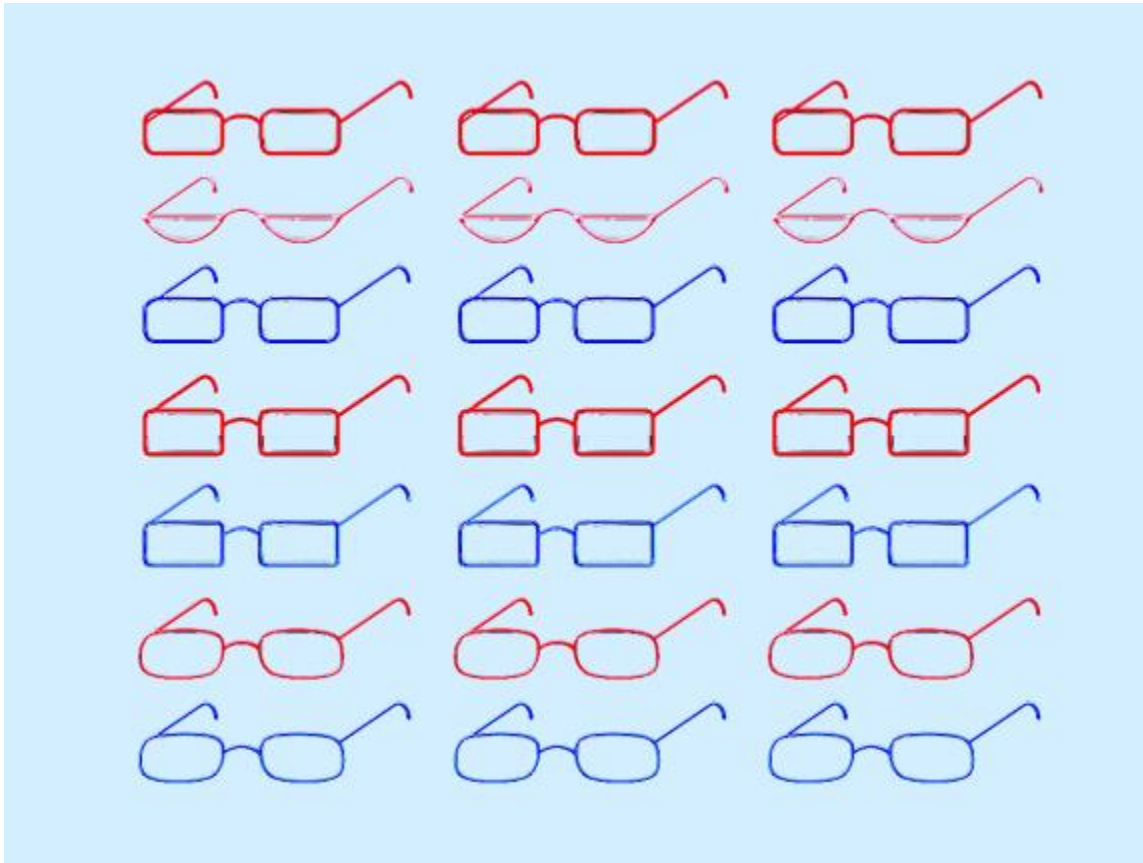# Models and Interpretations

Stephen Downes

December 9, 2021

Models and Interpretations

- The pebbles are the *model*
- What they stand for is the *interpretation*

What Does a Poll Mean?

- A poll is a collection of preferences for an upcoming election. But how do we know what the results *mean*?

- Consider, e.g., the margin of error. What is that? Can we trust it?

- Are polls snapshots how how people think or predictions of upcoming results?

https://fivethirtyeight.com/features/how-to-read-2020-polls-like-a-pro/

Modeling Can Be Tricky

● SEWING MACHINE ● WEBCAM ● ANDREW CUOMO ● FLOUR ● PANGOLIN

MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR
2019 2020
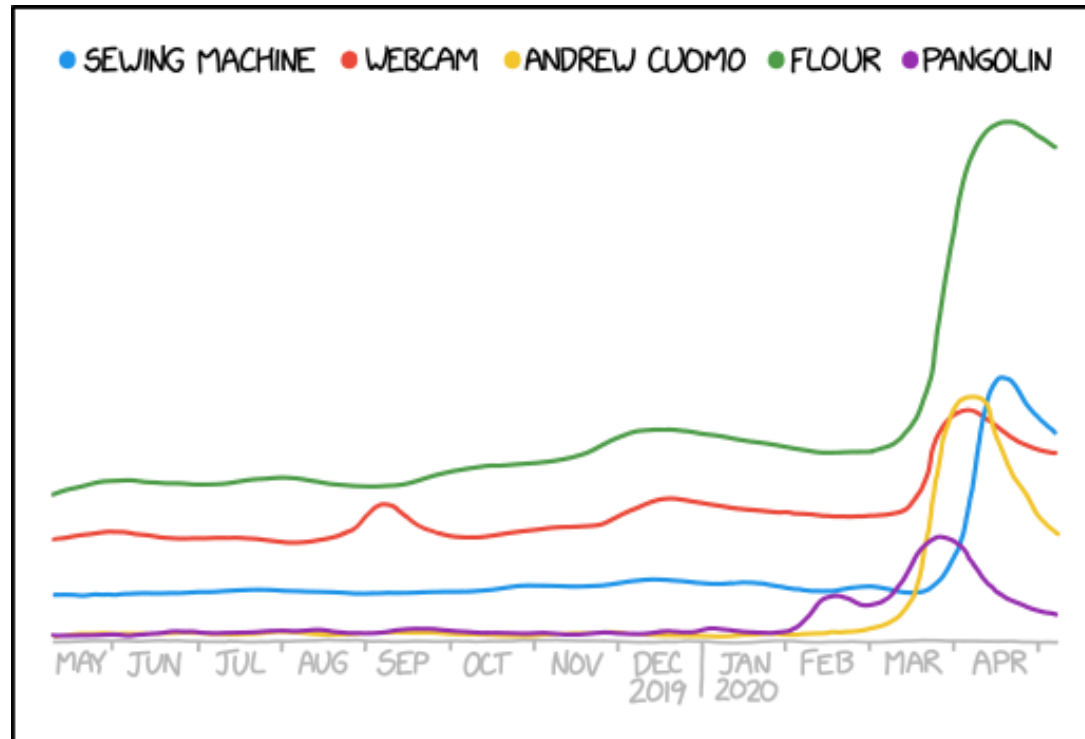
I WANT TO SHOW SOMEONE FROM 2019 THIS GOOGLE TRENDS
GRAPH AND WATCH THEM TRY TO GUESS WHAT HAPPENED IN 2020.

"Today's xkcd illustrates why topic modeling can be tricky, for people as well as for machines: It's one thing to detect a new cluster of words and phrases, and something else to assign an interpretation."

https://languagelog.ldc.upenn.edu/nll/?p=46996
https://www.explainxkcd.com/wiki/index.php/2302:_2020_Google_Trends

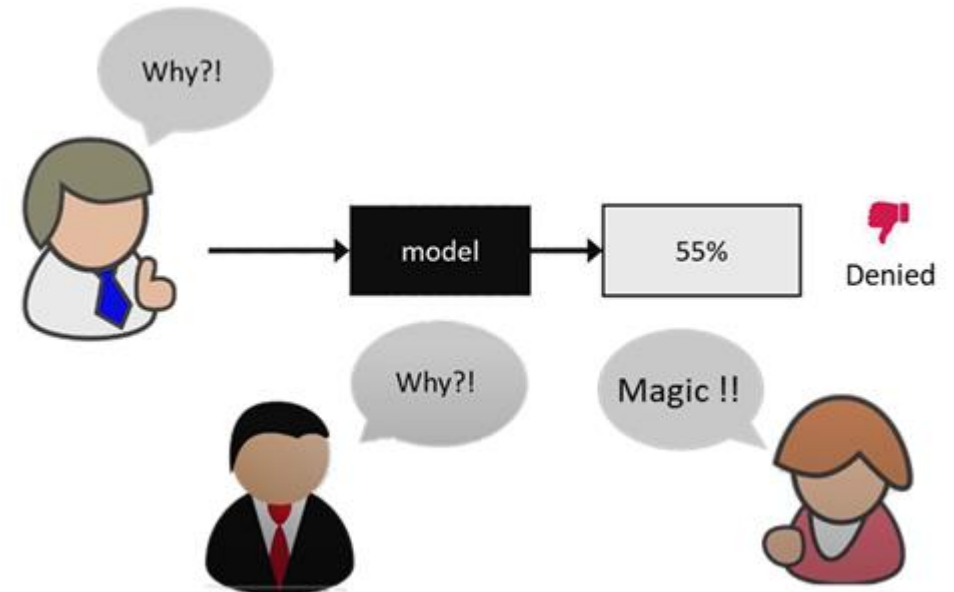# The Wrong Model

What happens when we choose the wrong model?

"My example may seem silly. So what if I chose the wrong algorithm to predict which instructors teach programming? But what if I had instead been creating a model to predict which patients should receive extra care? Then using the wrong algorithm could be a significant problem."

By Nicholas T. Young. (2020). I Know Some Algorithms Are Biased—because I Created One. Scientific American. January 31, 2020. https://blogs.scientificamerican.com/voices/i-know-some-algorithms-are-biased-because-i-created-one/

Models in AI and Analytics

"AI raises new questions: For example, the use of black-box models makes it difficult for us to determine why decisions are being made. Paradoxically, traditional limitations on accessing data on protected groups can hinder the ability to assess models properly."
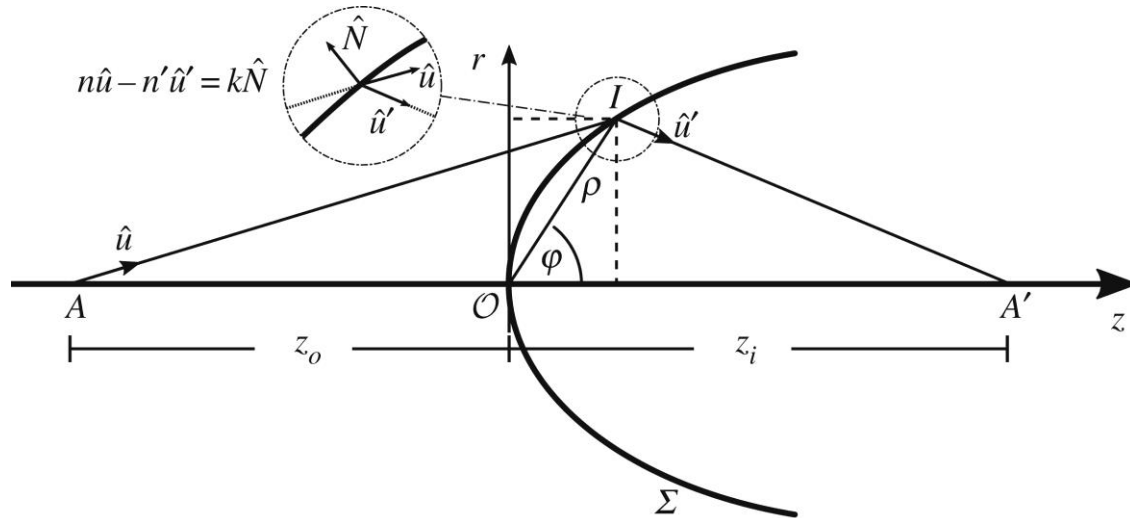
What do we even *mean* by 'black box model'?

https://mailchi.mp/protocol/protocol-braintrust-the-unintended-consequences-of-unethical-ai?e=ebba0444a7
https://medium.com/swlh/explainable-ai-making-sense-of-the-black-box-32ebf2d16c61
https://en.wikipedia.org/wiki/Black_box

The Cartesian Revolution

*Quaecumque ab Aristotele dicta essent, commentitia esse ***

$$n\hat{u} - n'\hat{u}' = k\hat{N}$$

Nicolaus Copernicus 1473 – 1543
Gerolamo Cardano 1501 – 1576
Petrus Ramus 1515 –1572
François Viète 1540 – 1603
Tycho Brahe 1546 – 1601
Pierre de Fermat 1607 – 1665
Giordano Bruno 1548 – 1600
Galileo Galilei 1564 – 1642
Johannes Kepler 1571 – 1630
René Descartes 1596 – 1650
Blaise Pascal 1623 – 1662
Gottfried Wilhelm Leibniz 1646 – 1716
Isaac Newton 1642 – 1726

* All the things that Aristotle has said are inconsistent because they are poorly systematized and can be called to mind only by the use of arbitrary mnemonic devices. - Ramus

The Rise and Fall of Wired - https://www.downes.ca/wired/conclusion.htm

Mathematics

- Idealism (Plato)
- Formalism (Hilbert, Gödel)
- Intuitionism (Brouwer)
- Anti-Realism (Dummett)
- Operationalism (Mill, Kitcher)
- Conventionalism (Wittgenstein)
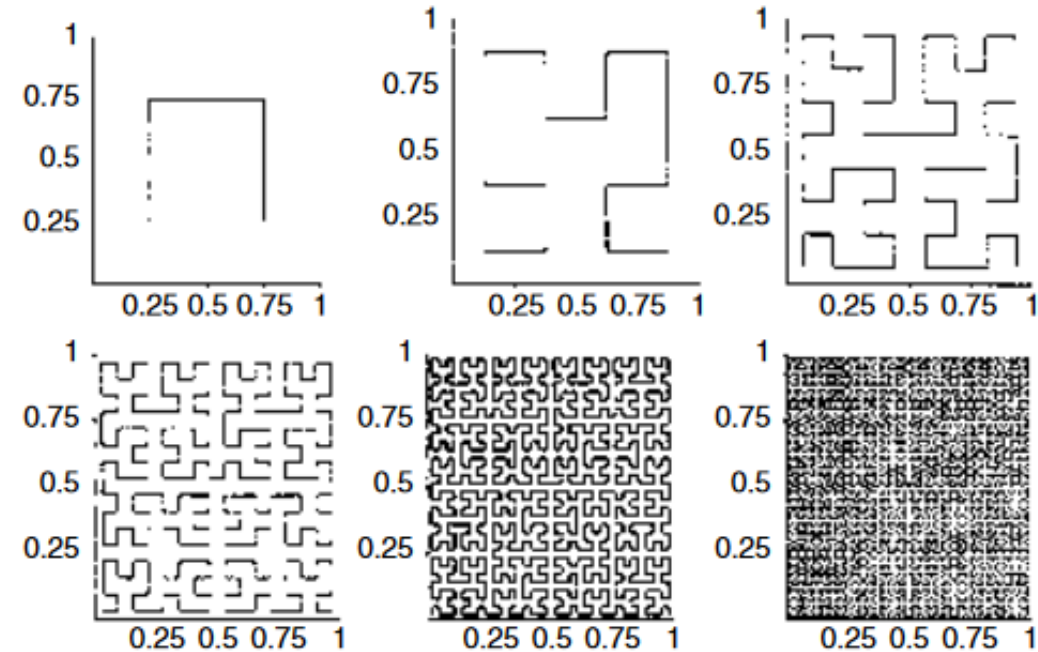- Computation (Turing)

Figure 12.3 The first six iterations of Hilbert's space-filling curve

http://homes.chass.utoronto.ca/~jrbrown/Brown_Philosophy_of_Mathematics.pdf

How We Prove Things

- Proofs e.g. symbolic derivations

- Intuition e.g. 2 + 2 = 4

- Induction e.g. counting crows

- H-D e.g. predictions / consequences

- Pictures e.g. gometry

- Diagonalization e.g. Gödel's proof

- Thought Experiments e.g. Einstein

James Robert brown http://homes.chass.utoronto.ca/~jrbrown/Brown_Philosophy_of_Mathematics.pdf p. 206
Image: https://www.soiladvocates.ca/why-do-we-need-to-prove-things-in-our-society/

State Space and Probability

SAMPLE SPACE FOR A PAIR OF DICE

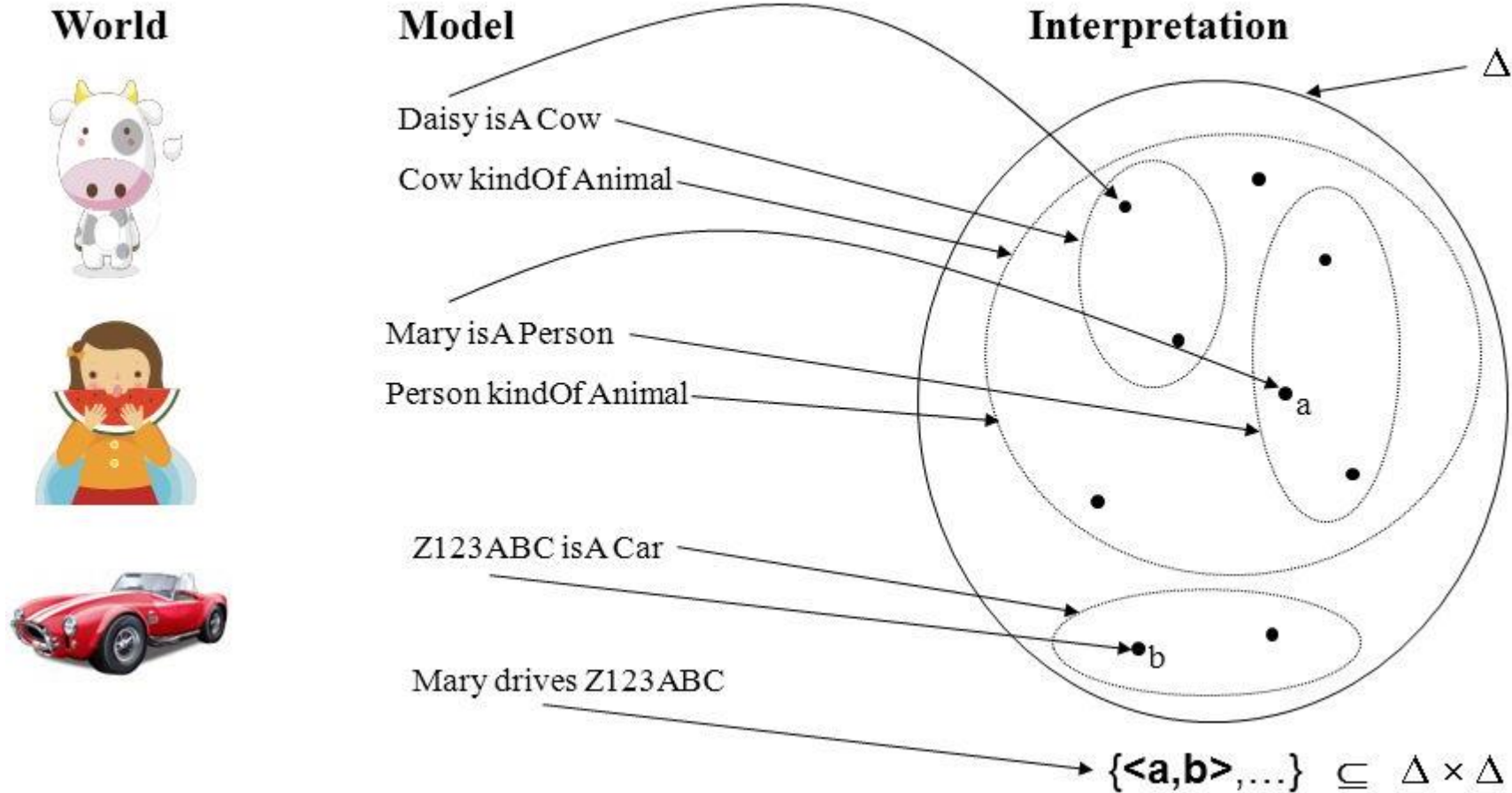|	1	2	3	4	5	6
1	2	3	4	5	6	7
2	3	4	5	6	7	8
3	4	5	6	7	8	9
4	5	6	7	8	9	10
5	6	7	8	9	10	11
6	7	8	9	10	11	12

A state space is a description of all possible states of affairs in a given world.

"In his first great work, *Der logische Aufbau der Welt* (1928; *The Logical Structure of the World*), Carnap developed, with unprecedented rigour, a version of the empiricist reducibility thesis according to which all terms suited to describe actual or possible empirical facts are fully definable by terms referring exclusively to aspects of immediate experience."

So *of course* we would measure the probability of dice using the state space, right? Unless perhaps the dice were rigged…

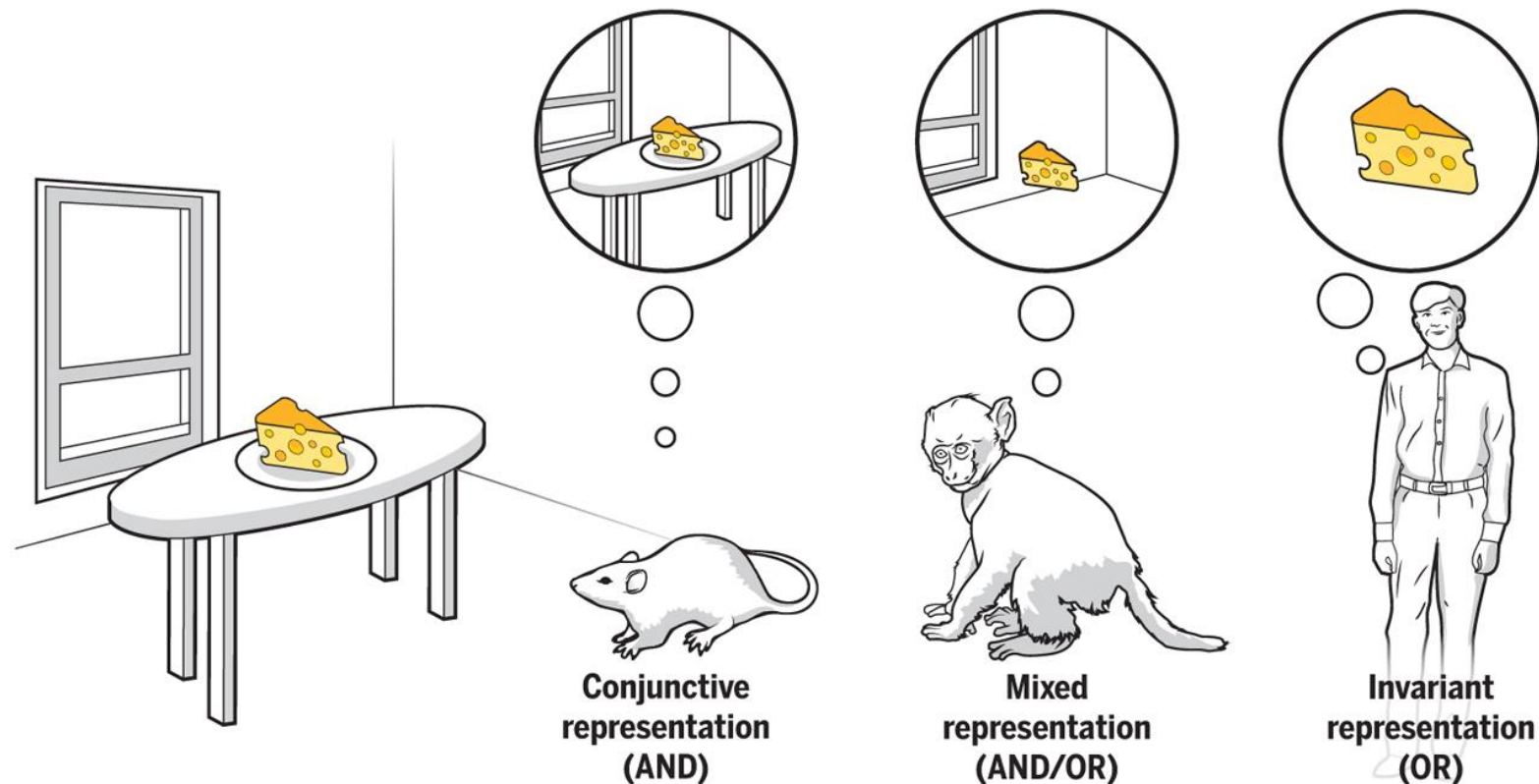https://www.britannica.com/biography/Rudolf-Carnap

Formal Semantics

McKinney https://slideplayer.com/slide/10741885/

Representations

Neuronal coding in the hippocampal formation

Rodents demonstrate a conjunctive coding to represent context, with neurons firing in response to specific places AND in specific conditions. Humans show an invariant coding, with neurons firing in response to concepts in one OR another condition. Monkeys display a mixed coding, with neurons being modulated by context but also showing an invariant representation.
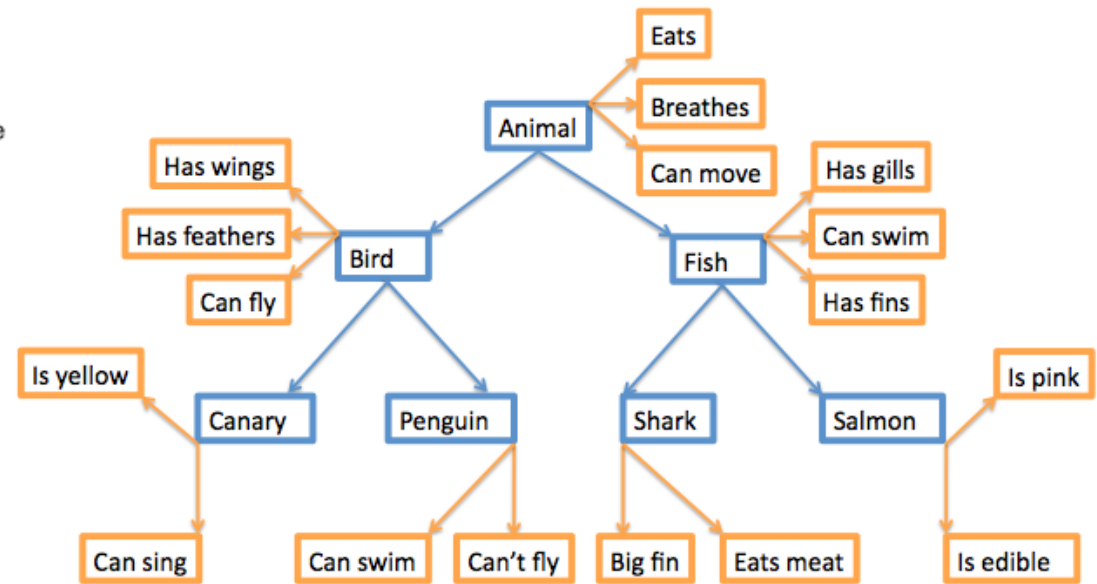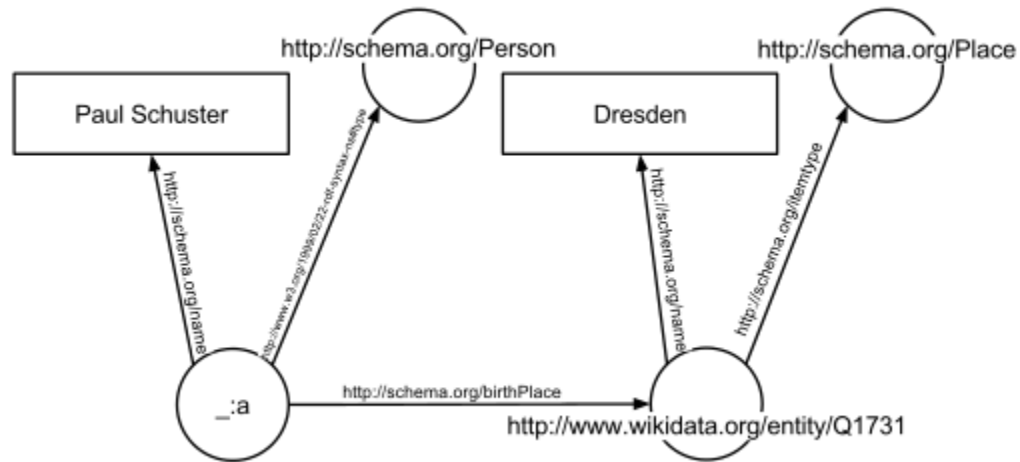
Conjunctive representation (AND)

Mixed representation (AND/OR)

Invariant representation (OR)

Neural Representations Across Species
https://www.science.org/doi/10.1126/science.aaw8829

The Representative Student - https://www.downes.ca/presentation/257

The Semantic Web

https://en.wikipedia.org/wiki/Semantic_Web
https://www.w3.org/standards/semanticweb/
https://www.youtube.com/watch?v=V6BR9DrmUQA

https://www-sop.inria.fr/acacia/cours/essi2006/Scientific%20American_%20Feature%20Article_%20The%20Semantic%20Web_%20May%202001.pdf
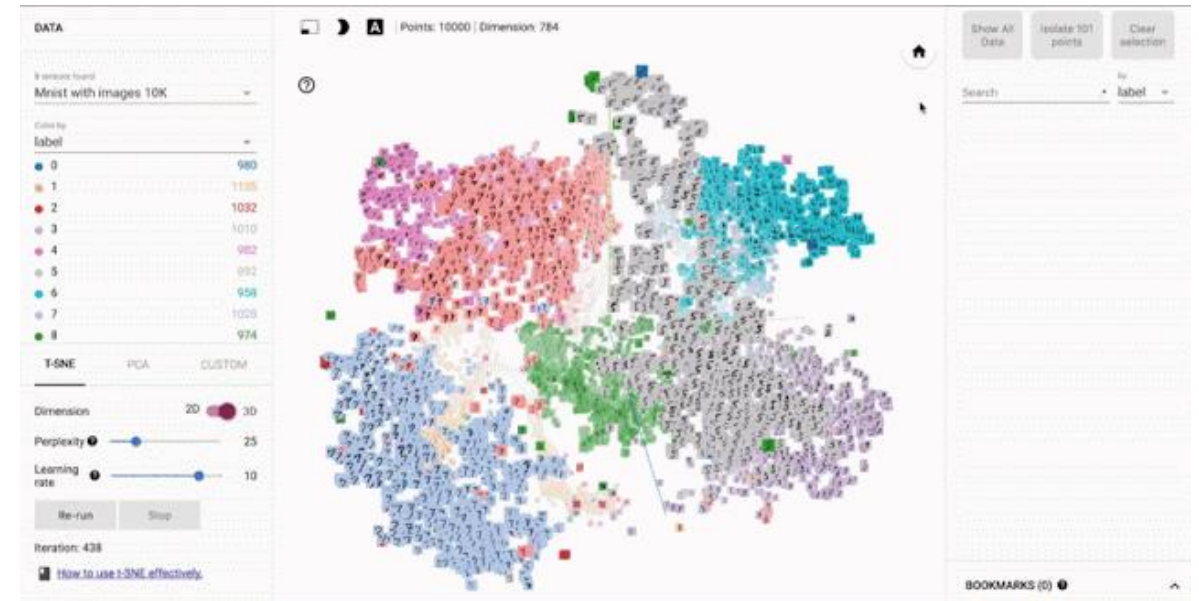
Models in AI

"An AI (artificial intelligence) model is a program that has been trained on a set of data (called the *training set*) to recognize certain types of patterns."

In a neural networks specifically) we can say that the model is the *set of connection weights* in a trained network

https://chooch.ai/computer-vision/what-is-an-ai-model/
https://resource.revealdata.com/en/blog/what-is-an-ai-model
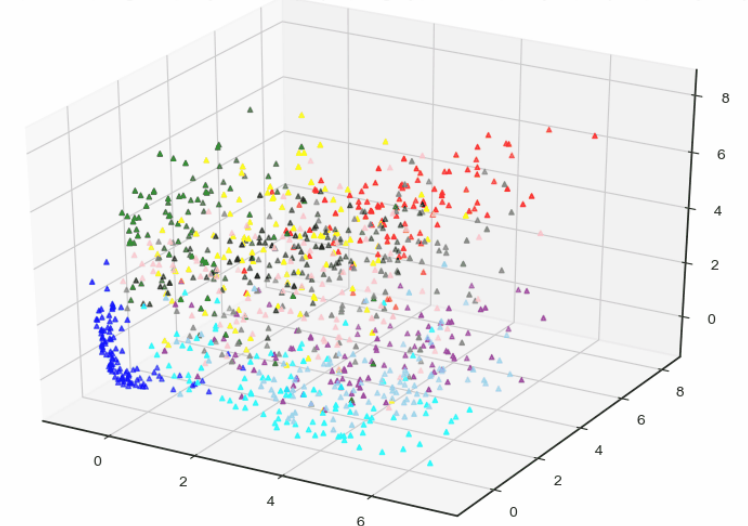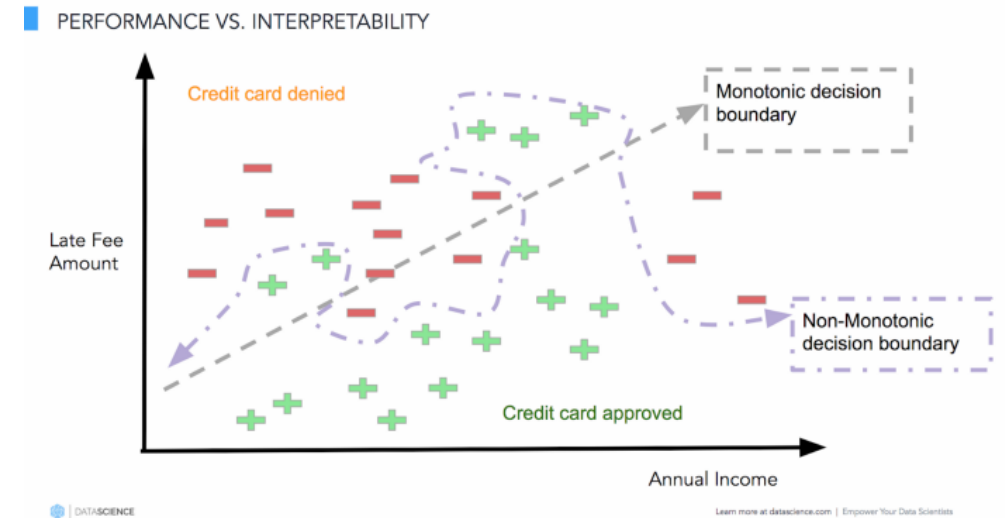https://buddhirajsahu.medium.com/ai-what-is-since-when-79a25bb7b6f4

{0: 'red', 1: 'blue', 2: 'green', 3: 'yellow', 4: 'purple', 5: 'grey', 6: 'black', 7: 'cyan', 8: 'pink', 9: 'skyblue'}

Interpretation in AI Models

- Anderson: "This is a world where massive amounts of data and applied mathematics replace every other tool that might be brought to bear."

- Boyd & Crawford: "Do numbers speak for themselves? We believe the answer is 'no'. Significantly, Anderson's sweeping dismissal of all other theories and disciplines is a tell: it reveals an arrogant undercurrent in many Big Data debates where other forms of analysis are too easily sidelined."

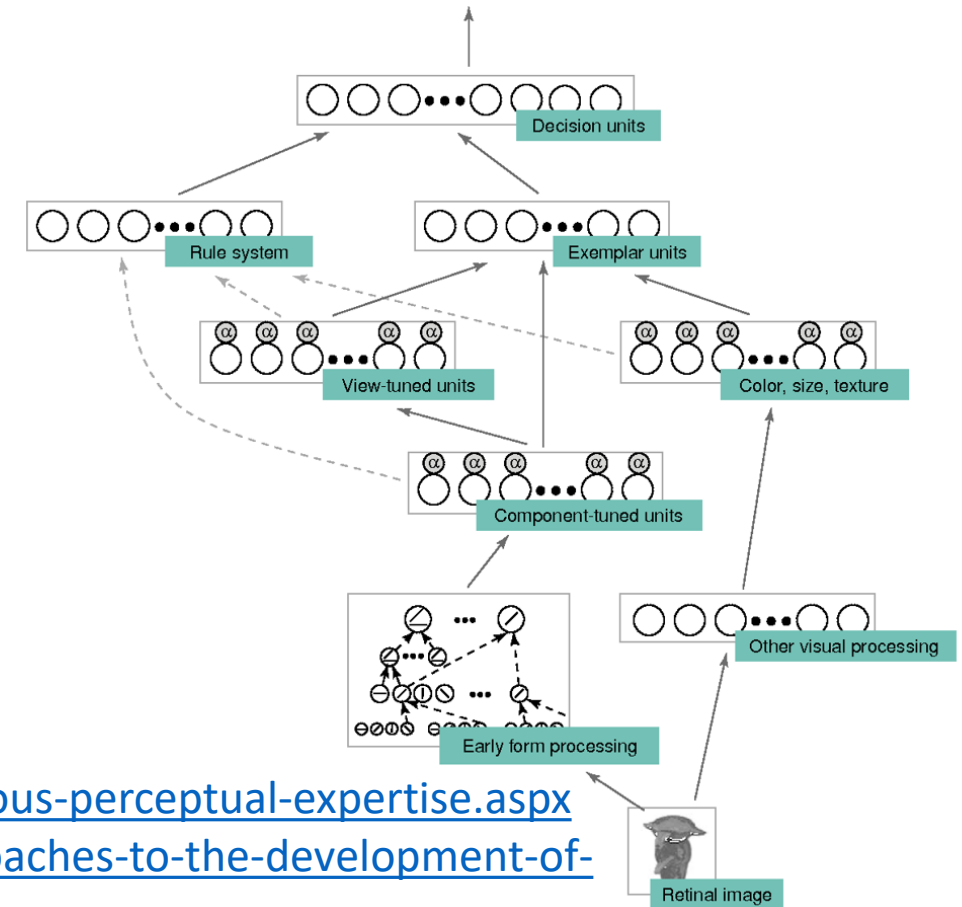danah boyd & Kate Crawford - Critical Questions for Big Data

https://www.dhi.ac.uk/san/waysofbeing/data/communication-zangana-boyd-2012.pdf

https://towardsdatascience.com/explainable-artificial-intelligence-part-2-model-interpretation-strategies-75d4afa6b739
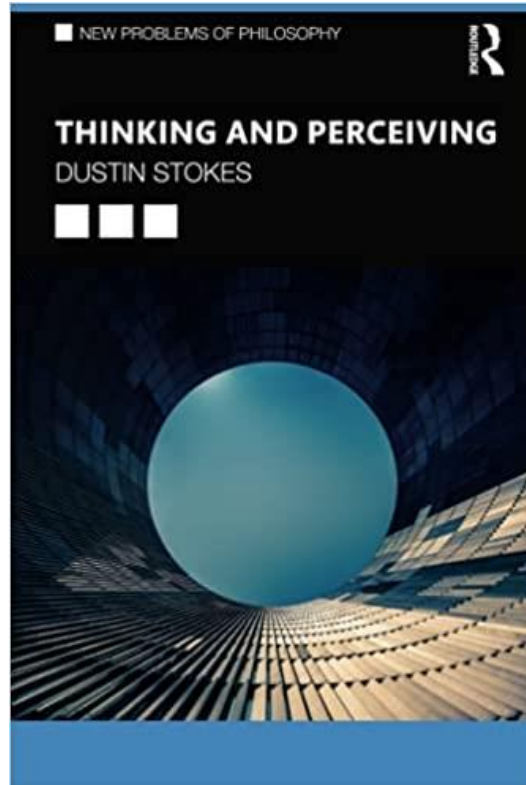
Model as Perceptual Expertise

Jonna Vance: perceptual expertise as "an enhanced capacity for perceptual recognition or discrimination with respect to some feature or category." For example, "one can be a perceptually expert recognizer or discriminator of bird species, cars, or tumors depicted in X-rays."

https://philosophyofbrains.com/2021/09/29/jonna-vance-vicious-perceptual-expertise.aspx
https://www.semanticscholar.org/paper/Computational-approaches-to-the-development-of-Palmeri-Wong/69321f0f2ec191da26b53396b539ffb66b6c2ca0
https://www.downes.ca/post/72827

Models and Ethics

NEW PROBLEMS OF PHILOSOPHY

THINKING AND PERCEIVING
DUSTIN STOKES

- Is perceptual expertise always virtuous?
- Daniel Burnston: "there is no guarantee that perceptual expertise will have a net positive contribution to the proportion of true beliefs or knowledge."
- So, "are privileged epistemic agents subject to different epistemic obligations than marginalized or oppressed epistemic agents are?"

Making Models

- Defining a model inherently means asking a question, and the choice of question is critical (Seufert, et.al., 2019):
  - What problems are high priorities?
  - How will the outcome be used?
  - How will we respond to adverse outcomes (esp. in statistical cases)
  - How will the outcomes be measured?
- Models are 'trained', yes, but the training is the result of extensive programming:
  - Are rigorous programming standards used
  - Is the program open source

http://web.eecs.utk.edu/~azh/pubs/Chattopadhyay2020CHI_NotebookPainpoints.pdf

Choices, Choices

Assumption	Question
Ontological choice	What ontological perspective do we choose to adopt, and why?
Ontological knowledge	How do we know about the social categories?
Semantic choice	Close-enough-possible-worlds or causal modeling? What is the justification?
Evaluation reliability	What happens to the truth value of the counterfactuals of interest
Similarity choice	How do we choose what similarity means in this context?
Comparison criteria	What are our chosen criteria for comparing the similar worlds of interests to the actual world?
Idealization	What do we miss by translating social categories into random variables?
Context	How do these categories operate in the world?
Ethical and social harm	Does our ontological preference generate harms in relation to social justice

From: http://philsci-archive.pitt.edu/19538/1/3442188.3445886.pdf

Validating Models

- What choices do we make?
  - which problems to make high priorities
  - how the model will be used
  - what… interventions will be provided?

- Standards for validation

- Standards for transparency
  - What are the "key independent variables"?

- Outcomes assessment
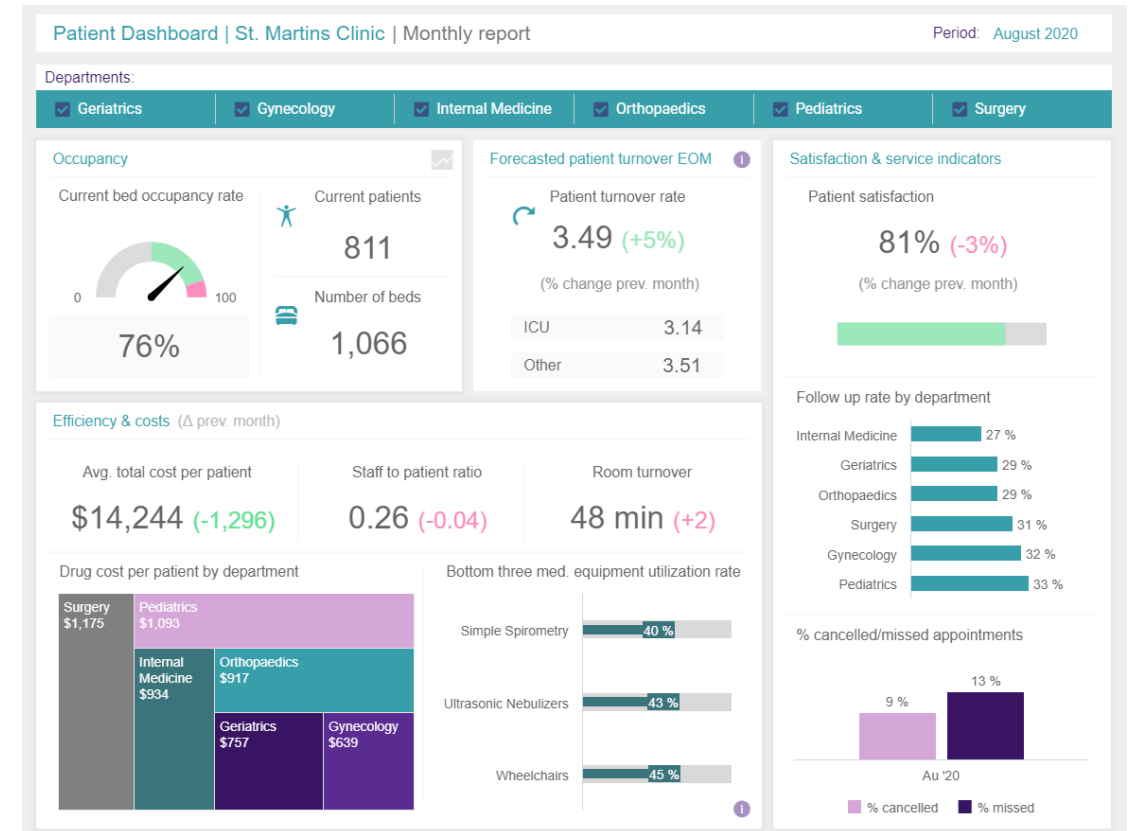
Learning Analytics Models

Dimensions

- Pedagogic theory and learning design
- Objective
- Stakeholders
- LA model
- LA application: data
- LA application: instruments
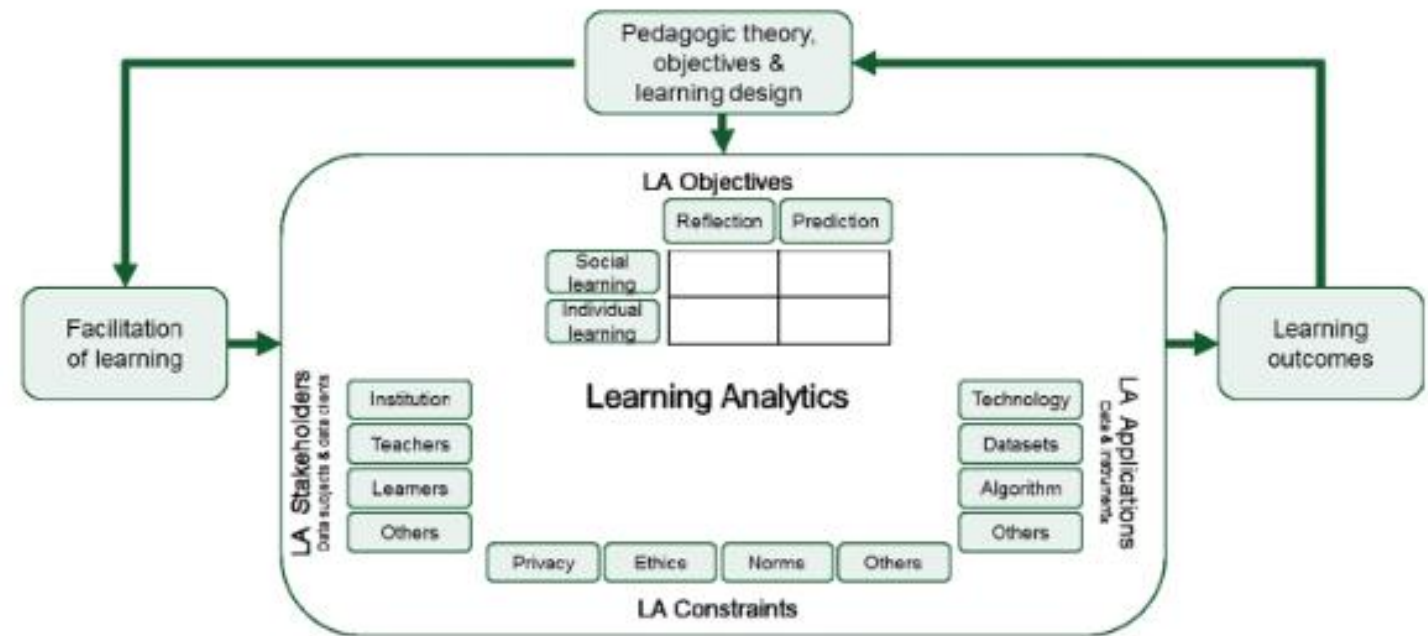- Competences required
- Constraints

Fig. 1 Design framework for LA

Seufert, et.al., 2019, Pedagogical Perspective on Big Data and Learning Analytics https://ibb.unisg.ch/-/media/images-2000x1125/instituteundcenter/ibb/forschung/learning-analytics.pdf?la=de&hash=EDA4D55AA5BADE6627081BFBED5B19880879A025

Model Risk Management

- Model risks occur because:
  - The model may have fundamental errors
  - The model may be used incorrectly or inappropriately
- Model risk management combines:
  - Model development and implementation processes
  - Model validation processes
  - Model governance process (roles, responsibilities)
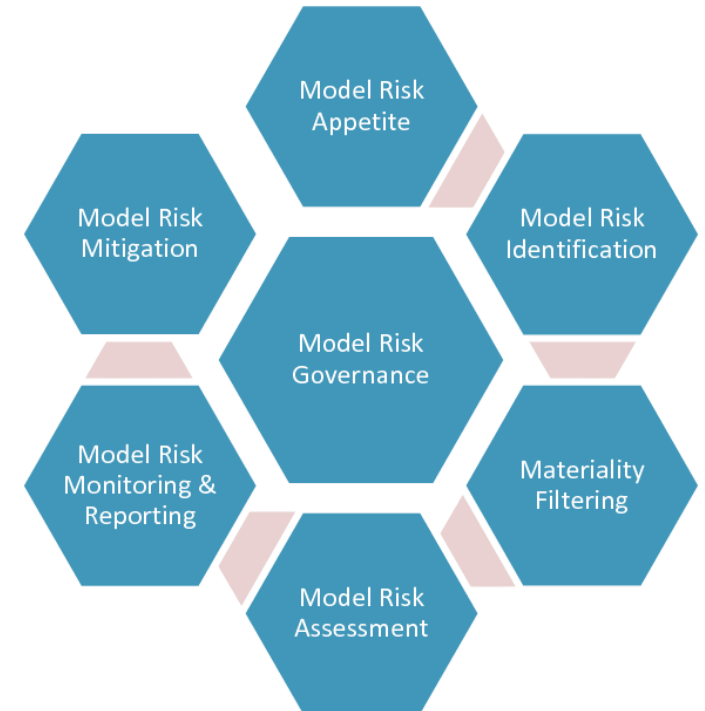
Board of Governors of the Federal Reserve System
https://www.federalreserve.gov/supervisionreg/srletters/sr1107a1.pdf
Image: https://www.researchgate.net/figure/The-Model-Risk-Management-Framework_fig4_277138848

Practices

Practice	Description
Stay in the operational field	Models can never simulate all the behavior/reactions of a system: they operate only in one limited field with a restricted number of variables. When a model is used, it is always necessary to make sure that the parameters and data inputs are part of the operation field. If not, there is a high risk of irregular outputs.
Evolve models	Models shall evolve during the project: by modification of parameter settings, by entering new data when modified (modification of assessment criteria, functions to perform, requirements, etc.), by the use of new tools when those used reach their limits.
Use several types of models	It is recommended to concurrently use several types of models in order to compare the results and/or to take into account another aspect of the system.
Keep context elements consistent	Results of a simulation shall always be given in their modeling context: tool used, selected assumptions, parameters and data introduced, and variance of the outputs.

https://www.sebokwiki.org/wiki/System_Analysis