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

Observe the Past

Predict the Future

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

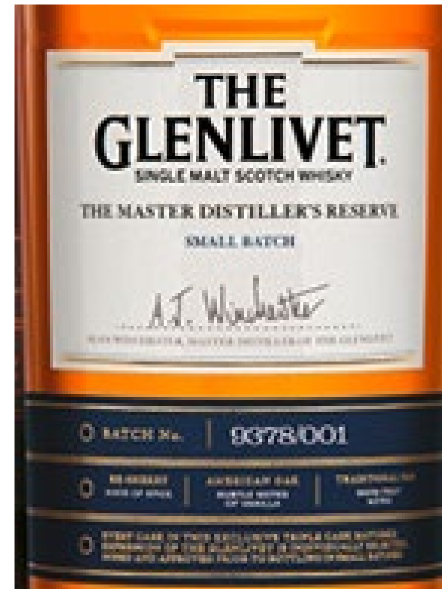
CHF 24.90

Cold Start: New or Limited Products

Single Cask

Limited Editions

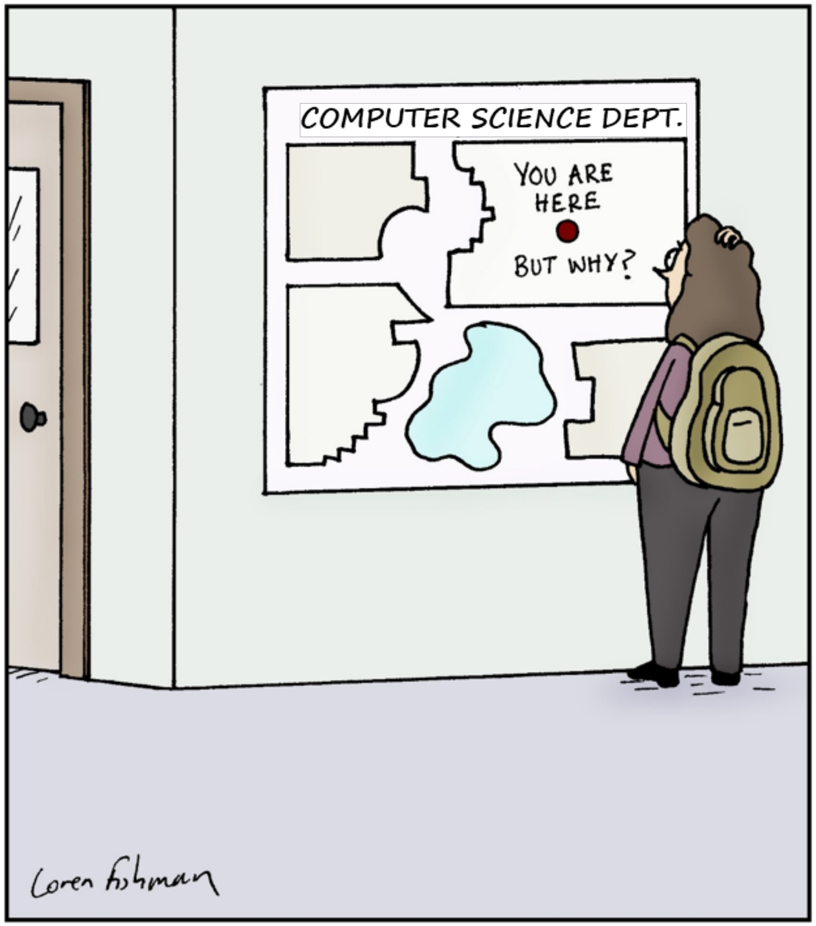
Small Batch



New Distilleries/Brands

Explanations

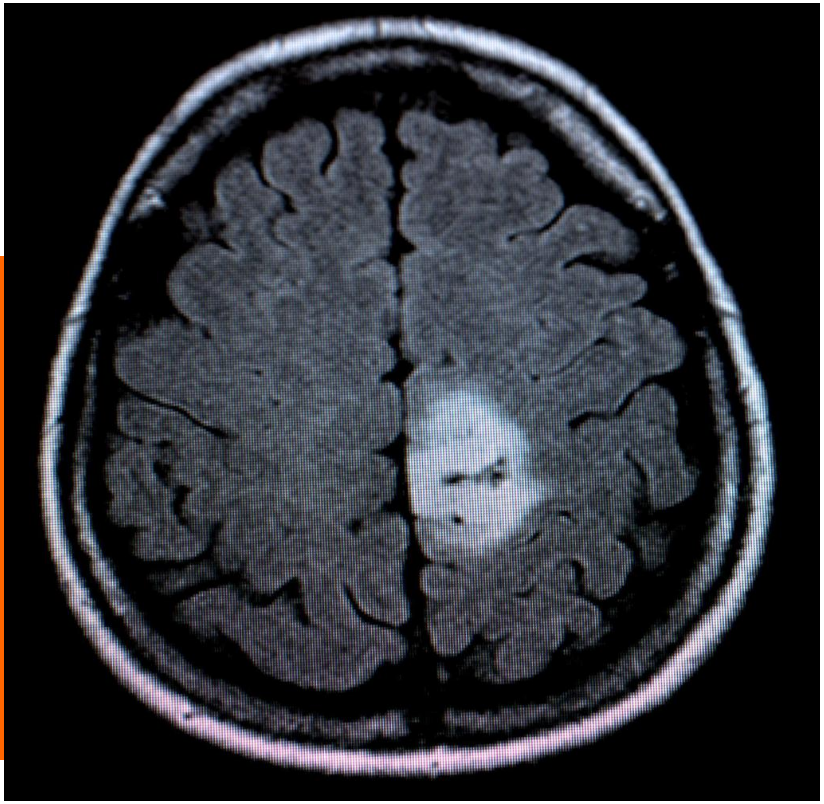
Can decisions without explanation be intelligent?



Trust
Compliance
Traceability

In particular for subsymbolic learning (neural networks)

Diagnosis



Therapy

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

Compliance with Regulations

Example:Autonomous Driving

- Machine Learning:
  Driving Behaviour

- Knowledge Engineering:
  Traffic Rules

Compliance Rules

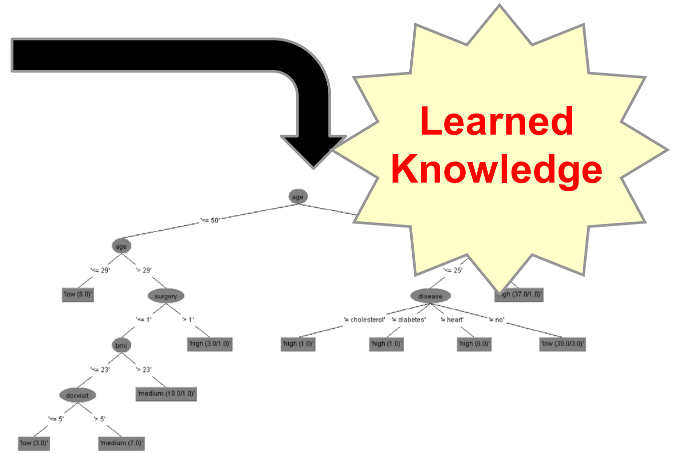
Example: Eligibility Decision for Insurance

Accept yes/no

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	disieases	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
…

Engineered Knowledge

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.
```

Learned Knowledge

Examples of engineered rules:

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

Engineered Knowledge

Combining engineered and learned rules:

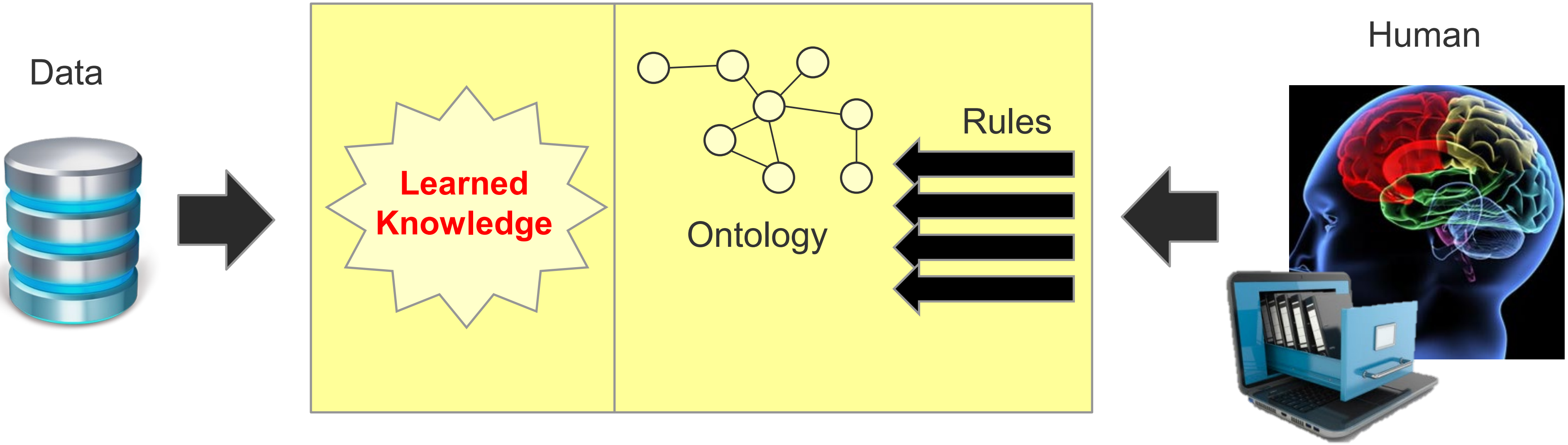
```
accept(Person, yes) :- eligible(Person, yes), risk(Person, low).
accept(Person, yes) :- eligible(Person, yes), risk(Person, medium).
accept(Person, no) :- eligible(Person, no).
accept(Person, no) :- risk(Person, high)
```

Engineered Knowledge

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