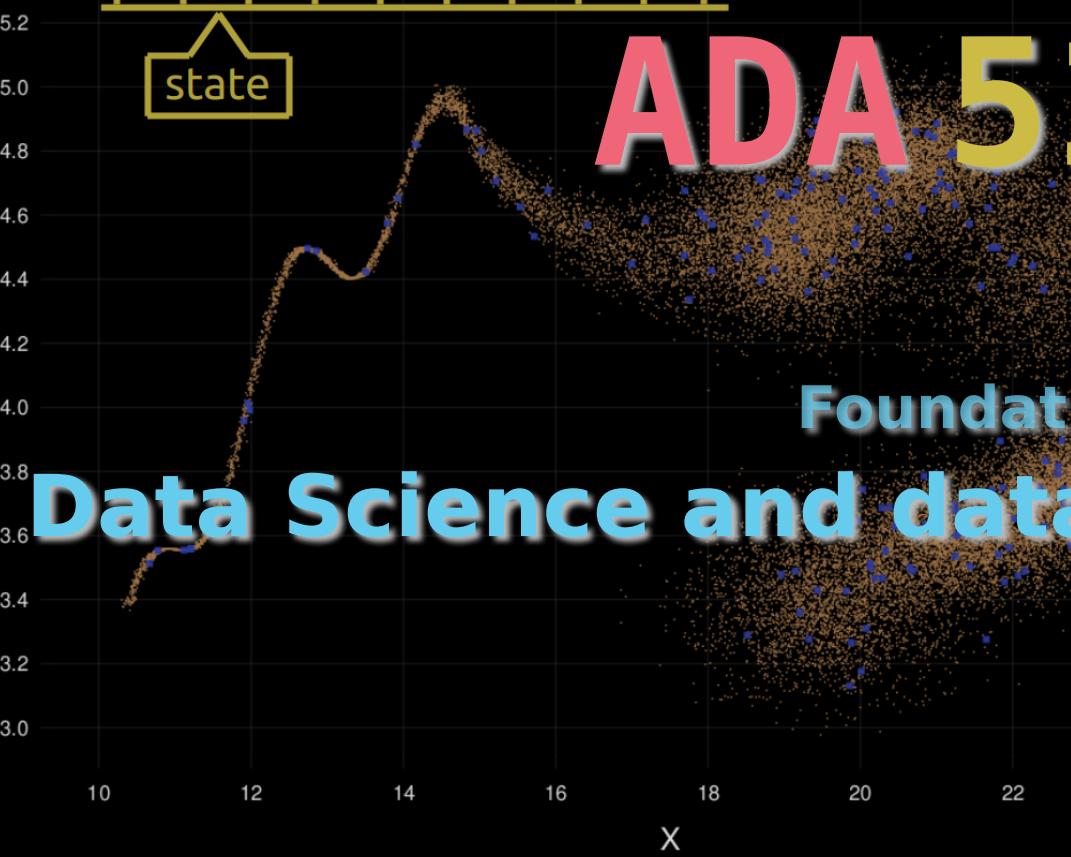


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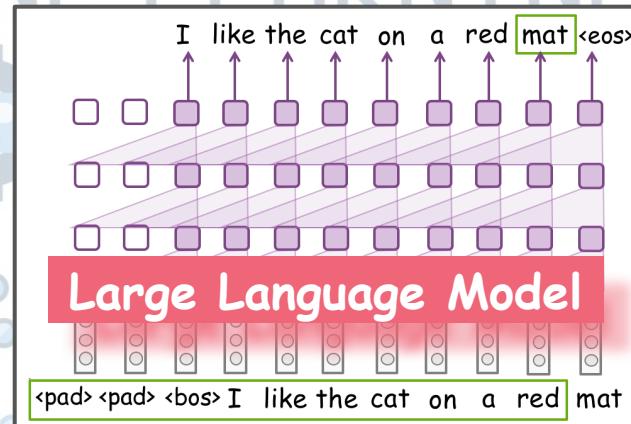
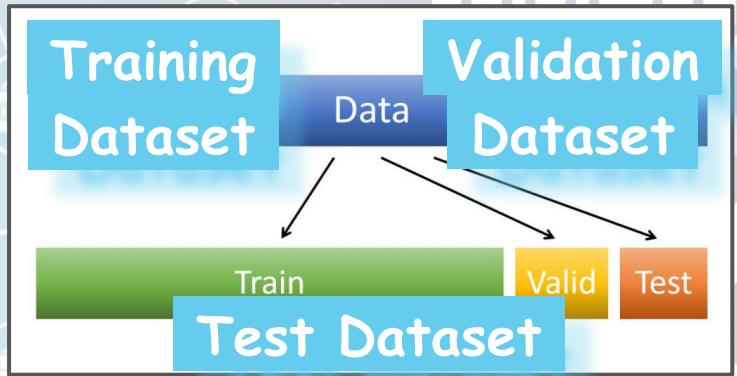
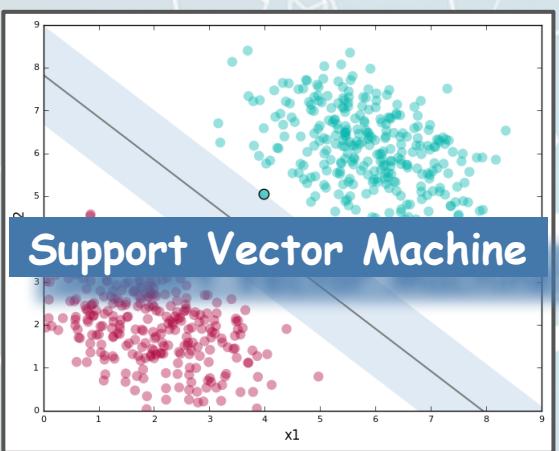
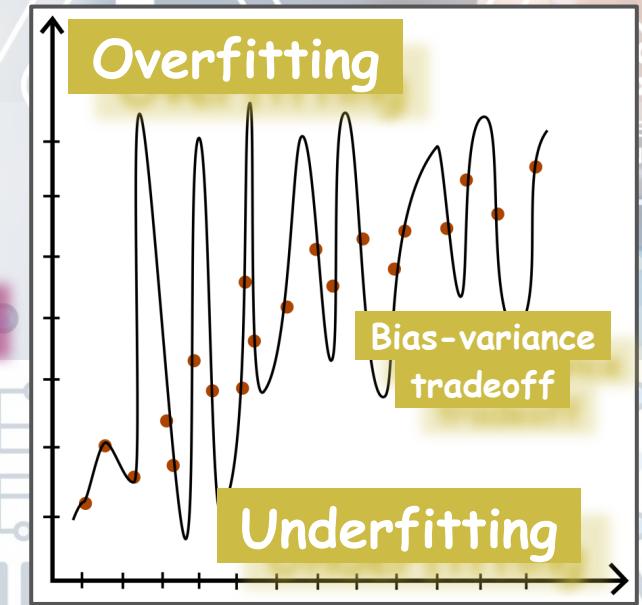
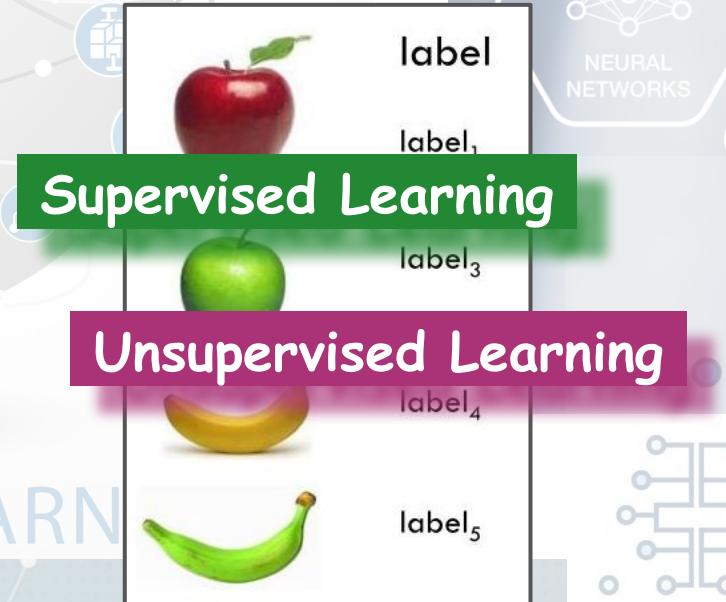
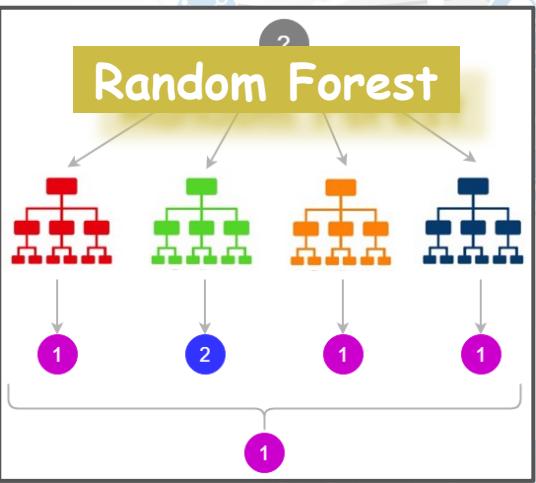
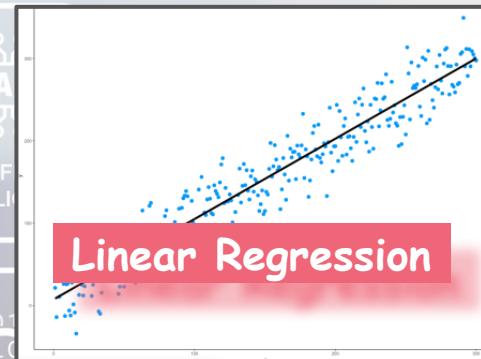
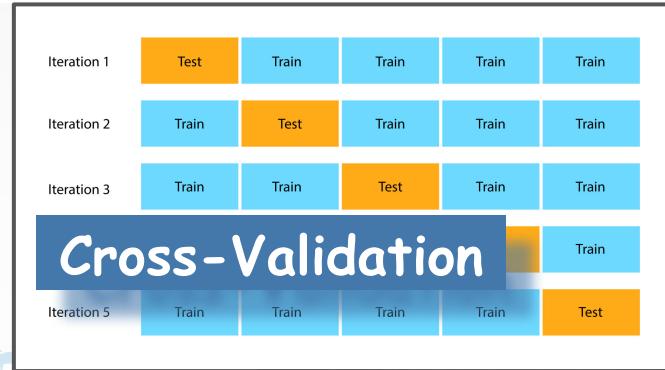
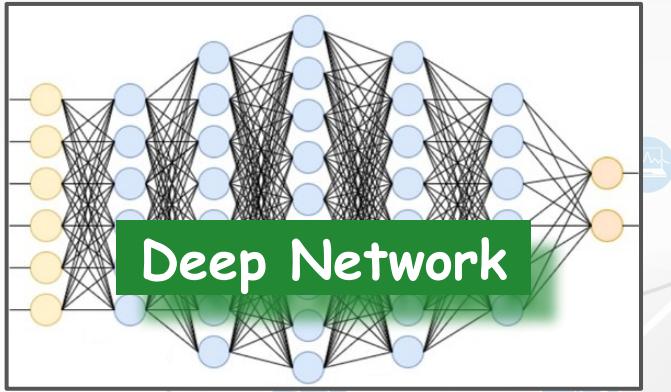


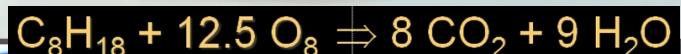
Data Science and data-driven engineering

Foundations of

$P(Y|X)$







Isooctane Oxygen Carbon dioxide Water



SEDAN

HATCHBACK



CUV



SUV



MICRO



CABRIOLET



SUPERCAR



COUPE



VAN



MINIVAN



CAMPERVAN



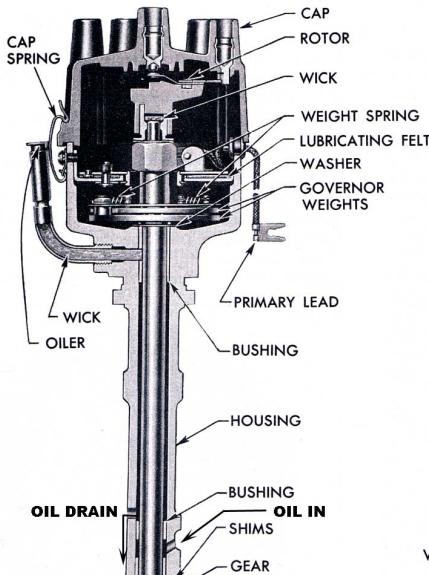
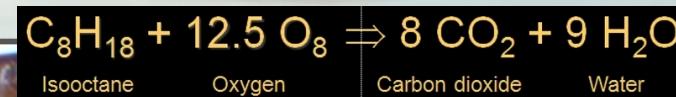
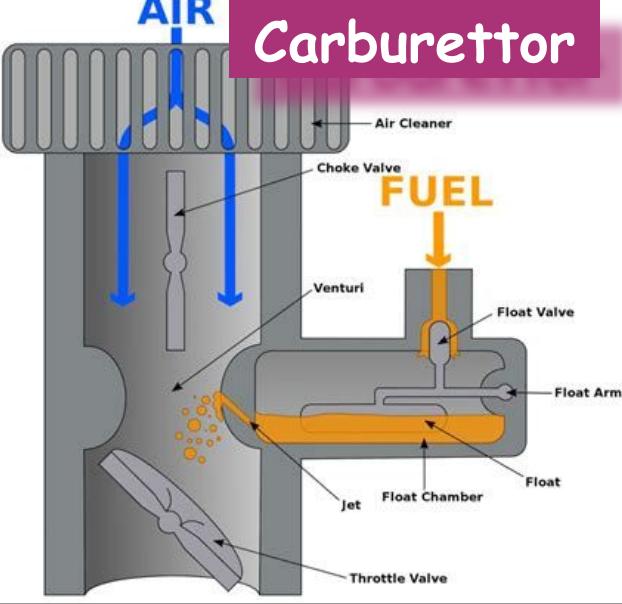
TRUCK



BIGTRUCK

AIR

Carburettor



Distributor



Spark plug

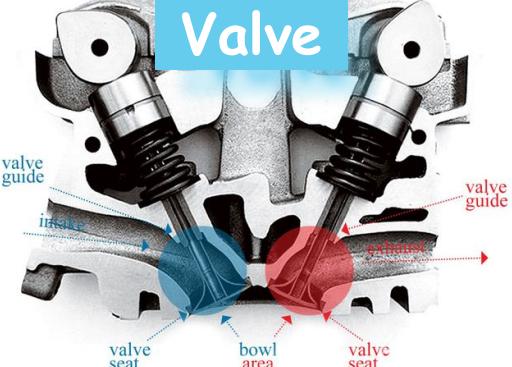
CAMPERVAN

TRUCK

Fuel



Octanes

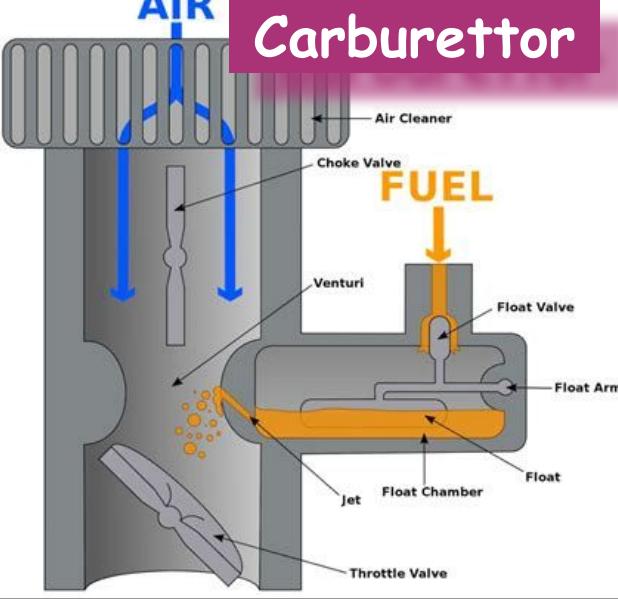


Silencer (muffler)



AIR

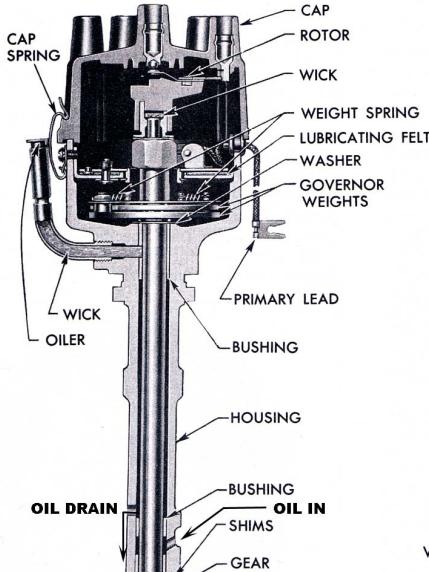
Carburettor



Fuel



Octanes



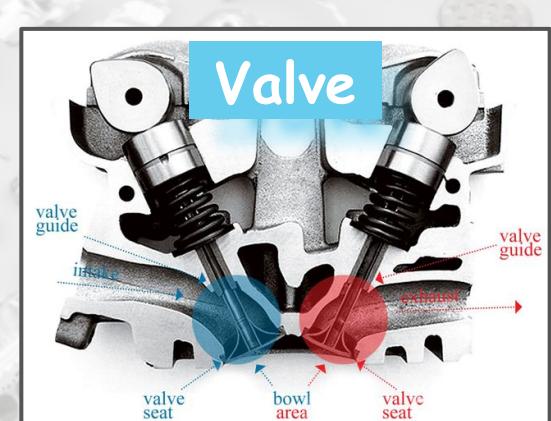
Distributor



Spark plug



Valve



Silencer (muffler)



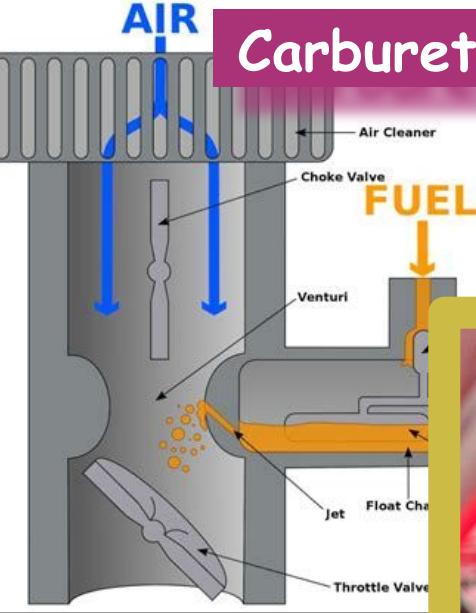
Green emissions

CAMPVAN

TRUCK

AIR

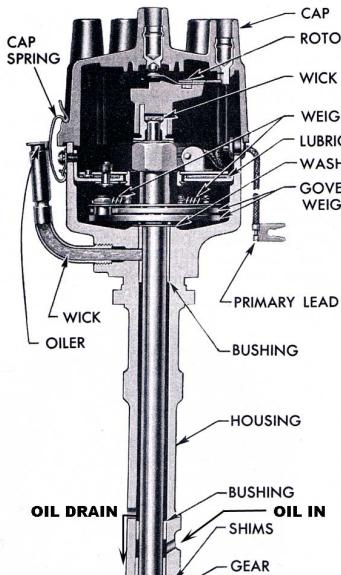
Carburettor



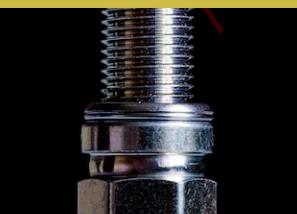
Fuel



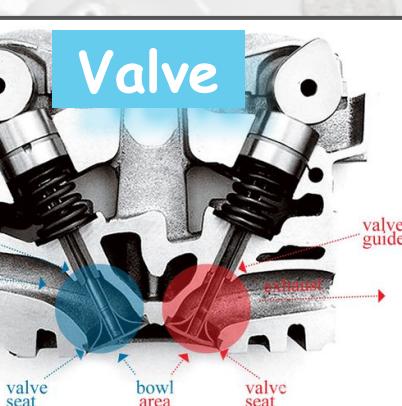
car mechanic



Distributor



Spark plug



Silencer (muffler)



Engine oil

Green emissions

Fuel

Octanes

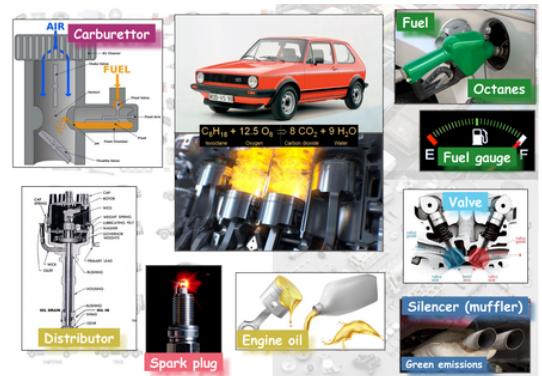


Valve

CAMPERVAN

TRUCK

🔧 car mechanic





🔧 car mechanic



cartwright



car mechanic



EV mechanic



cartwright



car mechanic



EV mechanic



cartwright



car mechanic



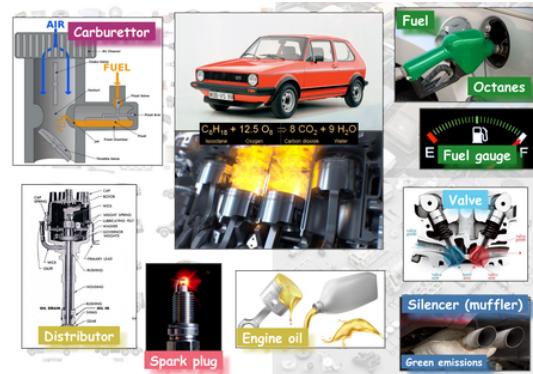
EV mechanic



 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**

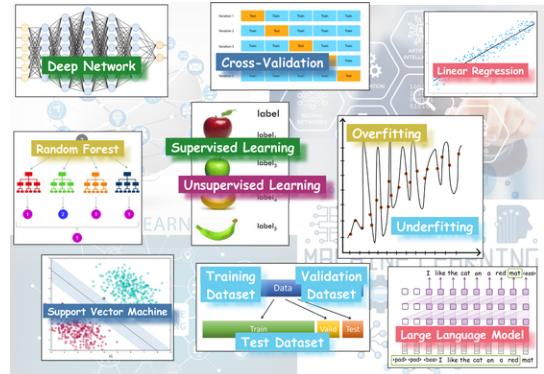
💡 *general*

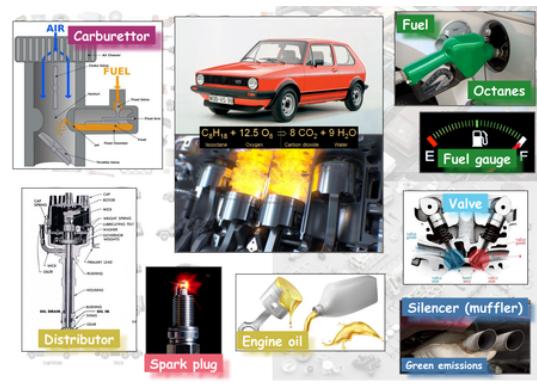
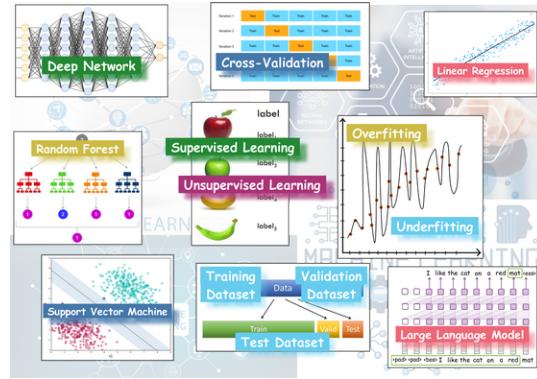
Ἁ *principled*

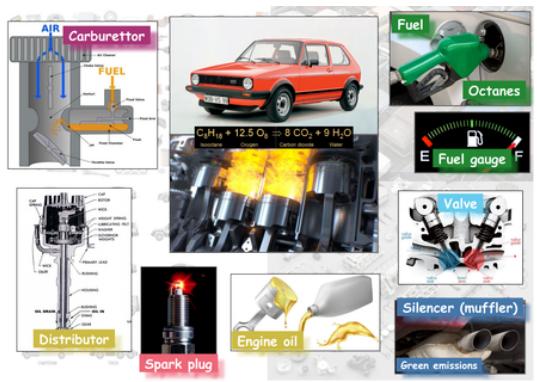
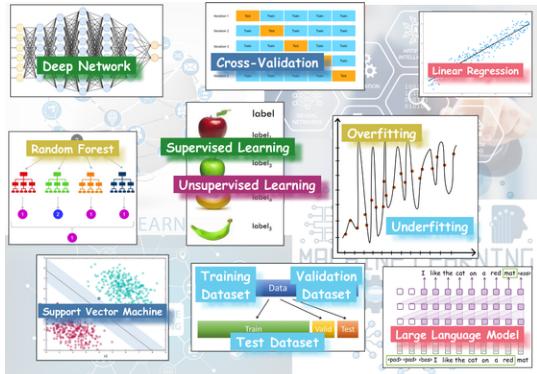
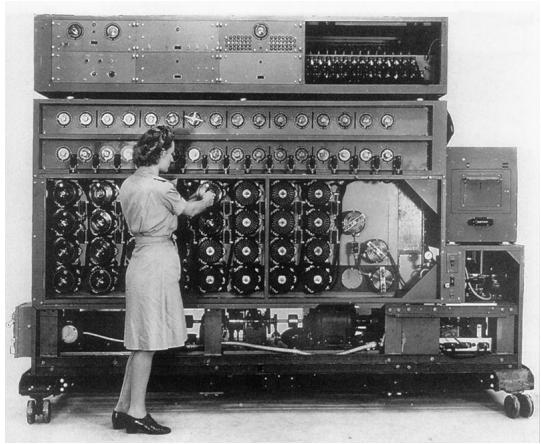
🧭 *exploratory*

🐦 *technology-independent*

...

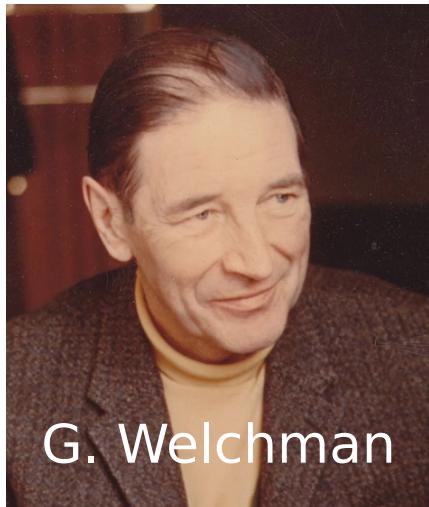








Alan Turing



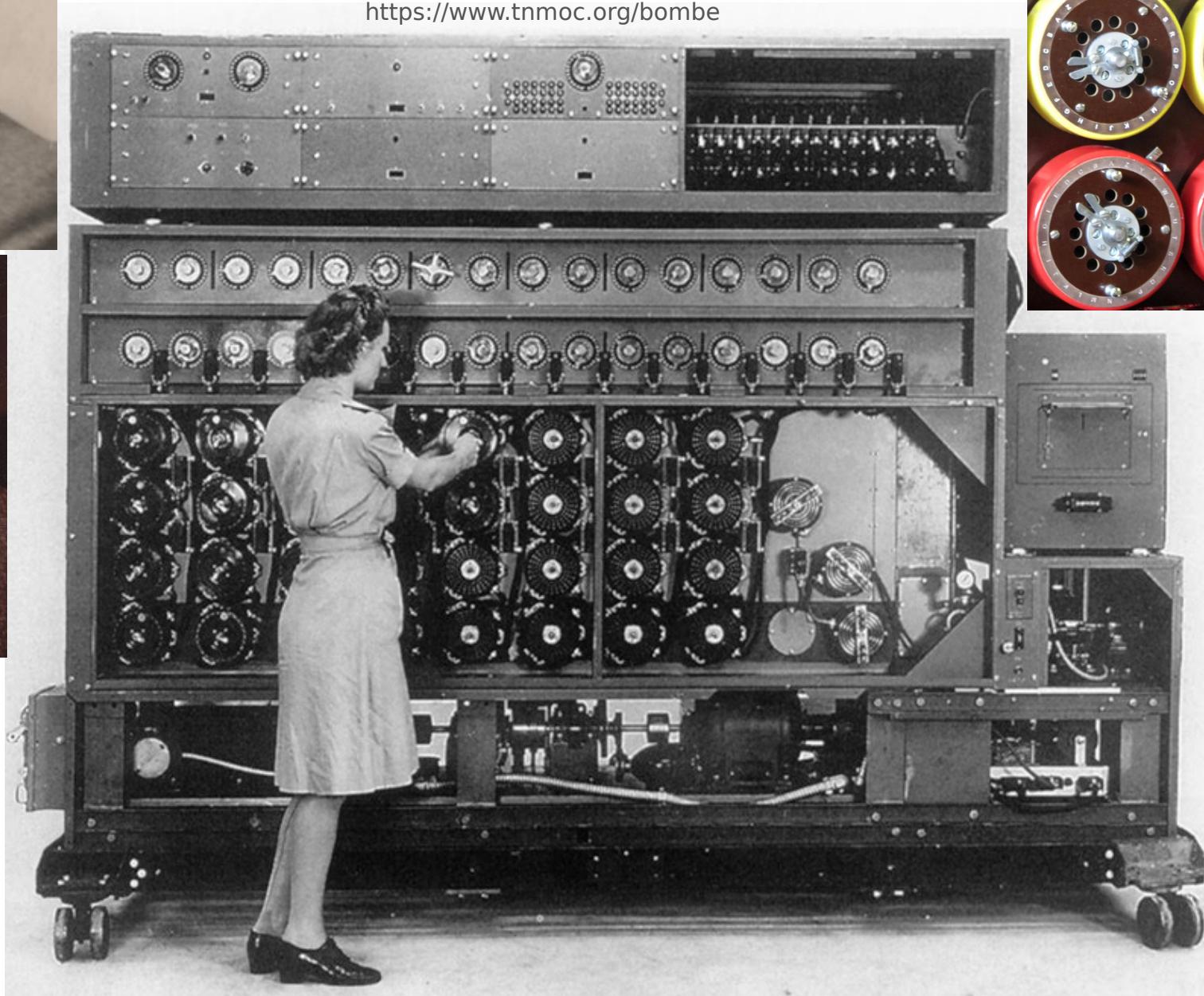
G. Welchman

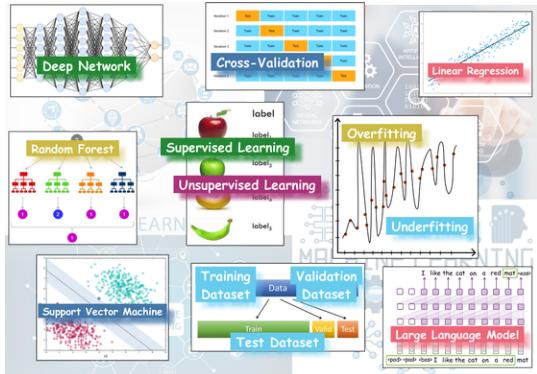
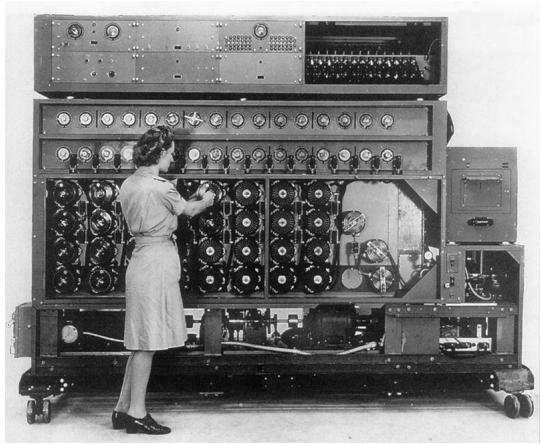
The Bombe a.k.a. *Agnes* electromechanical computer

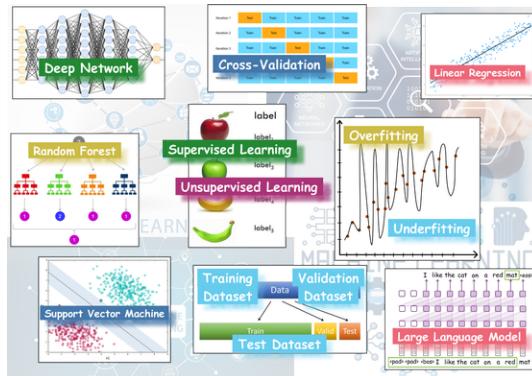
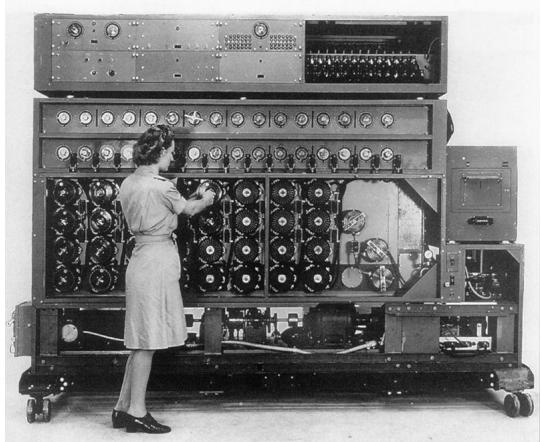
Decoded encrypted Nazi communications during World War II
(efficiency rate: 98.8%)

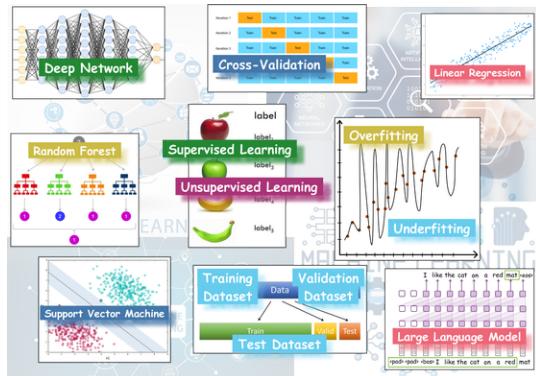
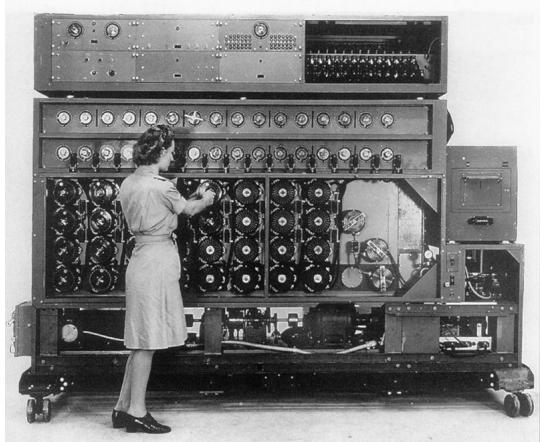
<https://www.britannica.com/topic/Bombe>

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









cartwright

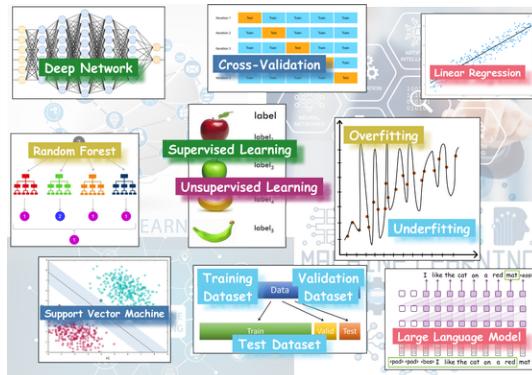
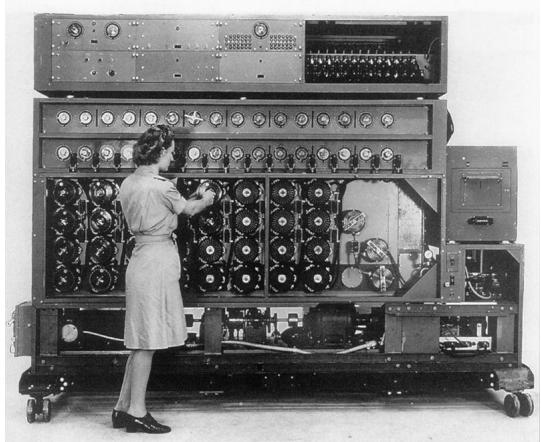


car mechanic



EV mechanic





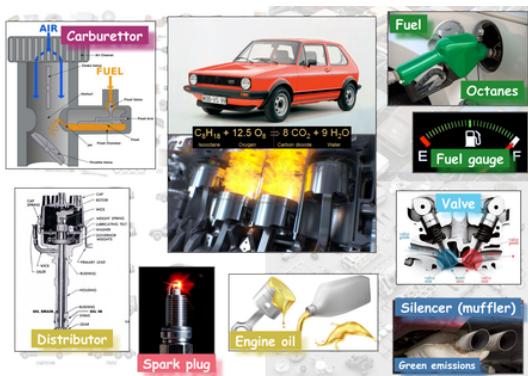
“data mechanic”



cartwright

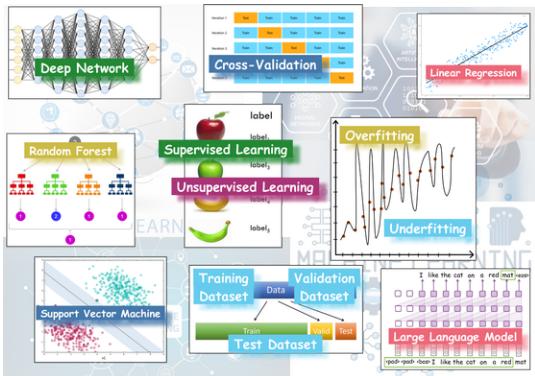
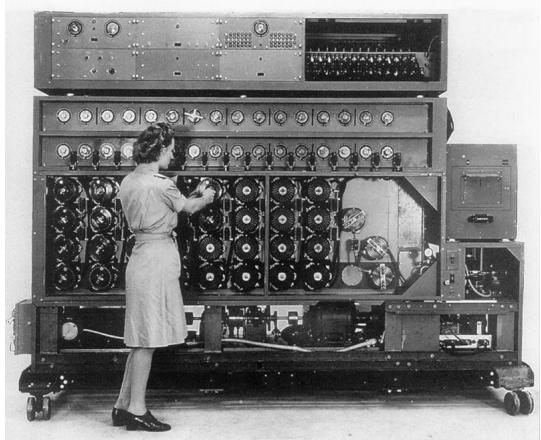


car mechanic

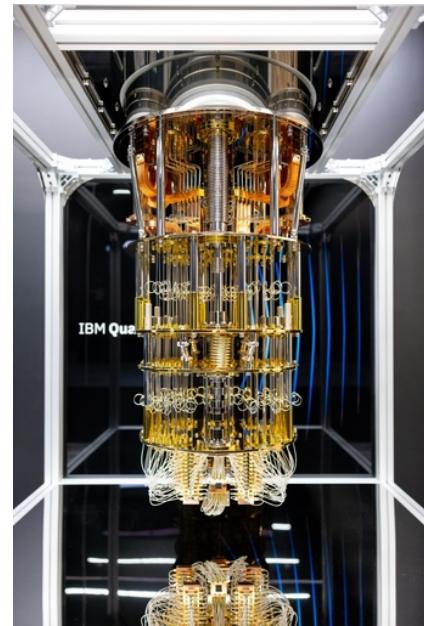


EV mechanic





“data mechanic”



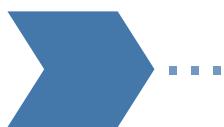
cartwright

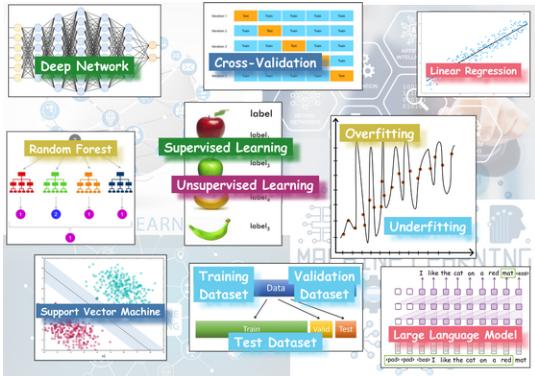
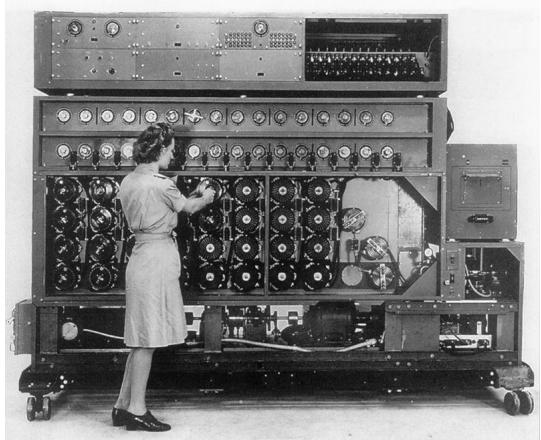


car mechanic

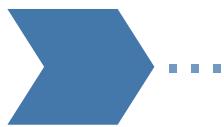


EV mechanic





“data mechanic”



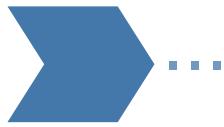
cartwright

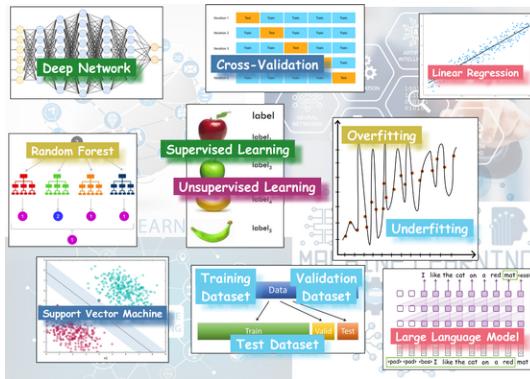
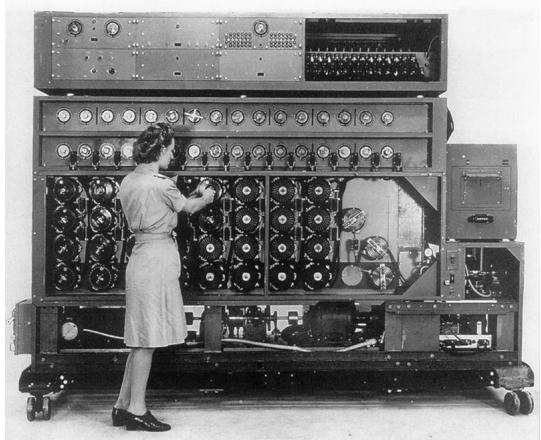


car mechanic

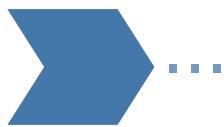


EV mechanic

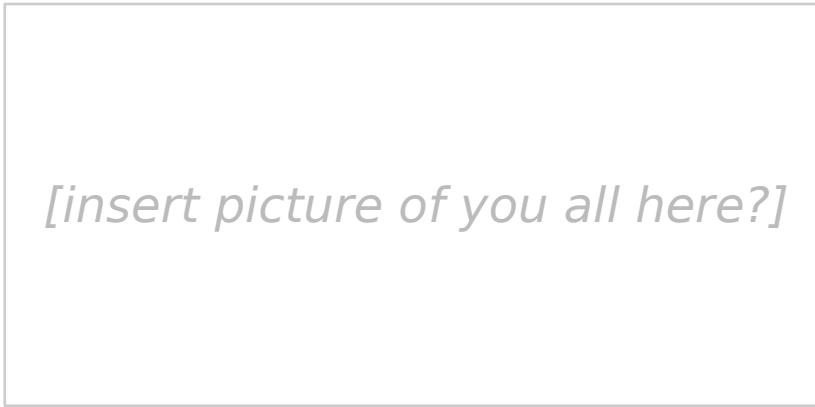




“data mechanic”

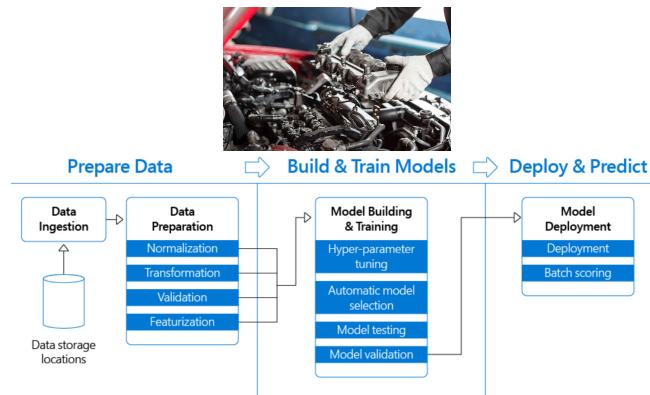


“data engineer”

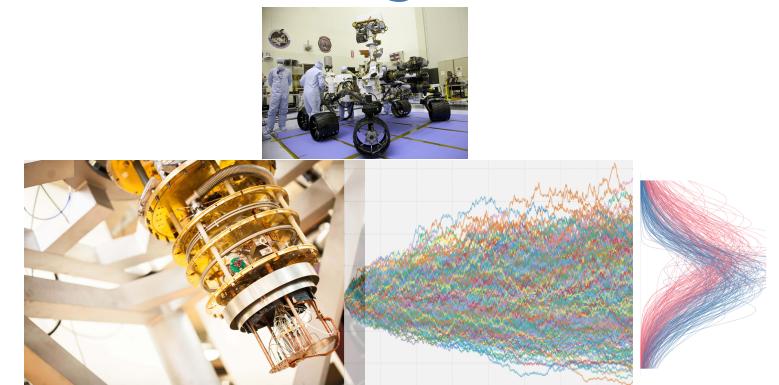


[insert picture of you all here?]

“data mechanic”



“data engineer”



knowledge

🔍 *specific*

👀 *general*

🔨 *practical*

📐 *principled*

🛠️ *procedural*

🧭 *exploratory*

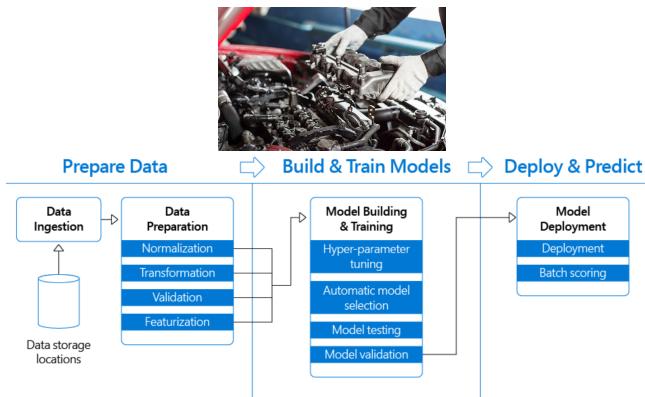
⚓ *technology-dependent*

🐦 *technology-independent*

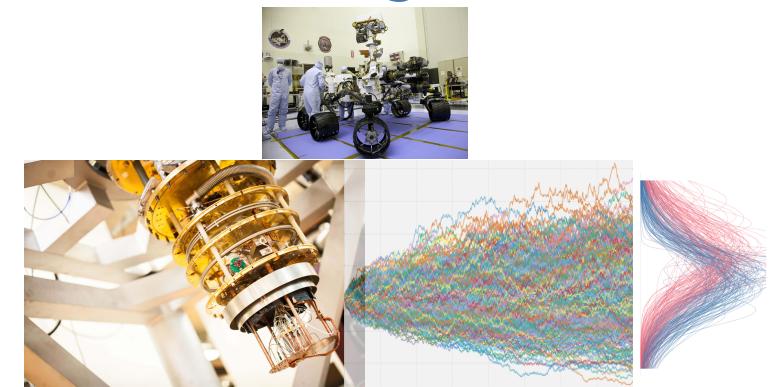
...

...

“data mechanic”



“data engineer”



knowledge

🔍 *specific*

👀 *general*

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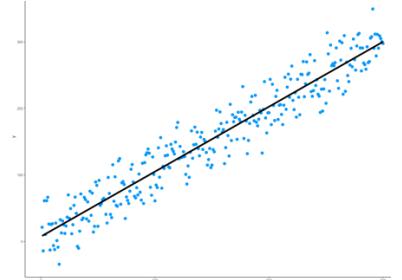
🧭 *exploratory*

⚓ *technology-dependent*

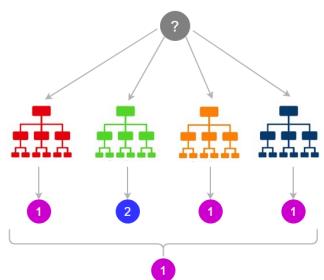
🐦 *technology-independent*

...

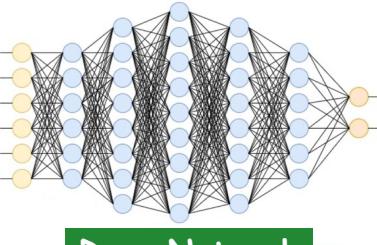
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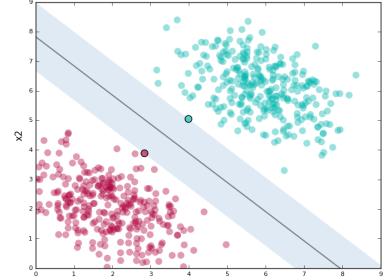
Linear Regression



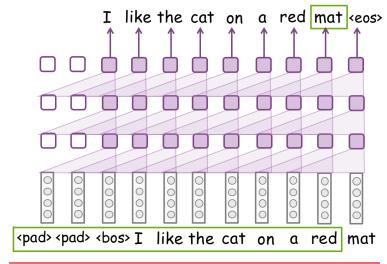
Random Forest



Deep Network



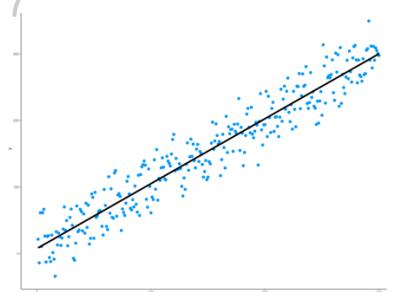
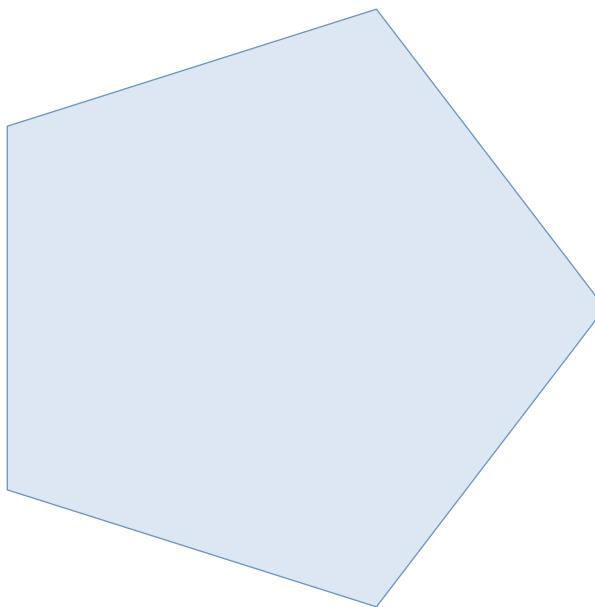
Support Vector Machine



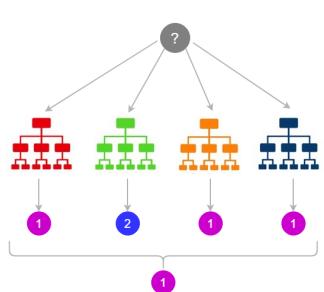
Large Language Model



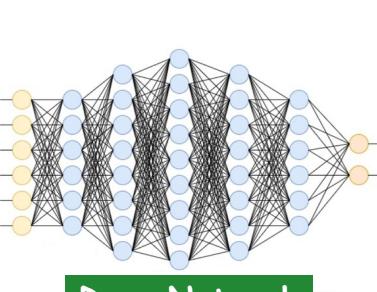
Optimal Predictor Machine



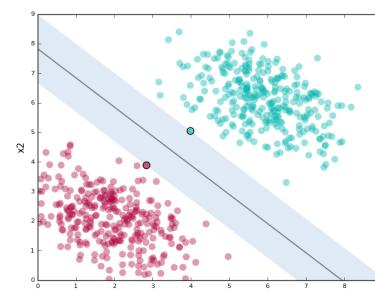
Linear Regression



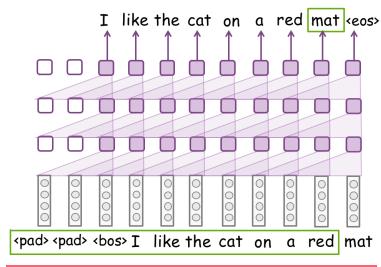
Random Forest



Deep Network



Support Vector Machine



Large Language Model



...

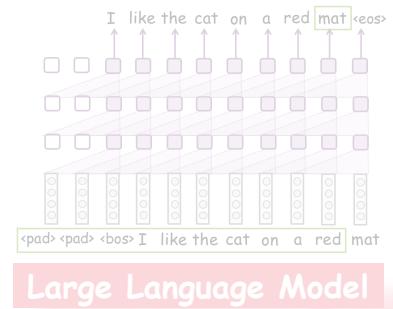
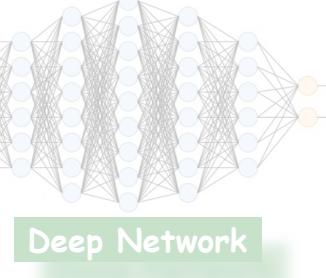
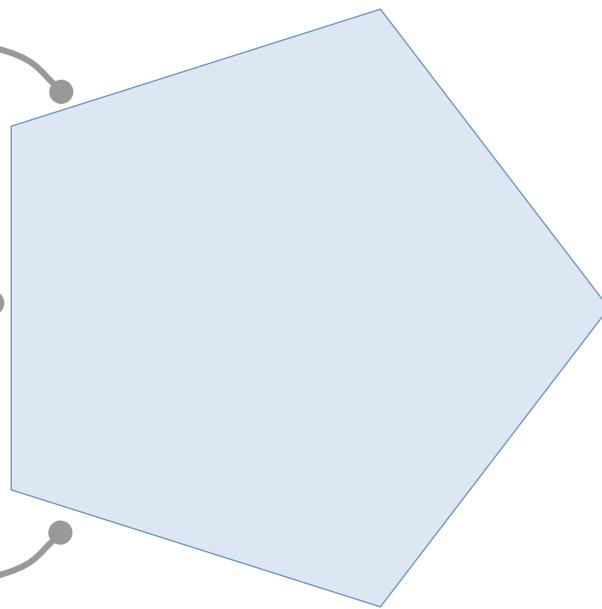
Optimal Predictor Machine

problem-dependent

i metadata

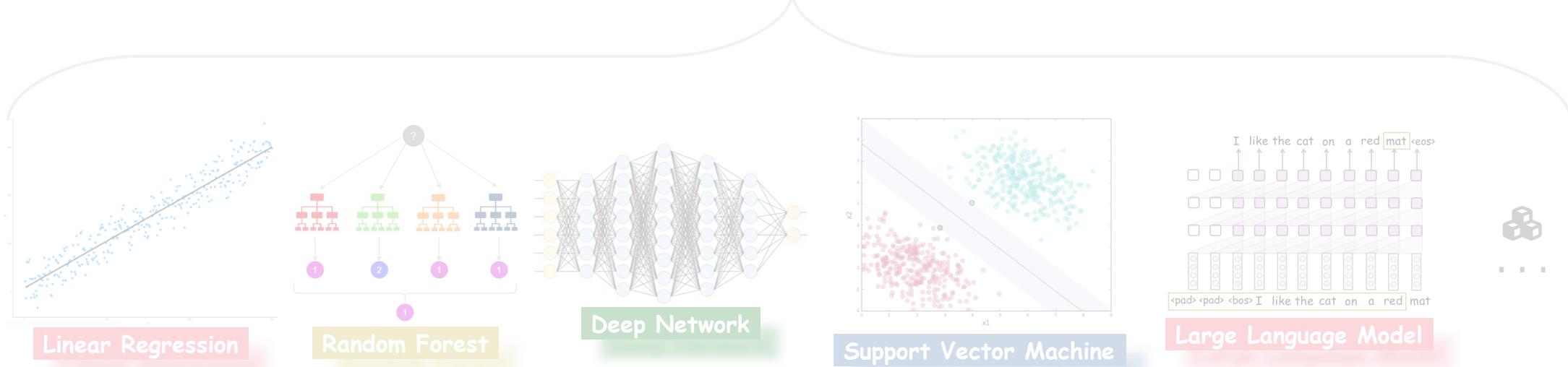
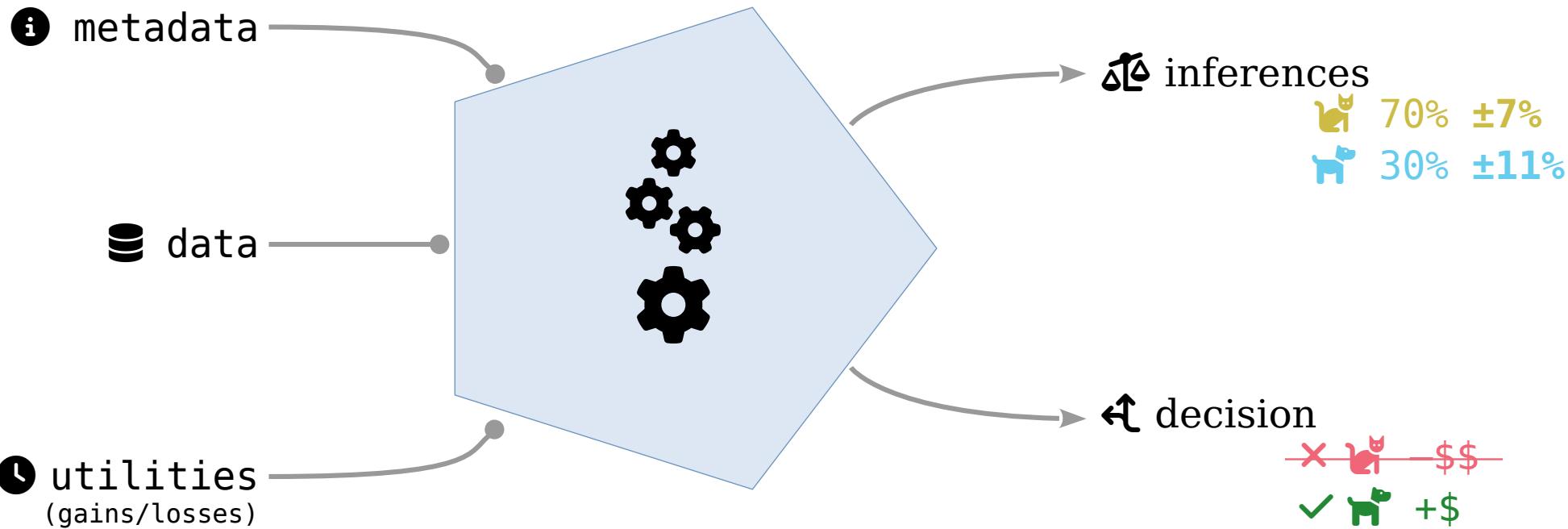
data

\$⌚ utilities
(gains/losses)

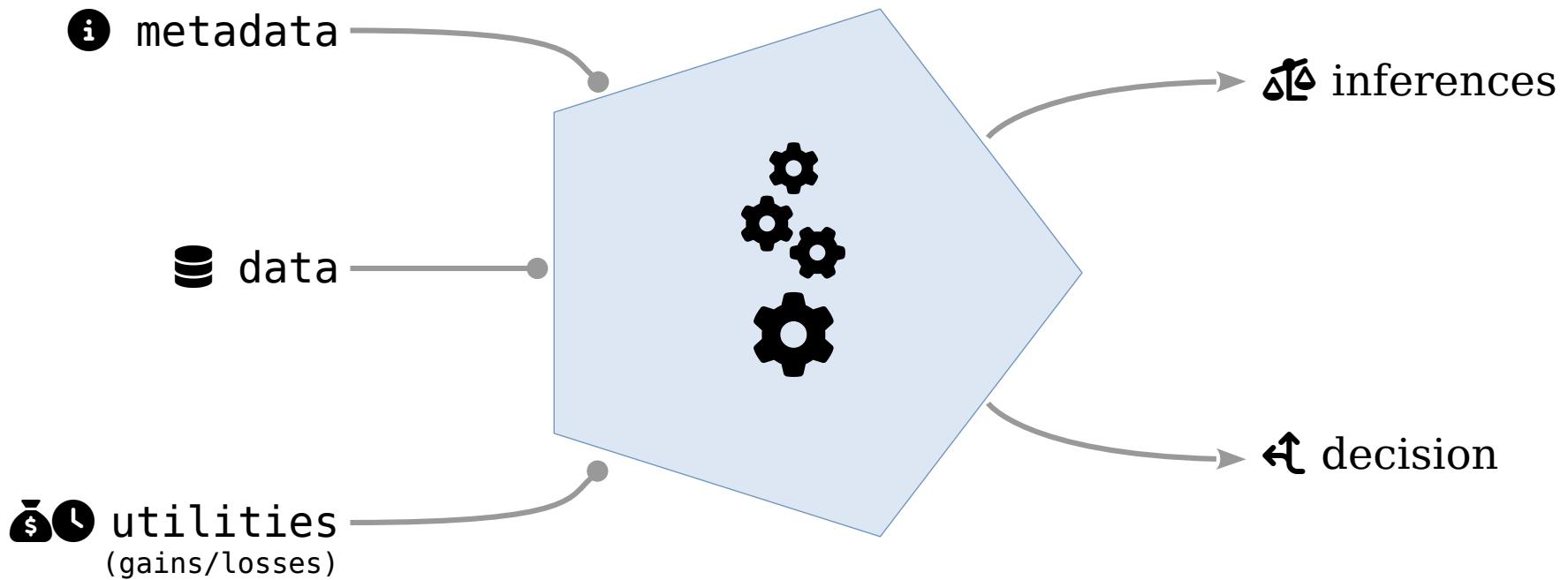


Optimal Predictor Machine

problem-dependent

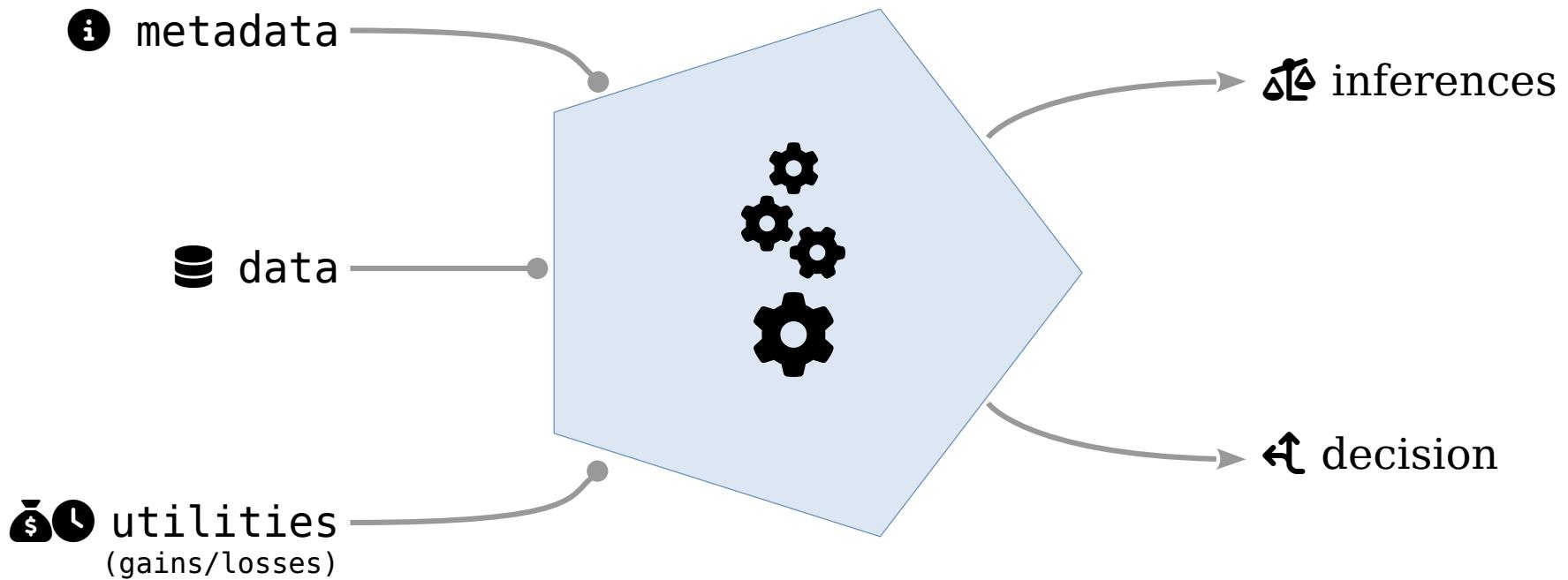


Optimal Predictor Machine



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

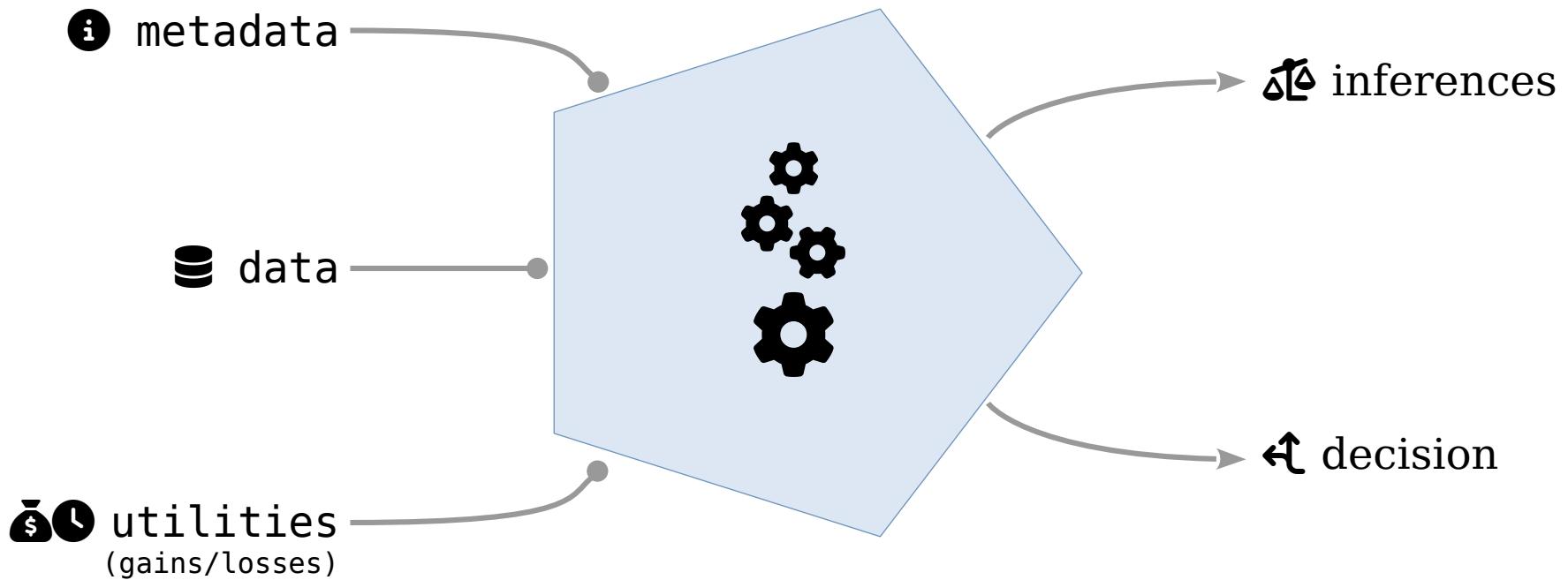
Optimal Predictor Machine



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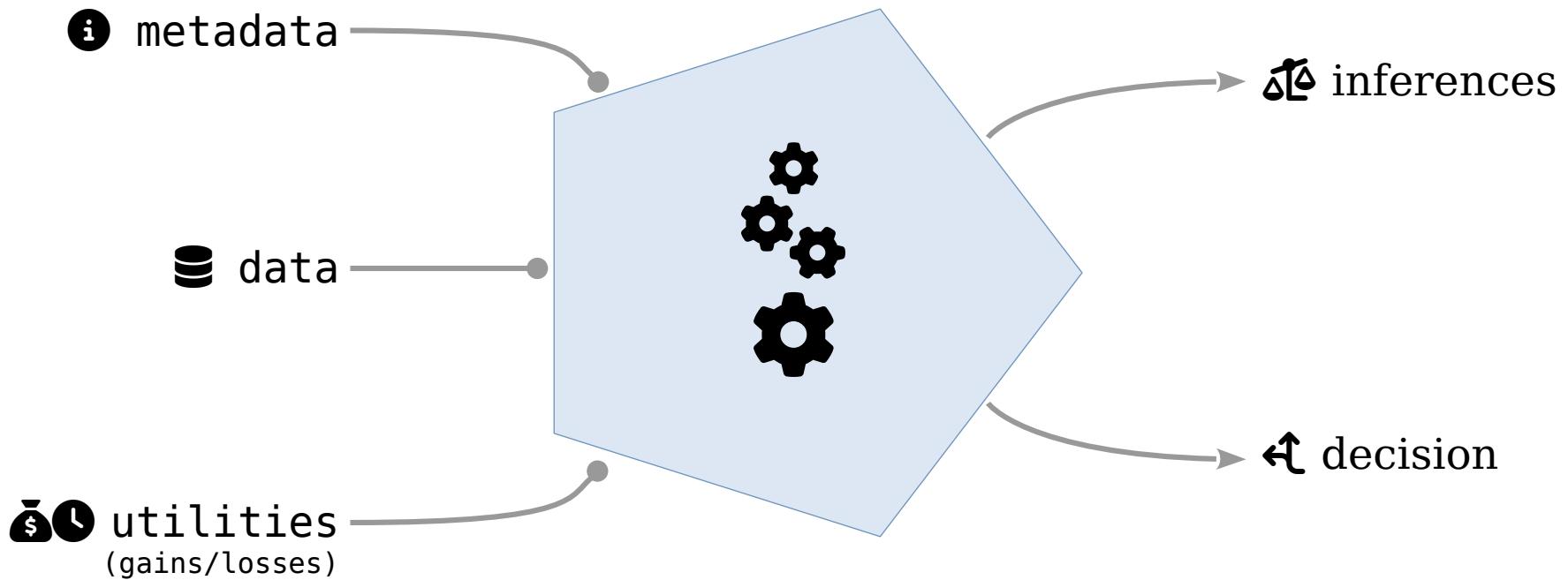
Optimal Predictor Machine



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



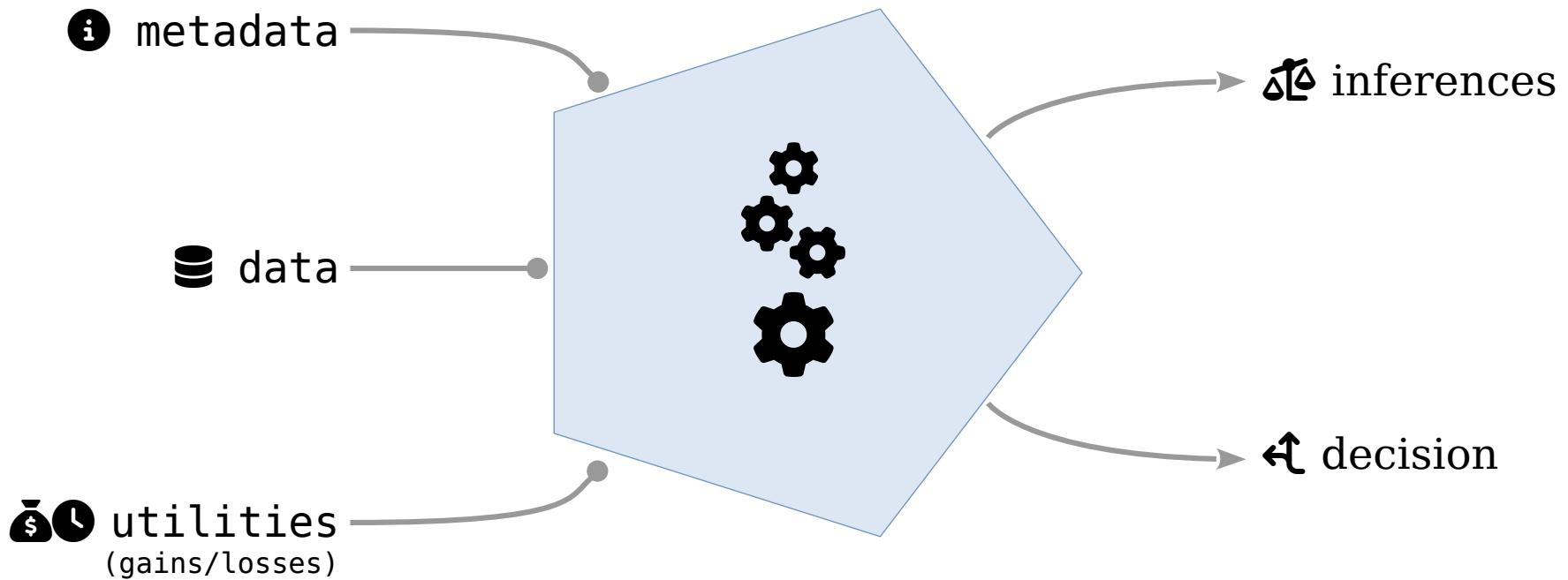
Optimal Predictor Machine



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



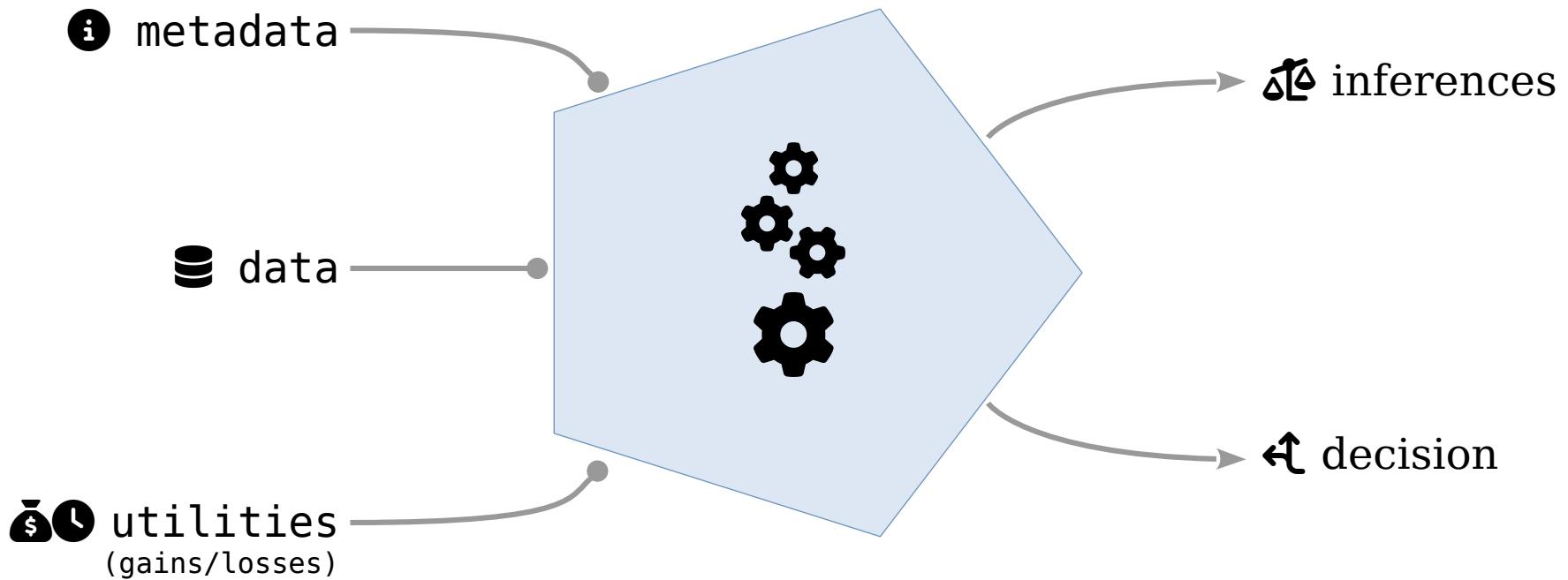
Optimal Predictor Machine



- ✓ 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)





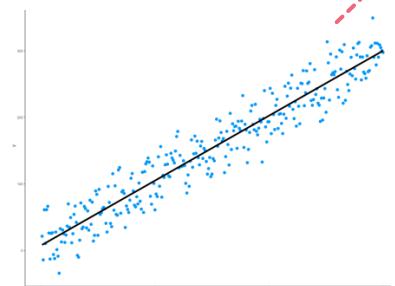
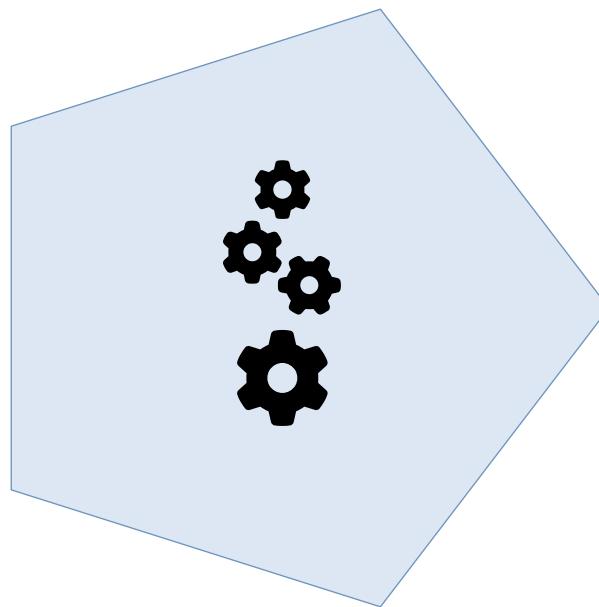
$P(\neg Y | X) = 1 - P(Y | X)$
 $P(Z \wedge Y | X) = P(Z | Y \wedge X) \cdot P(Y | X)$
 $P(Z \vee Y | X) = P(Z | X) + P(Y | X) - P(Z \wedge Y | X)$
choose $\arg \max_D U(D | Y \wedge X) \cdot P(Y | D \wedge X)$

the machine works by **4 fundamental mechanisms**

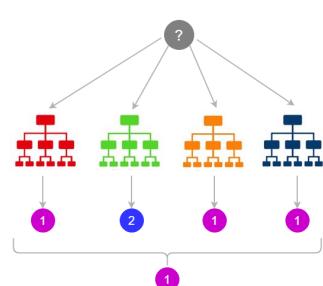
“laws of robotics”
for **AI** dealing with *uncertainty & decision-making*

Breaking the laws → logical inconsistency & suboptimality

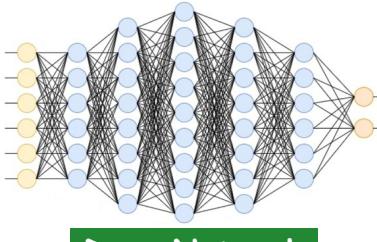
Optimal Predictor Machine



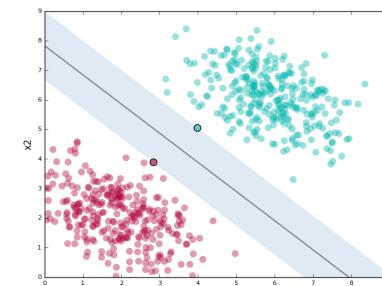
Linear Regression



Random Forest



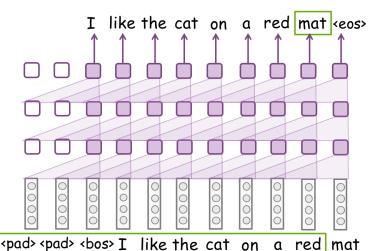
Deep Network



Support Vector Machine



...



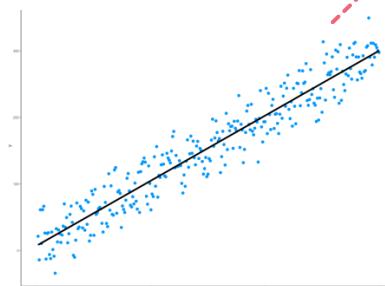
Large Language Model

Optimal Predictor Machine

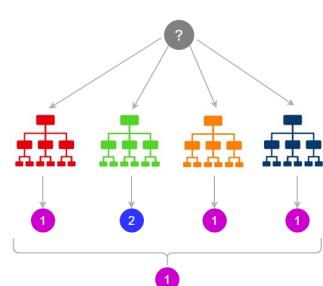
~~Σ SLOW...~~

(with present technologies)

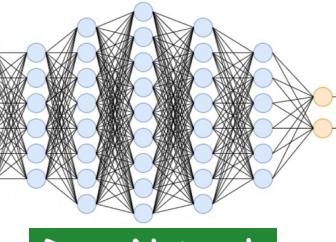
~~✈~~ fast!



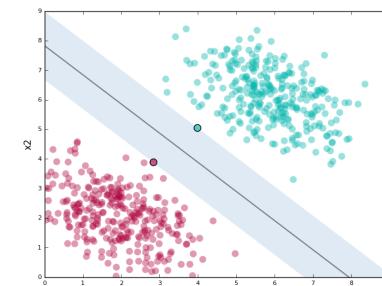
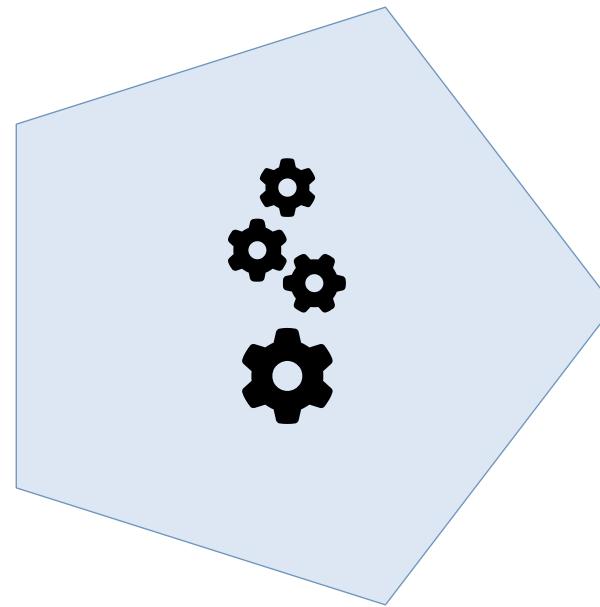
Linear Regression



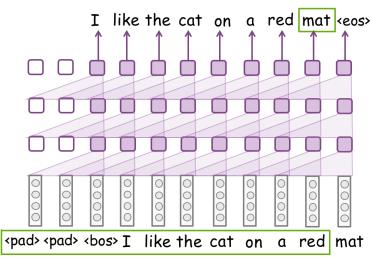
Random Forest



Deep Network



Support Vector Machine

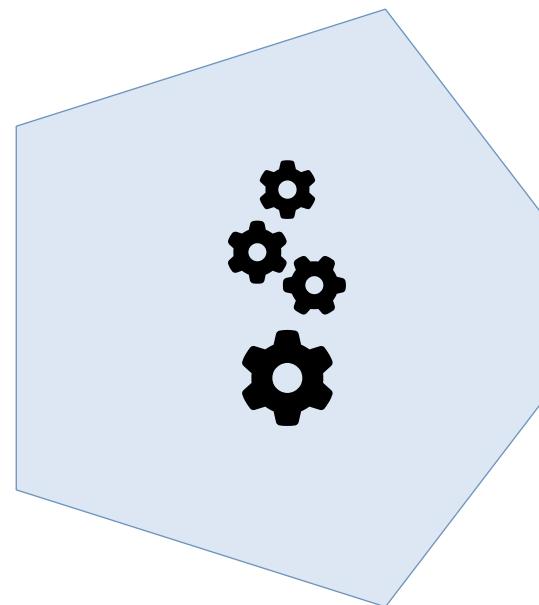


Large Language Model

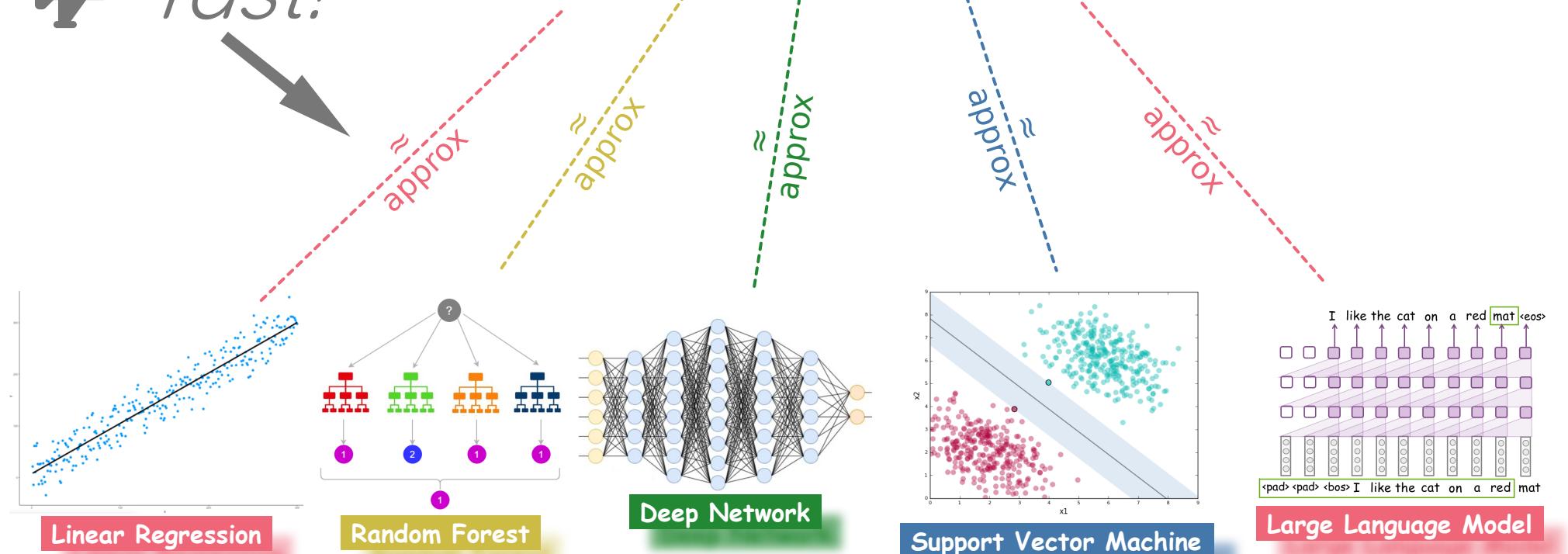


Optimal Predictor Machine

Σ SLOW...
(with present technologies)

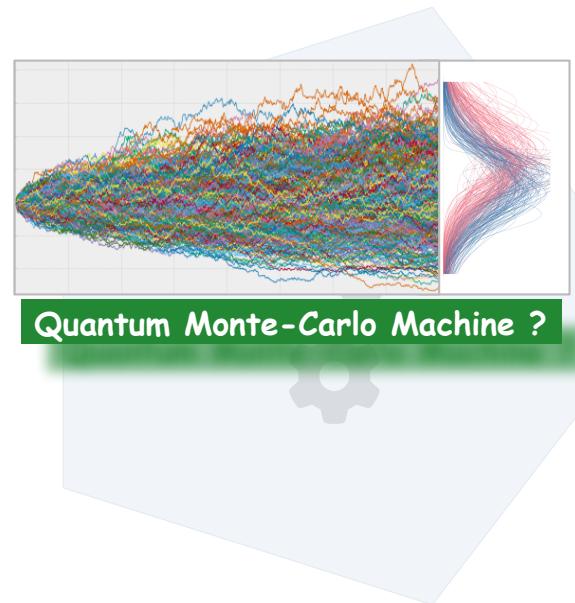


✈ fast!

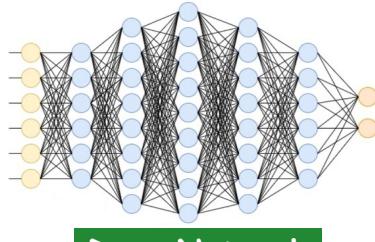
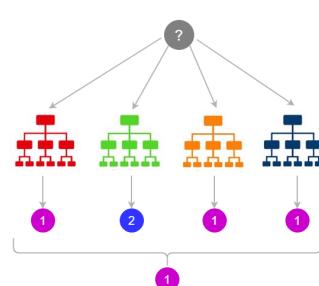
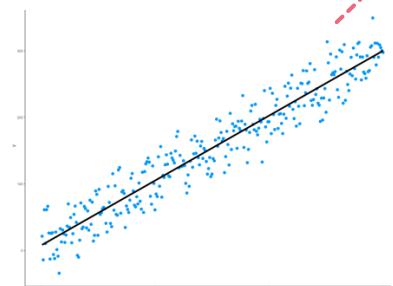


⋮

 *fast!* →
(with future technologies?)



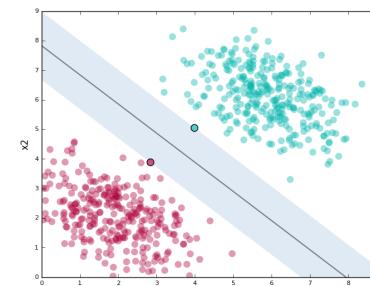
✗ SLOW...



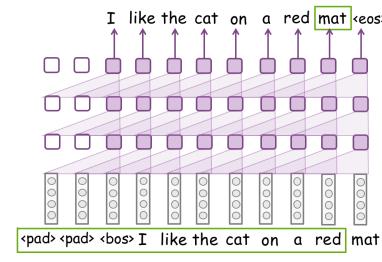
≈ approx

≈ approx

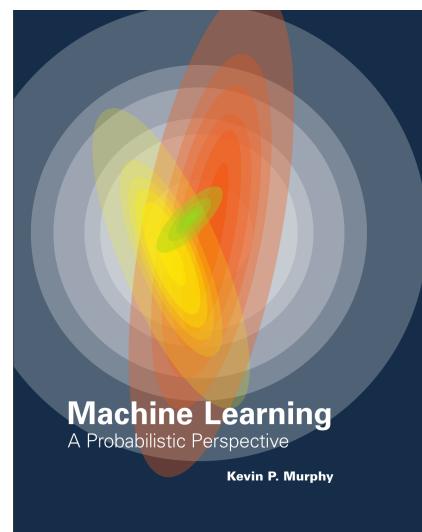
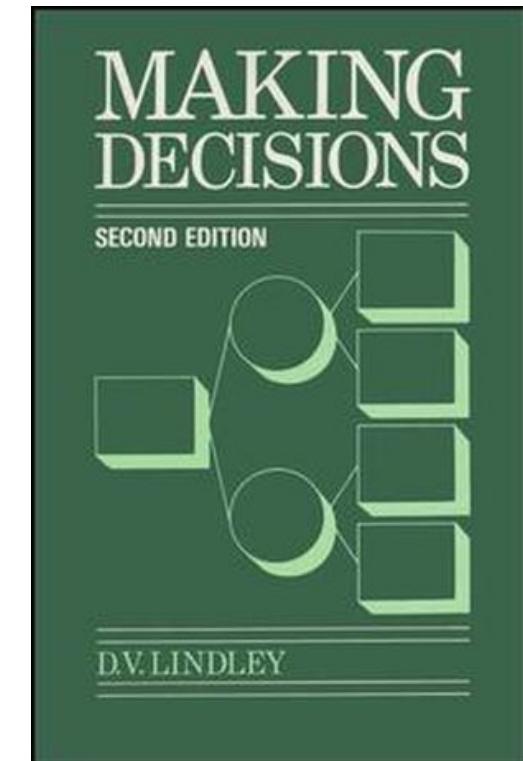
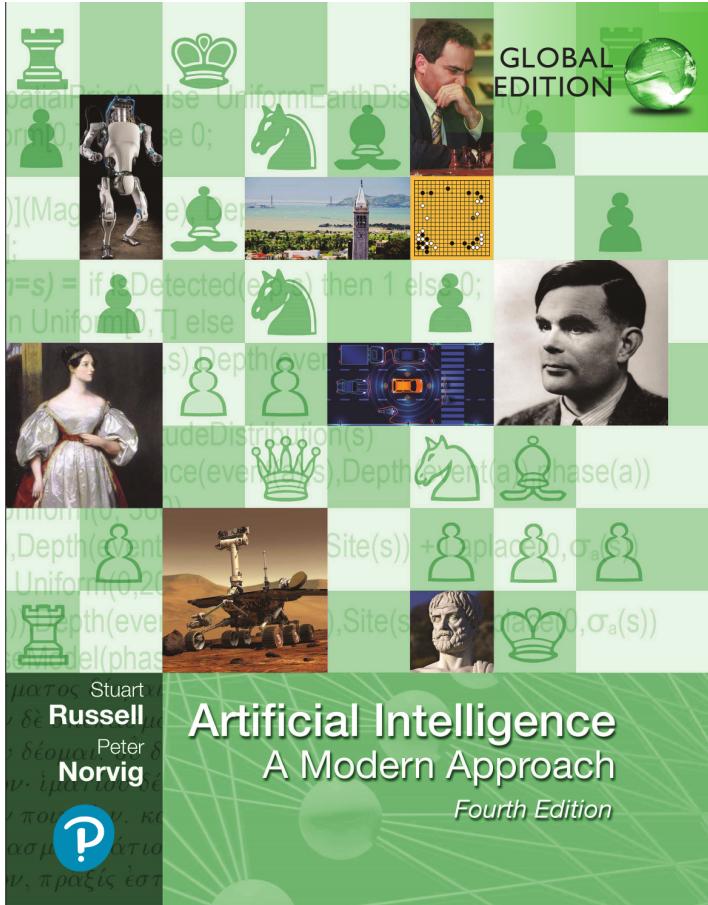
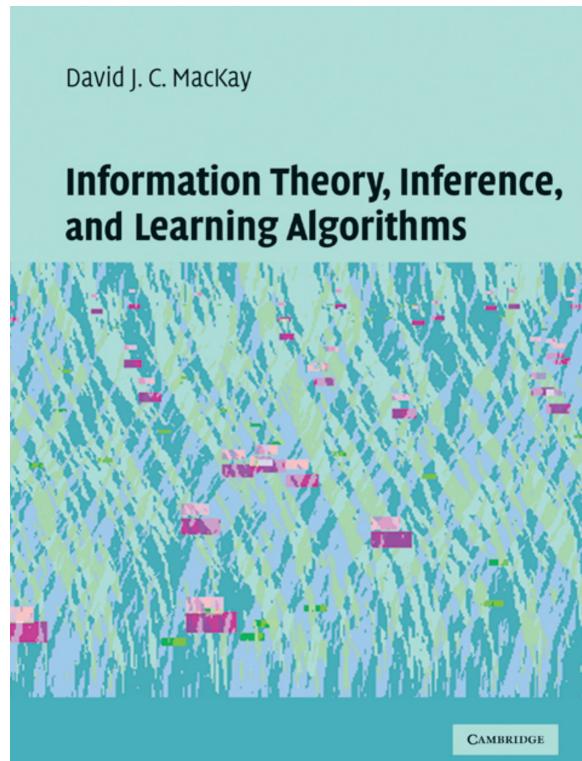
≈ approx



Support Vector Machine



⋮



- 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

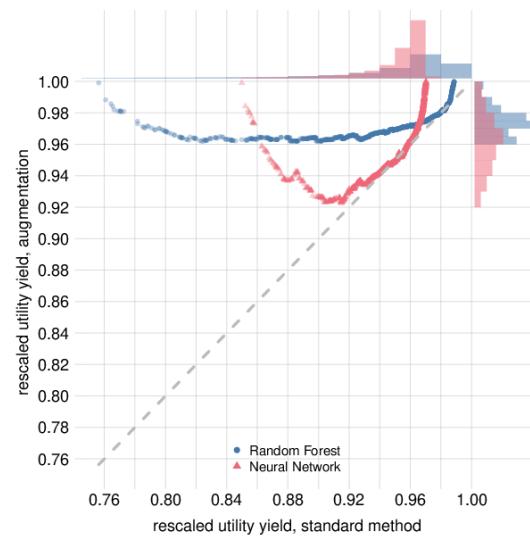
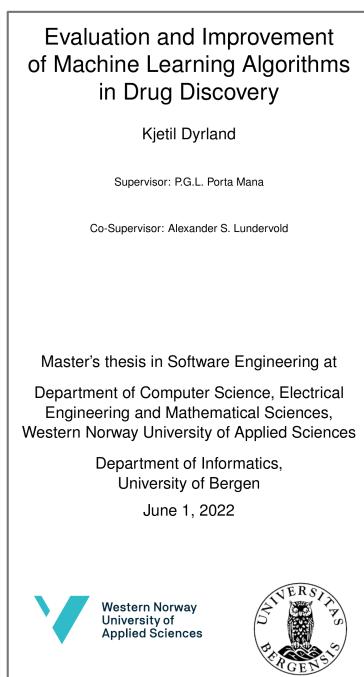
 Utility theory (gains & losses)

 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

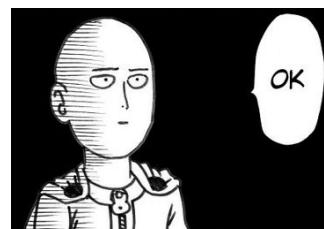
<https://www.r-project.org/>

Python

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

One Punch Man

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



Thank you!



