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Artificial Intelligence

3rd year, 1st semester

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Course information

Course timetable

Course webpage

Evaluation:

- Written test at the end of the semester (PEx - maximum 10).
- Points given for attendance at the seminars (12 * 0.1 = P, maximum 1.2) , homework (2 * 2 + 5 * 1 = T, maximum 9).
- Project work (weeks 8-13 - PP, maximum 10).
- Grades are set using the formula ROUNDUP((1+P+T)*0.4 + PP*0.2 + PEx*0.4). To pass you need P+T minim 4 and PEx minimum 4.

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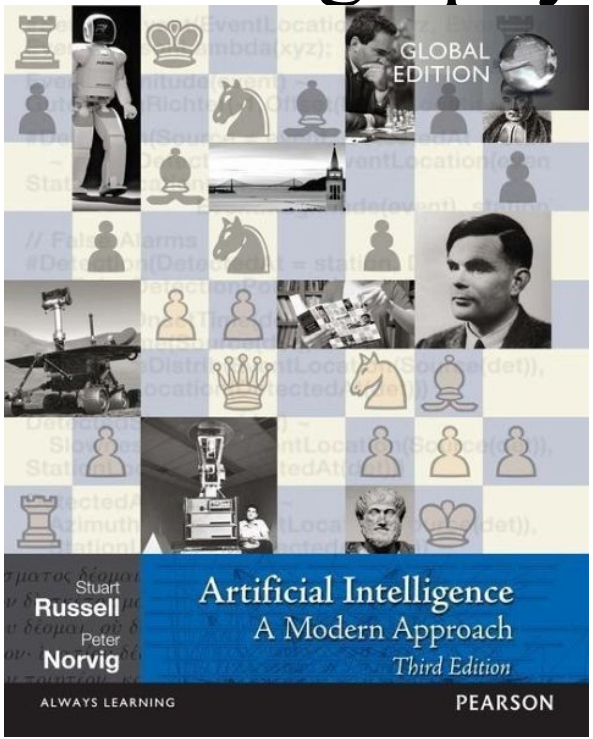
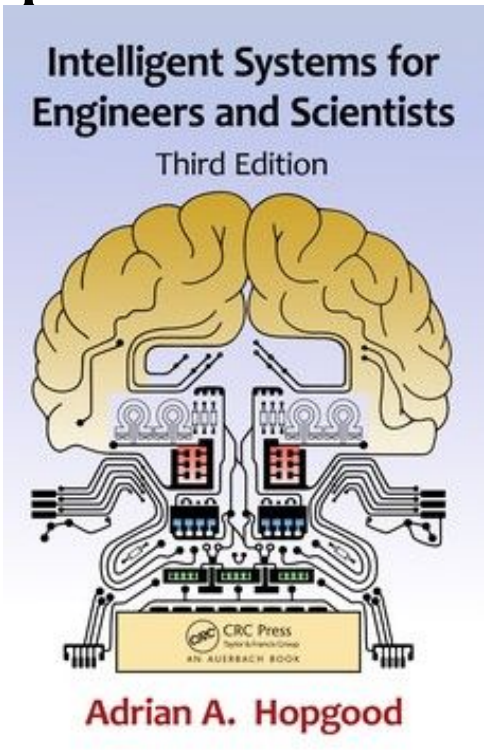
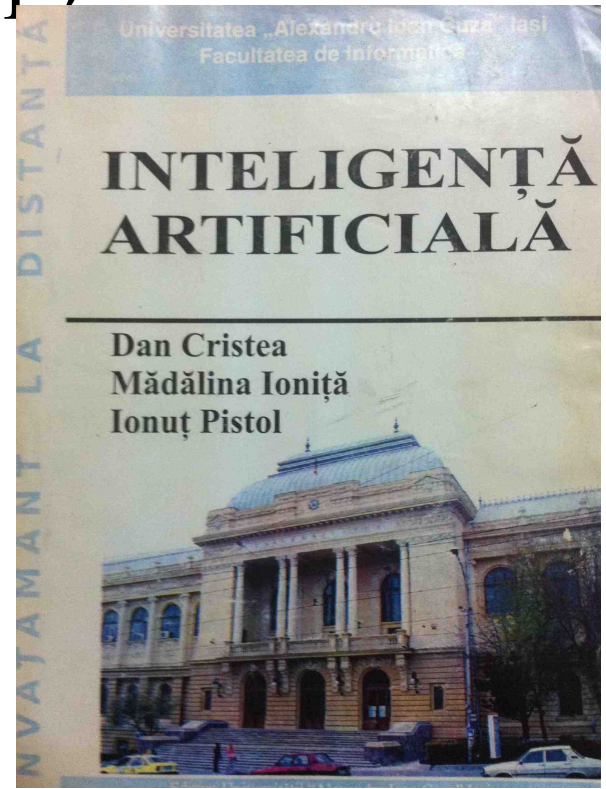
Bibliography (/~ipistol/IA/IA.zip)







Related course materials

Stanford: https://stanford-cs221.github.io/winter2021/

Berkeley: http://ai.berkeley.edu/lecture_videos.html

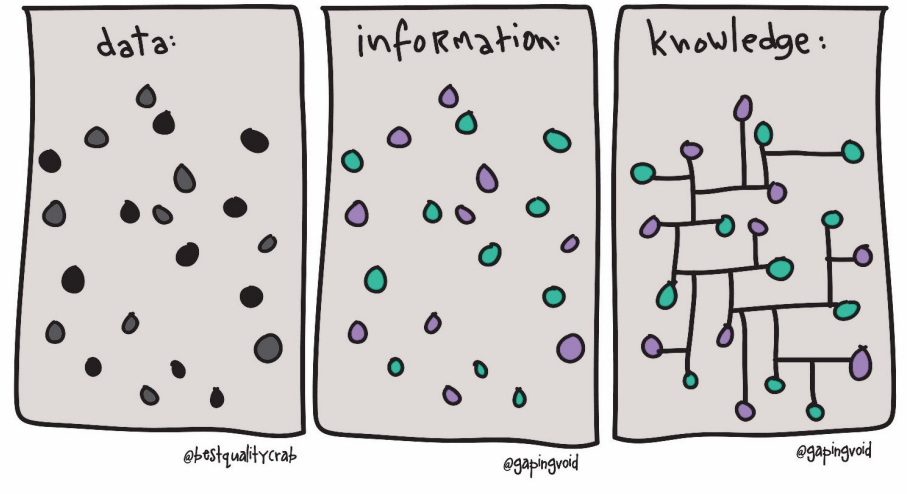
MIT: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-034-artificial-intelligence-fall-2010/lecture-videos/

What is knowledge?

Intelligence applied to information produces knowledge.

Knowledge supplements intelligence.

Intelligence is asking the right question, knowledge is having the right answer.



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What kind of course will this be?

Informative perspective

- Bottom-up approach: data>information>knowledge
- Useful when access to information is limited
- No guarantee that sufficient (or accurate) knowledge is obtained due to mostly unsupervised knowledge acquisition

Descriptive perspective

- Top-down approach: knowledge>information>data
- Useful when access to knowledge is limited
- No guarantee that available data will be interpreted in the context of the acquired knowledge

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Defining Artificial Intelligence

Artificial Intelligence: Wikipedia, Britannica, Merriam-Webster

Intelligence: Wikipedia, Britannica, Merriam-Webster

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Is this AI?

The following regex is sentient:

s/[Aa]re\s[Yy]ou\s\(.*\)?/Indeed, I am \1./

Input: “Are you sentient?”
Output: “Indeed, I am sentient.”

Input: “Are you capable of intelligence?”
Output: “Indeed, I am capable of intelligence.”

Input: “Are you going to take over the world?”
Output: “Indeed, I am going to take over the world.”

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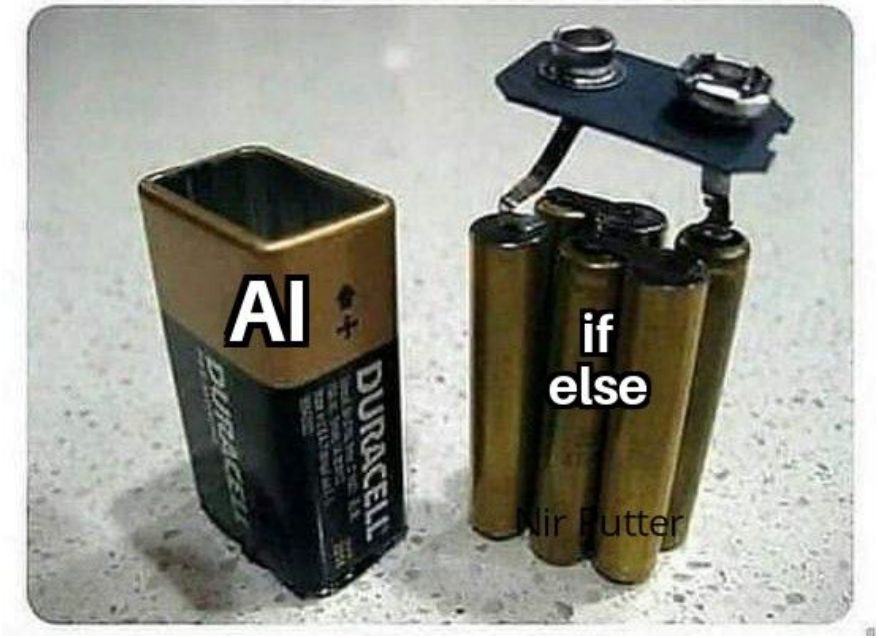
How about this?

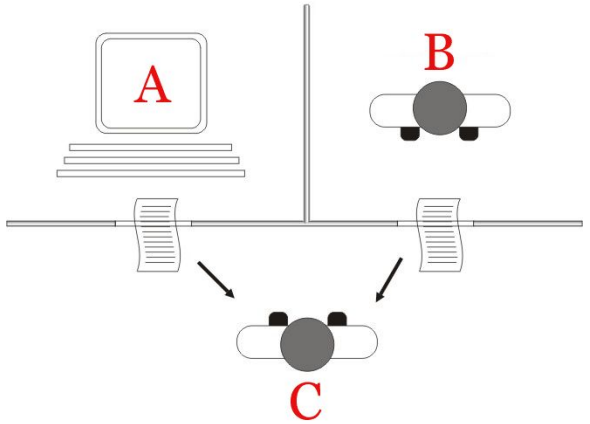
```
print("♜♞♝♛♚♝♞♜")
print("♟♟♟♟♟♟♟♟")
print("□ ■ □ ■ □ ■ □ ■")
print("■ □ ■ □ ■ □ ■ □")
print("□ ■ □ ■ □ ■ □ ■")
print("■ □ ■ □ ■ □ ■ □")
print("♙♙♙♙♙♙♙♙")
print("♖♘♗♕♔♗♘♖")

print("Your turn! 1.")
player = input()

if player == "e4":
    print("♜♞♝♛♚♝♞♜")
    print("♟♟♟♟♟♟♟♟")
    print("□ ■ □ ■ □ ■ □ ■")
    print("■ □ ■ □ ■ □ ■ □")
    print("□ ■ □ ■♙ ■ □ ■")
    print("■ □ ■ □ ■ □ ■ □")
    print("♙♙♙♙ □♙♙♙")
    print("♖♘♗♕♔♗♘♖")
elif player == "d4":
    print("♜♞♝♛♚♝♞♜")
    print("♟♟♟♟♟♟♟♟")
    print("□ ■ □ ■ □ ■ □ ■")
    print("■ □ ■ □ ■ □ ■ □")
    print("□ ■ □♙ □ ■ □ ■")
    print("■ □ ■ □ ■ □ ■ □")
    print("♙♙♙ ■♙♙♙♙")
    print("♖♘♗♕♔♗♘♖")
elif player == "e3":
```

This is not AI



Defining AI

- Turing test: is an average human able to distinguish between a human and a computer behind two terminals?
- Chinese room: is using rules equivalent to understanding?
- Strong vs weak AI



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Defining AI

Knowledge vs intelligence

Making decisions

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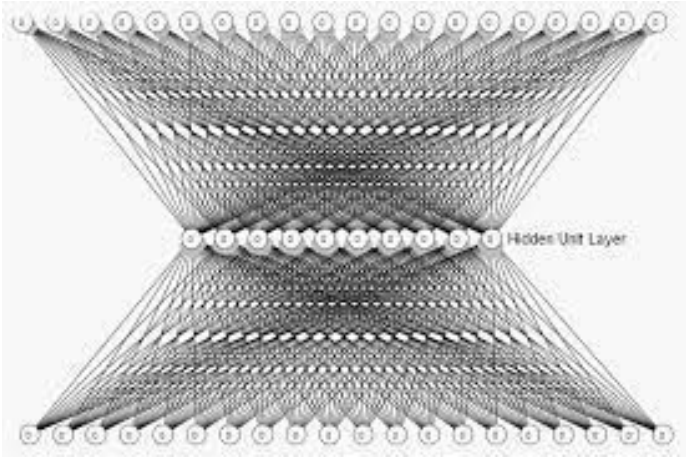
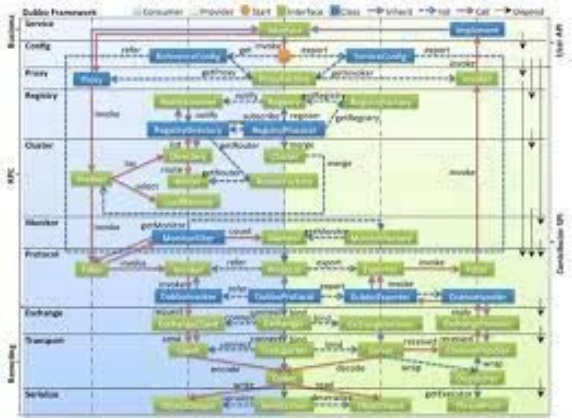
Connectionism vs computationalism: is intelligent behaviour a consequence or a goal?

Connectionism: intelligence is a product of structure



Computationalism: intelligence is a product of functions



Defining a functional and practical AI

An intelligent system has to be able to:

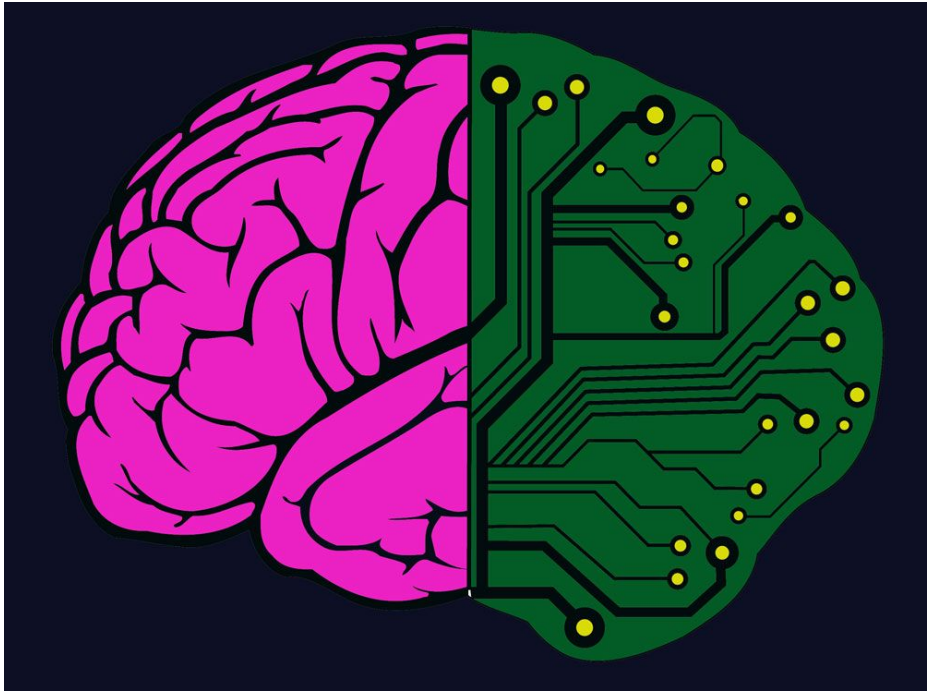
- Understand a model and a goal
- Recognize and be able to employ means to reach the goal
- **Decide** if and when to use those means
- Provide a satisfactory answer for the established goal

Four perspectives on AI: Acting humanly

- Computer manifest human capabilities: NLP, knowledge representation, reasoning, learning
- Pro: human intelligence is the highest form
- Cons: bird flight is the best kind of flight?

Four perspectives on AI: Thinking humanly

- Computer has similar thinking mechanisms as humans: artificial “brains” - replicated biological cognitive processes
- Pro: easy to explain and evaluate results
- Cons: do we know how humans think?

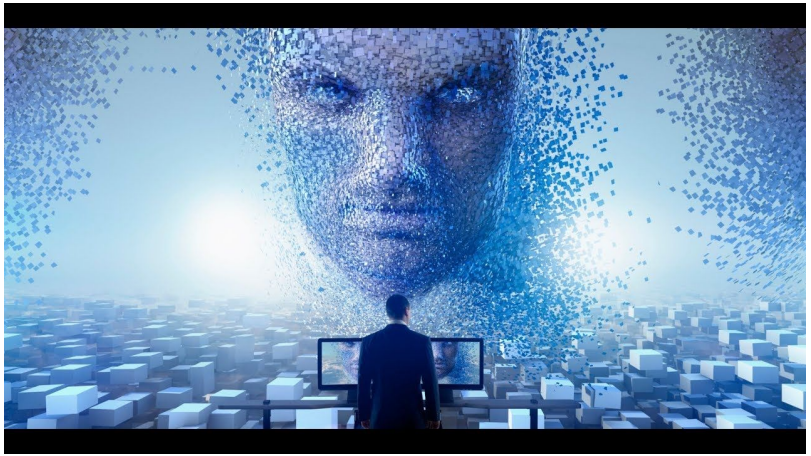


Four perspectives on AI: Thinking rationally

- Computer reasons using an accepted deductive system (a set of logical rules)
- Pro: Easy to replicate, easy to prove
- Cons: Informal knowledge is not conductive to formal rules, logical solutions are not conductive to informal realities

Four perspectives on AI: Acting rationally

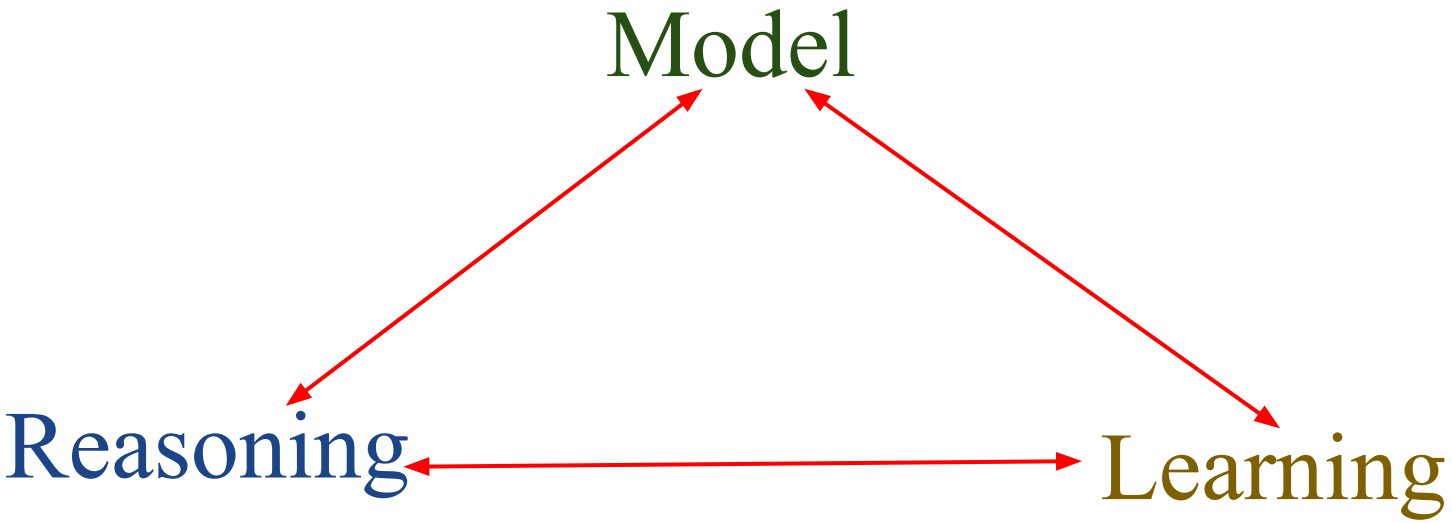
- Computer produces rational results: rational agents with well defined scopes
- Pro: most useful results, most common type of AI
- Cons: who defines the goals? can it really do everything? unexplainable AI



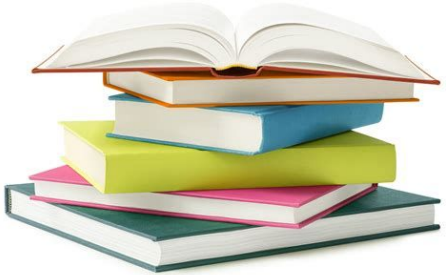
Four types of AI

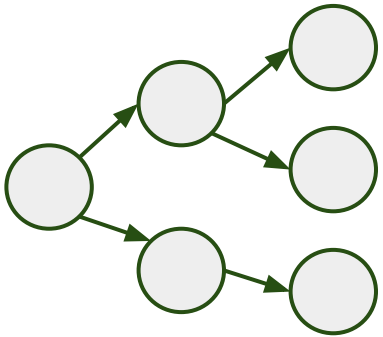
- **Reactive Machines**: AI produces an output based on the provided current goal. Significant techniques: rules (deterministic or stochastic), neural networks, state and variable based models.
- **Limited Memory**: AI adapts using current experiences in order to improve future behaviour. Significant techniques: reinforcement learning, genetic algorithms - evolutive networks, LSTM models.
- **Theory of Mind**: AI capable of analyzing, processing and predicting the human mind (behaviour and goals).
- **Self Aware**: AI capable of setting it's own goals and changing its own behaviour.

The pillars of modern AI



Modeling

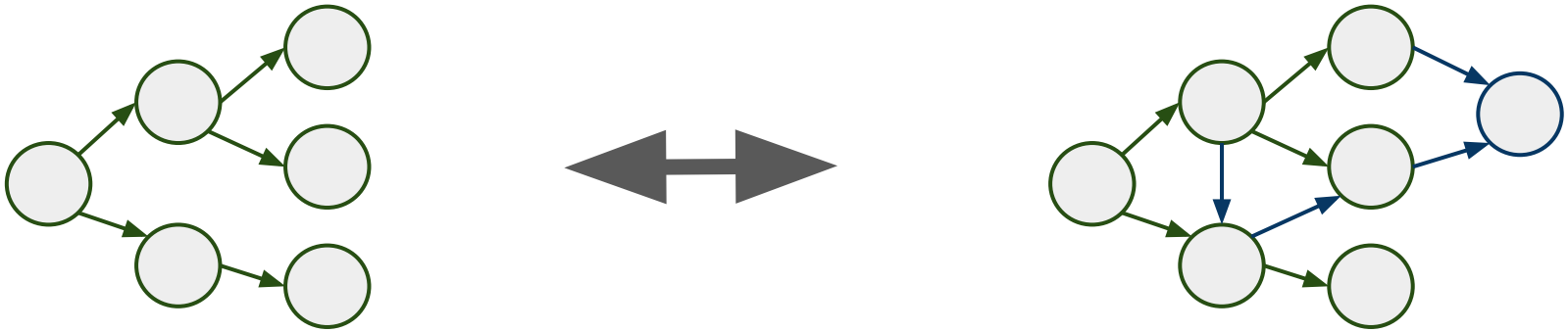




An AI engine should be able to describe, work with and output real-world data

All models are lossy

Reasoning



An AI engine should be able to discover new data (concepts, relations) from the available data

Inferred data can be contradicted by real data - exceptions are messy

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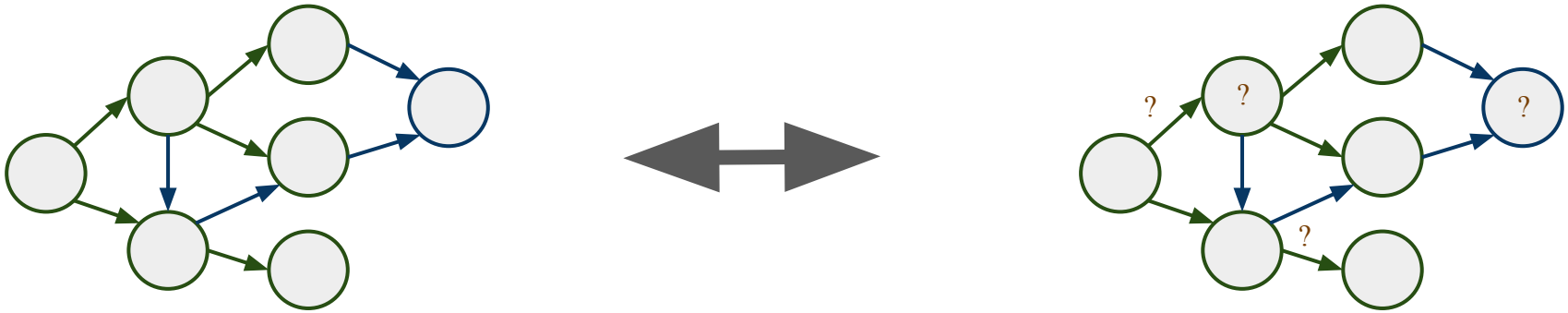
Learning



An AI engine should be able to adapt it's model for particular contexts

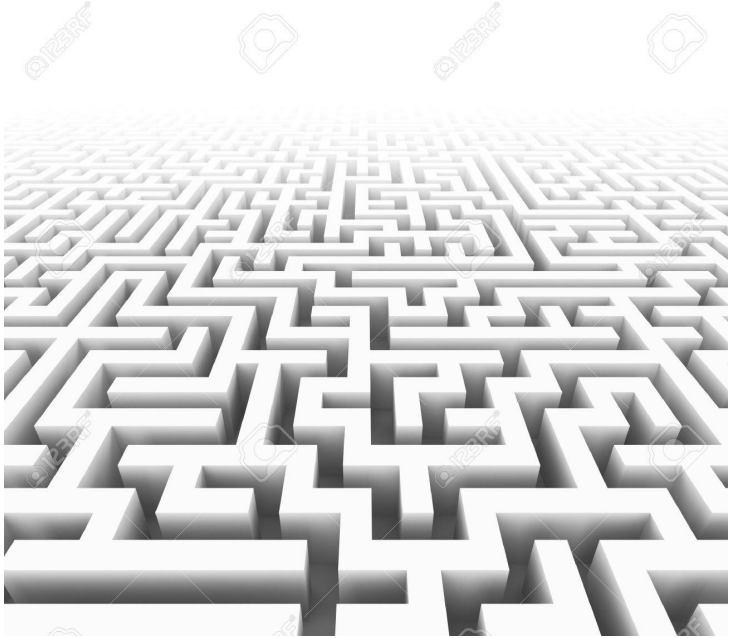
What is learned is at best as good as the available data

We aim to develop rational AI systems:

- we define a problem and goals (instances)
- the AI reaches the goals (solves the instances)
- the AI outputs the result (unexplainable AI) or the solution (explainable AI)

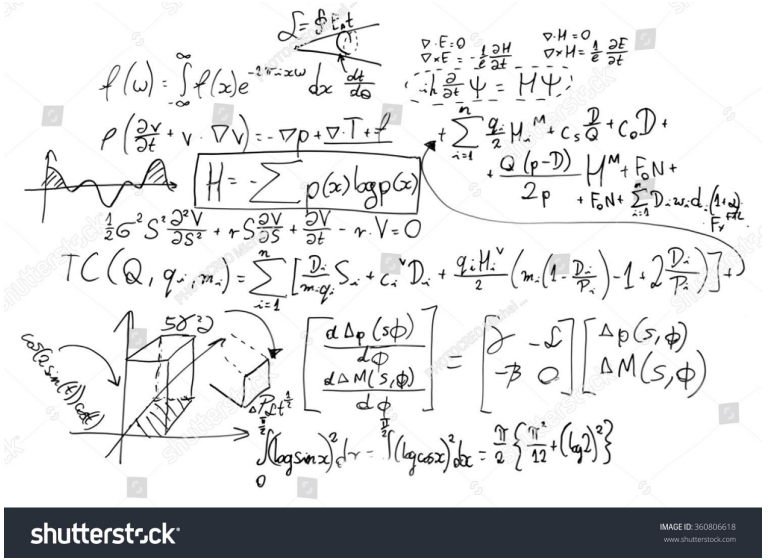
First approach: state-based models

- in what way should I change the current *state* of the problem in order to get closer or reach the goal?
- compute a solution (algorithm - sequence of transitions) starting from an initial *state* and ending in the goal *state*
- mostly covered by search strategies, reasoning systems, AI for games



Second approach: variable-based models

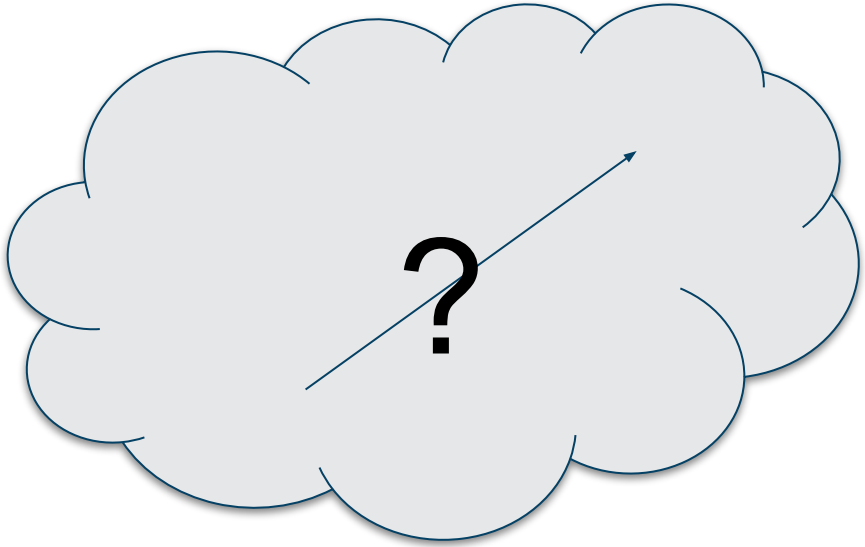
- what formula (function) can be applied to the problem data in order to output the goal?
- start from arbitrary formulas, test them over the expected results and adjust accordingly
- mostly covered by machine learning and constraint satisfaction problems



Course synopsis

Weeks 2 and 3: State-based models

- (Decision) problems
- Representing states
- Search strategies
- Deterministic and non-deterministic problem spaces



Can the computer solve NP-complete problems?

Course synopsis

Week 4: Constraint satisfaction problems

- Variable-based models
- Soft constraints
- Optimisations

Can the computer satisfy constraints over variables in a model?

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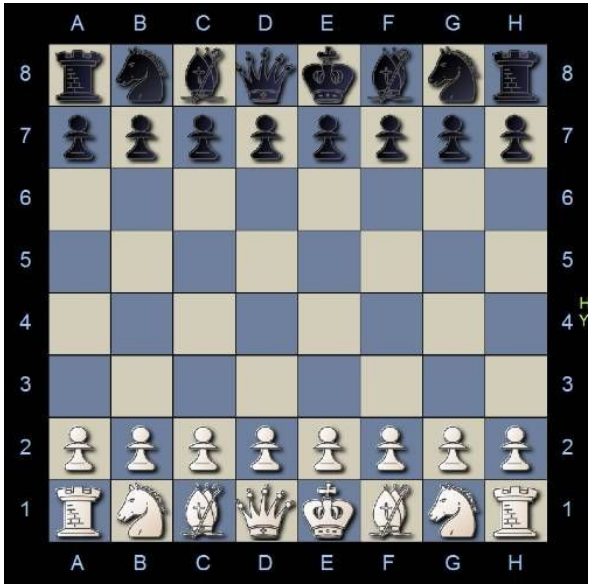
		7	2	6		4	8	
4			9	3	5			6
	3		4	8		2		
	4	1	6		9	3		
		6				8	9	
5	7	8		4				2
			3				7	
2								5

Course synopsis

Week 5: Games

- Types of games
- Games theory
- Strategies

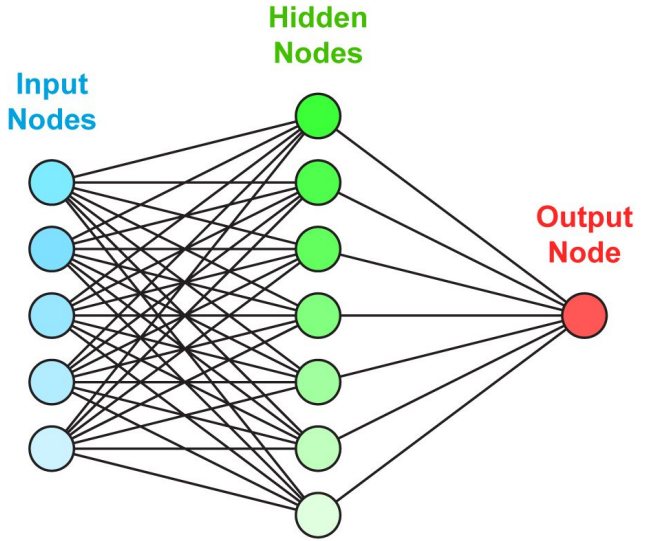
Can the computer play games competitively?



Course synopsis

Weeks 6: Neural networks

- Perceptrons
- Machine learning
- Applications in games and NLP



Can the computer learn anything?

Course synopsis

Weeks 6-7-10: Reinforcement learning and applications

- Markov decision process
- Q Learning

df	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	20
1	180.1	270.1	328.5	371.2	404.4	431.6	454.4	474.0	491.1	506.3	520.0	532.4	543.6	554.0	563.6	580.9	596.0
2	19.93	26.97	31.60	35.02	37.73	39.95	41.83	43.46	44.89	46.16	47.31	48.35	49.30	50.17	50.99	52.45	53.74
3	10.55	13.50	15.45	16.91	18.06	19.01	19.83	20.53	21.15	21.70	22.20	22.66	23.08	23.46	23.82	24.46	25.03
4	7.916	9.814	11.06	11.99	12.74	13.35	13.88	14.33	14.74	15.10	15.42	15.72	15.99	16.24	16.48	16.90	17.28
5	6.751	8.196	9.141	9.847	10.41	10.88	11.28	11.63	11.93	12.21	12.46	12.69	12.90	13.09	13.27	13.60	13.89
6	6.105	7.306	8.088	8.670	9.135	9.522	9.852	10.14	10.40	10.63	10.83	11.02	11.20	11.36	11.51	11.78	12.02
7	5.699	6.750	7.429	7.935	8.339	8.674	8.961	9.211	9.433	9.632	9.812	9.977	10.13	10.27	10.40	10.64	10.85
8	5.420	6.370	6.981	7.435	7.797	8.097	8.354	8.578	8.777	8.955	9.117	9.265	9.401	9.527	9.644	9.857	10.04
9	5.218	6.096	6.657	7.074	7.405	7.680	7.915	8.120	8.303	8.466	8.614	8.749	8.874	8.990	9.097	9.292	9.465
10	5.065	5.888	6.412	6.800	7.109	7.365	7.584	7.775	7.944	8.096	8.234	8.360	8.476	8.583	8.683	8.865	9.026
11	4.945	5.727	6.222	6.588	6.878	7.119	7.325	7.505	7.664	7.807	7.937	8.055	8.164	8.265	8.359	8.530	8.682
12	4.849	5.597	6.068	6.416	6.693	6.922	7.118	7.288	7.439	7.575	7.697	7.810	7.914	8.009	8.099	8.261	8.405
13	4.770	5.490	5.943	6.277	6.541	6.760	6.947	7.111	7.255	7.384	7.502	7.609	7.708	7.800	7.886	8.040	8.178
14	4.704	5.401	5.838	6.160	6.414	6.626	6.805	6.962	7.101	7.225	7.338	7.442	7.537	7.625	7.707	7.856	7.988
15	4.647	5.325	5.750	6.061	6.308	6.511	6.685	6.837	6.971	7.091	7.200	7.300	7.392	7.477	7.556	7.699	7.827
16	4.599	5.261	5.674	5.977	6.216	6.413	6.582	6.729	6.859	6.976	7.081	7.178	7.267	7.349	7.426	7.566	7.689
17	4.557	5.205	5.608	5.903	6.136	6.329	6.493	6.636	6.763	6.876	6.979	7.072	7.159	7.239	7.314	7.449	7.569
18	4.521	5.156	5.550	5.839	6.067	6.255	6.415	6.554	6.678	6.788	6.888	6.980	7.064	7.142	7.215	7.347	7.464
19	4.488	5.113	5.500	5.783	6.005	6.189	6.346	6.482	6.603	6.711	6.809	6.898	6.981	7.057	7.128	7.257	7.372
20	4.460	5.074	5.455	5.732	5.951	6.131	6.285	6.418	6.537	6.642	6.738	6.826	6.907	6.981	7.051	7.177	7.289
24	4.371	4.955	5.315	5.577	5.783	5.952	6.096	6.221	6.332	6.431	6.520	6.602	6.677	6.747	6.812	6.930	7.034
30	4.285	4.841	5.181	5.428	5.621	5.780	5.914	6.031	6.135	6.227	6.310	6.387	6.456	6.521	6.581	6.691	6.788
40	4.202	4.731	5.053	5.284	5.465	5.614	5.739	5.848	5.944	6.030	6.108	6.179	6.244	6.304	6.360	6.461	6.550
60	4.122	4.625	4.928	5.146	5.316	5.454	5.571	5.673	5.762	5.841	5.913	5.979	6.039	6.094	6.146	6.239	6.321
120	4.045	4.523	4.809	5.013	5.172	5.301	5.410	5.504	5.586	5.660	5.726	5.786	5.842	5.893	5.940	6.025	6.101
inf	3.970	4.424	4.694	4.886	5.033	5.154	5.255	5.341	5.418	5.485	5.546	5.602	5.652	5.699	5.742	5.820	5.889

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Course synopsis

Weeks 9-11: Knowledge representation and NLP

- Ontologies
- Understanding natural language
- Language ambiguity

Can the computer talk to us using our language?

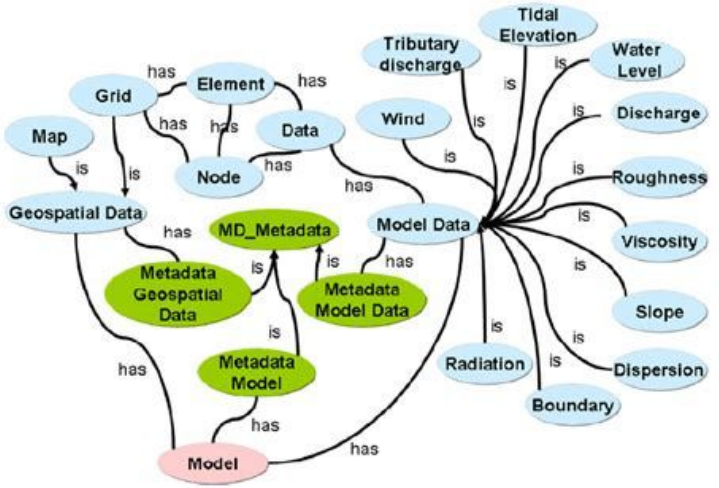


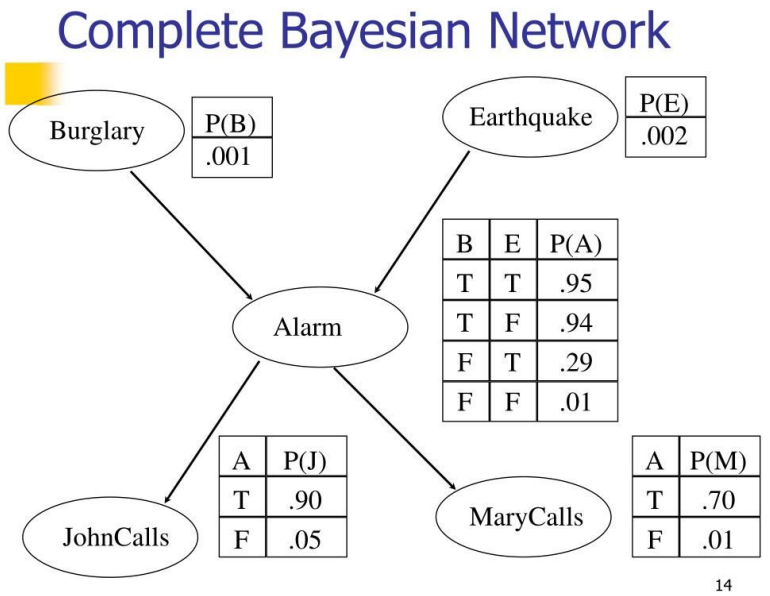
Fig. 2. Ontology for data and metadata of a numerical model.

Course synopsis

Week 12: Bayesian networks

- Reasoning with probabilities
- Independence and conditional independence

Can the computer decide and learn on probabilistic data?



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Week 13: Planning

- STRIPS and PDDL
- Forward and backward search

Can the computer find a plan which is guaranteed to succeed?