

# MACHINE LEARNING TOOLS

Central European University  
2024



@divenyijanos



Google Cloud Platform

# Introduction to ML & AI

Part 1 of Making Friends with Machine Learning

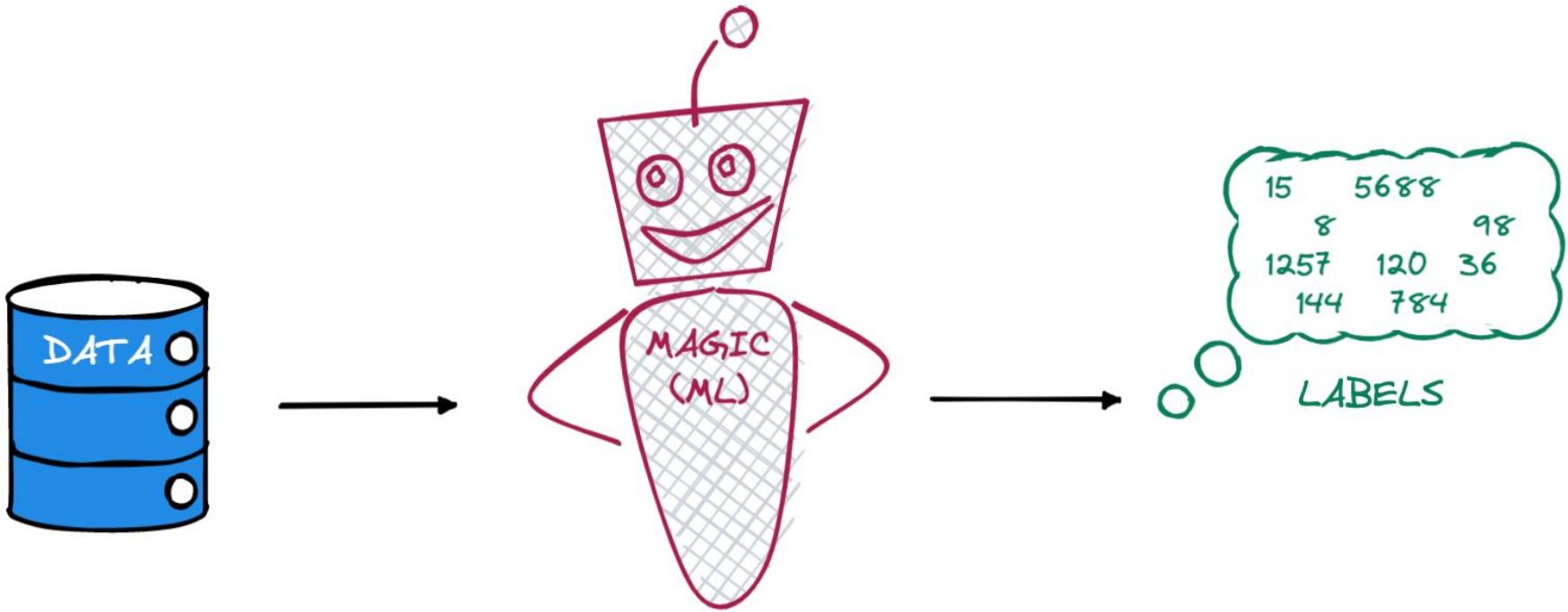


A photograph of a woman with short brown hair, wearing a red t-shirt, speaking into a black microphone. She is gesturing with her right hand towards a whiteboard or screen behind her. The background shows a presentation slide with some text and graphics. The overall scene suggests a live video recording of a lecture or presentation.

Episodes 000-028

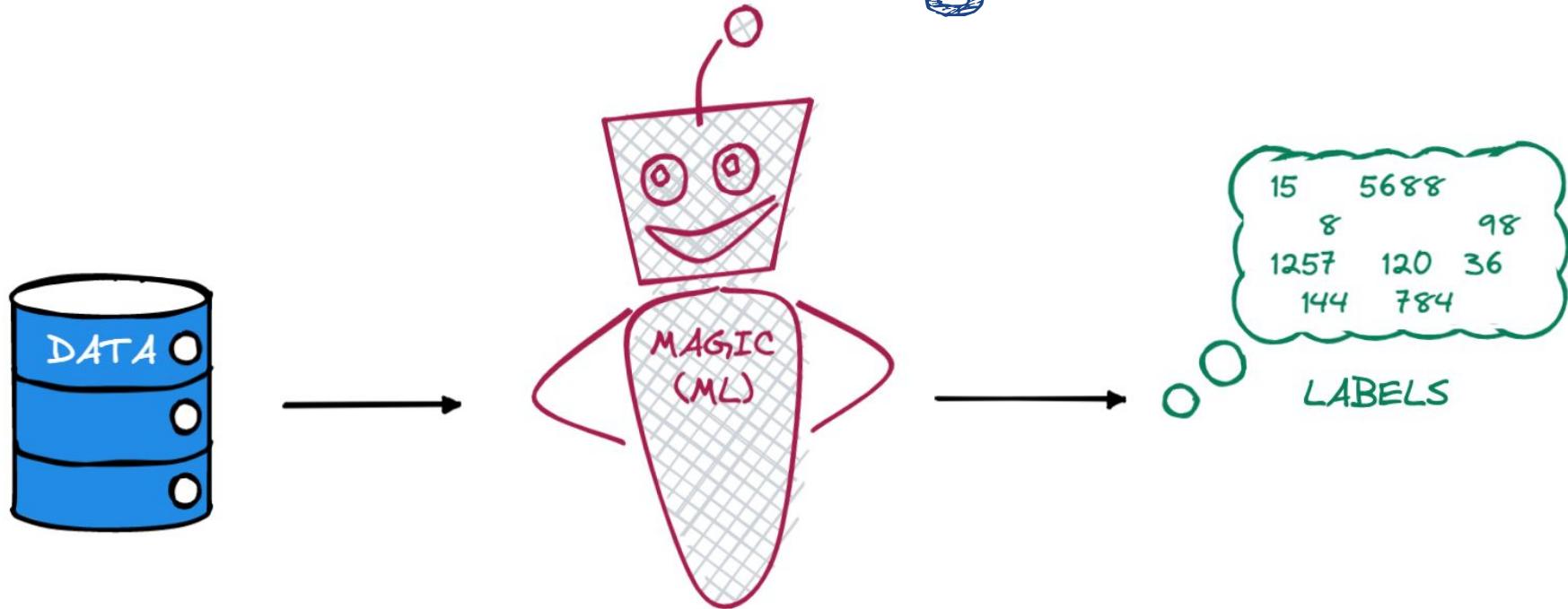


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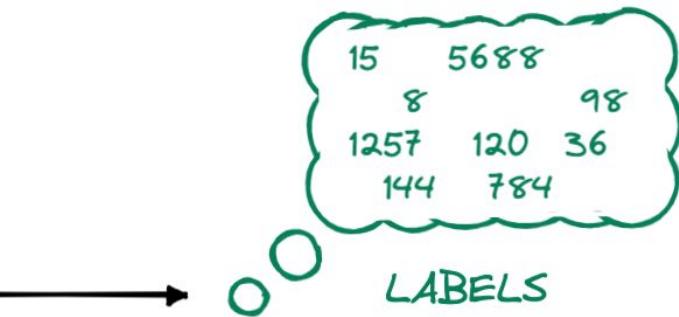


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# Machine Learning =



## Thing Labeller



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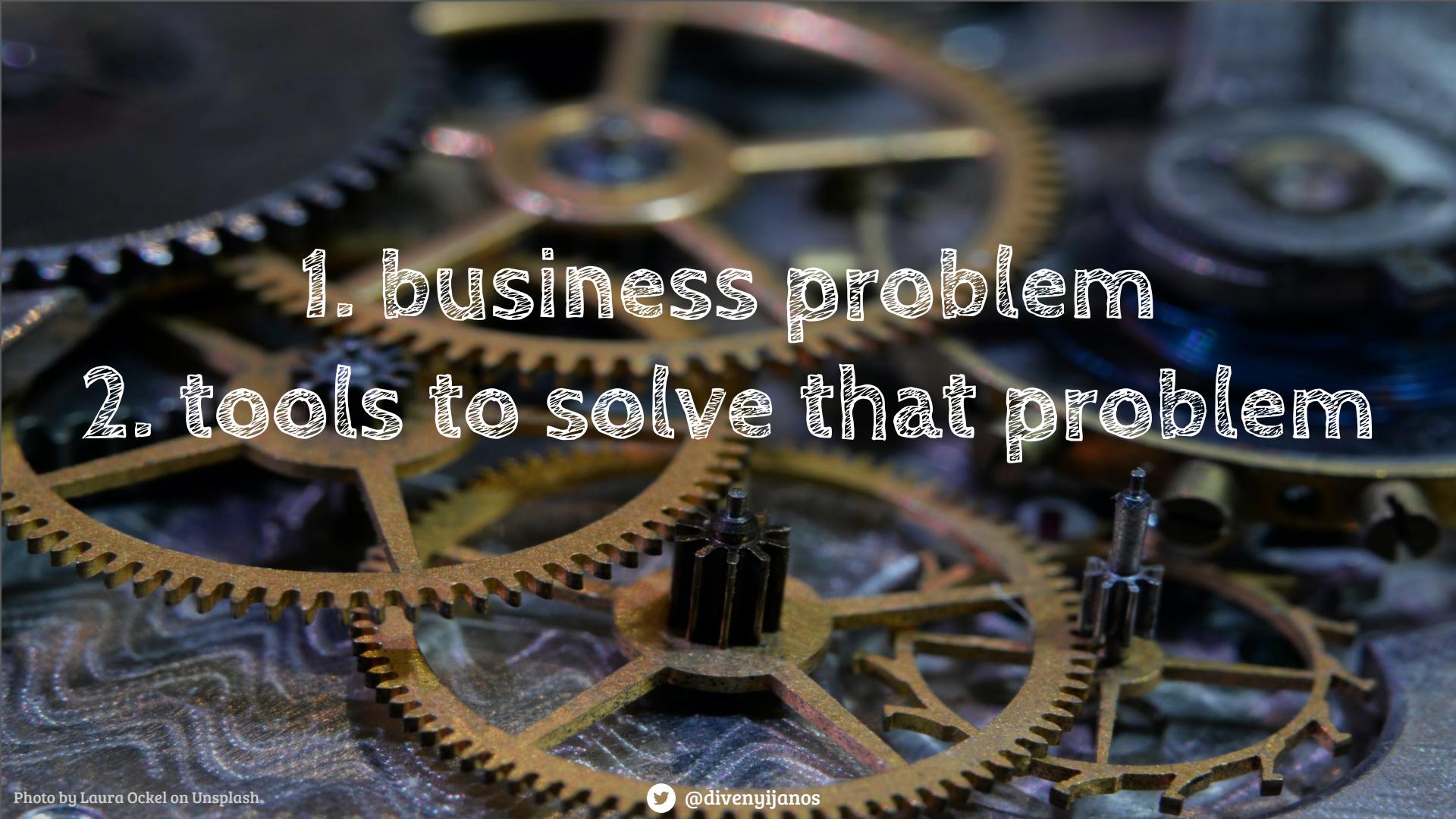








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- 
- A close-up photograph of several interlocking gold-colored metal gears. The gears have intricate patterns on their faces and are set against a dark, slightly blurred background. The lighting highlights the metallic texture and the complex meshing of the gear teeth.
1. business problem
  2. tools to solve that problem

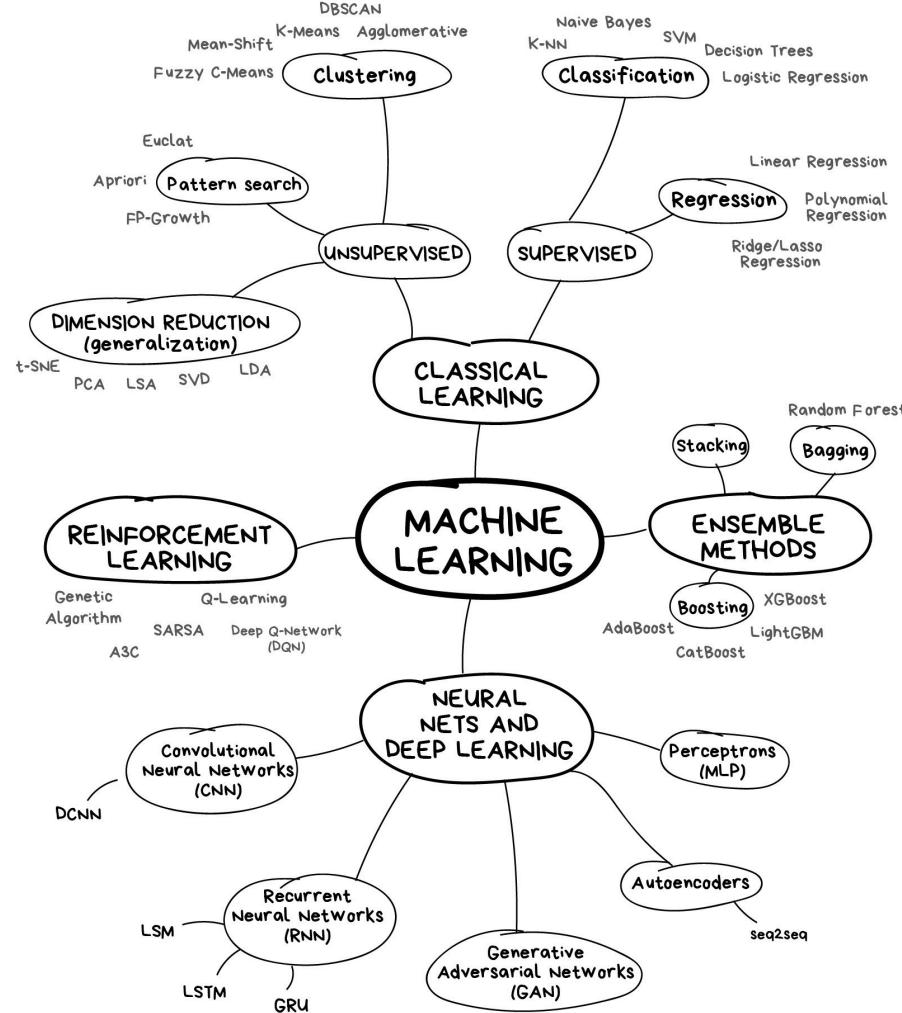
# No Free Lunch theorem

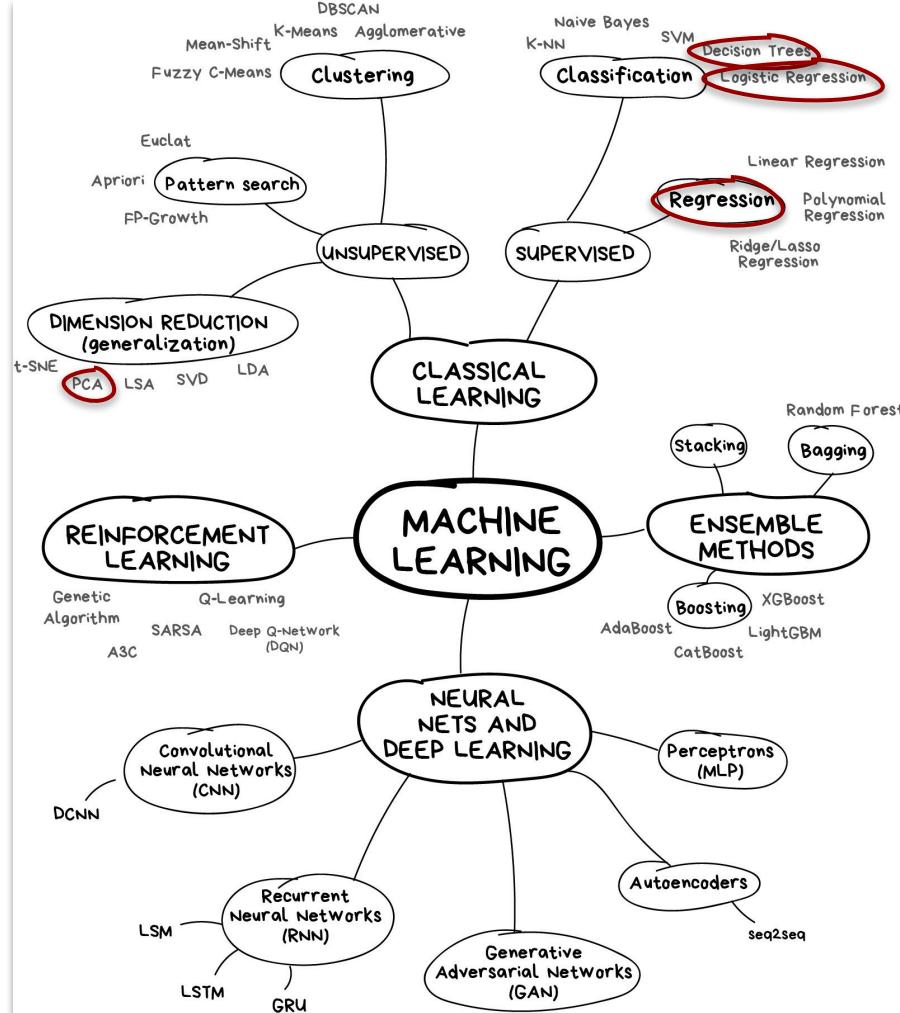
ENTIRE SET OF PROBLEMS IN THE UNIVERSE

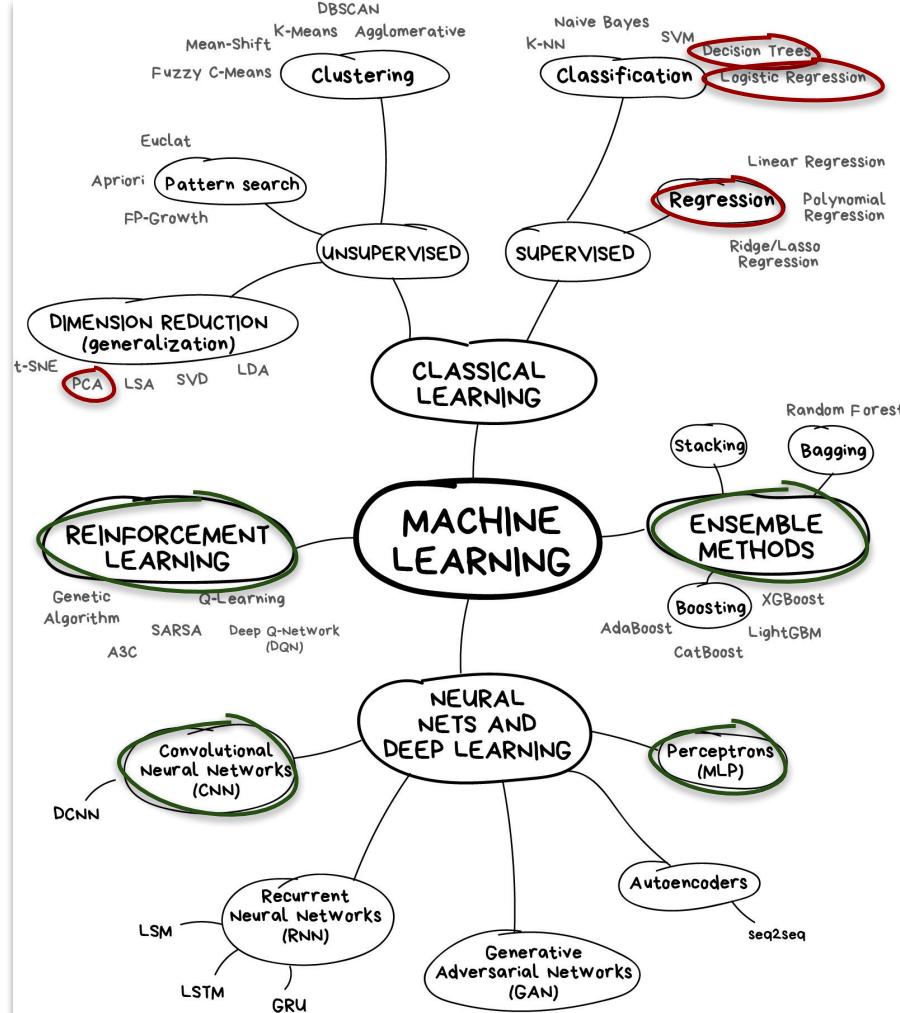


ASSUMING THERE ARE ONLY 2 ALGORITHMS

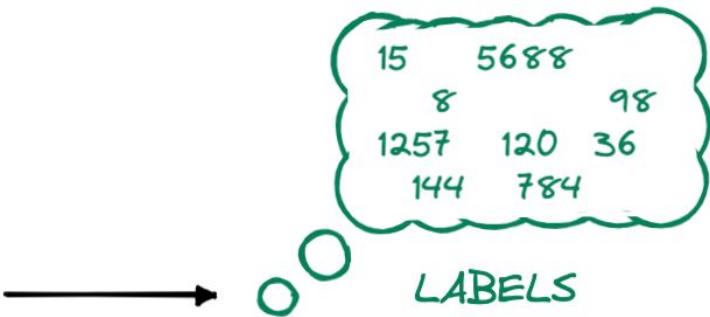








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$$^1 \sin \left(3t_2 + \frac{\pi}{6}\right) = A \sin \left(3t_2 + \frac{\pi}{6}\right);$$

$$= \frac{1}{2} k y_2^2; \quad E_c = E - E_p = \frac{1}{2} k (A^2 - y_2^2)$$

$$= \frac{1}{2} k (A^2 - y_2^2) \Rightarrow y_2 = A \frac{\sqrt{2}}{2} = \frac{4}{3} \cdot 10^{-1} \sqrt{}$$

$$E_p = E_{p_{\max}} \Rightarrow \sin^2 \left(3t_p + \frac{\pi}{3}\right) = 1 \Rightarrow \sin \left(\frac{\pi}{2} + n\pi\right); \quad n = 0, 1, 2, \dots$$

$$y * z = \left[ \frac{1}{2} (x + y - xy + 1) \right] * z =$$

$$+ xy - xyz + z + 1 \right] = \frac{1}{2} \left[ \frac{1}{2} (x + y$$

$$y * z) = x * \left[ \frac{1}{2} (y + z - yz + 1) \right] =$$

$$x(y + z - yz + 1) + 1 \right] = (x * y) *$$

$$x * y = \frac{1}{2} (x + y - xy + 1)$$

$$= \int_{-a}^0 x^2 e^{ax} dx = \frac{1}{a} (x^2 e^{ax}) \Big|_{-a}^0 - \frac{2}{a} \int_{-a}^0$$

$$-a^2 - \frac{2}{a} \left[ \frac{1}{a} (x e^{ax}) \Big|_{-a}^0 - \frac{1}{a} \int_{-a}^0 e^{ax} dx \right]$$

$$+ \frac{2}{a} \left[ \frac{1}{a} (e^{ax}) \Big|_{-a}^0 - \frac{2}{a} e^{-a^2} - \frac{2}{a} e^{-a^2} \right]$$

$$\frac{1 - \left(-\frac{1}{n+2}\right)^{n+1}}{1 + \frac{1}{n+2}} + \frac{1}{n+1} \cdot \frac{1 - \left(-\frac{1}{n+1}\right)}{1 + \frac{1}{n+1}}$$

$$\left[ \frac{-\frac{1}{n+1}}{n+2} - \frac{1 - \left(-\frac{1}{n+2}\right)^{n+1}}{n+3} \right] = (-1)^{n+1} \frac{1}{(n+2)^n} + (-1)^n \cdot \frac{n+3}{n+1} \cdot \frac{1}{(n+1)^{n+1}}$$

$$\boxed{I_R = \frac{U}{R} = \frac{220}{17,32} = 12,7 \text{ A}},$$

$$\boxed{\frac{I_R}{I_R + I_L^2} = \frac{M/L}{M^2 + L^2 \omega^2} = \frac{17,32}{34,64} = \frac{1}{2}, \quad \varphi = \frac{\omega_0}{C \omega_0} \Rightarrow v_0 = \frac{1}{2\pi V L C} = \frac{1}{\sqrt{X_L C}}}$$

$$\boxed{-(x+t)I_2 + (xt-yz)I_2 = 0.}$$

$$\begin{pmatrix} x & y \\ z & t \end{pmatrix} - \begin{pmatrix} x+t & 0 \\ 0 & x+t \end{pmatrix} = \begin{pmatrix} -t & y \\ z & -x \end{pmatrix}.$$

$$\begin{pmatrix} y & -t & z & -x \\ t & yz - xt & 0 & uz - tx \end{pmatrix} =$$

$$t_1 \simeq \sqrt{\frac{2h_0}{g}} \cdot \frac{s}{s} = \sqrt{\frac{2 \cdot 0,8}{9,8}} \cdot \frac{8 \cdot 10^{-2}}{10^{-4}} = 3$$

$$= \frac{s}{\sqrt{S^2 - s^2}} \sqrt{2g h_0},$$

$$= sv_2(h_0)t_1 = \frac{sS}{\sqrt{S^2 - s^2}} \sqrt{2gh_0} \sqrt{\frac{2h_0}{g}} \cdot \frac{\sqrt{s}}{s}$$

$$Sh_0 = 2V_0 = 2 \cdot 8 \cdot 10^{-2} \cdot 0,8 = 12,8 \cdot 10$$

$$_{12} = -K \frac{m_1 m_2}{r_{12}^2}, \quad F_{12} = -K \frac{m_1 m_2}{r_{12}^2} \cdot \frac{\bar{r}_{12}}{r_{12}}, \quad \bar{\Gamma}$$

$$E_p = E_{p_{\max}} \Rightarrow \sin^2 \left(3t_p + \frac{\pi}{3}\right) = 1$$

$$= \sin \left(\frac{\pi}{2} + n\pi\right); \quad n = 0, 1, 2, \dots$$

$$t_p = \frac{\pi}{3} \left( n + \frac{1}{6} \right); \quad n = 0, 1, 2, \dots$$

$$E_c = E_{c_{\max}} \Rightarrow \cos^2 \left(3t_c + \frac{\pi}{3}\right) = 1 \Rightarrow \cos \left(3t_c + \frac{\pi}{3}\right) = \pm 1 = \cos(n\pi) \Rightarrow t_c = \frac{\pi}{3} \left( n - \frac{1}{3} \right)$$

$$\frac{dx}{1+x^2} + \int \frac{x}{\sqrt{1+x^2}} dx = J + \sqrt{1+x^2}$$

$$-\sqrt{\frac{-\frac{dx}{x^2}}{\sqrt{\frac{1}{x}+1}}} = -\sqrt{\frac{d\left(\frac{1}{x}\right)}{\sqrt{\frac{1}{x}+1}}} =$$

$$^1 \sin \left(3t_2 + \frac{\pi}{6}\right) = A \sin \left(3t_2 + \frac{\pi}{6}\right);$$

$$= \frac{1}{2} k y_2^2; \quad E_c = E - E_p = \frac{1}{2} k (A^2 - y_2^2)$$

$$= \frac{1}{2} k (A^2 - y_2^2) \Rightarrow y_2 = A \frac{\sqrt{2}}{2} = \frac{4}{3} \cdot 10^{-1} \text{ V}$$

$$E_p = E_{p_{\max}} \Rightarrow \sin^2 \left(3t_p + \frac{\pi}{3}\right) = 1 \Rightarrow \sin = \sin \left(\frac{\pi}{2} + n\pi\right); \quad n = 0,1,2,\dots$$

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$$t_1 \simeq \sqrt{\frac{2h_0}{g}} \cdot \frac{s}{s} = \sqrt{\frac{2 \cdot 0,8}{9,8}} \cdot \frac{8 \cdot 10^{-2}}{10^{-4}} = 3 = \frac{s}{\sqrt{S^2 - s^2}} \sqrt{2gh_0},$$

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$$E_c = E_{c_{\max}} \Rightarrow \cos^2 \left(3t_c + \frac{\pi}{3}\right) = 1 \Rightarrow \cos \left(3$$

$$= \pm 1 = \cos(n\pi) \Rightarrow t_c = \frac{\pi}{3} \left(n - \frac{1}{3}\right)$$

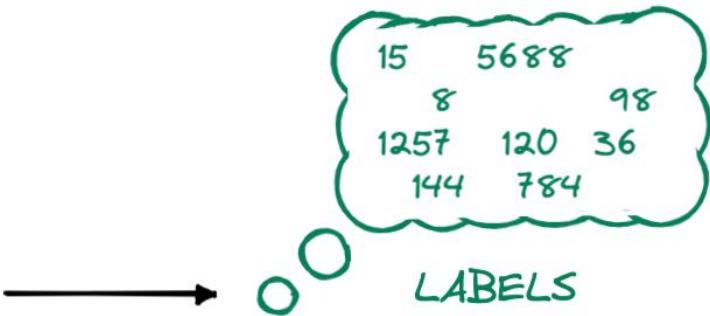
$$- \frac{dx}{1+x^2} + \int \frac{x}{\sqrt{1+x^2}} dx = J + \sqrt{1+x^2}$$

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$$y \begin{pmatrix} -t & y \\ t & -x \end{pmatrix} = \begin{pmatrix} yz - xt & 0 \\ 0 & uz - tx \end{pmatrix} =$$

$$-\sqrt{\frac{-\frac{dx}{x^2}}{\sqrt{\frac{1}{x} + 1}}} = -\sqrt{\frac{d\left(\frac{1}{x}\right)}{\sqrt{\frac{1}{x} + 1}}} =$$

GIF made from video by @kareem\_carr



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## Loss function predicted vs real (e.g. MSE)



**Loss function** predicted vs real depending on params (e.g. MSE)

**Optimization algorithm** tweak params to minimize loss (e.g. derivation)



**Loss function** predicted vs real depending on params (e.g. MSE)

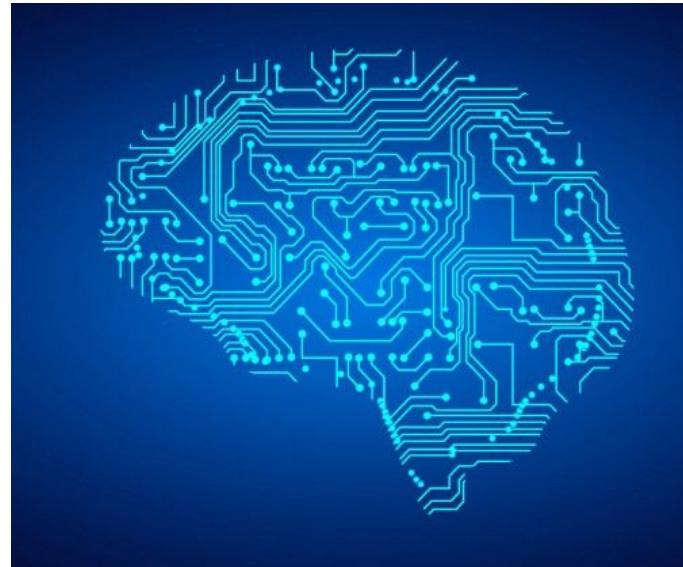
**Optimization algorithm** tweak params to minimize loss (e.g. derivation)



Memorization

vs

Generalization



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**Loss function** predicted vs real depending on params (e.g. MSE)

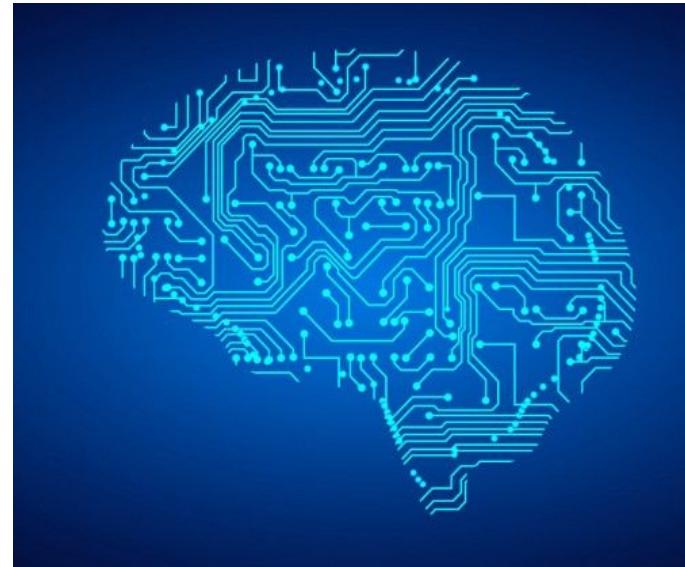
**Optimization algorithm** tweak params to minimize loss (e.g. derivation)



**Memorization**

vs

**Generalization**



**Loss function** predicted vs real depending on params (e.g. MSE)

**Optimization algorithm** tweak params to minimize loss (e.g. derivation)



evaluate on  
**NEW** data

**Memorization**

vs



seen to **unseen**  
training to **application**  
sample to **population**

**Generalization**



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**Loss function** predicted vs real depending on params (e.g. MSE)

**Optimization algorithm** tweak params to minimize loss (e.g. derivation)

**+regularization** prefer simpler models → optimize for Loss + Penalty



**Loss function** predicted vs real depending on params (e.g. MSE)

**Optimization algorithm** tweak params to minimize loss (e.g. derivation)

**+regularization** prefer simpler models → optimize for Loss + Penalty

**+hyperparameters** control penalty + algo details



A close-up photograph of several interlocking brass or gold-colored gears. The gears have intricate patterns and some are engraved with numbers like '100' and '10'. The lighting highlights the metallic texture and the way the gears mesh together.

business

↔ methods

↔ technicalities

# Miscellaneous

- Materials on Moodle: ~~mandatory~~ recommended reading & videos
- Discussion in Slack: help each other!
- Grading
  - 30% Quizzes (3x10): 7 test questions on Moodle 13:30-13:45
    - points = #correct answers + 5 (no answer: 0)
  - 40% Assignments (2x20)
    - practical tasks that require coding + explanation
    - .ipynb and rendered .pdf expected (2 separate files!)
    - deadlines: Friday 8PM of 22 March and 5 April
  - 30% Take home exam
    - Kaggle competition
    - submission + .ipynb and rendered .pdf expected (2 separate files!)
    - deadline: Friday 8PM of 19 April





# Demand Forecast for Bike Share

👉 in Washington DC...



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# Recommended Materials

## Video:

- Cassie Kozyrkov (Google): [Introduction to ML and AI](#) (recommended)
- Josh Starmer (StatQuest): [Random Forests Part 1](#)
- Josh Starmer (StatQuest): [AdaBoost, Clearly Explained](#)
- Josh Starmer (StatQuest): [Gradient Boost Part 1](#)

## Text:

- [r2d3](#): Visual explanation of how tree model works
- ISLR 8.2: Bagging, Random Forests, Boosting, and Bayesian Additive Regression Trees
- ESL 10: Boosting and Additive Trees
- ESL 15: Random Forests

