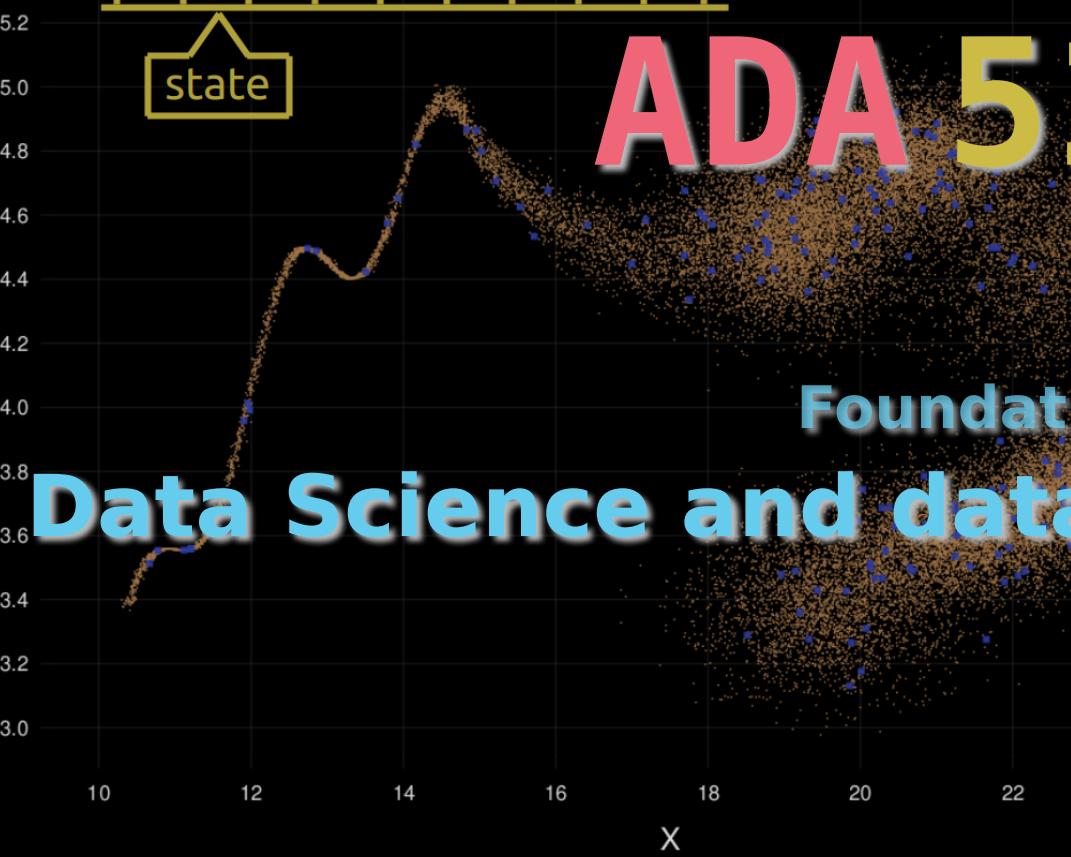


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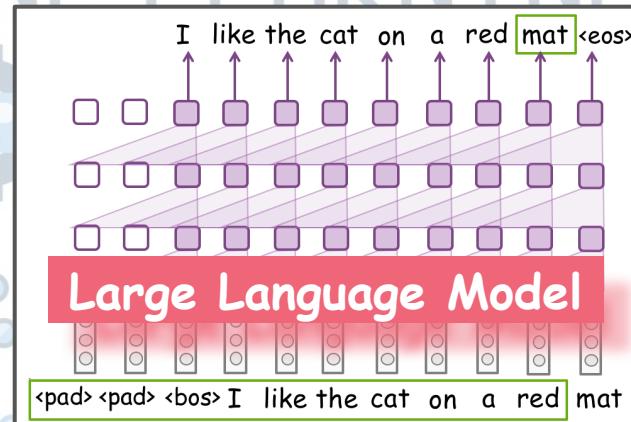
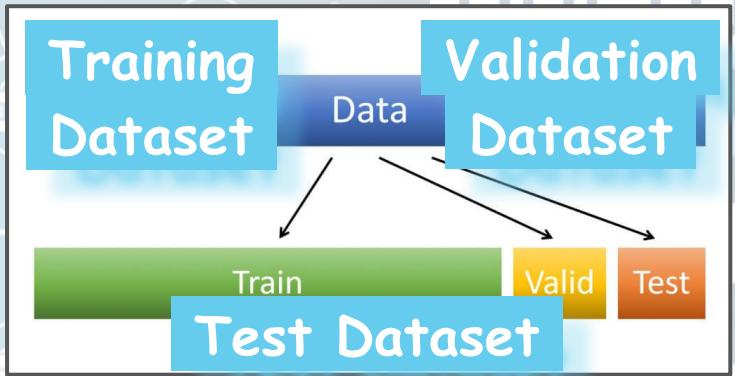
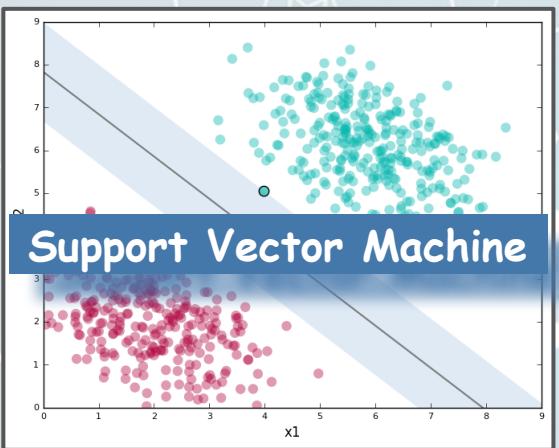
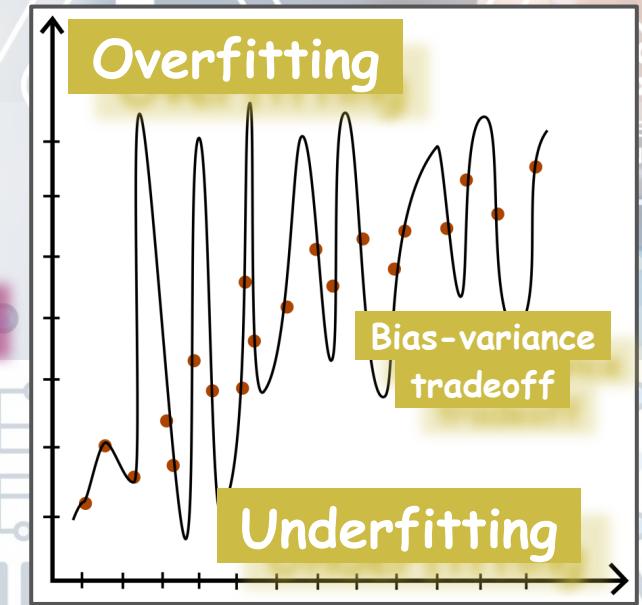
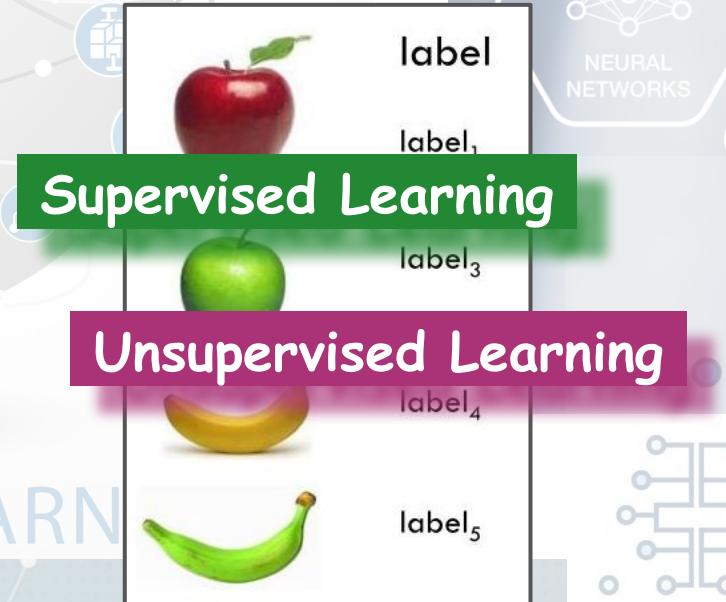
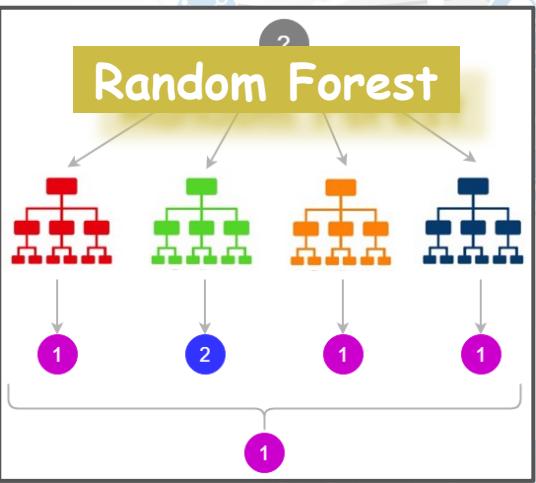
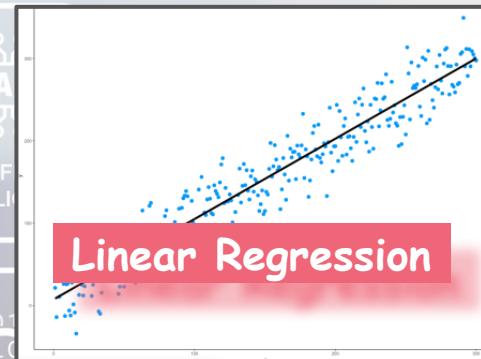
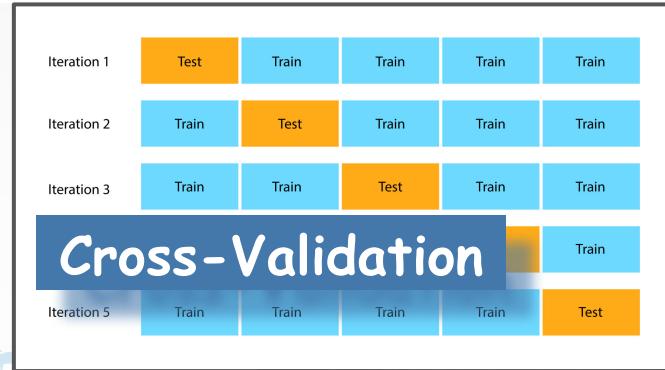
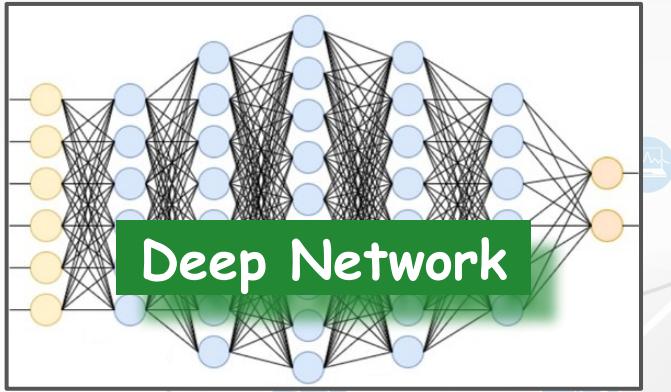


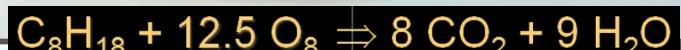
Foundations of

Data Science and data-driven engineering

$$P(Y|X)$$







Isooctane

Oxygen

Carbon dioxide

Water



SEDAN



HATCHBACK



CUV



SUV



MICRO



CABRIOLET



SUPERCAR



COUPE



VAN



MINIVAN



CAMPER VAN



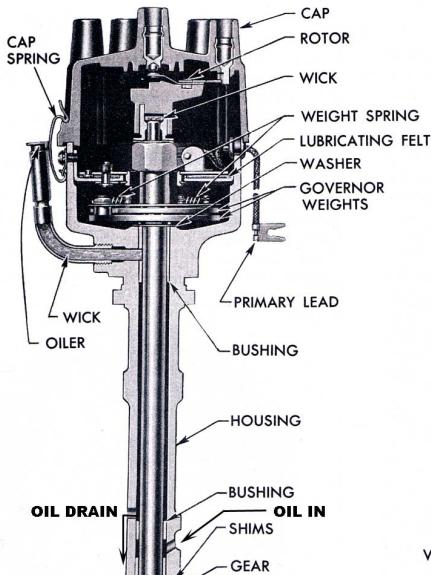
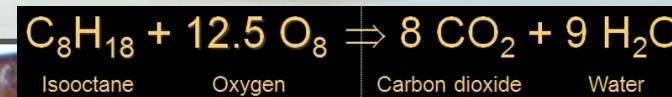
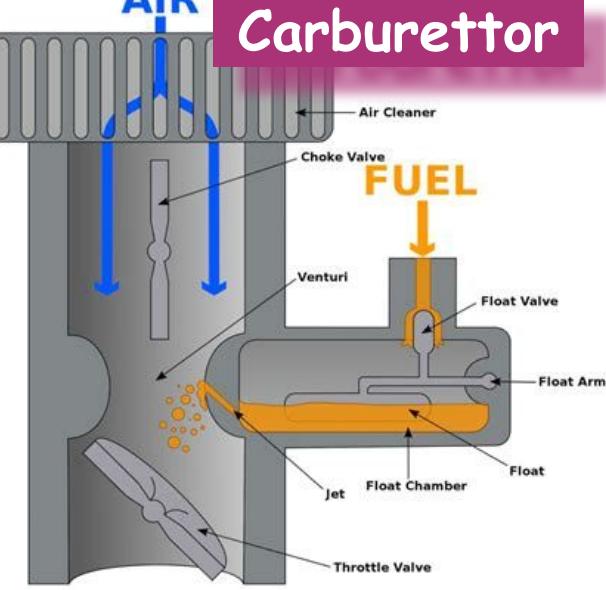
TRUCK



BIGTRUCK

AIR

Carburettor



Distributor

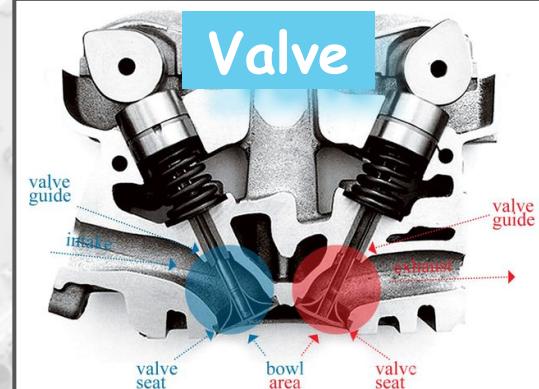


Spark plug

Fuel



Octanes



Silencer (muffler)



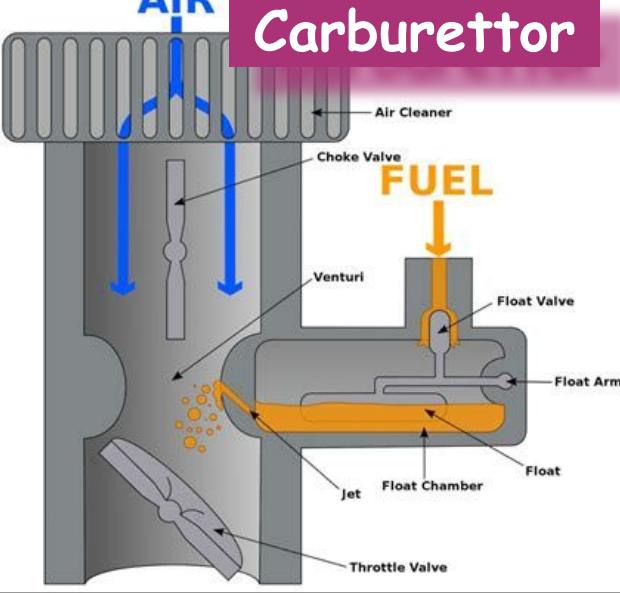
CAMPVAN

TRUCK

Green emissions

AIR

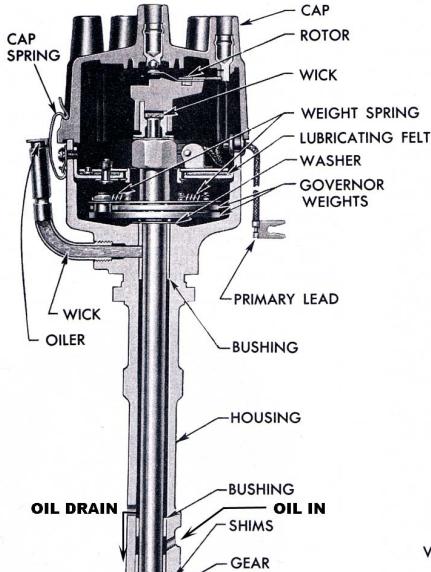
Carburettor



Fuel



Octanes



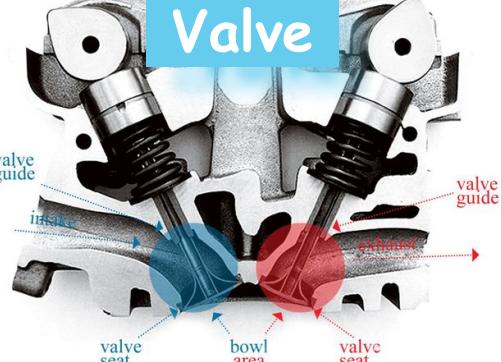
Distributor



Spark plug

CAMPVAN

TRUCK



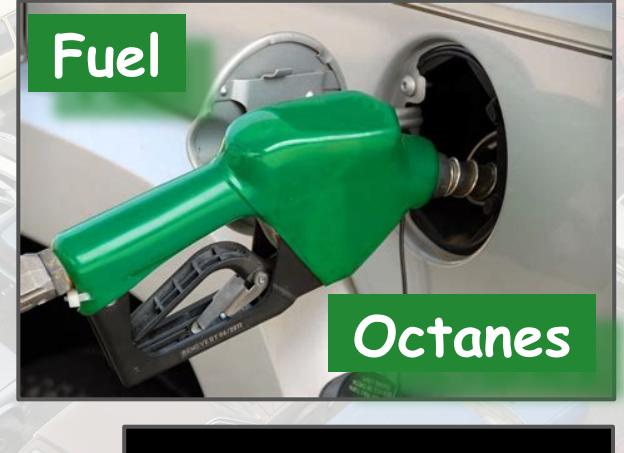
Valve



Engine oil

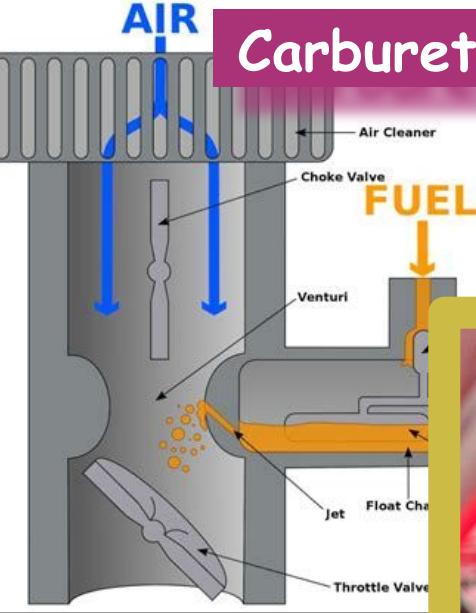
Green emissions

Silencer (muffler)



AIR

Carburettor

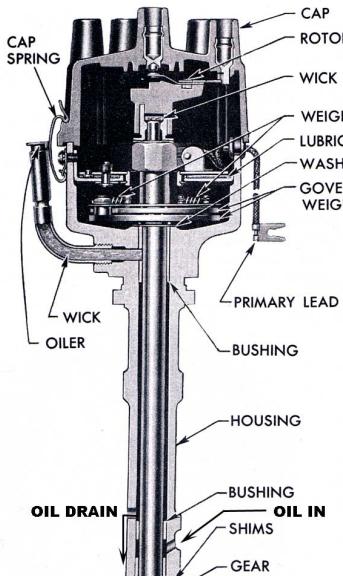


Fuel



Octanes

car mechanic



Distributor



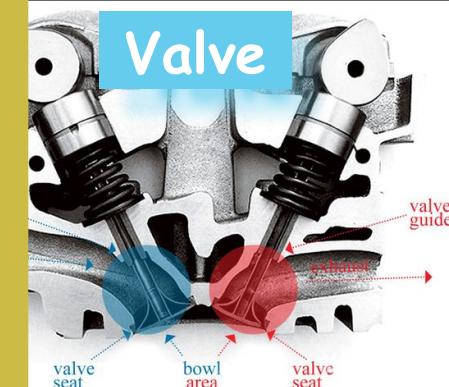
Spark plug

Engine oil



Silencer (muffler)

Green emissions



🔧 car mechanic





🔧 car mechanic



cartwright



car mechanic



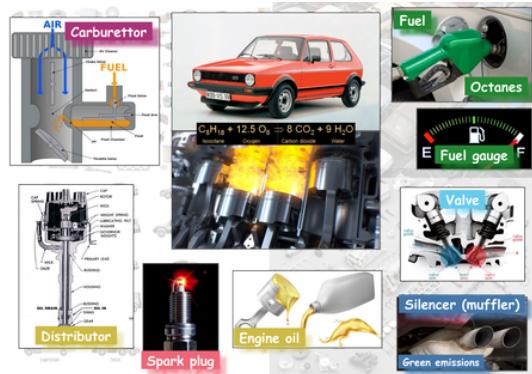
EV mechanic



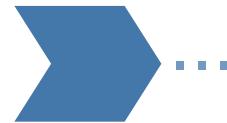
cartwright



car mechanic



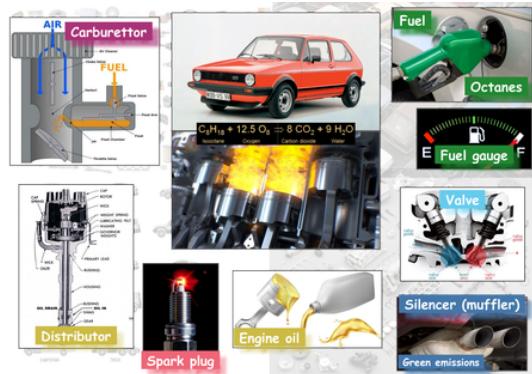
EV mechanic



cartwright



car mechanic



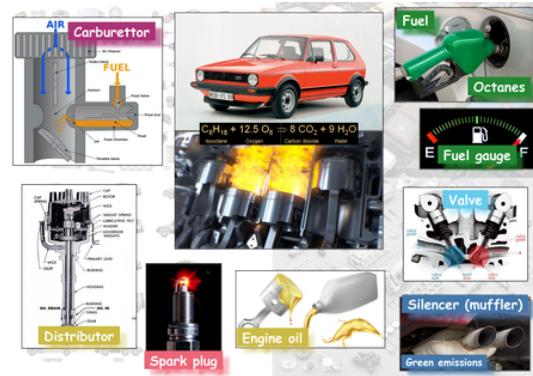
EV mechanic



 cartwright



 car mechanic



 EV mechanic



automotive engineer



car mechanic



automotive engineer



car mechanic



automotive engineer



 knowledge

car mechanic



Q *specific*

automotive engineer



knowledge

i'i *general*

car mechanic



🔍 *specific*

🔨 *practical*

automotive engineer



🎓 **knowledge**

💡 *general*

Ἁ *principled*

car mechanic



Q *specific*

🔧 *practical*

☰ *procedural*

automotive engineer



🎓 **knowledge**

蔀 *general*

Ἁ *principled*

⌚ *exploratory*

car mechanic



🔍 *specific*

🔨 *practical*

🛠️ *procedural*

⚓ *technology-dependent*

...

automotive engineer



🎓 *knowledge*

💡 *general*

Ἁ *principled*

🧭 *exploratory*

🐦 *technology-independent*

...

car mechanic



🔍 *specific*

🔨 *practical*

🛠 *procedural*

⚓ *technology-dependent*

...

automotive engineer



🎓 **knowledge**

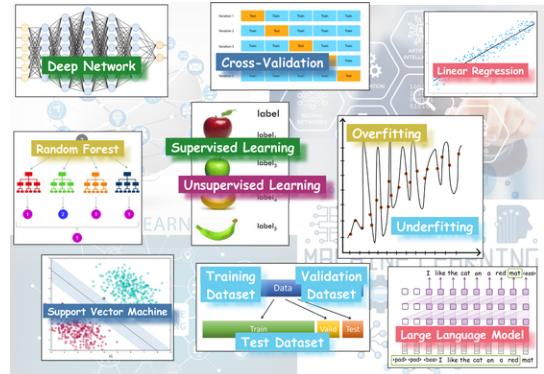
💡 *general*

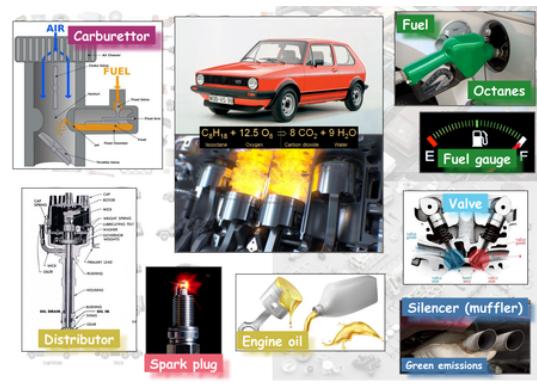
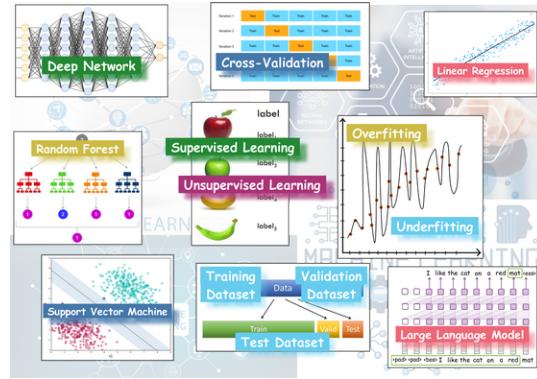
Ἁ *principled*

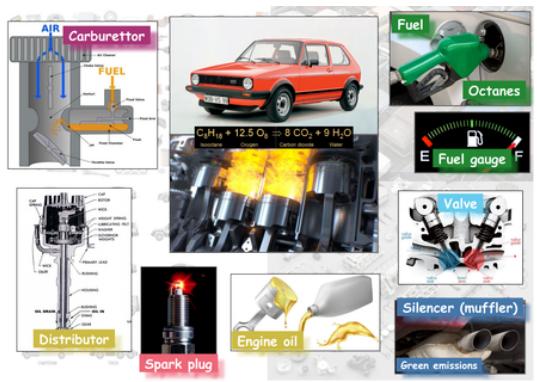
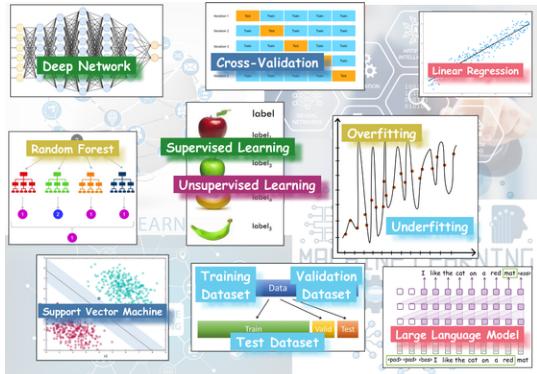
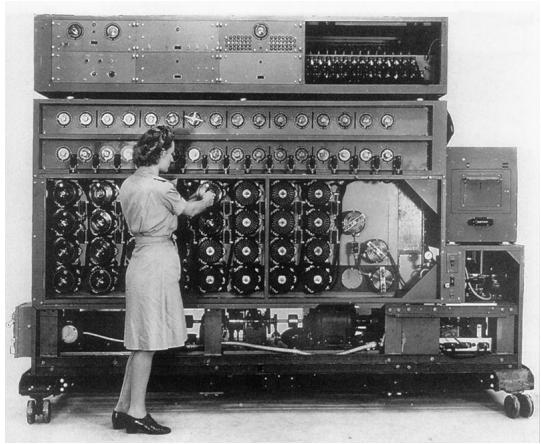
🧭 *exploratory*

🐦 *technology-independent*

...

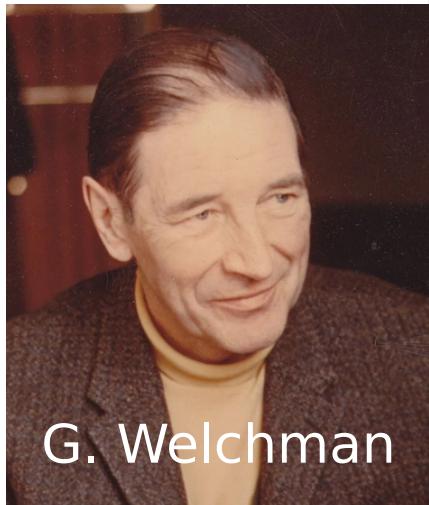








Alan Turing



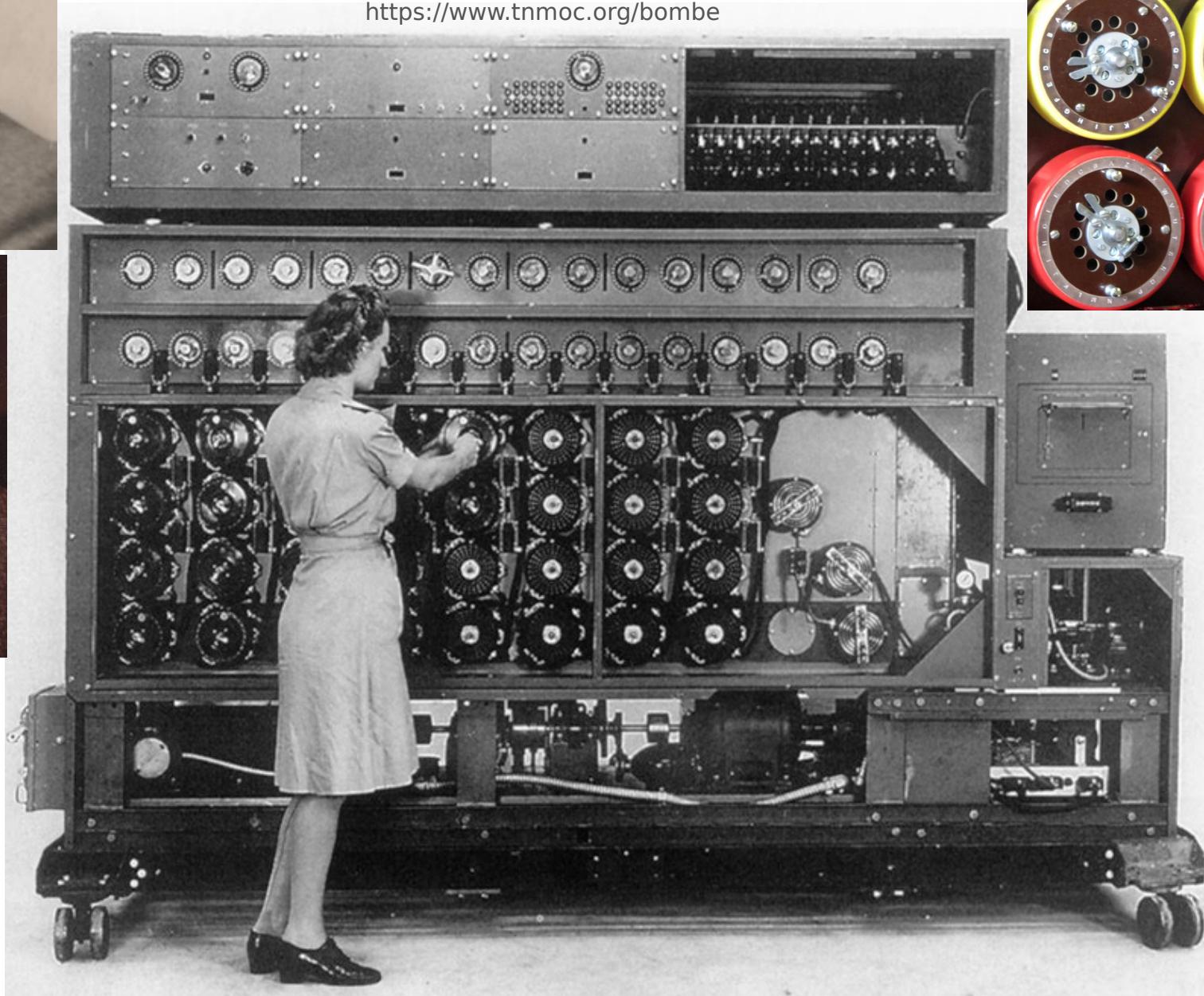
G. Welchman

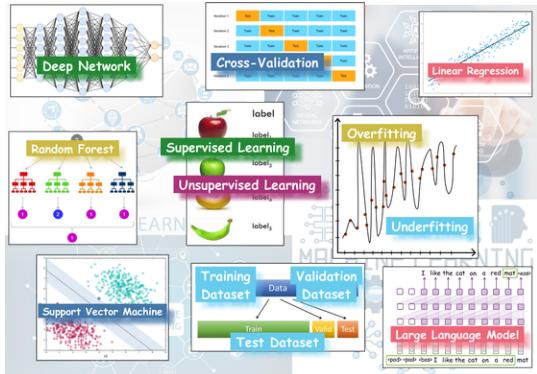
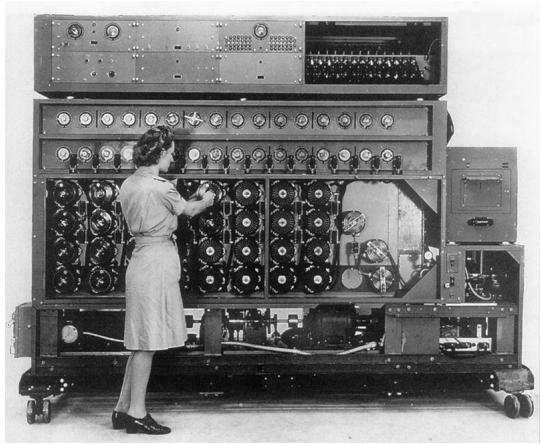
The Bombe a.k.a. *Agnes* electromechanical computer

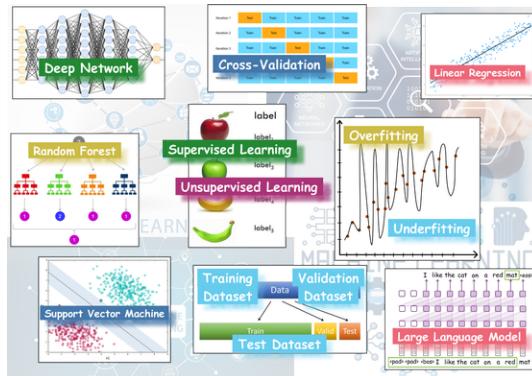
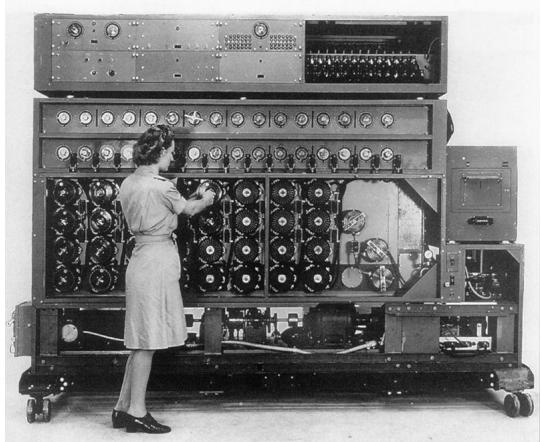
Decoded encrypted Nazi communications during World War II
(efficiency rate: 98.8%)

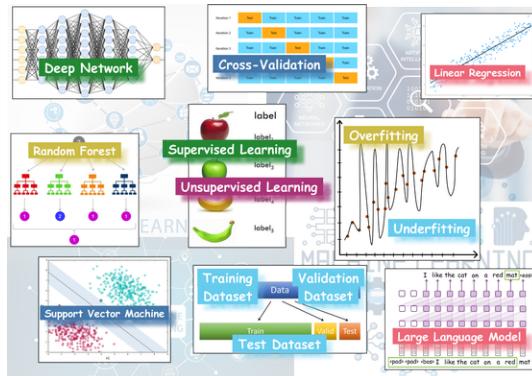
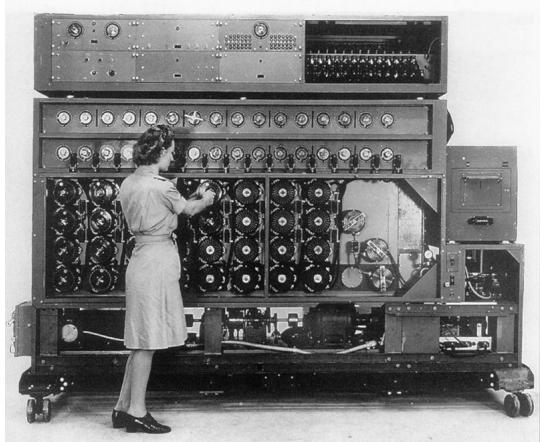
<https://www.britannica.com/topic/Bombe>

<https://www.tnmoc.org/bombe>





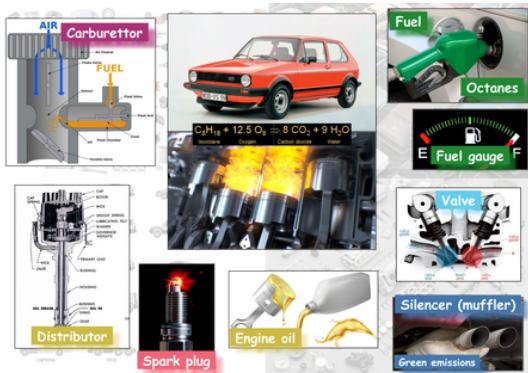




cartwright

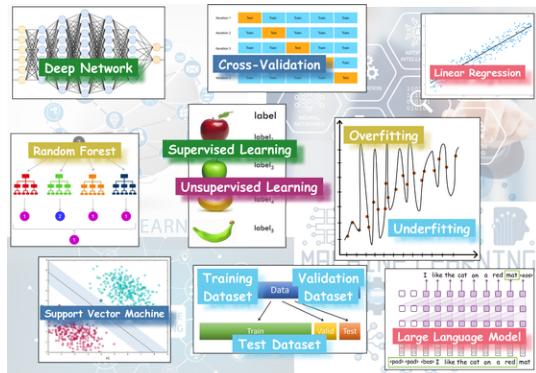
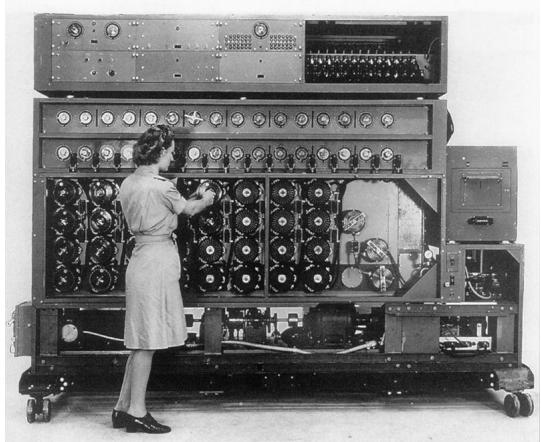


car mechanic



EV mechanic





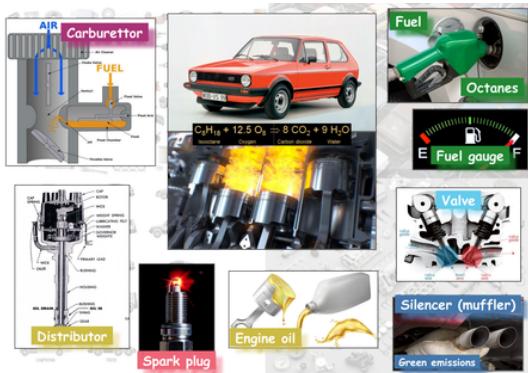
“data mechanic”



cartwright

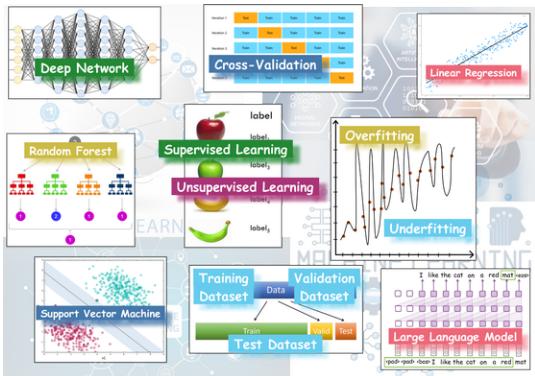
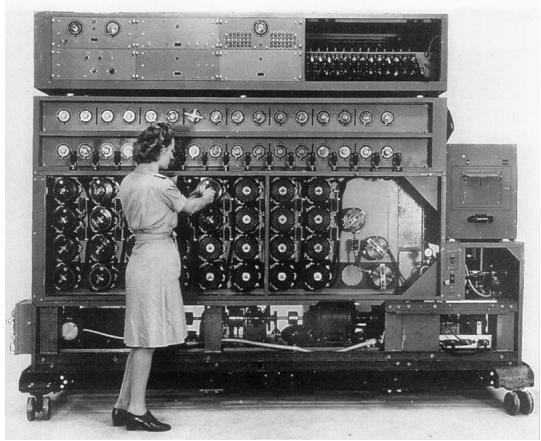


car mechanic

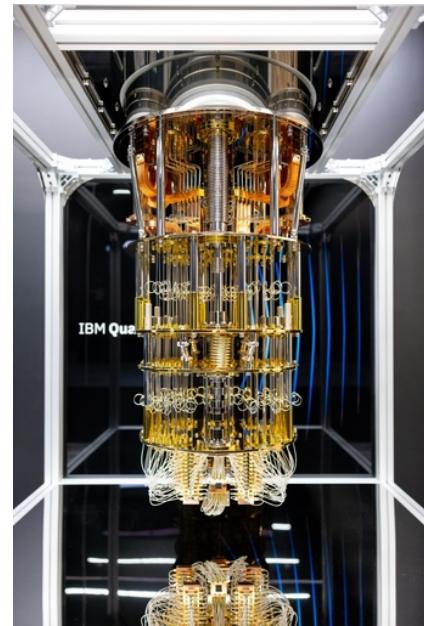


EV mechanic





“data mechanic”



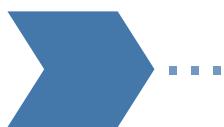
cartwright

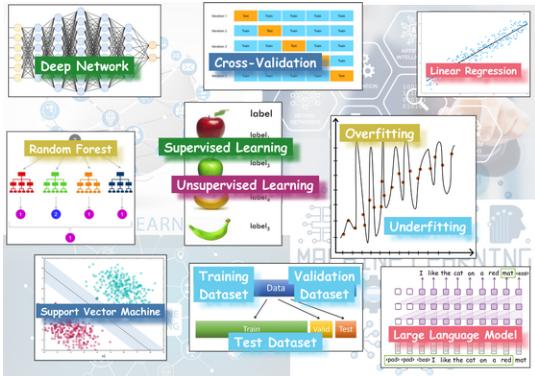
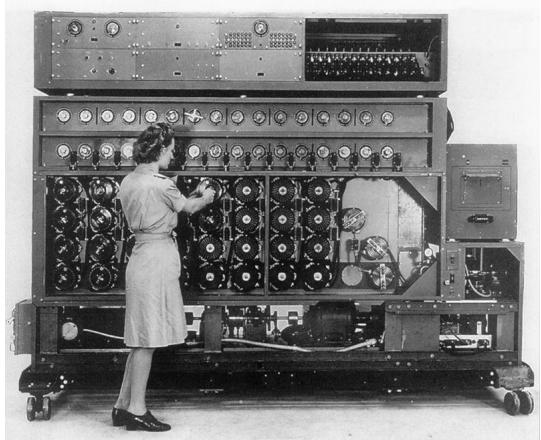


car mechanic

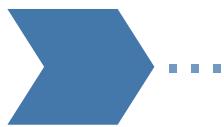


EV mechanic





“data mechanic”



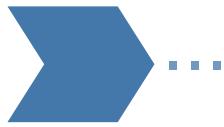
cartwright

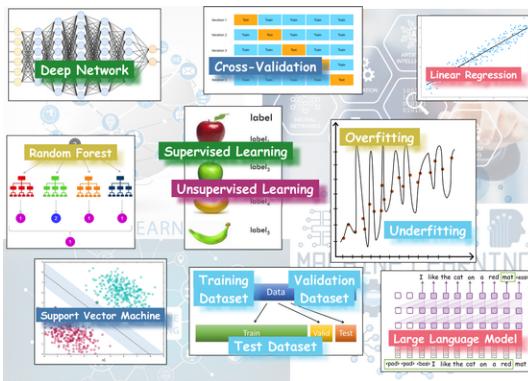
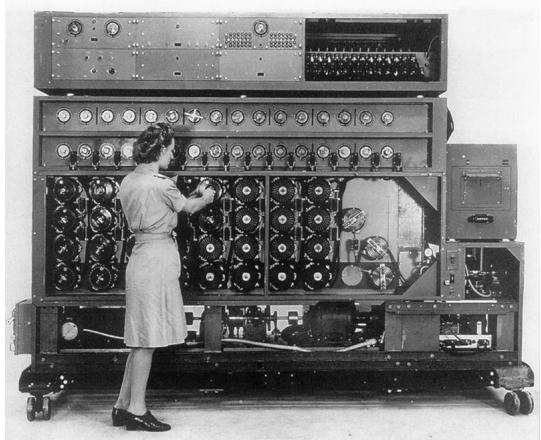


car mechanic



EV mechanic

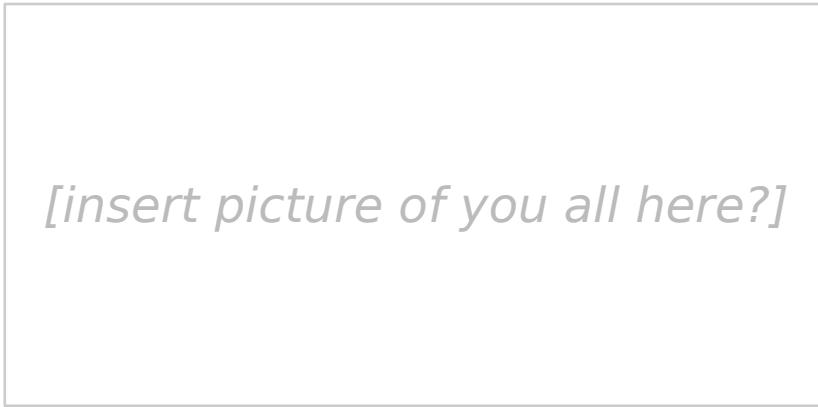




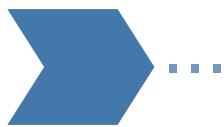
“data mechanic”



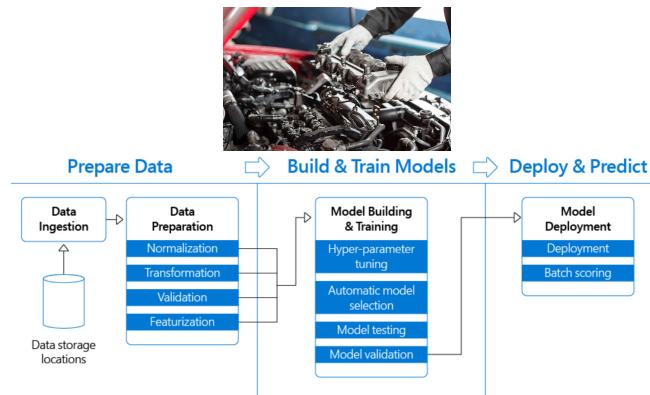
“data engineer”



[insert picture of you all here?]



“data mechanic”



knowledge

🔍 *specific*

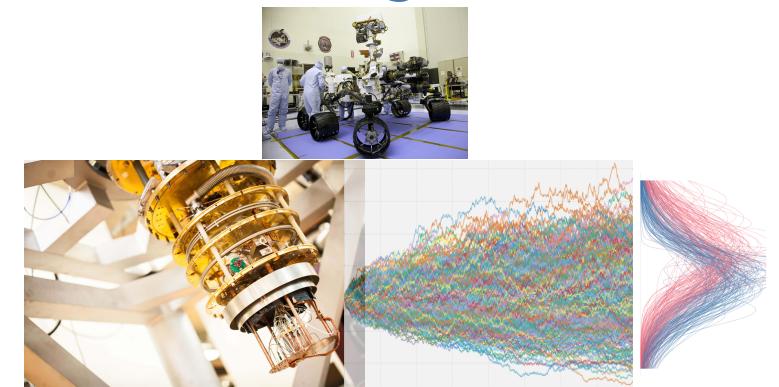
🔨 *practical*

🛠 *procedural*

⚓ *technology-dependent*

...

“data engineer”



🔭 *general*

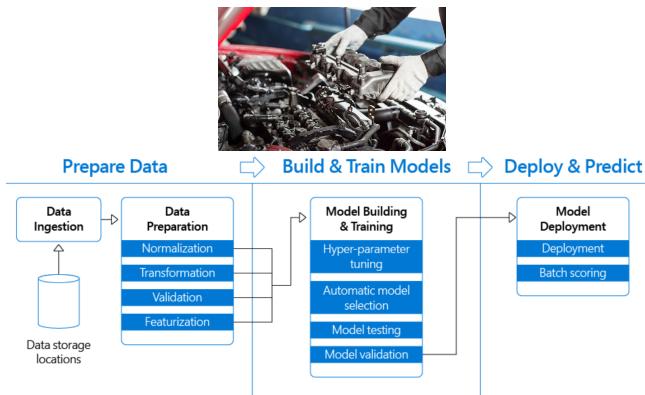
📘 *principled*

🧭 *exploratory*

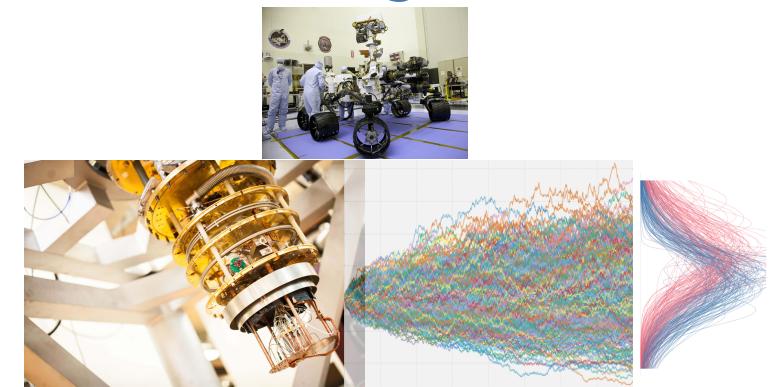
🐦 *technology-independent*

...

“data mechanic”



“data engineer”



🔍 *specific*

👀 *general*

🔨 *practical*

📐 *principled*

🛠️ *procedural*

🧭 *exploratory*

⚓ *technology-dependent*

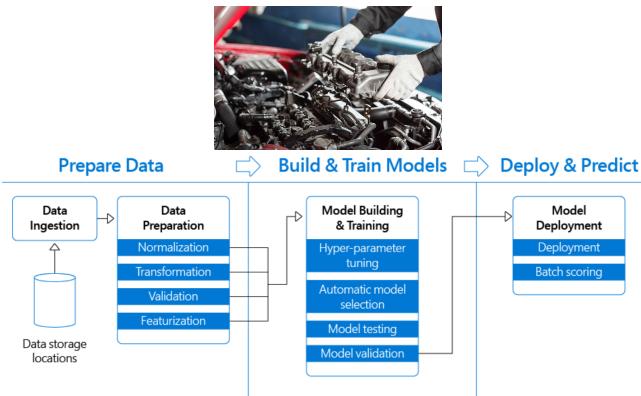
🐦 *technology-independent*

...

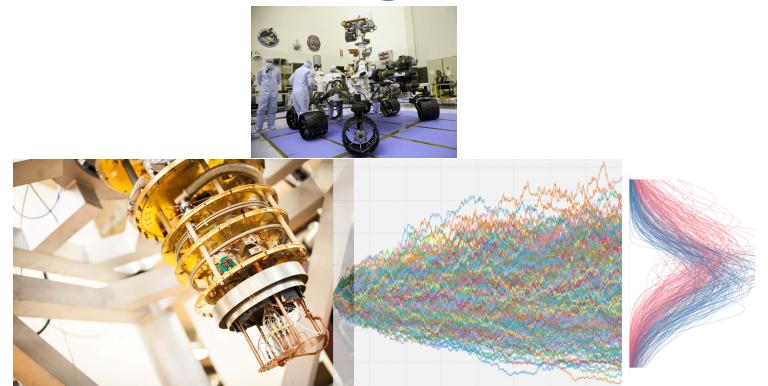
...

THIS IS THE BEST! 😍
don't listen to what he's saying

“data mechanic”



“data engineer”



knowledge

🔍 *specific*

👀 *general*

🔨 *practical*

📐 *principled*

🛠 *procedural*

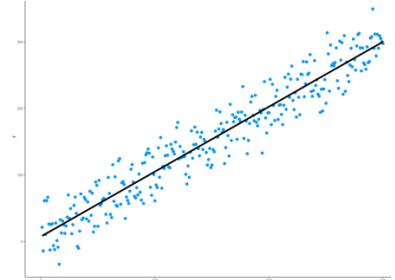
🧭 *exploratory*

⚓ *technology-dependent*

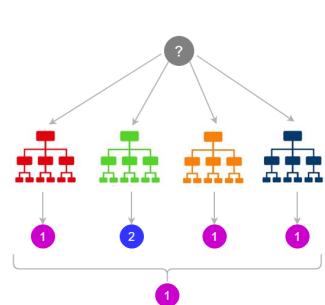
🐦 *technology-independent*

...

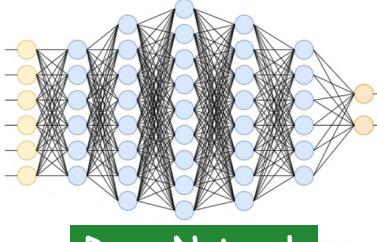
...



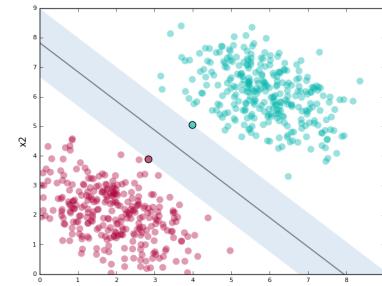
Linear Regression



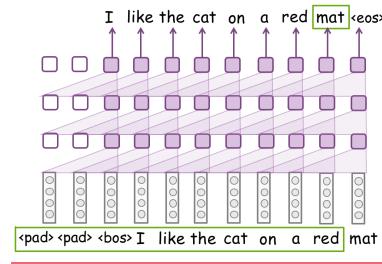
Random Forest



Deep Network



Support Vector Machine

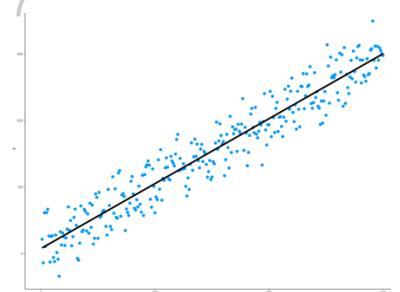
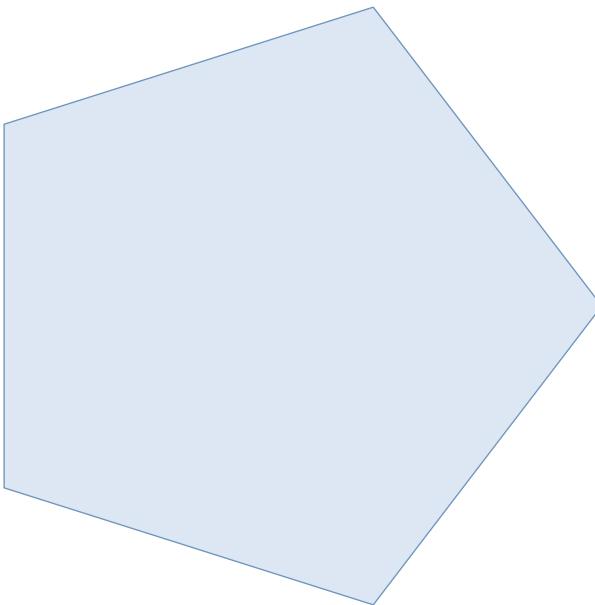


Large Language Model

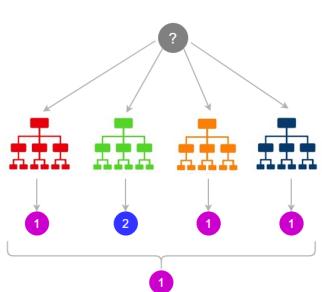


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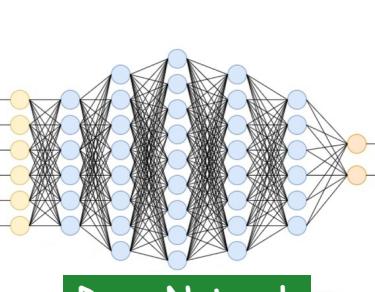
Optimal Predictor Machine



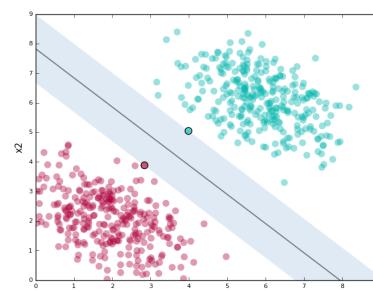
Linear Regression



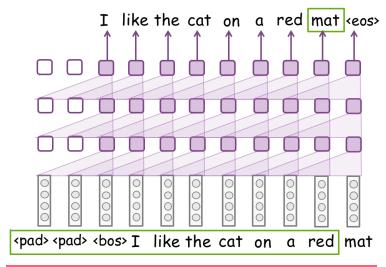
Random Forest



Deep Network



Support Vector Machine



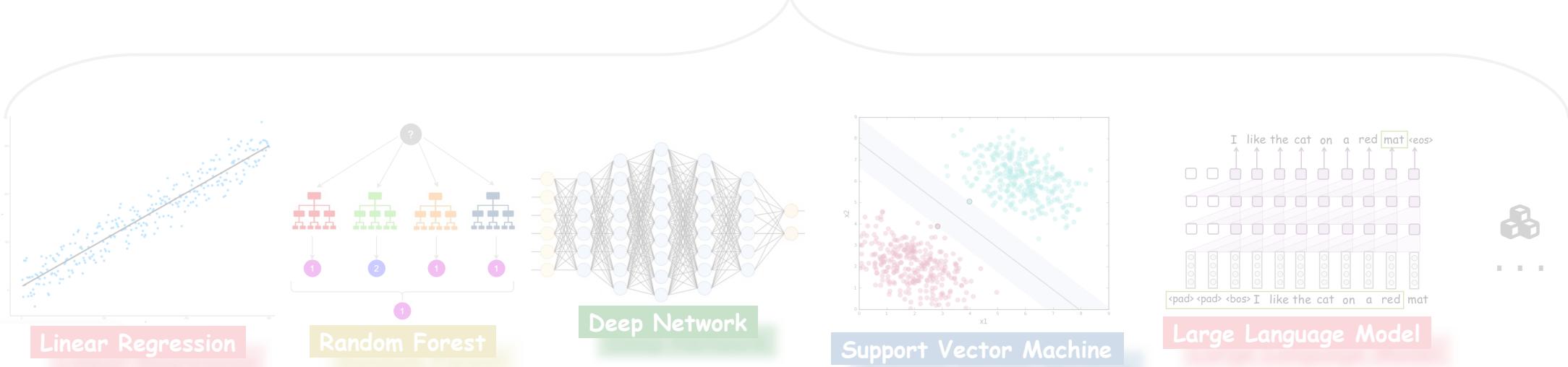
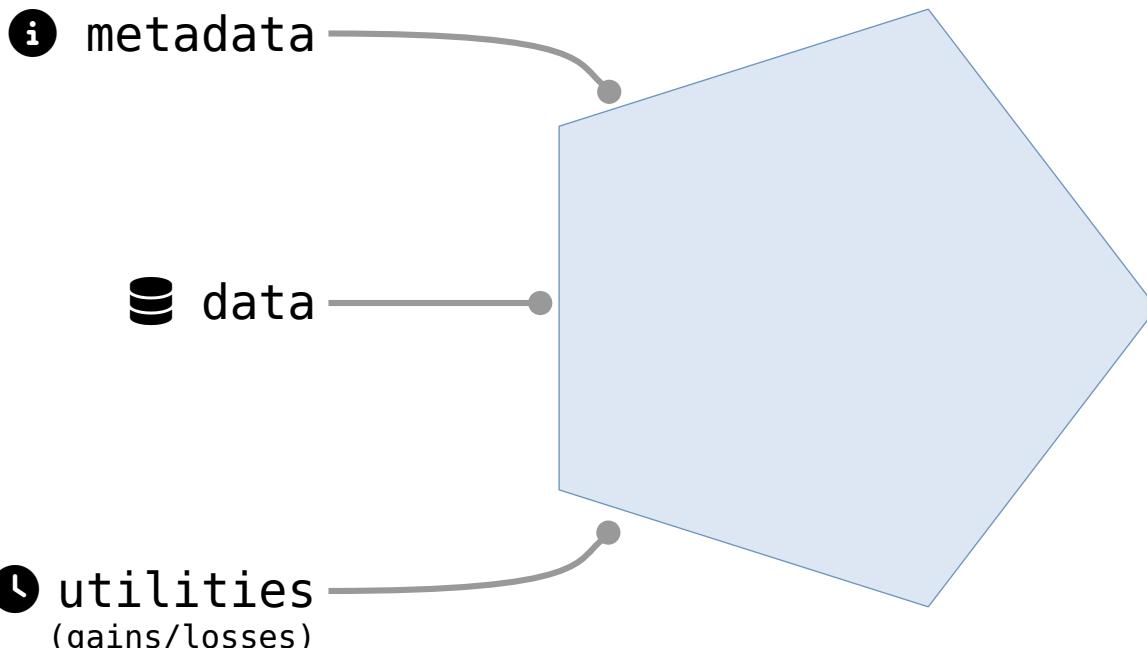
Large Language Model



...

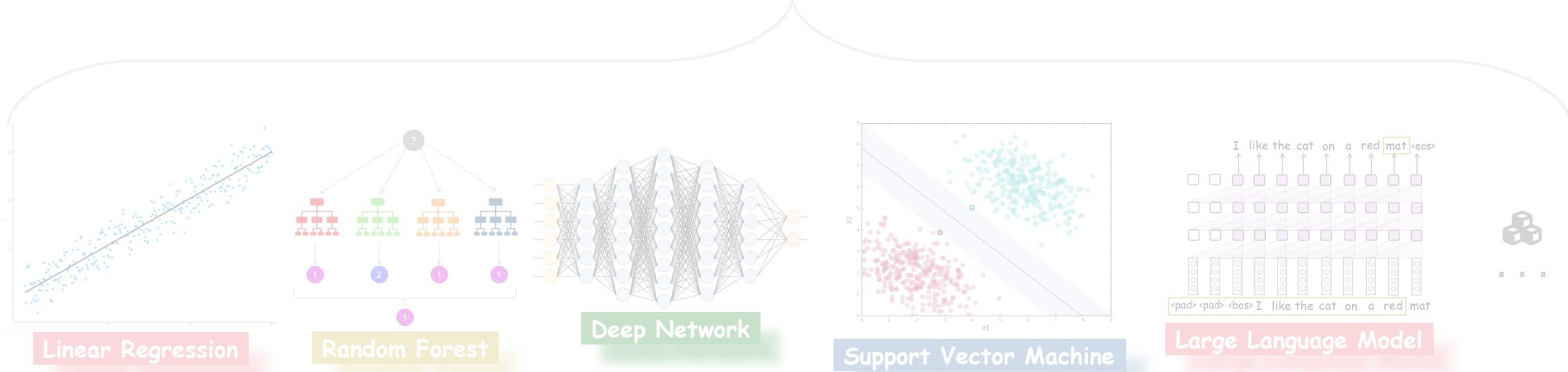
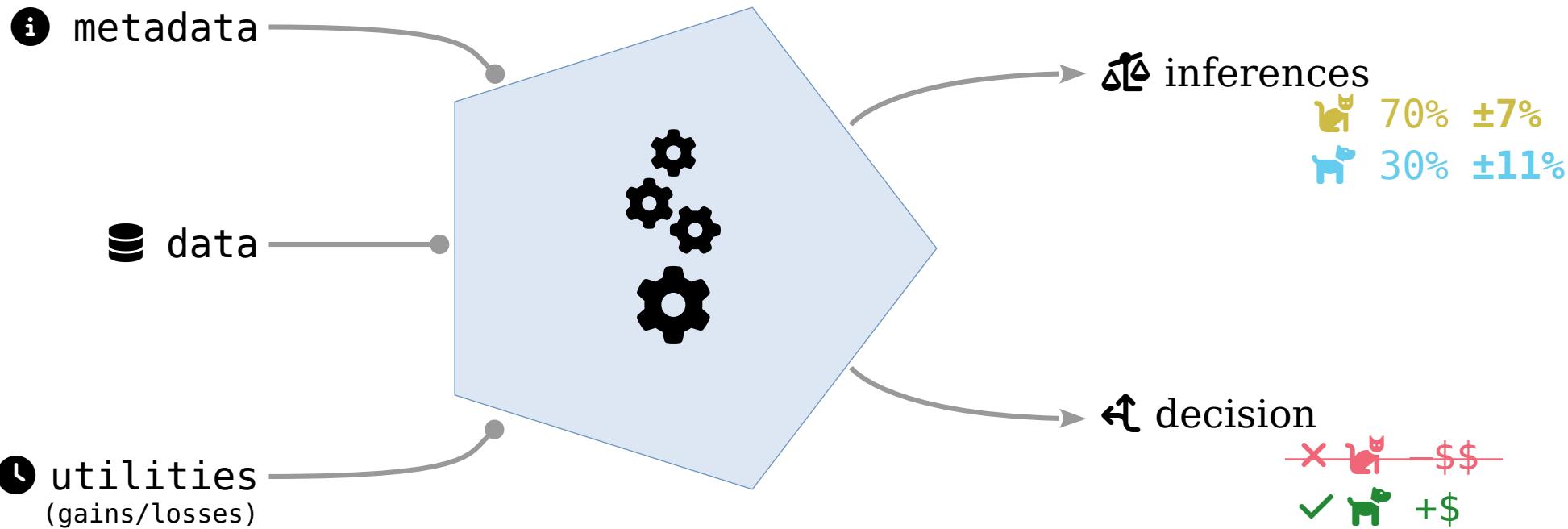
Optimal Predictor Machine

problem-dependent

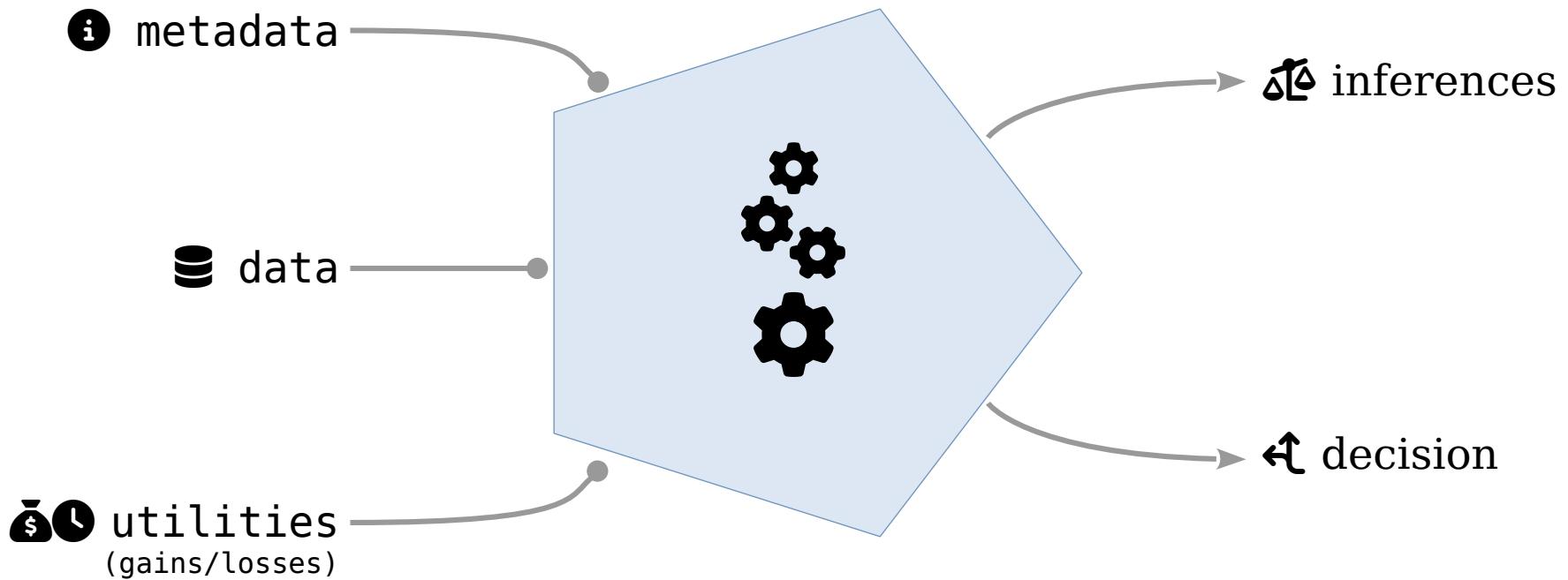


Optimal Predictor Machine

problem-dependent

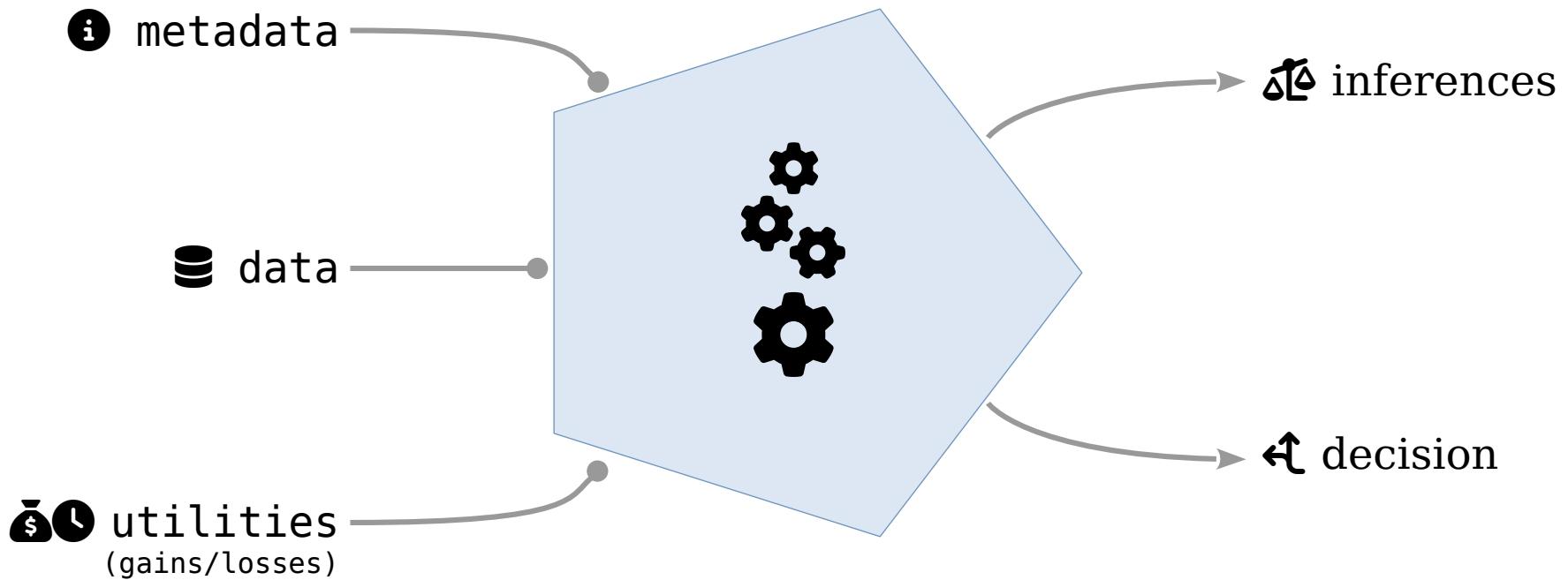


Optimal Predictor Machine



✓ mathematically guaranteed **optimal** outcome, by design → unbeatable!

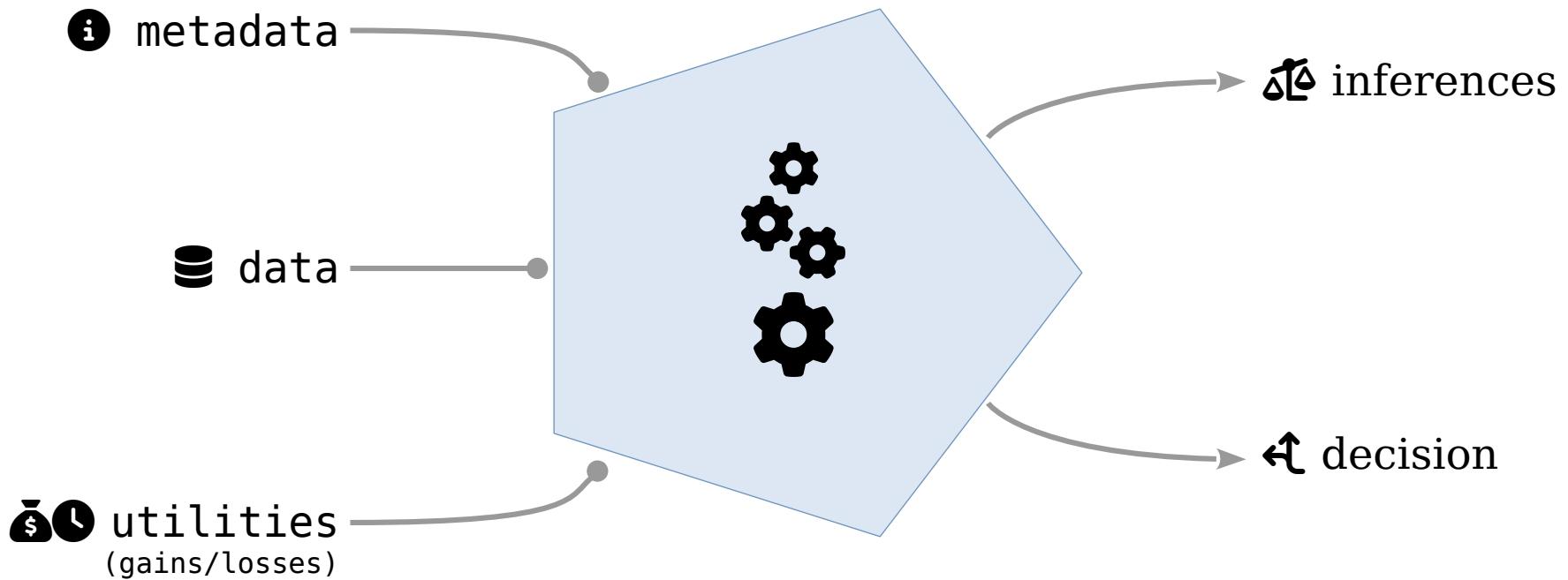
Optimal Predictor Machine



✓ mathematically guaranteed **optimal** outcome, by design → unbeatable!



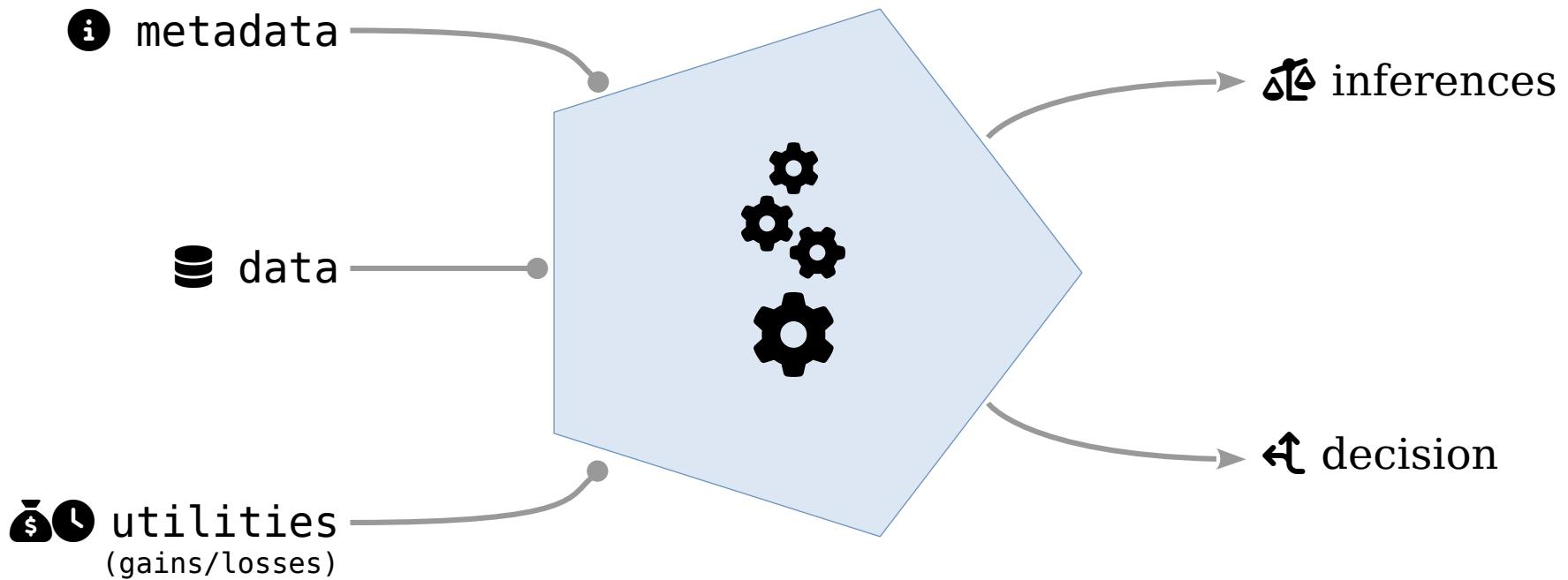
Optimal Predictor Machine



- ✓ mathematically guaranteed **optimal** outcome, by design → unbeatable!
- ✓ mathematically guaranteed maximally-informative output



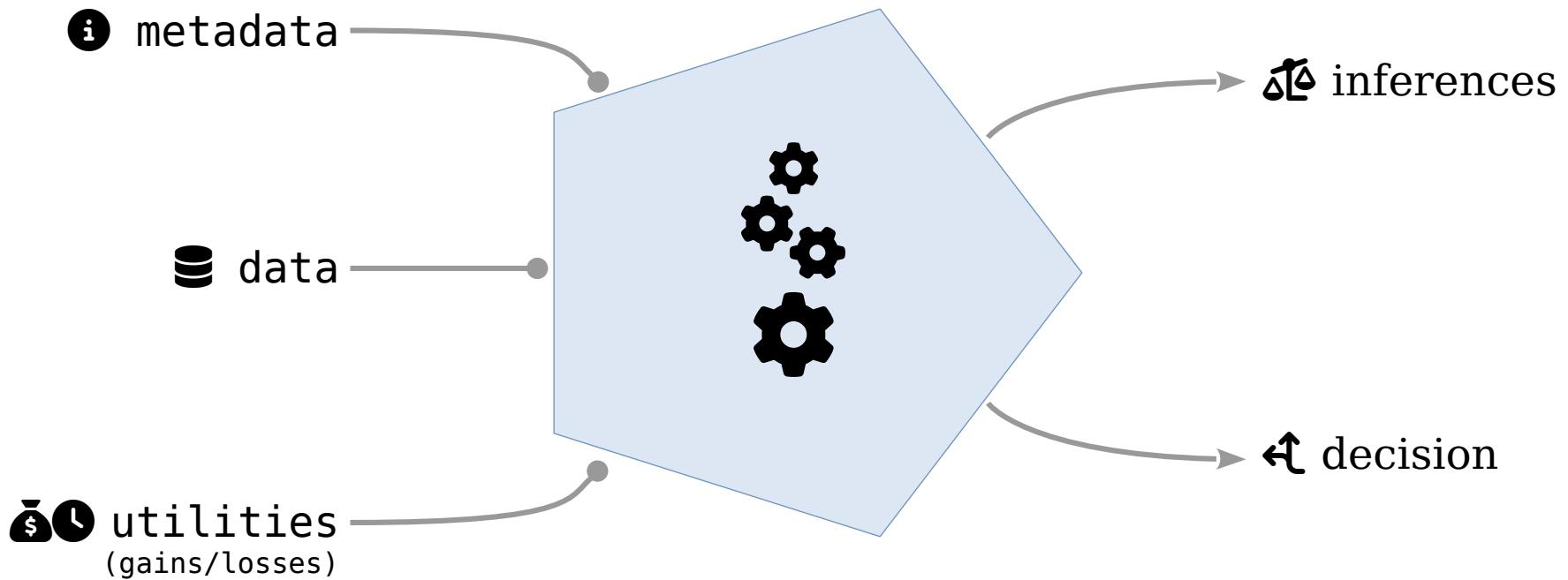
Optimal Predictor Machine



- ✓ mathematically guaranteed **optimal** outcome, by design → unbeatable!
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- ✓ learning is built-in



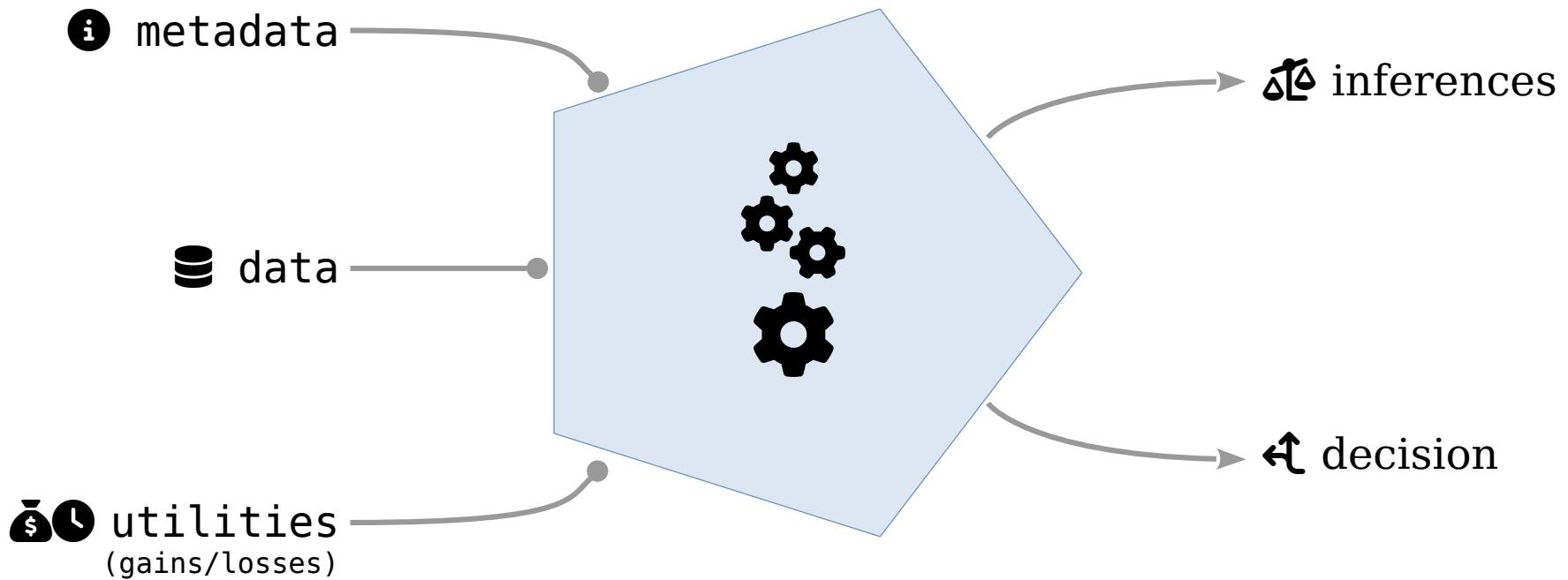
Optimal Predictor Machine



- ✓ mathematically guaranteed **optimal** outcome, by design → unbeatable!
- ✓ mathematically guaranteed maximally-informative output
- ✓ learning is built-in
- ✓ no need to handle “un/supervised” or “discriminative/generative” differently



Optimal Predictor Machine



- ✓ mathematically guaranteed **optimal** outcome, by design → unbeatable!
- ✓ mathematically guaranteed maximally-informative output
- ✓ learning is built-in
- ✓ no need to handle “un/supervised” or “discriminative/generative” differently
- ✓ no need for data splits, cross-validation, under/overfit... (all implicit in how it works)




$$P(\neg Y | X) = 1 - P(Y | X)$$
$$P(Z \wedge Y | X) = P(Z | Y \wedge X) \cdot P(Y | X)$$
$$P(Z \vee Y | X) = P(Z | X) + P(Y | X) - P(Z \wedge Y | X)$$

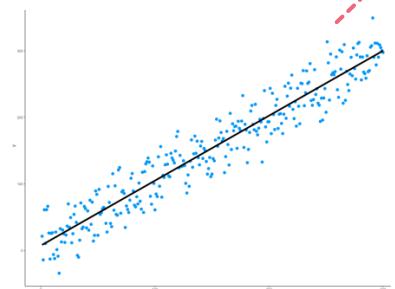
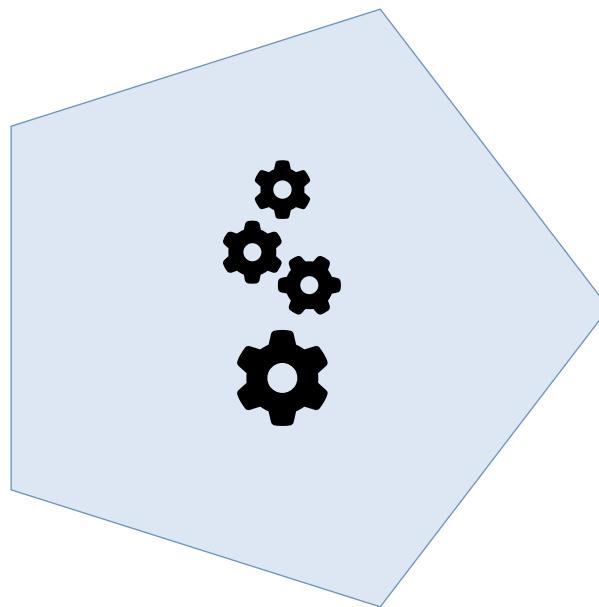
choose $\arg \max_D U(D | Y \wedge X) \cdot P(Y | D \wedge X)$

the machine works by **4 fundamental mechanisms**

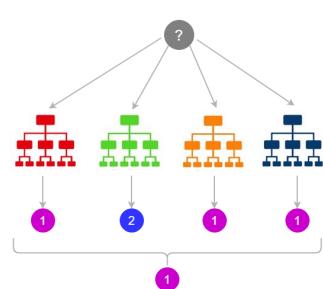
“laws of robotics”
for **AI** dealing with *uncertainty & decision-making*

Breaking the laws → logical inconsistency & suboptimality

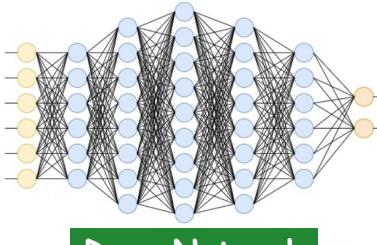
Optimal Predictor Machine



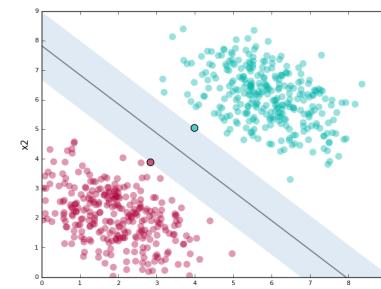
Linear Regression



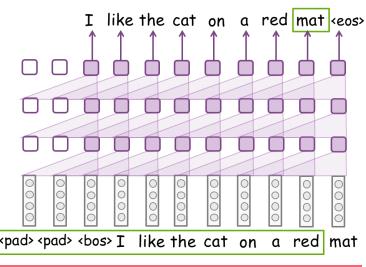
Random Forest



Deep Network



Support Vector Machine



Large Language Model

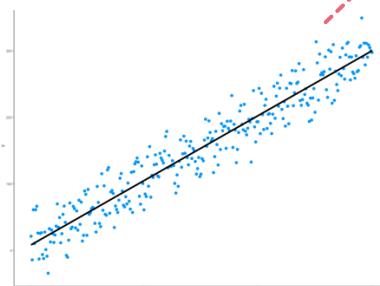


...

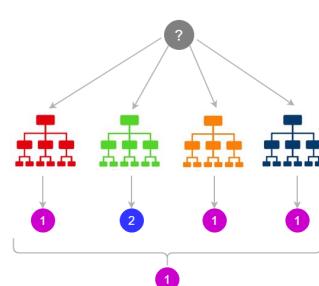
Optimal Predictor Machine

~~Σ SLOW...~~

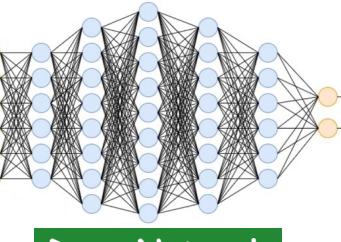
~~✈ fast!~~



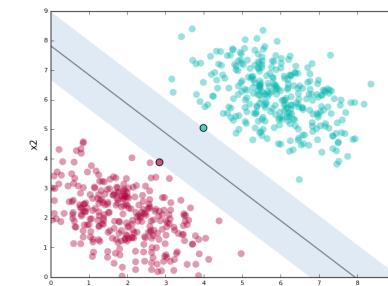
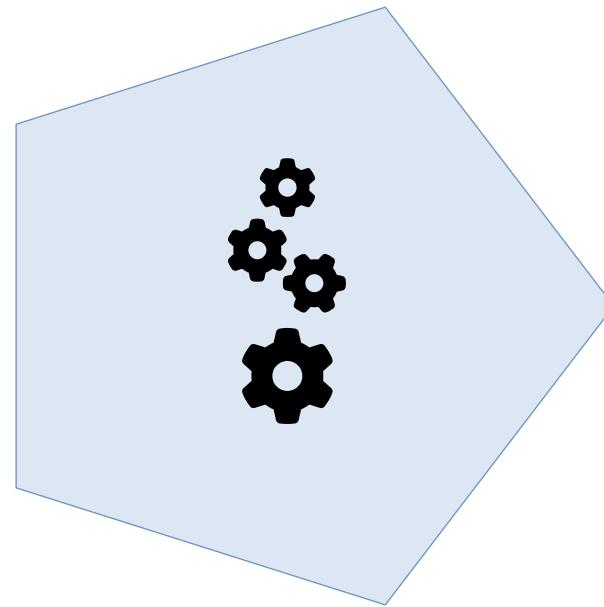
Linear Regression



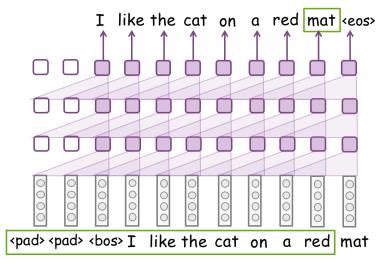
Random Forest



Deep Network



Support Vector Machine

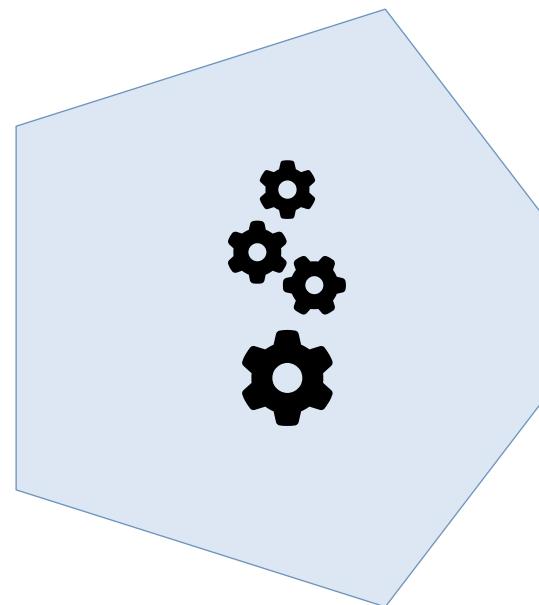


Large Language Model

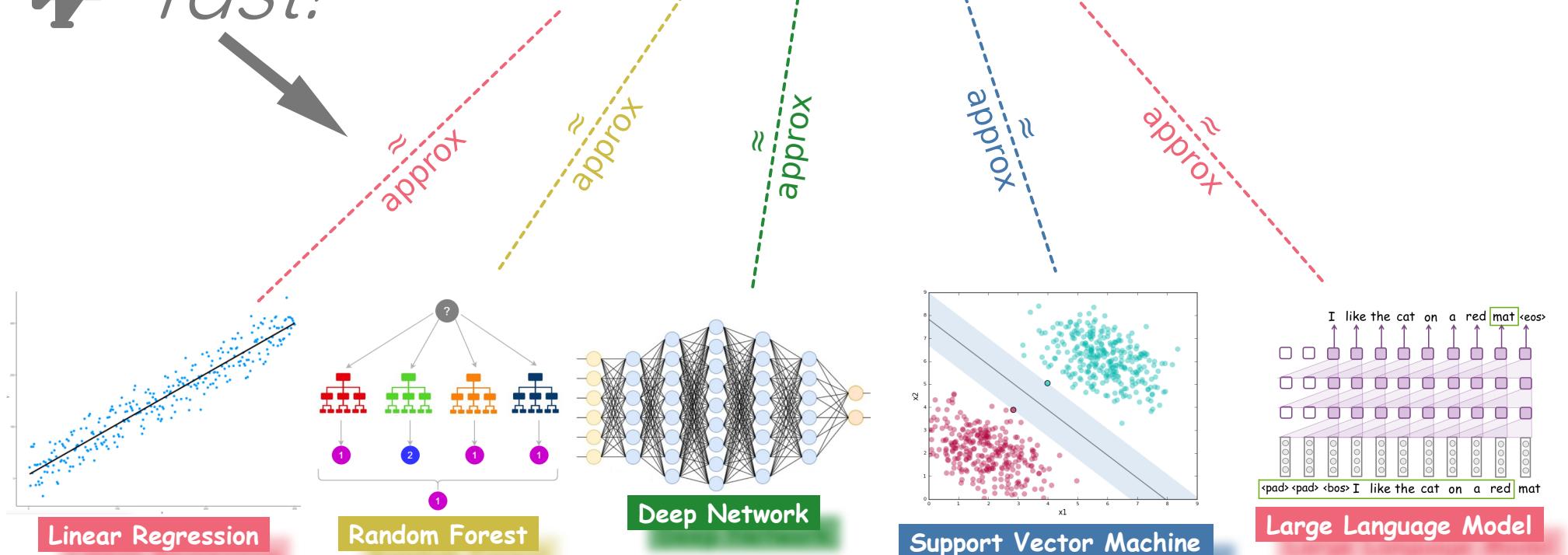


Optimal Predictor Machine

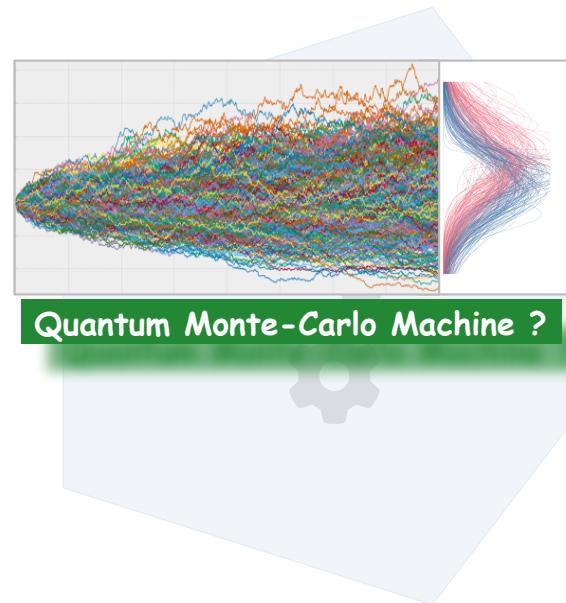
Σ SLOW...
(with present technologies)



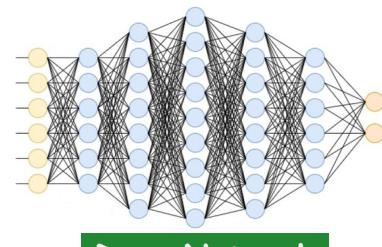
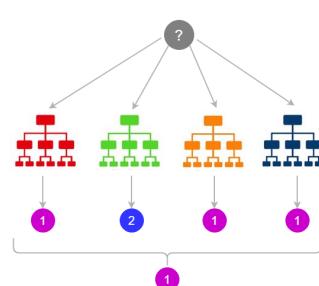
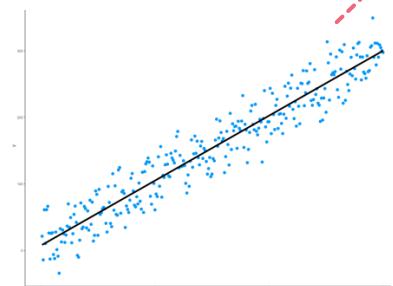
\oplus fast!



 *fast!* →
(with future technologies?)



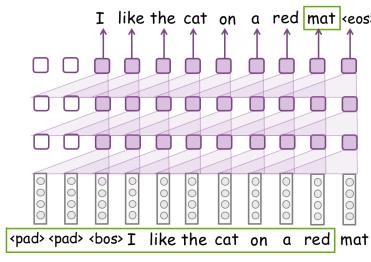
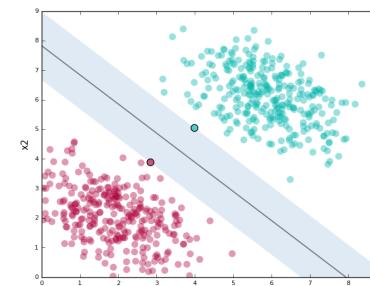
✗ SLOW...



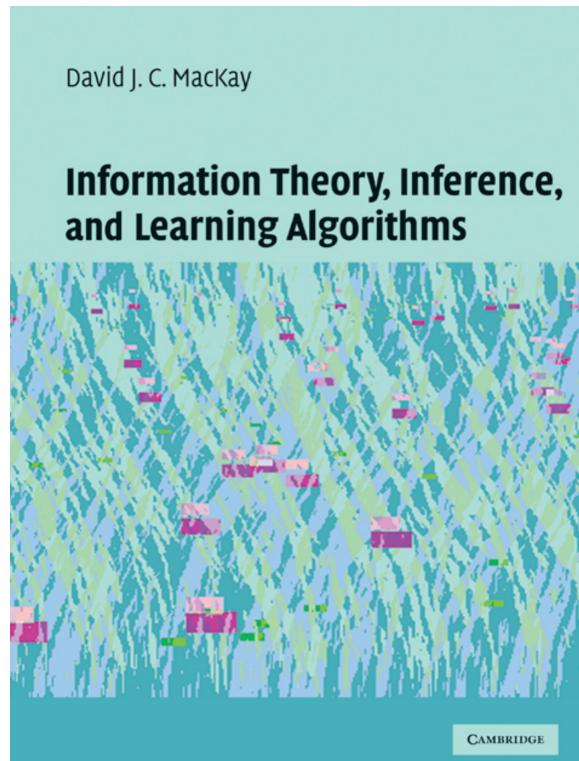
≈ approx

≈ approx

≈ approx

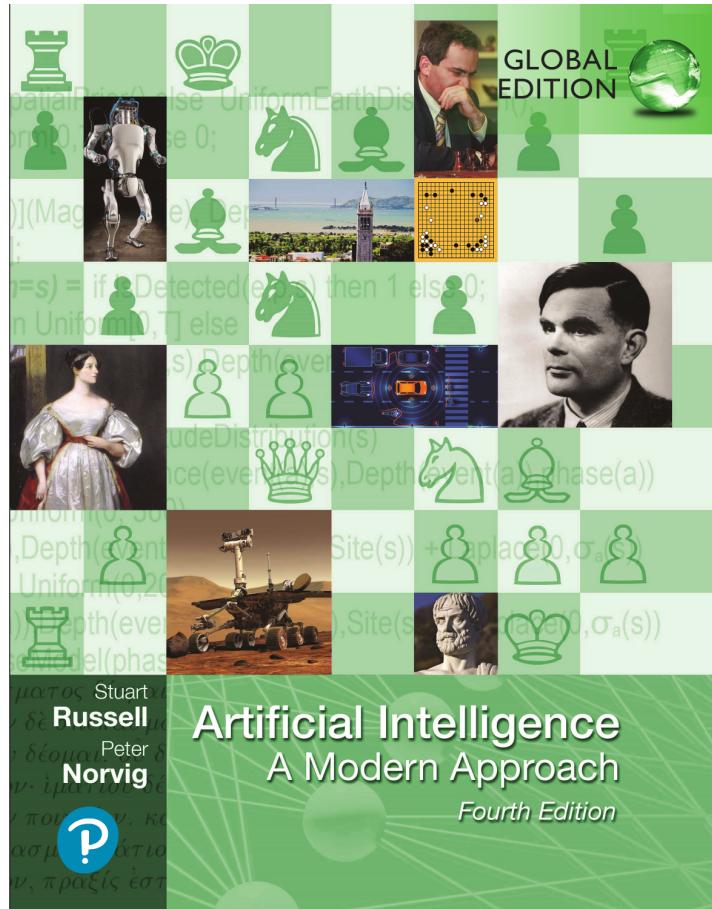


⋮

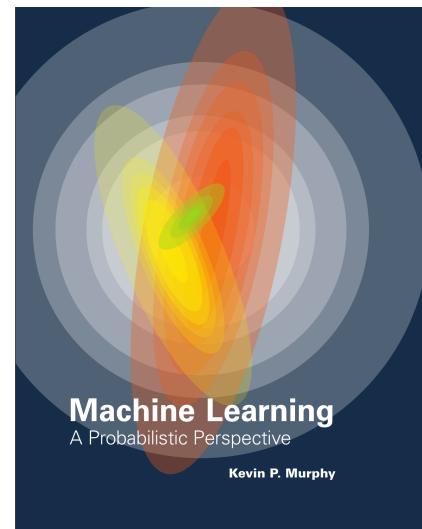
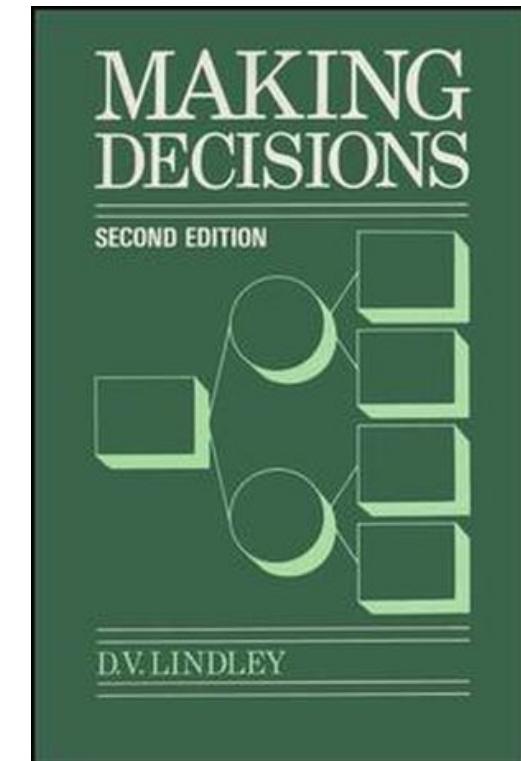


David J. C. MacKay

Information Theory, Inference, and Learning Algorithms



Artificial Intelligence A Modern Approach *Fourth Edition*



- Topic plan (subject to changes) -

💡 Goals & strategy

🤖 Inference I (and some AI)

- *1st connection with machine learning*

>Data I

⚙️ Inference II

- *2nd connection with machine learning*

Data II

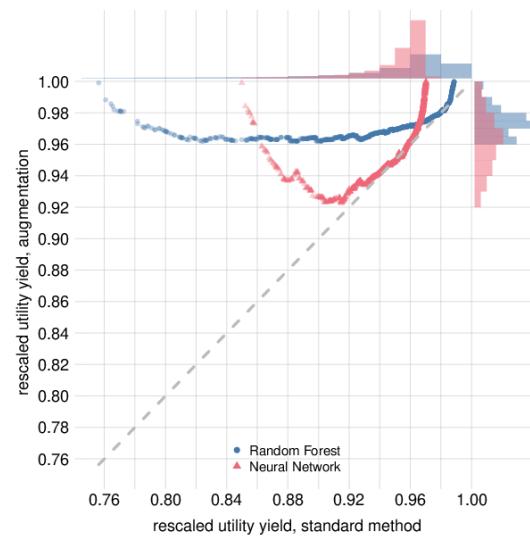
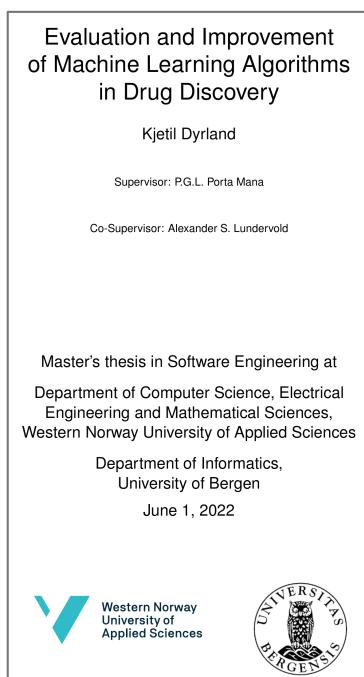
💰 Utility theory (gains & losses)

↔ Decision-making

👉 Machine learning
... and how to improve it!

- Projects & ideas -

- Implement utilities in present ML algorithms
- Predict max achievable accuracy of some ML algorithms
- Push the operative boundaries of the Optimal Machine
- ...



Canvas

<https://hvl.instructure.com/courses/25074>

Course notes

<https://pglpm.github.io/ADA511/>

Software:

R

<https://www.r-project.org/>

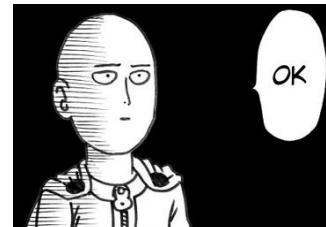
Python

<https://www.python.org/>

One Punch Man

<https://onepunchman.fandom.com/>

The screenshot shows the course page for 'ADA511 0.1 Data science and data-driven engineering'. At the top, there's a sidebar with navigation links like 'Dear student and aspiring data engineer', 'Preface', 'An invitation', 'Inference I', and 'Data I'. The main content area features a title card with the course name and authors (Steffen Mæland and PierGianLuca Porta Mana). Below the title card is a section titled 'Dear student and aspiring data engineer' with a quote from U.Schinnerer: 'If you can't join 'em, beat 'em.' The page also includes a table of contents on the right side.



Thank you!



