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Artificial Intelligence

3rd year, 1st semester

”Science is the belief in the ignorance of experts.” Richard Feynman

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Course information

Timetable

Course webpage

Discord server

Evaluation:

- Points given for project tasks (4) and written tests (3) at seminars(4 X 1 + 3 X 2 = L, maximum 10).
- Project (PP, maximum 10).
- Written exam (E, maximum 10).
- Bonus points for course and lab activity (B).
- Grades are given using the formula ROUND(L*0.4 + PP*0.2 + E*0.4 + B). To pass you need E at least 5 and final score of at least 4.5.

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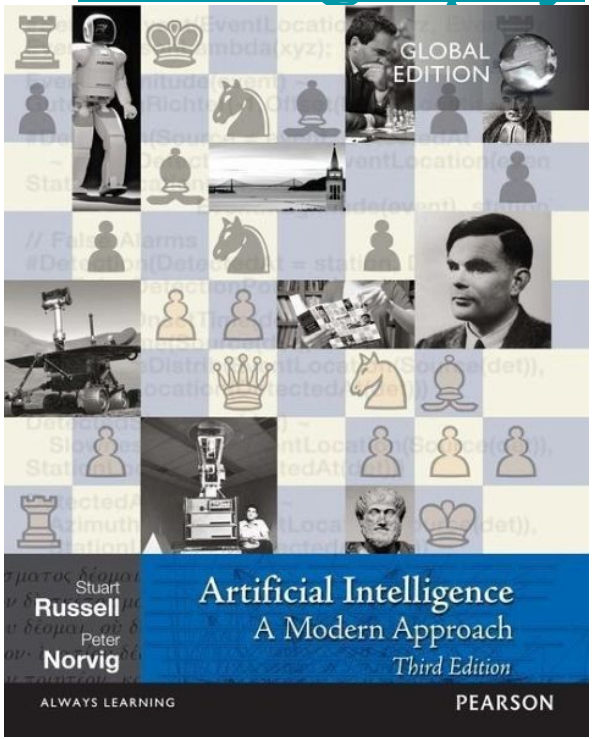
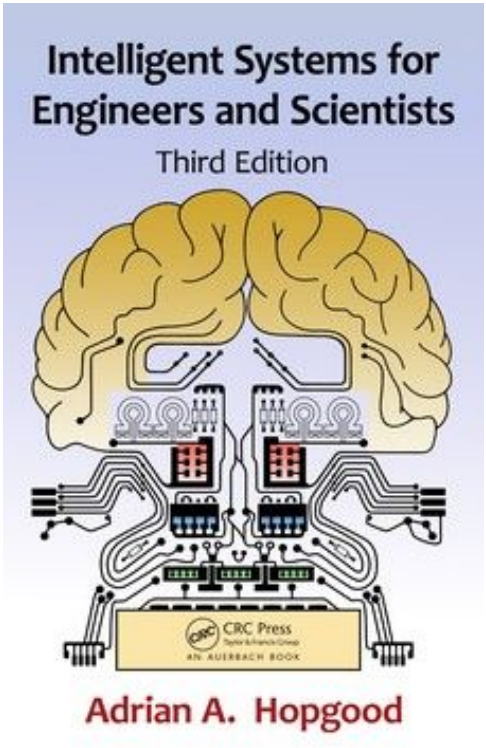
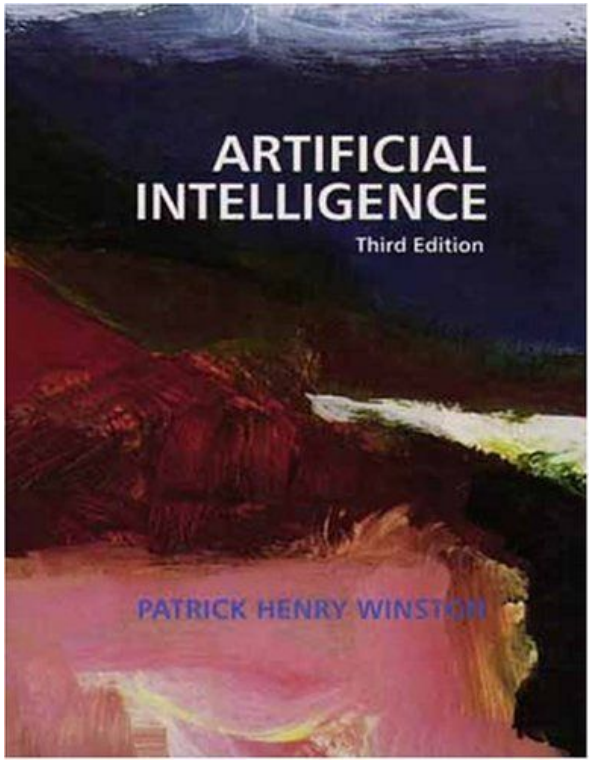
Bibliography







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Related course materials

CS221: Artificial Intelligence: Principles and Techniques

Massachusetts
Institute of
Technology

Lecture Videos | Artificial Intelligence | Electrical Engineering and Computer Science | MIT OpenCourseWare

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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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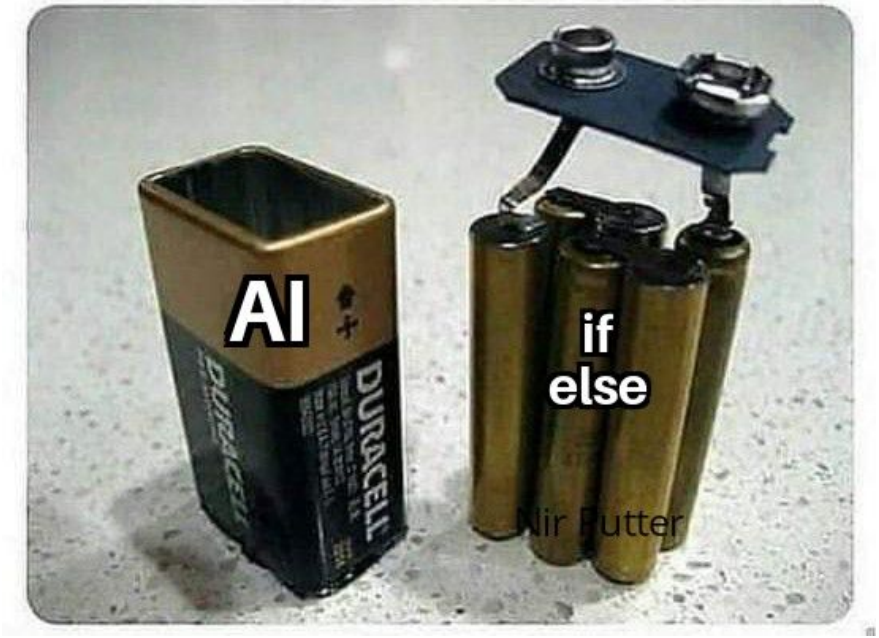
How about this?

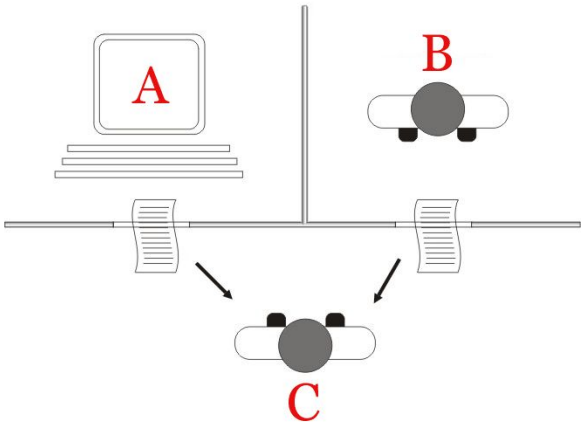
```
print("♜♞♝♛♚♝♞♜")
print("♟♟♟♟♟♟♟♟")
print("□ ■ □ ■ □ ■ □ ■")
print("■ □ ■ □ ■ □ ■ □")
print("□ ■ □ ■ □ ■ □ ■")
print("■ □ ■ □ ■ □ ■ □")
print("♙♙♙♙♙♙♙♙")
print("♖♘♗♕♔♗♘♖")

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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Brief history of conversational agents: 50s to 70s - templates and regular expressions

```
<aiml version="1.0.1" encoding = "UTF-8"?>
   <category>
      <pattern> HELLO ALICE </pattern>
      <template>
         Hello User
      </template>
   </category>
</aiml>
```

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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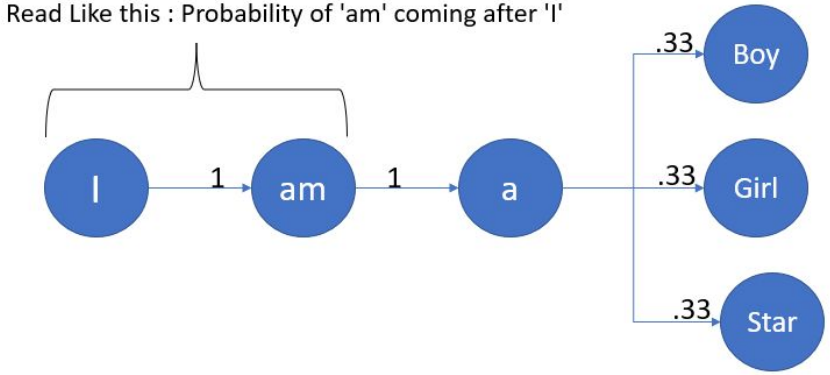
Brief history of conversational agents: 80s to 2000s - language models and Markov chains



Current State \ Next State	I	am	a	Boy	Girl	Star
I	0	1	0	0	0	0
am	0	0	1	0	0	0
a	0	0	0	1	1	1
Boy	0	0	0	0	0	0
Girl	0	0	0	0	0	0
Star	0	0	0	0	0	0

Read Like this : After 'I' which word(s) has appeared?
Only one word that is 'am' so the probability will be 1

Read Like this : After 'a' which word(s) has appeared?
3 words appeared 'Boy','Girl','Star'.
So out of these 3 word what is the probability of those 3 words appearing after a? Ans 1/2

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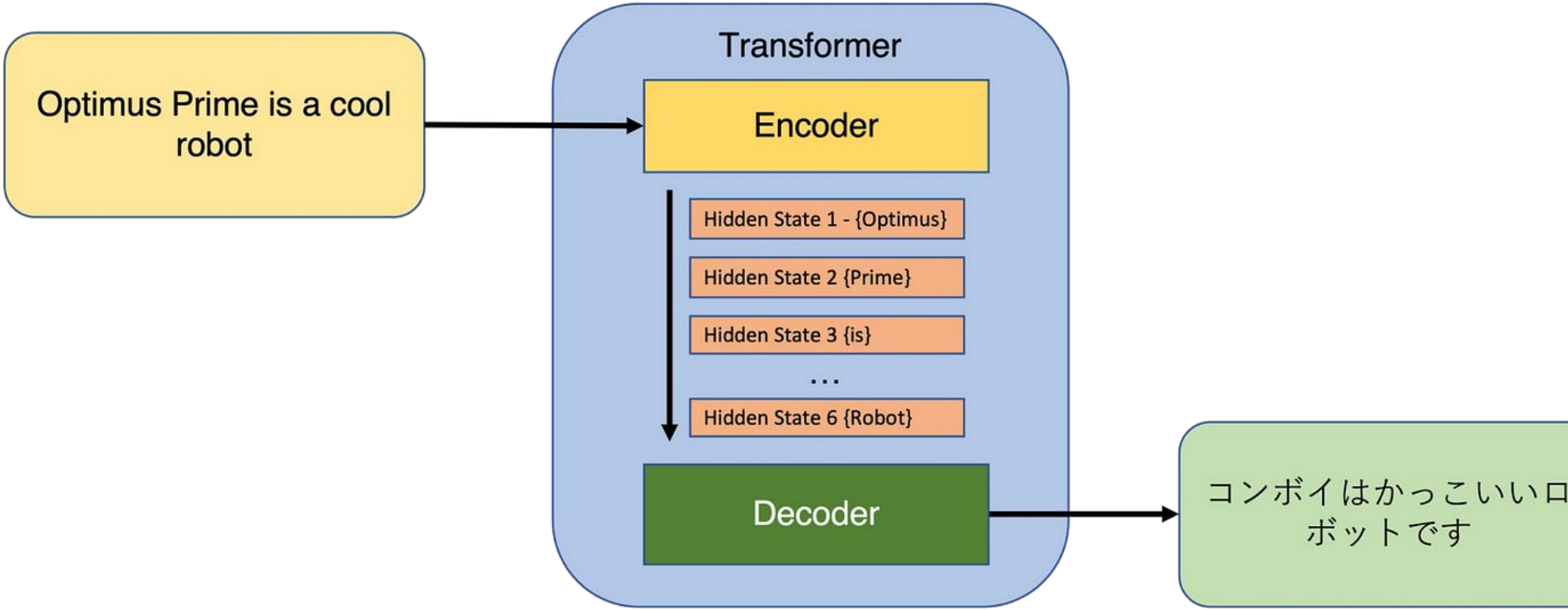
Brief history of conversational agents: Current state-of-the-art - Transformers and Reinforcement Learning



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To conclude this interlude…

- ChatGPTs are conversational agents, not AIs or LLMs
- Current conversational agents don’t think, they just re-use approximate human reasoning
- They need to hallucinate to cover inevitable lack of coverage
- They are (and should be used as) powerful search and summarisation engines, editors and virtual assistants.
- For this year’s project you will be required to use them.

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Defining AI

Knowledge vs intelligence

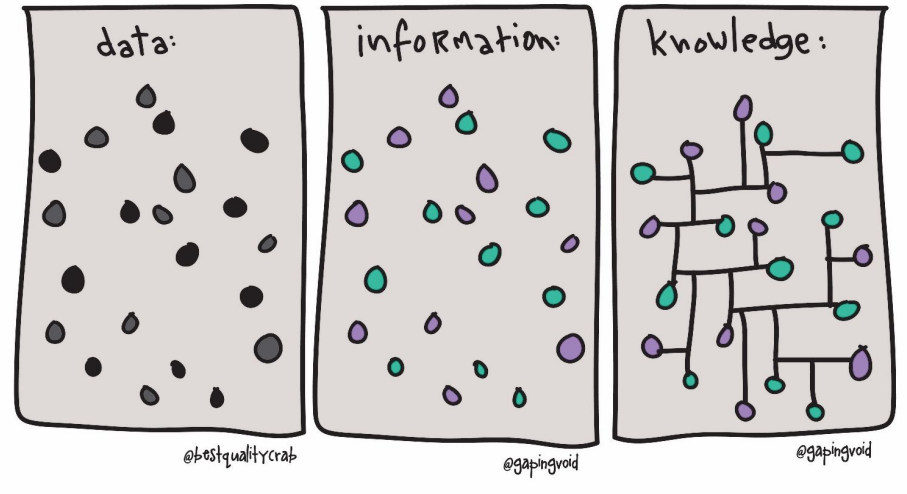
Making decisions

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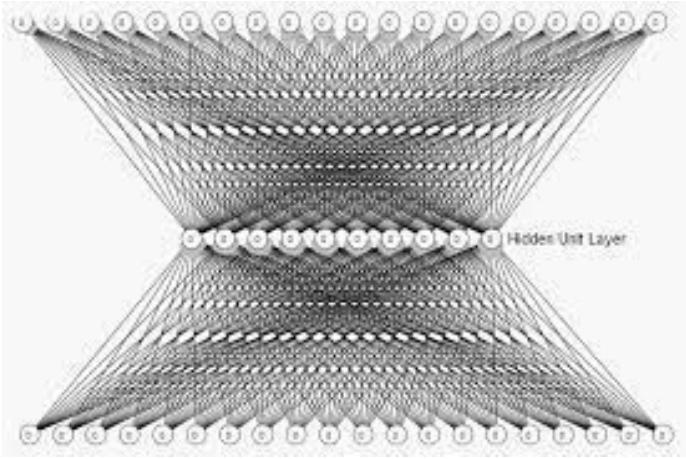
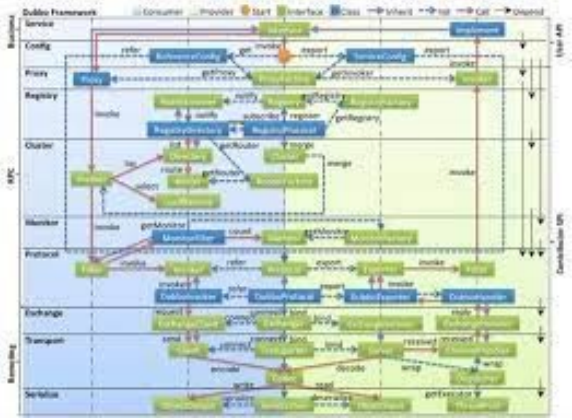
Connectionism vs computationalism: is intelligent behaviour a consequence or a goal?

Connectionism: intelligence is a product of structure



Computationalism: intelligence is a product of functions

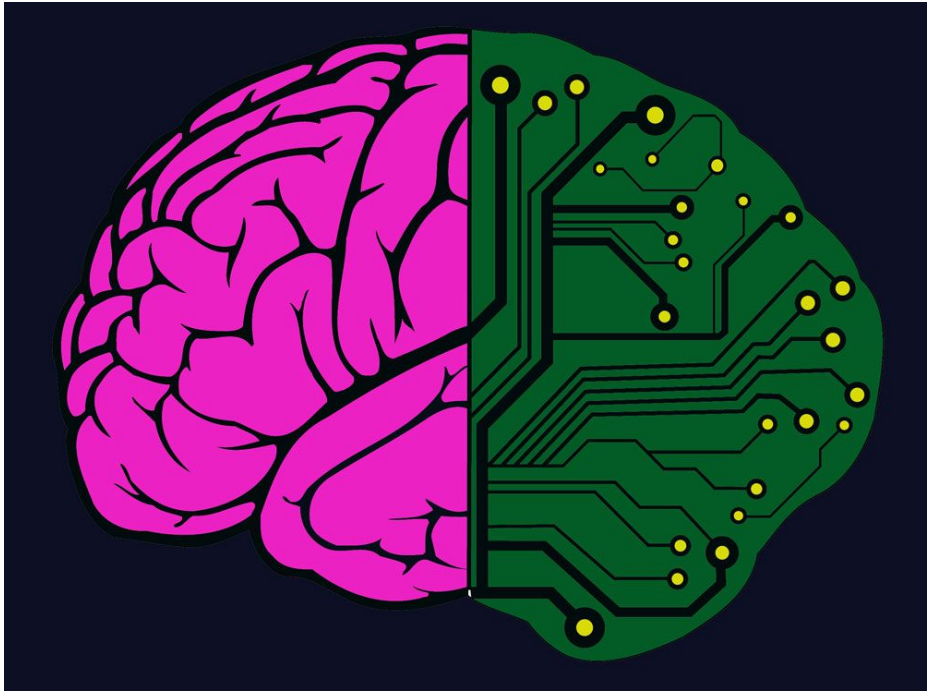


Four perspectives on AI: Acting humanly

- 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?

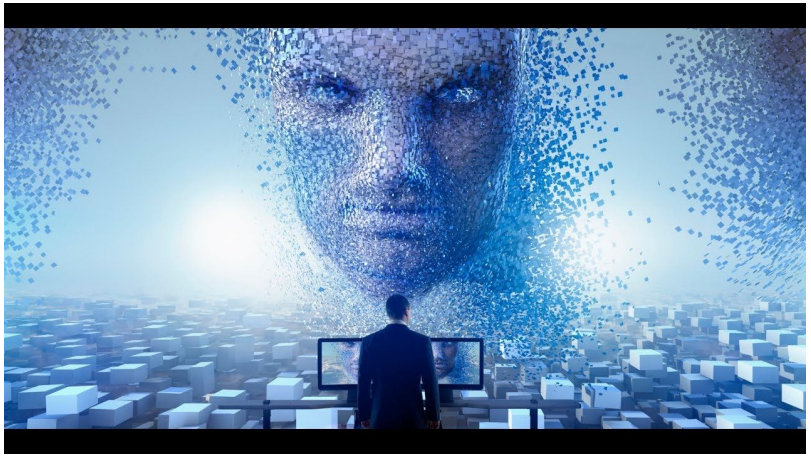


Four perspectives on AI: Thinking rationally

- 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 functional 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.

Defining a reasonable and practical decision system

An decision (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

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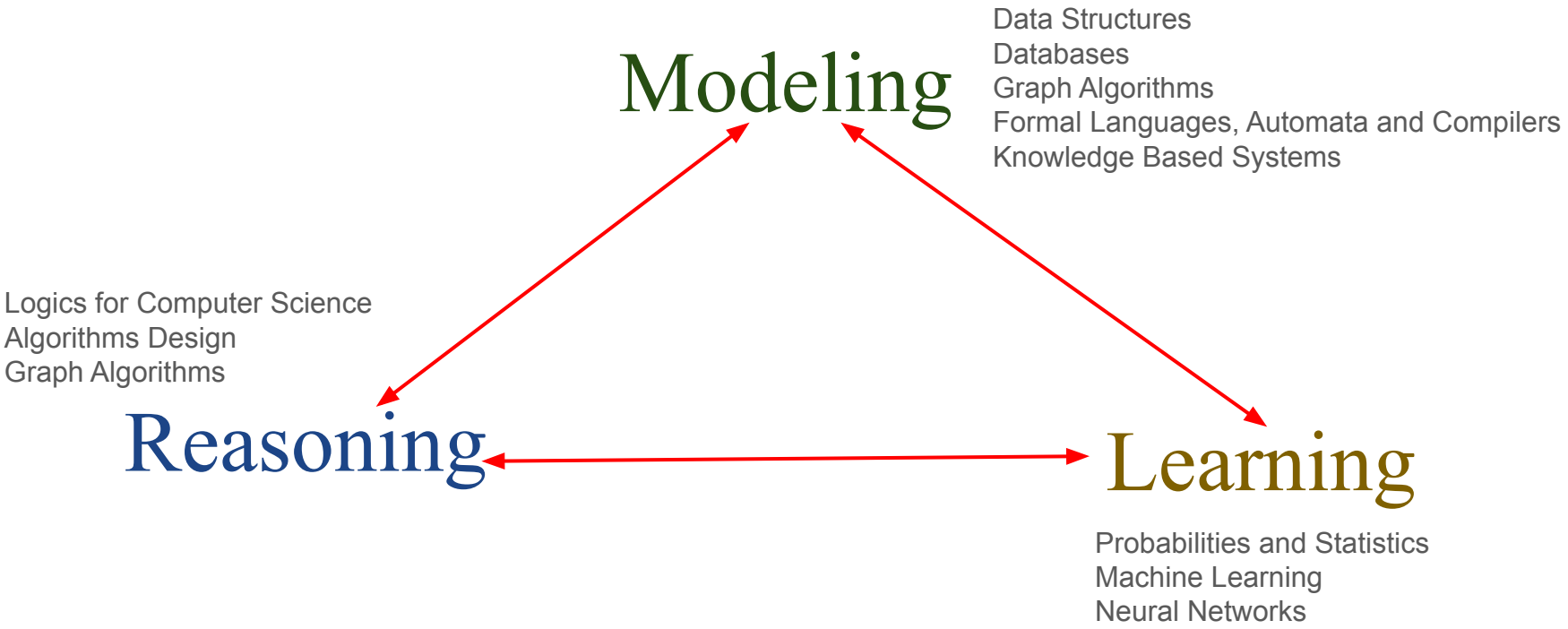
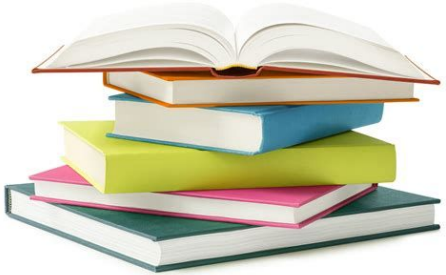
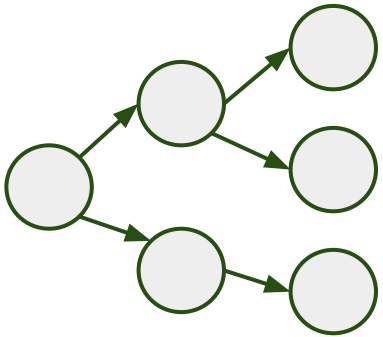
The pillars of modern AI



Modeling

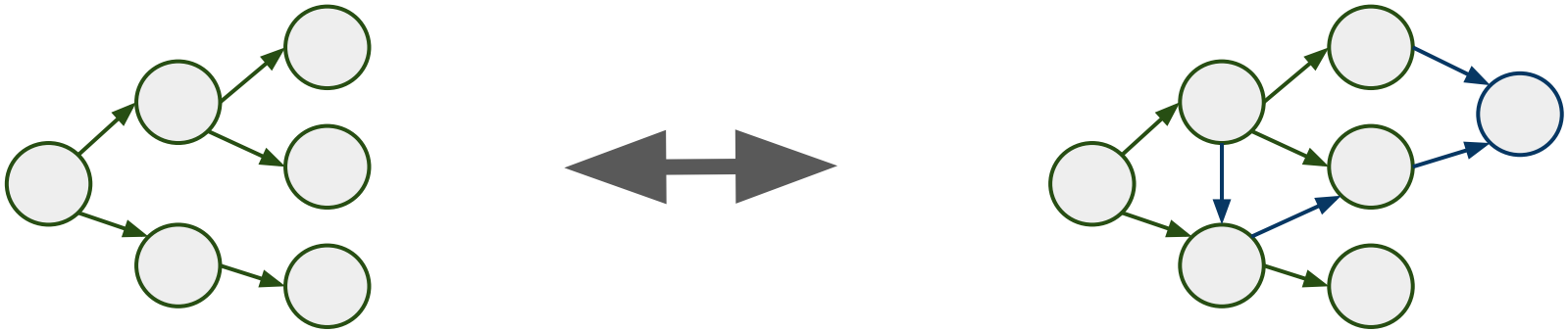




An AI engine should be able to describe, work with and output real-world data

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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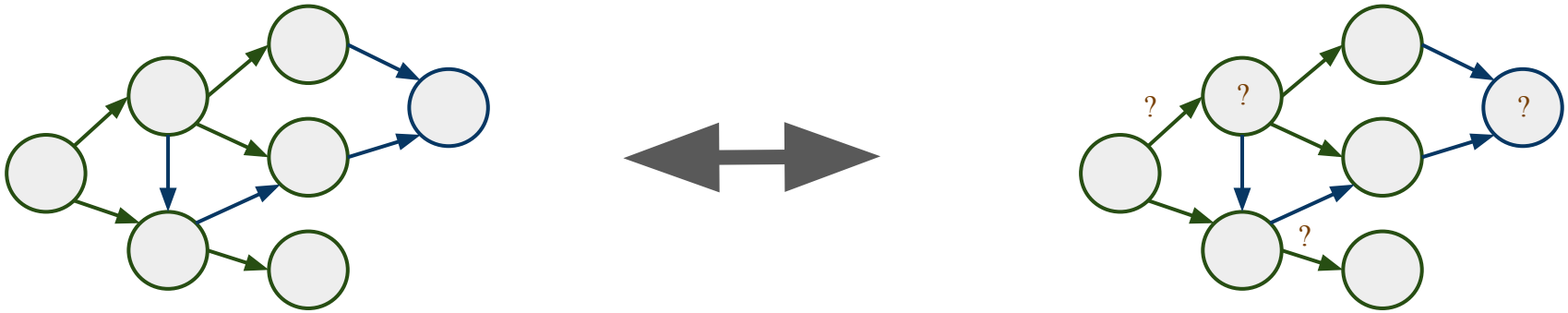
Learning

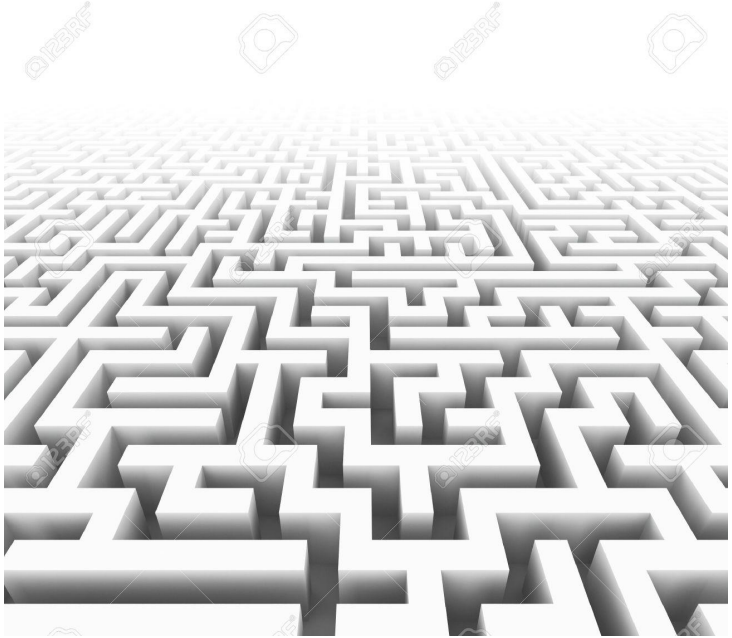


An AI engine should be able to adapt it's model for particular contexts

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

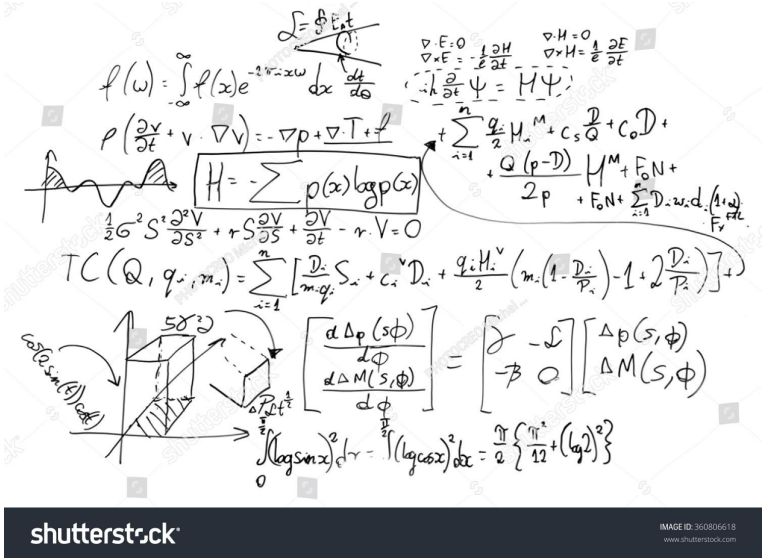
First approach: state-based models

- 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

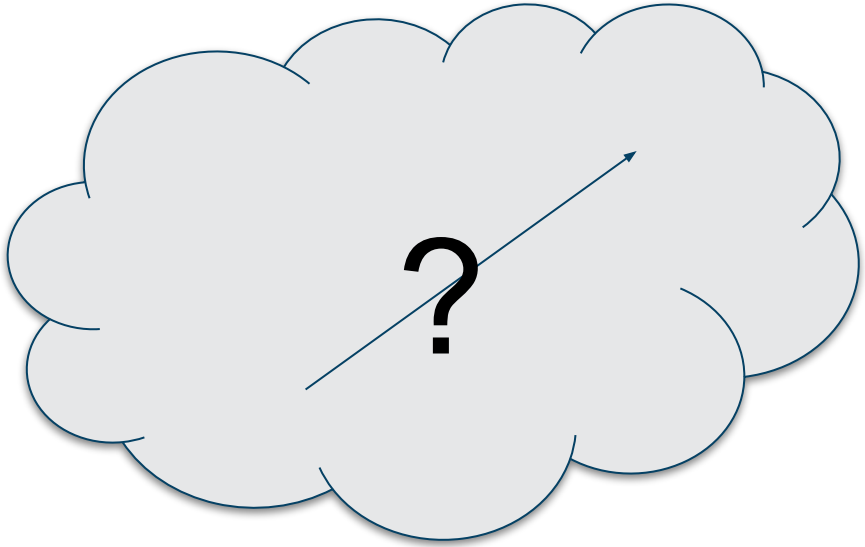
- what formula (function) can be applied to the problem data in order to output the goal?
- start from arbitrary formulas, test them over the expected results and adjust accordingly
- mostly covered by machine learning and constraint satisfaction problems



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?

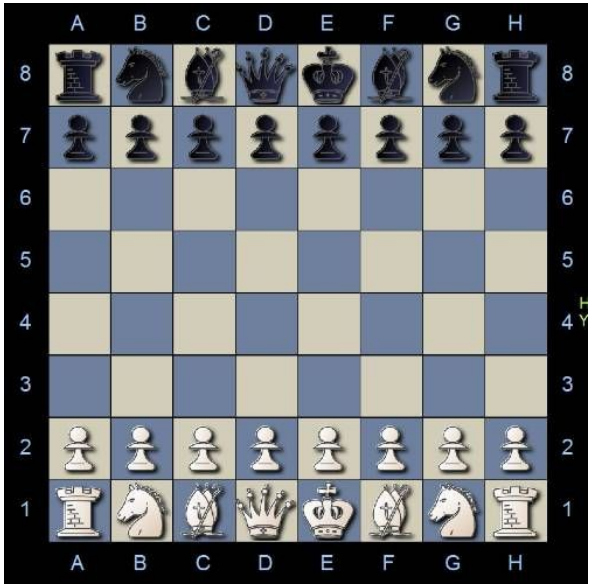
1								3
		7	2	6		4	8	
4			9	3	5			6
	3		4	8		2		
	4	1	6		9	3		
		6				8	9	
5	7	8		4				2
			3				7	
2								5

Course synopsis

Week 5: Games

- Types of games
- Games theory
- Strategies

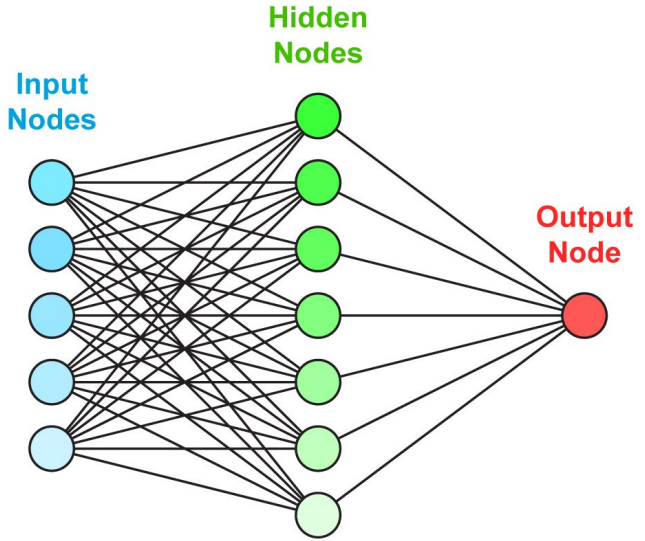
Can the computer play games competitively?



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?

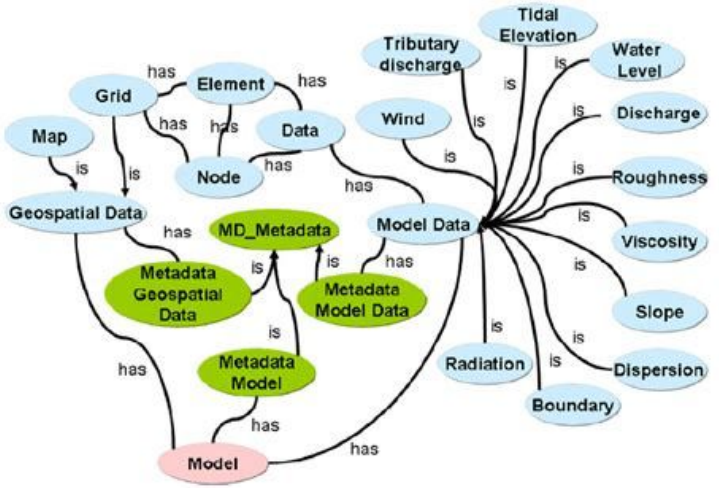


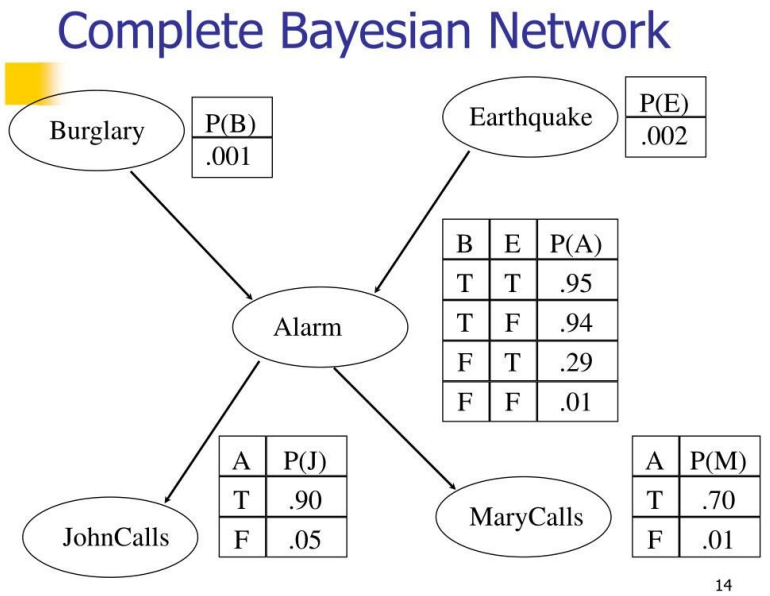
Fig. 2. Ontology for data and metadata of a numerical model.

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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Course synopsis

Week 13: Planning

- STRIPS and PDDL
- Forward and backward search

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

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More about AI

[Why Intelligence Is Not a Computational Process]

[von Neumann bottleneck]

[Reasoning agents]