

Combining Machine Learning and Knowledge Engineering



Challenges for Data Driven Solutions

- Consistency of Past and Future
- Cold Start/ New Products
- Explanations
- Compliance



A Temporal View



Data



Decision



Time



Consistency of Past and Future

Example: Changes in Customer Behaviour because of climate change and Pandemic



Consistency between Data and Intent

Customers also bought

Neu



Talisker Skye Single Malt Scotch Whisky 70cl mit Etui und 2 Rocking Gläsern

CHF 58.00



The Ultimate Mortlach 2008 Single Malt Scotch Whisky 70cl

CHF 68.00



Talisker Port Ruighe Single Malt Scotch Whisky 70cl mit Etui

CHF 65.00



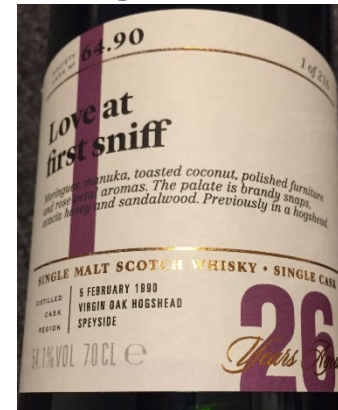
Kopfgetriebeöl 10T30 Nuss-Karamell Likör 50cl

CHF 24.90

Cold Start: New or Limited Products

Single Cask

Limited Editions



Small Batch

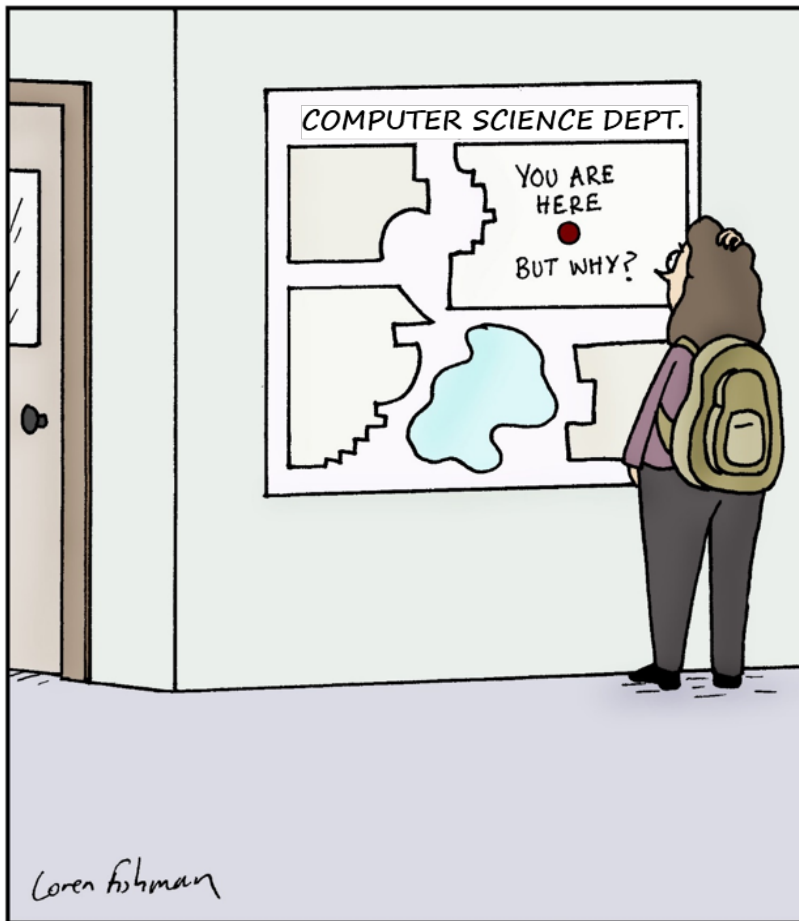


New Distilleries/Brands



Explanations

Can decisions without explanation be intelligent?

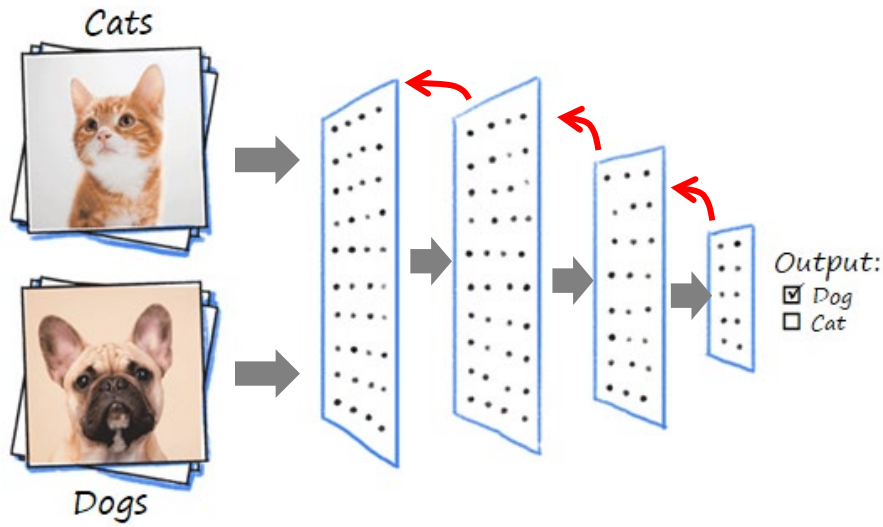


Trust
Compliance
Traceability

In particular for
subsymbolic learning
(neural networks)



AI Systems are Highly Specialized for one Problem



Dog or Cat?
→ Wolf

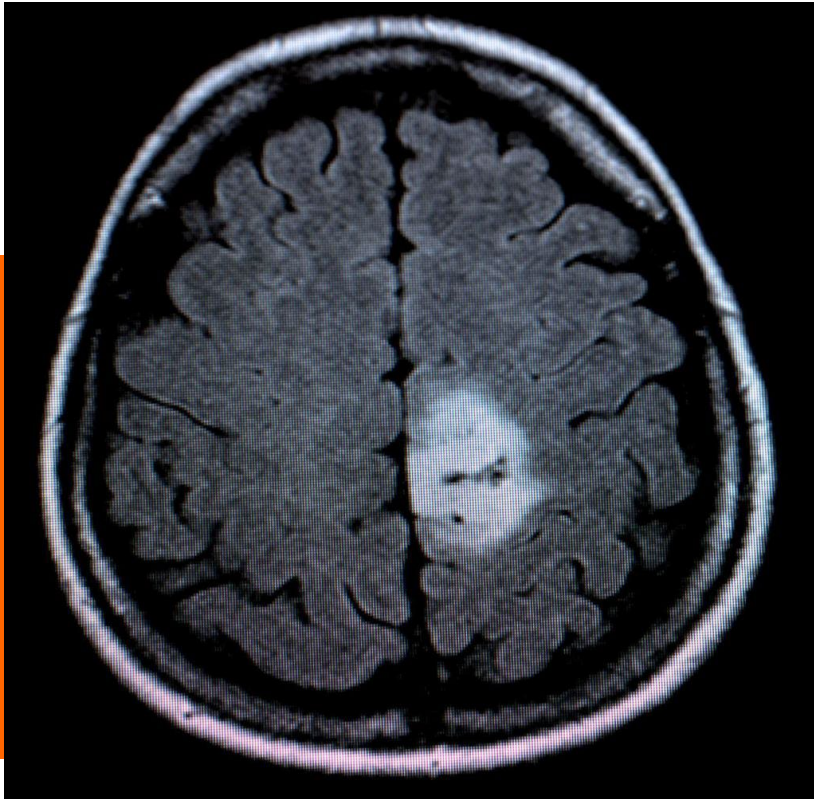
The system does not have the concept of a wolf



Photo by [Marc-Olivier Jodoin](#) on [Unsplash](#)



Diagnosis

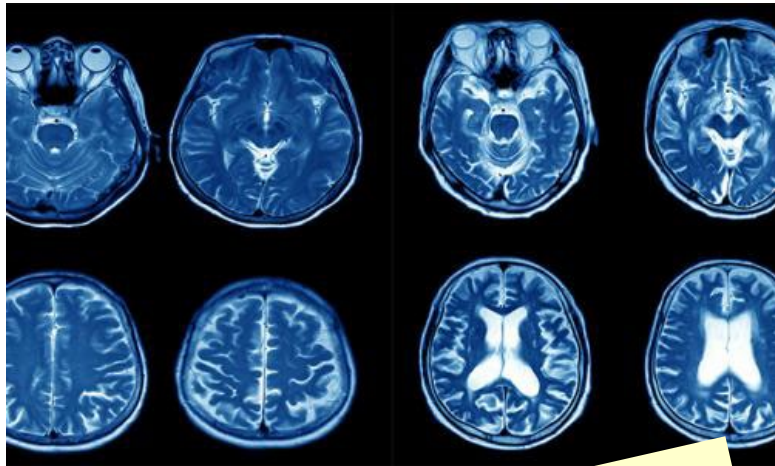


Therapy



**Would you trust your physician,
if she cannot explain, why she
recommends a surgery?**

AI Systems are Highly Specialized for one Problem



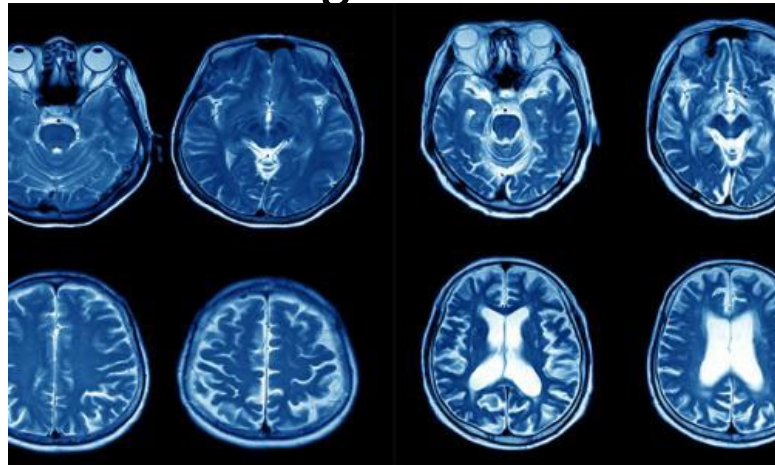
Recognizes
only cancer



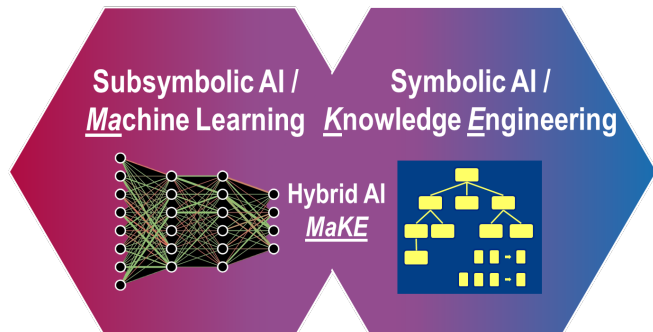
Bild von [Anh Nguyễn Duy](#) auf [Pixabay](#)

Combing Machine Learning with Knowledge

Diagnosis



Therapy



Data Processing



Knowledge Base

Domain Knowledge
(human or knowledge base)



Compliance with Regulations

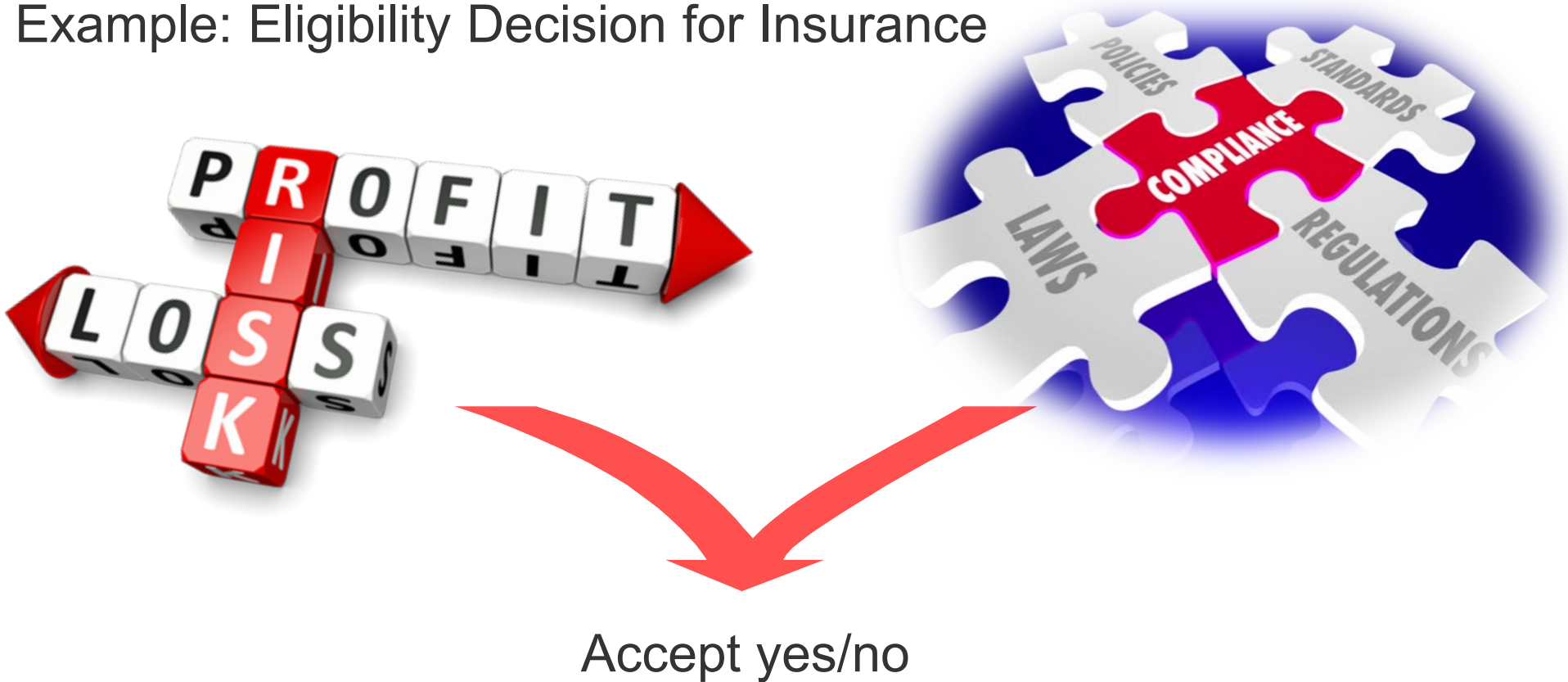
Example: Autonomous Driving

- Machine Learning:
Driving Behaviour
- Knowledge Engineering:
Traffic Rules



Compliance Rules

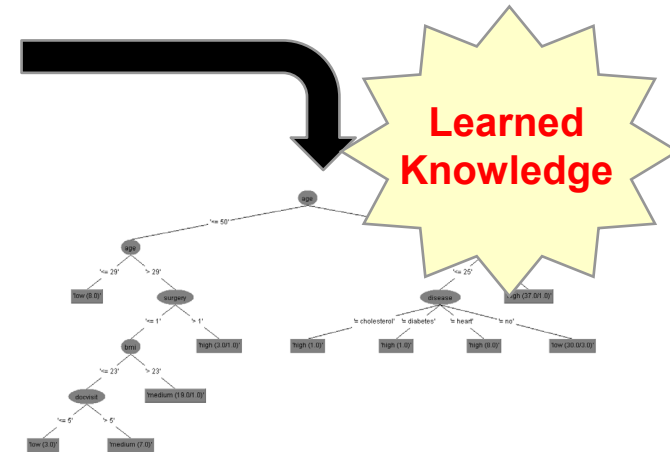
Example: Eligibility Decision for Insurance



Combining Machine Learning and Knowledge Engineering for Eligibility Decisions (1/2)

- Example: Application of health insurance
 - ◆ Machine Learning: data records about risks of clients

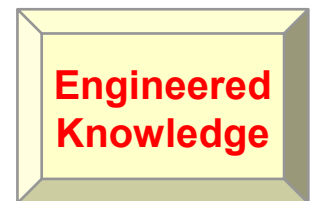
Age	surgery	docvisit	allergy	med	diseases	bmi	class
20	0	2	no	no	cholesterol	28	low
21	0	4	no	no	no	23	low
49	2	12	yes	yes	heart	34	high
22	0	3	no	no	no	23	low
51	2	2	yes	yes	diabetes	26	high
52	2	8	no	no	heart	31	high
52	0	3	yes	no	no	22	low
52	2	12	yes	yes	diabetes	27	high
52	0	11	yes	no	cholesterol	29	high
23	0	3	no	no	no	23	low



- ◆ Engineered knowledge: eligibility and compliance

Applicants from Switzerland are eligible.
A person younger than 21 year is not able to apply

...



Combining Machine Learning and Knowledge Engineering for Eligibility Decisions (2/2)

Examples of learned rules:

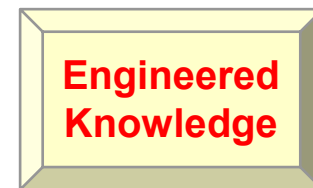
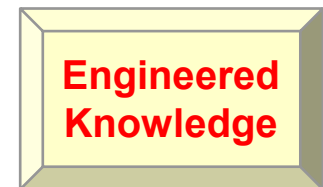
risk (Person, high) :-
 age(Person,A), A > 50,
 bmi(Person, Bmi), Bmi =<25,
 disease(Person, diabetes).
risk (Person, low) :-
 age(Person,A), A =< 29.

Examples of engineered rules:

eligible(Person, no) :-
 age(Person,A), A =< 21.
eligible(Person,no) :-
 country(Person,C), C != switzerland.

Combining engineered and learned rules:

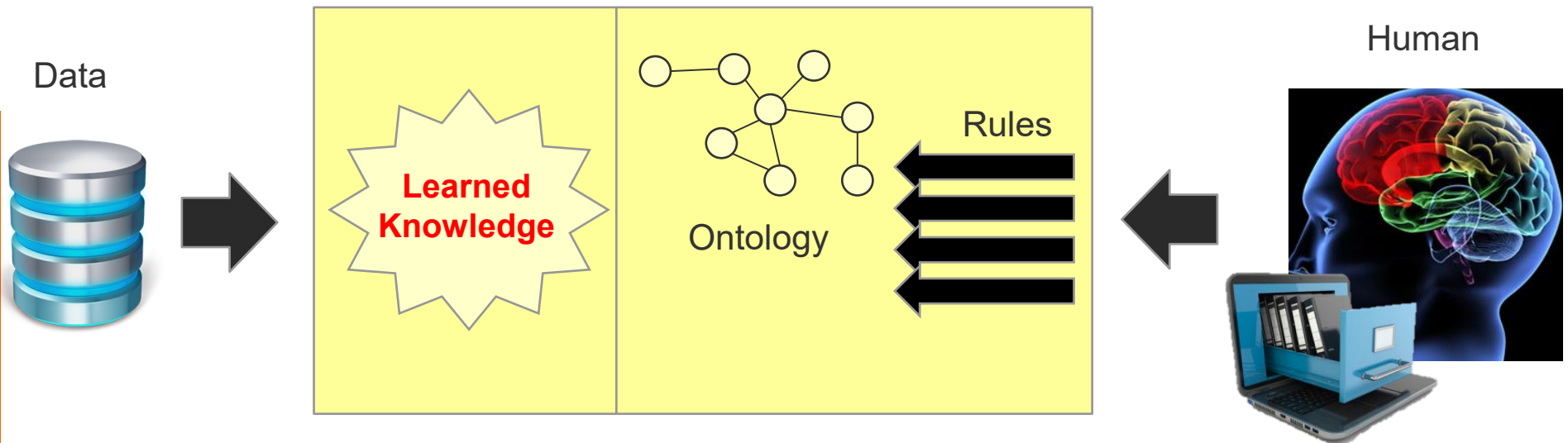
accept(Person, yes) :- eligible(Person, yes), risk(Person, low).
accept(Person, yes) :- eligible(Person, yes), risk(Person, medium).
accept(Person, no) :- eligible(Person, no).
accept(Person, no) :- risk(Person, high)



Combining Machine Learning and Knowledge Base

Machine Learning

Knowledge Base



- Tacit or unknown knowledge
- Stable knowledge

- Knowledge we are aware of
- Knowledge that must be correct
- Explanations

Summary: Creating Knowledge Bases

- **Knowledge Engineering:** Human experts build knowledge base
 - ◆ For knowledge we are aware of
 - ◆ For knowledge that must be correct (e.g. compliance rules)
 - ◆ Inferences are explainable (trust)

- **Machine Learning:** automatic creation of knowledge from example data
 - ◆ Can solve complex tasks for which
 - knowledge is not known
 - knowledge is tacit
 - ◆ For stable world, where future can be predicted from past
 - ◆ Reliance on real-world data instead of pure intuition
 - ◆ Requires large sets of data

