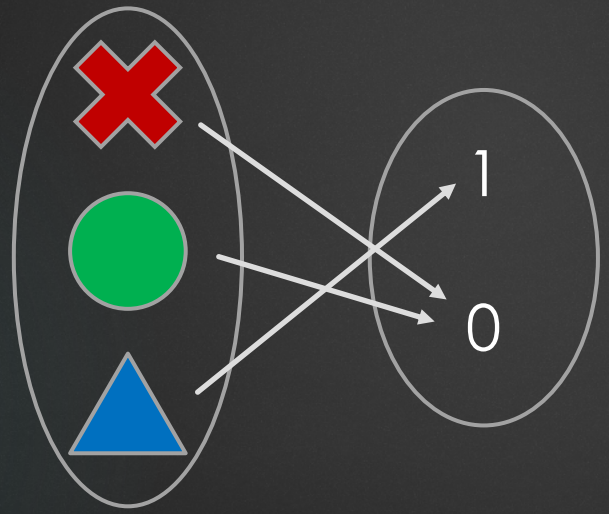


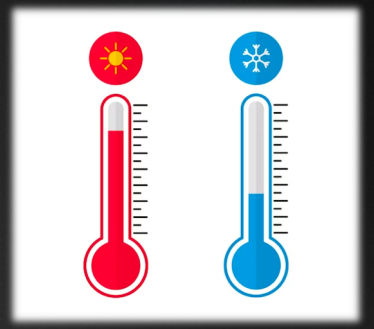


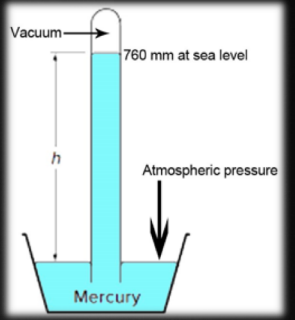
Mathematical modelling

- A mathematical model is representation of a real-world system using mathematical concepts and language

$$f: X \to Y$$







- Mathematical modelling is the process of developing a mathematical model

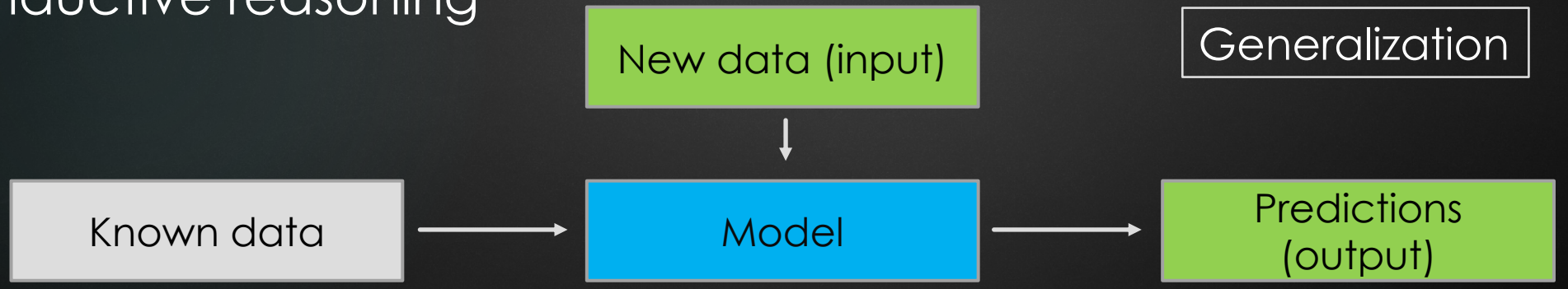
Mathematical modelling

- Newton's universal law of gravitation: "every particle in the universe attracts every other particle with a force that is proportional to the masses of both particles and to the distance between their centers"
- Derived from empirical observations by inductive reasoning

$$F = G\frac{m_1 m_2}{r^2}$$

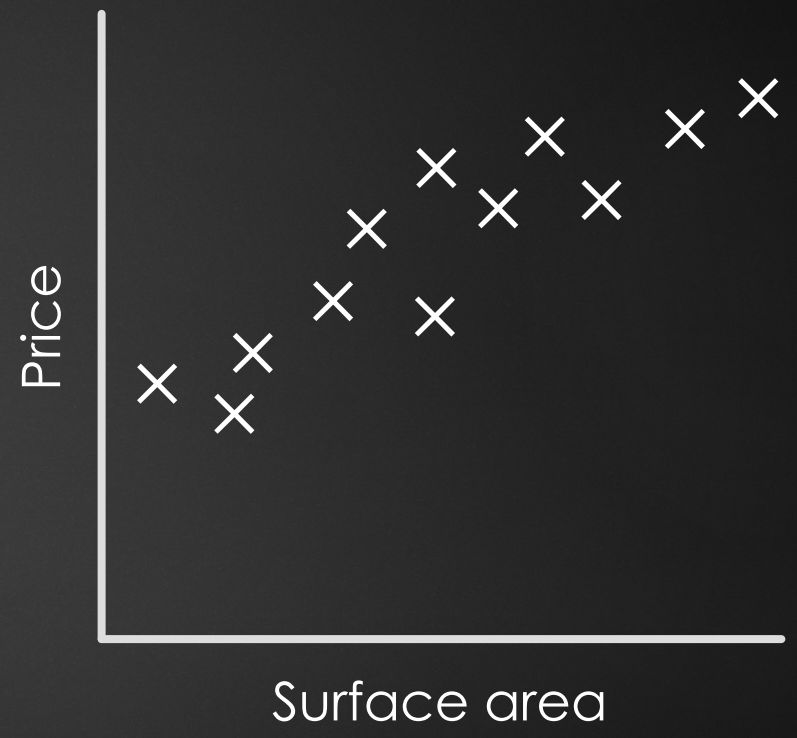
m_1, m_2 and r are variables

G is a parameter which depends on the units (kg, m, s)



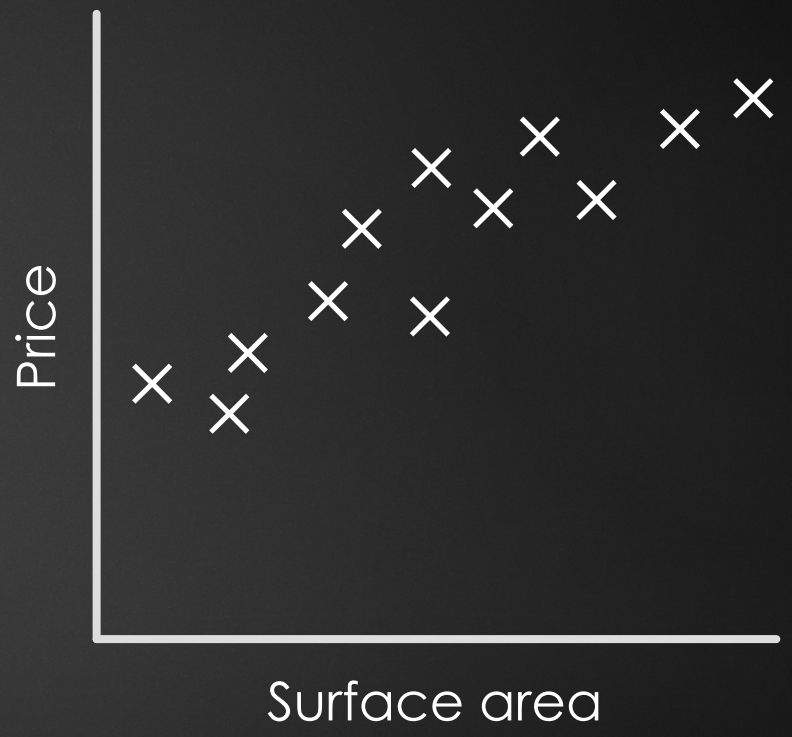
House price model

- A model to predict the price of a house based on its surface area in square meters
- Observations
- Linear model: $y = ax + b$: how do we find a and b ?
- Iterative process



House price model

1. Initial guess: $a = 0$, $b = 0$
2. Compute the error of the model
3. Slightly increase or decrease the value of a such that the error of the new model is lower
4. Do the same for b
5. Repeat step 2 until the error no longer decreases



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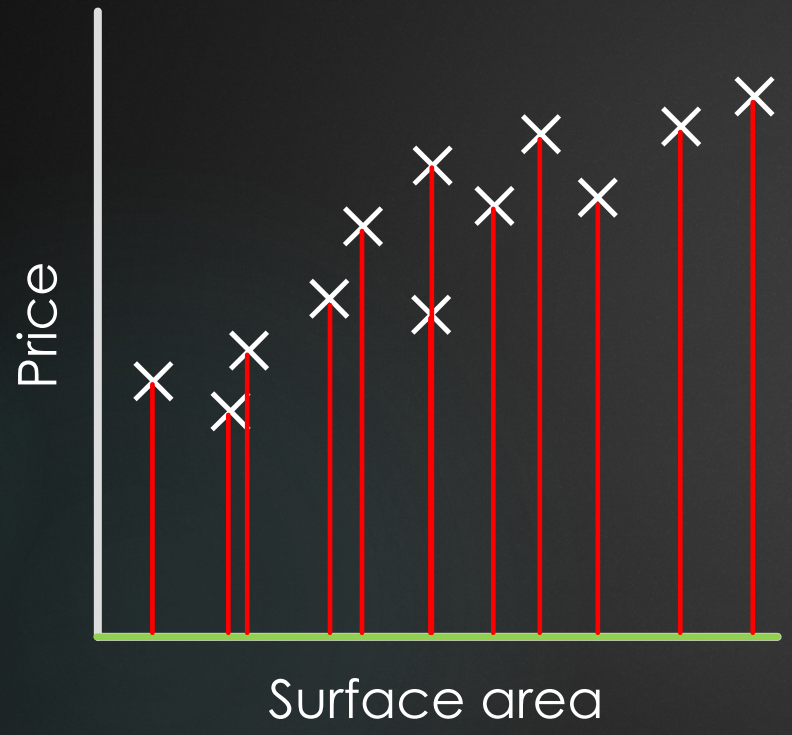
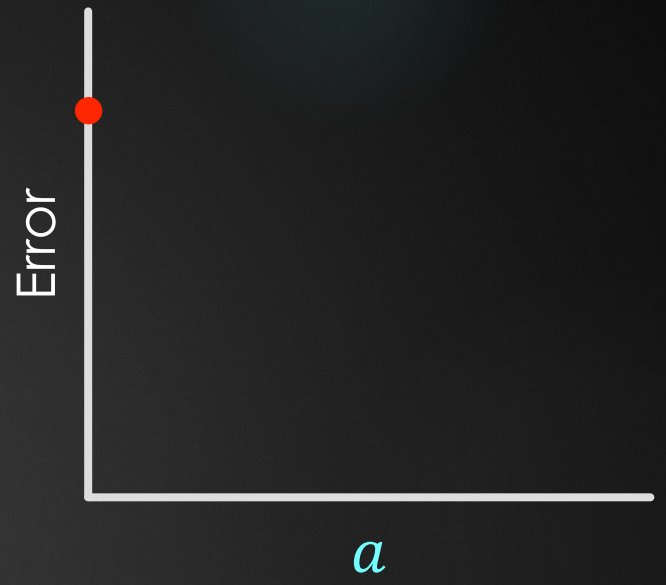
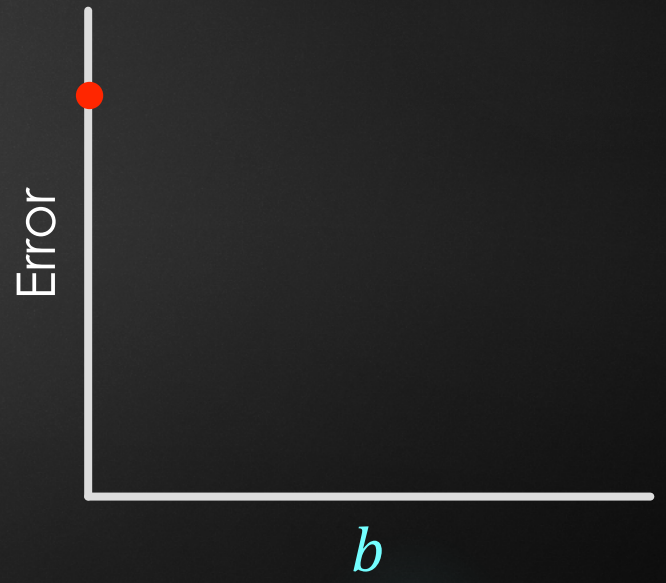


$\hat{y} = ax + b$

$$Error(MSE) = \frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$$





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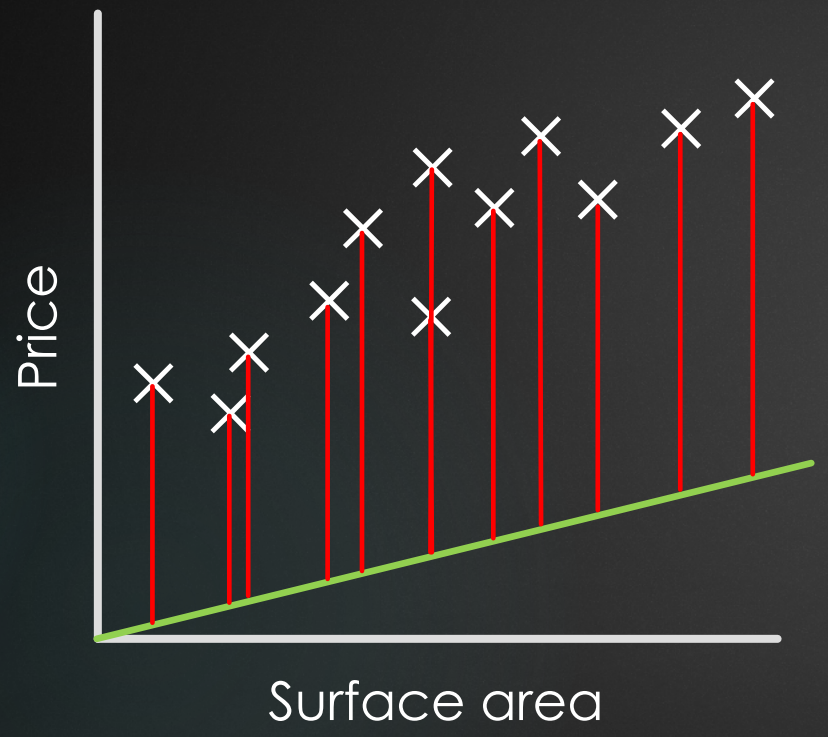

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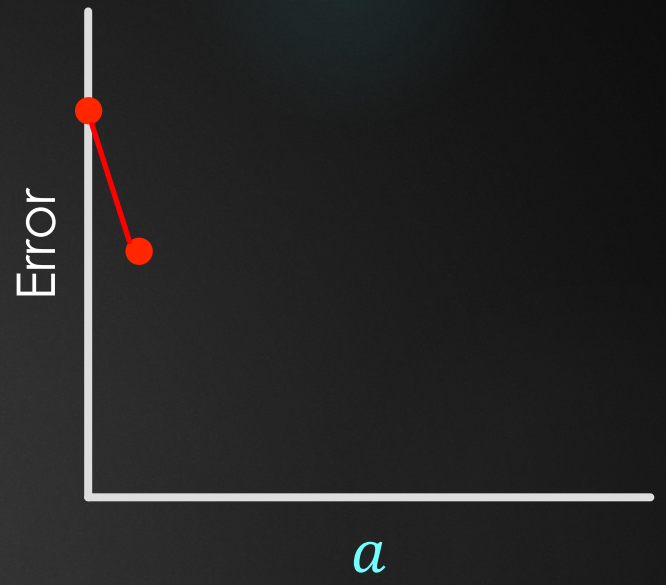

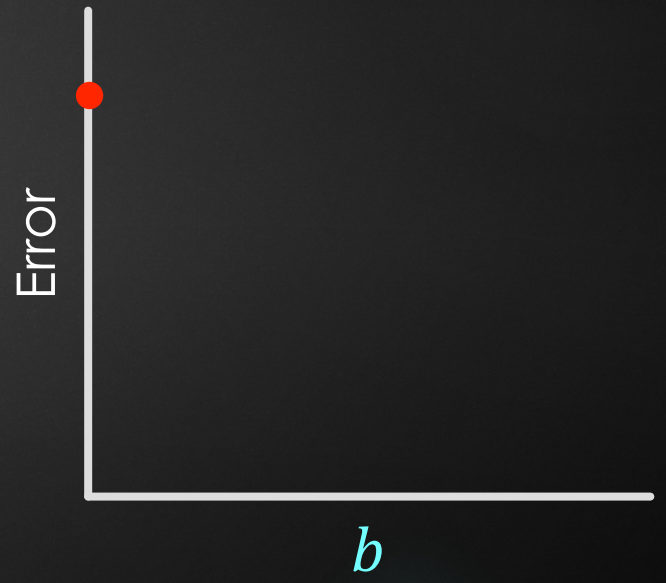

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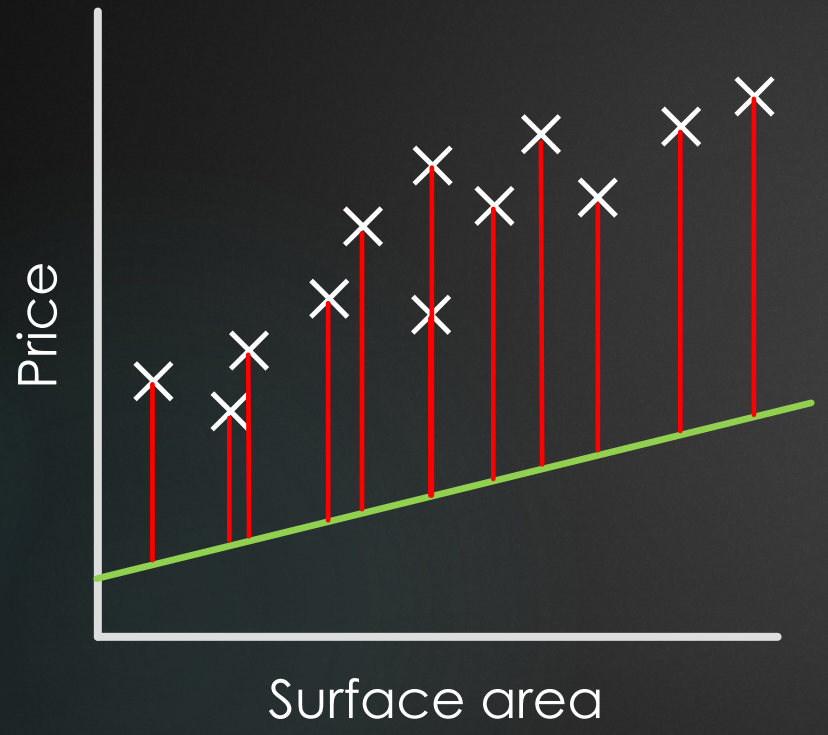

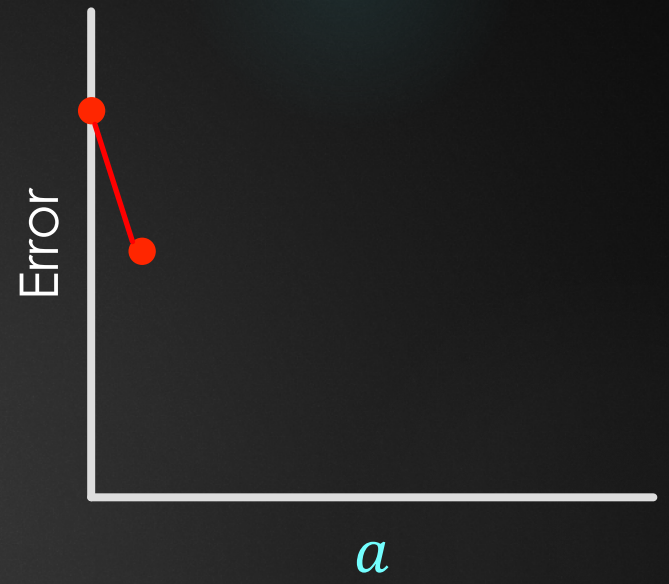

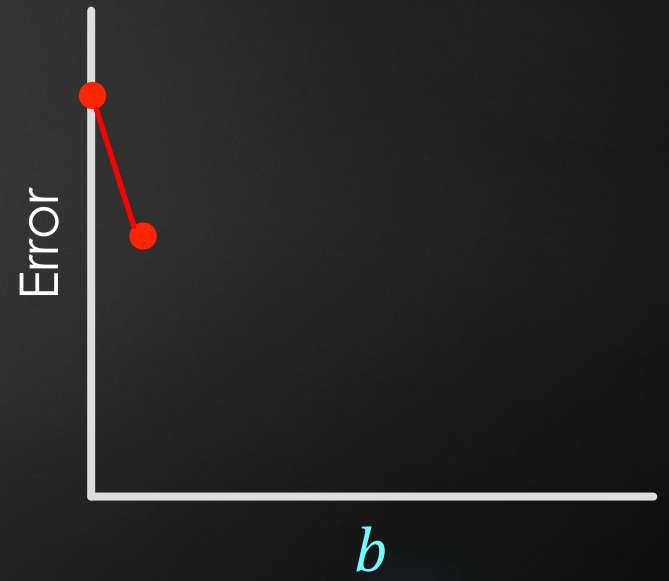

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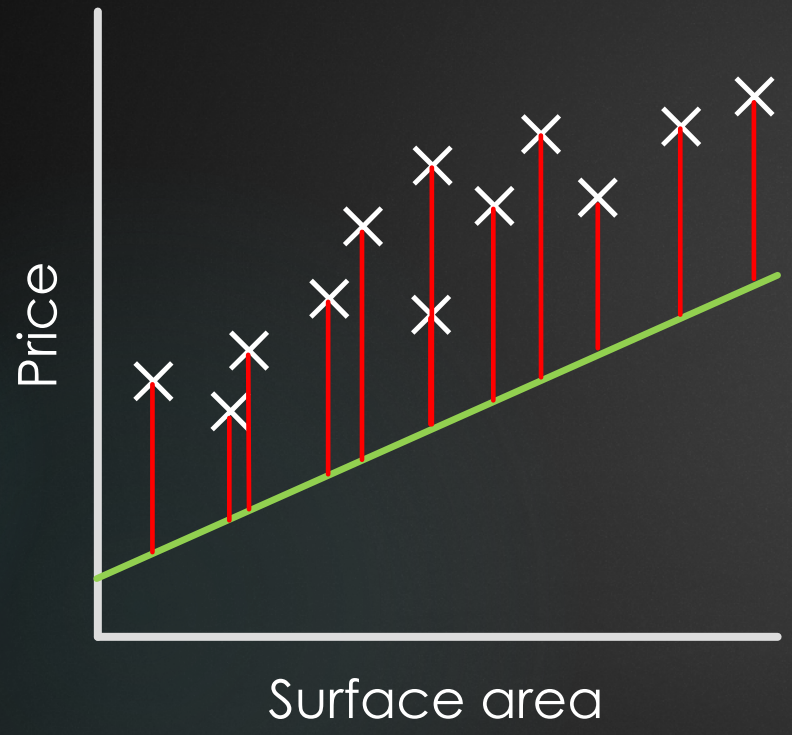

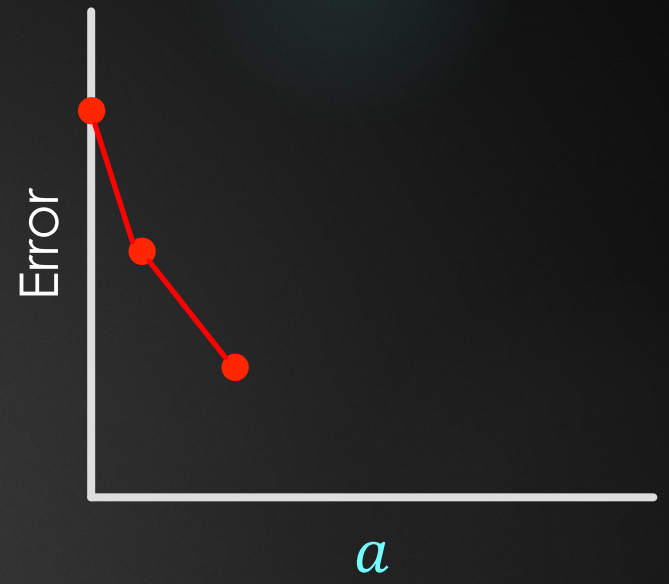

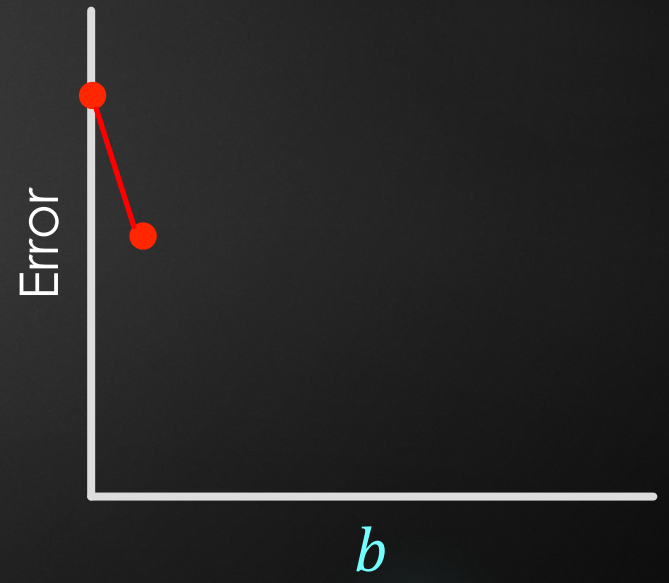

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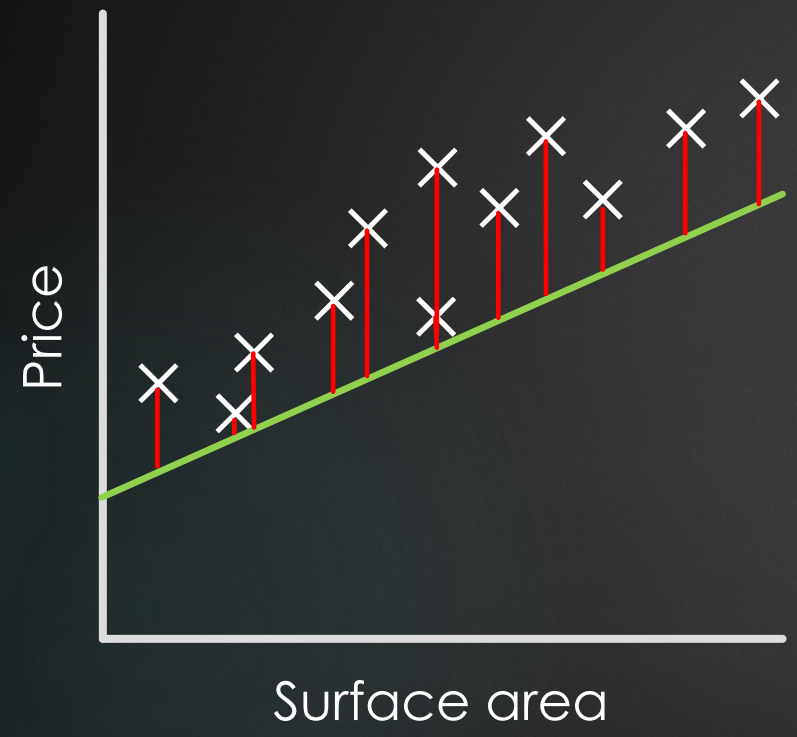

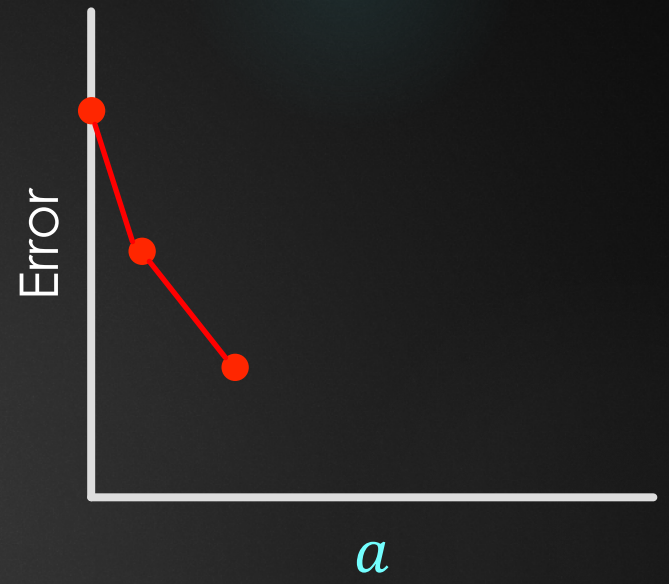

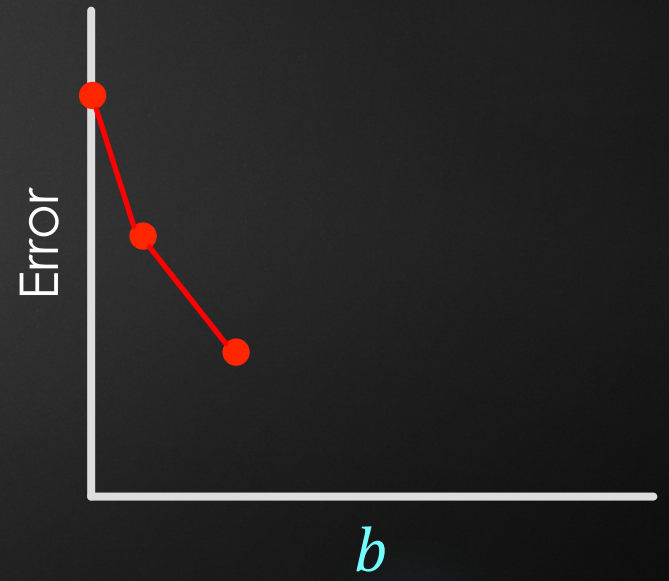

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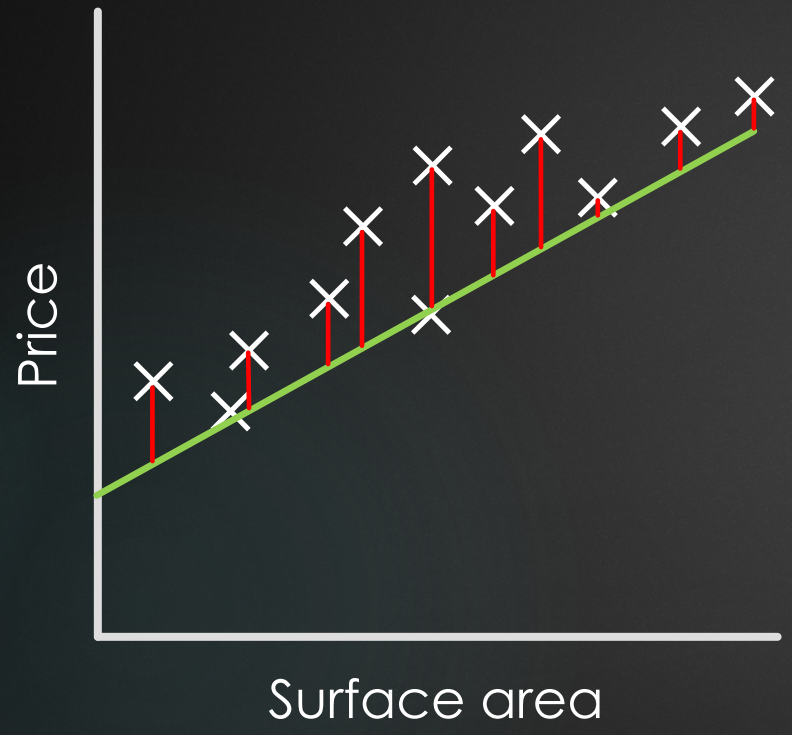

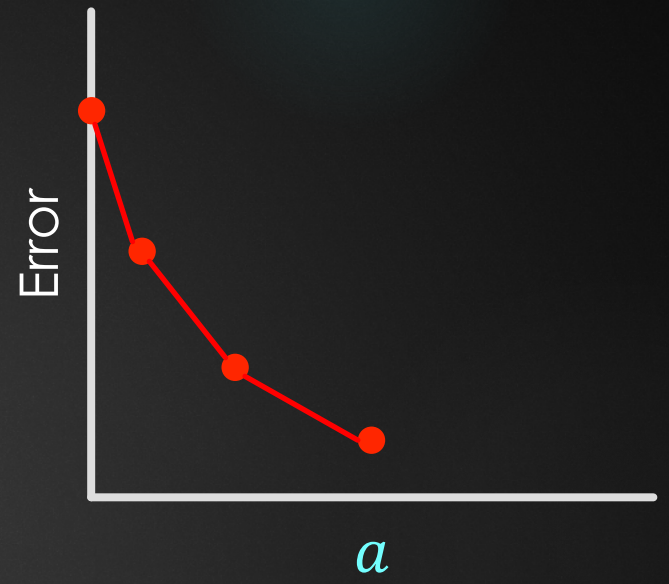

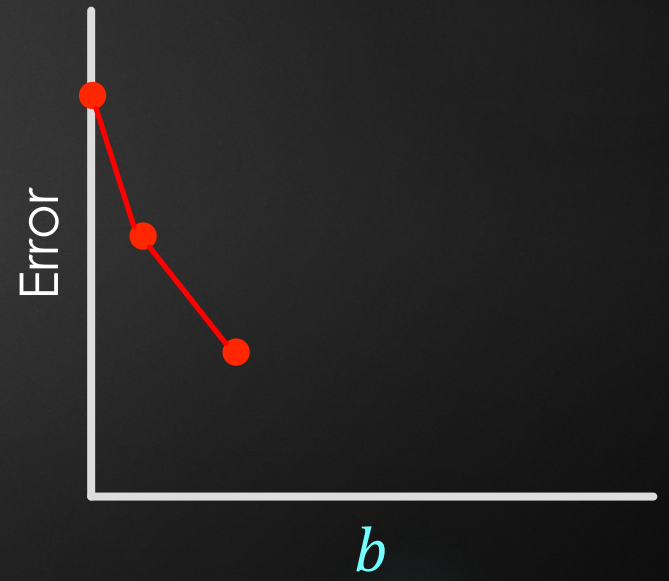

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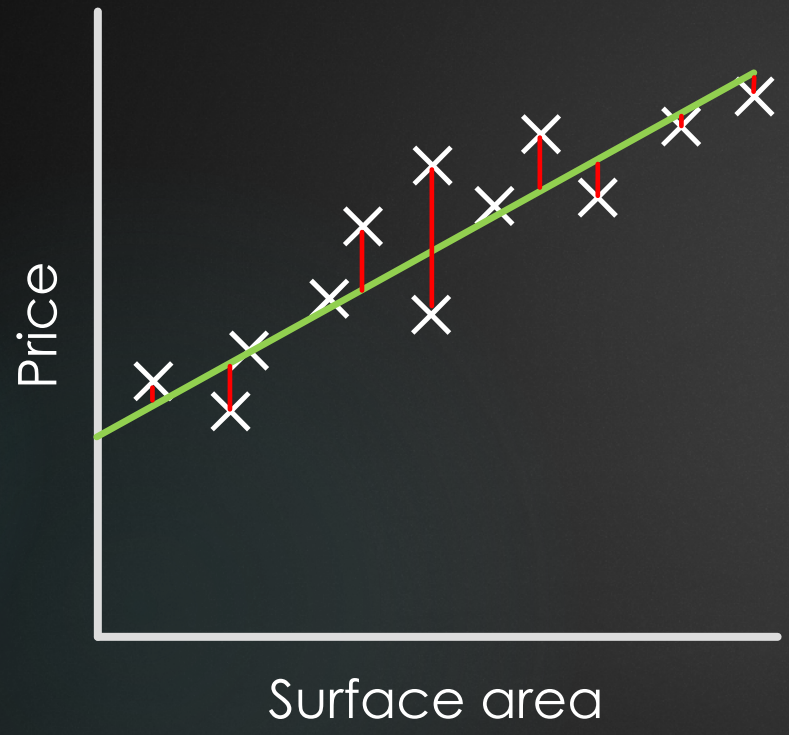
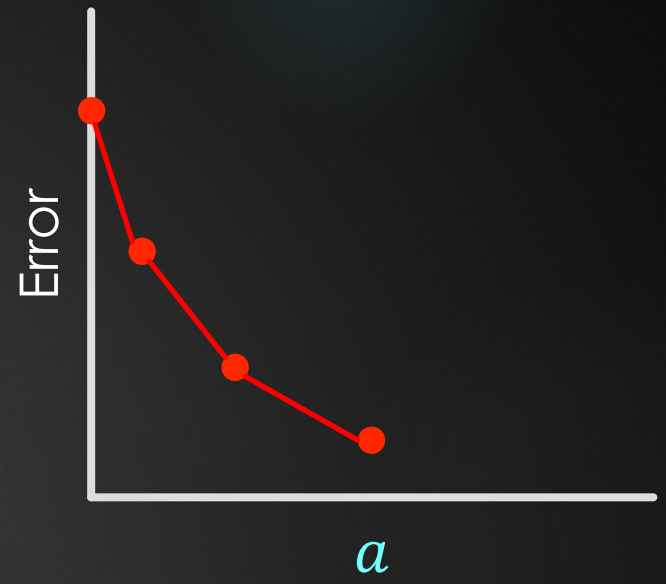
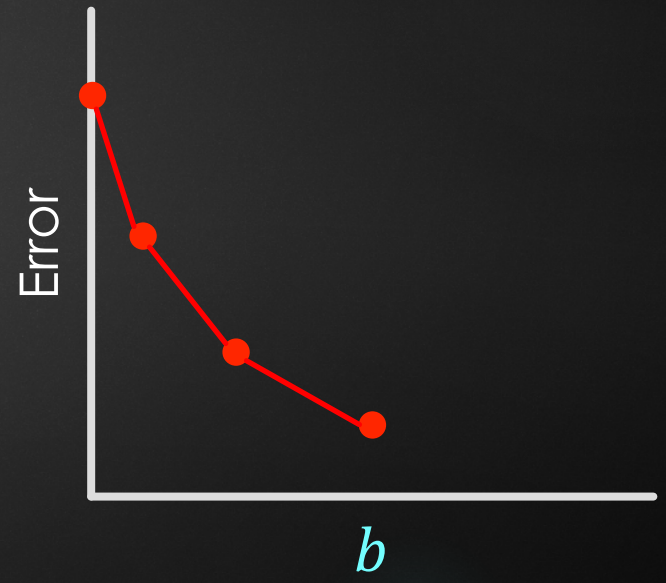






$$\hat{y} = ax + b$$

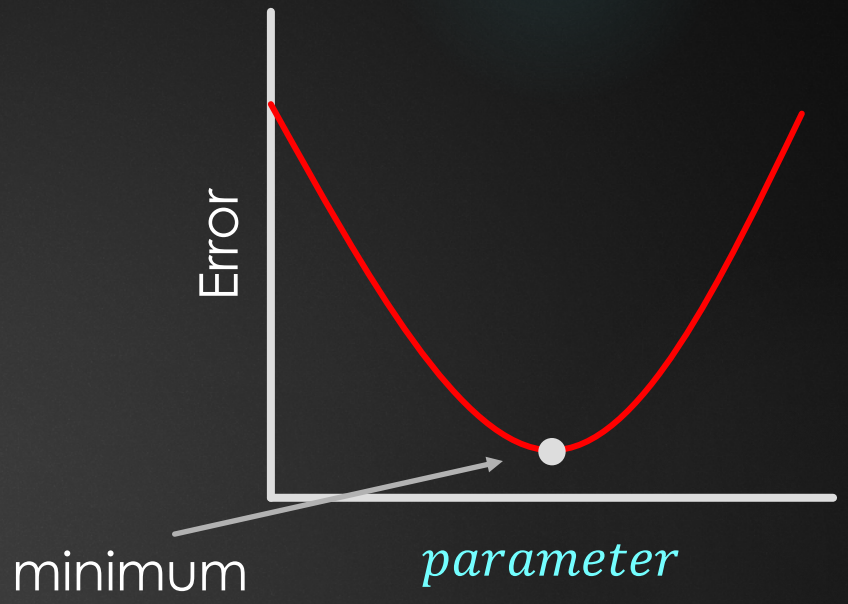
$$Error(MSE) = \frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$$

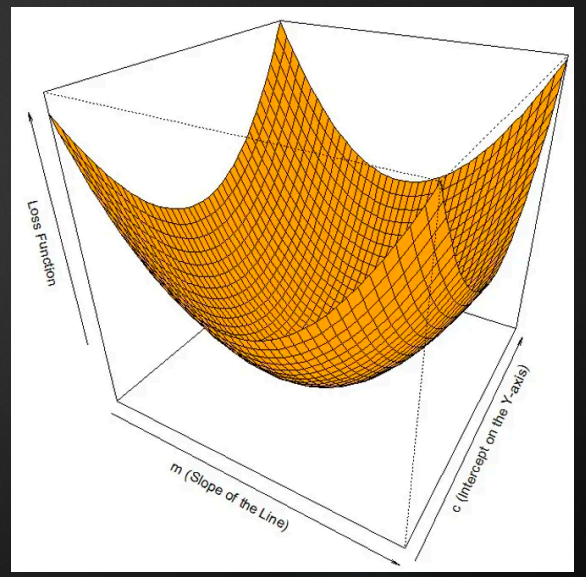
House price model

- Optimization problem: minimize the loss function (MSE)
- Simple linear regression with ordinary least squares (OLS)
- Unique global minimum

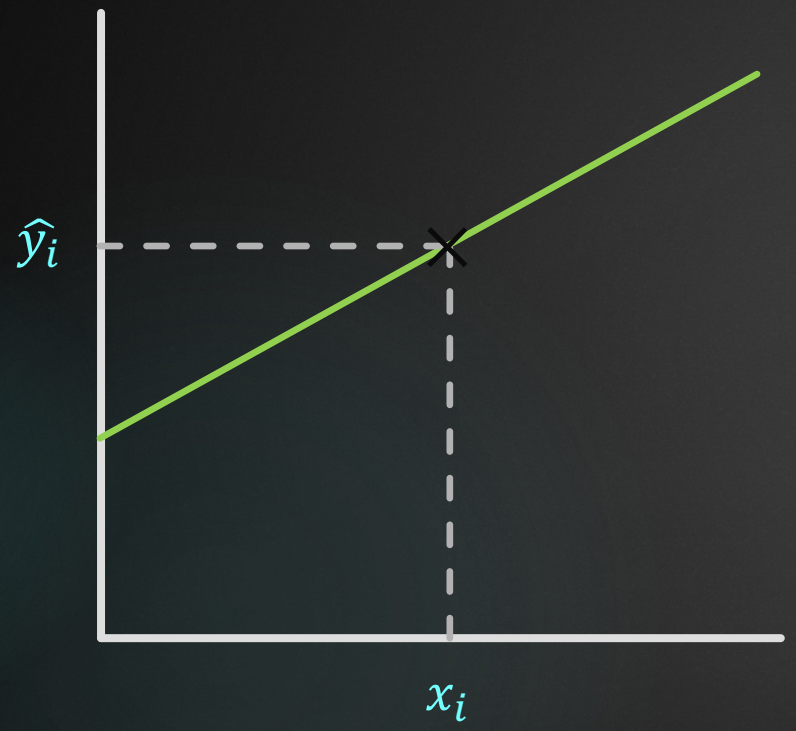
$$\widehat{\alpha} = \bar{y} - (\widehat{\beta}\,\bar{x}),$$

$$\widehat{\beta} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

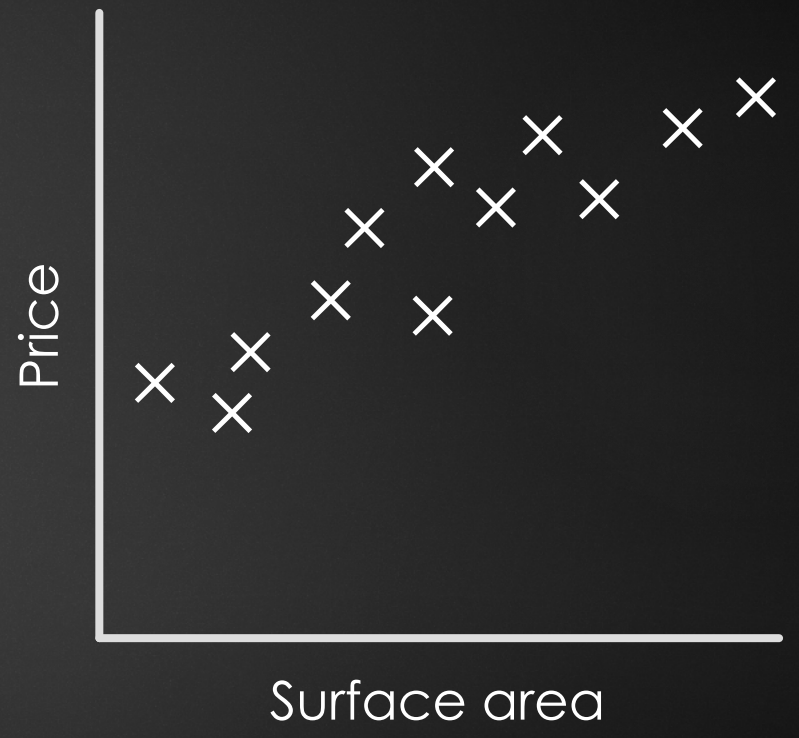




Predictive model



Trained model



Training data

Machine learning

- Field in artificial intelligence / data science
- We don't explicitly program the instructions
- Learning algorithm that uses available data to develop a model
- Optimization: find the parameters that minimize the loss function → learning
- The model must be able to generalize: accurate predictions with new unseen data

Images sources

- Dogs: https://wendywoodvet.co.za/acquiring-two-puppies-at-the-same-time/
- Humans: https://a24films.com/films/the-humans
- Automatic breaking system: https://www.torque.com.sg/features/how-does-automatic-emergency-braking-work/
- Protein folding: https://eu.usatoday.com/story/news/nation/2020/12/03/protein-folding-discovery-major-breakthrough-deepmind/3809693001/
- DNA: https://learn.genetics.utah.edu/content/basics/dnacodes
- Cell tracking: https://phiab.com/applications/single-cell-tracking/
- Brain MRI: https://ijisae.org/index.php/IJISAE/article/view/1310
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- AI diagram: http://danieljhand.com/the-relationship-between-artificial-intelligence-ai-machine-learning-ml-and-deep-learning-dl.html
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- Humidity: https://www.wonderopolis.org/wonder/what-is-humidity/
- Cloud with rain: https://vecta.io/symbols/211/travel-places-sky-weather/25/cloud-with-rain
- Sun: https://www.vecteezy.com/free-vector/yellow-sun
- Loss function: http://ucanalytics.com/blogs/intuitive-machine-learning-gradient-descent-simplified/