UNIVERSITÄT DES SAARLANDES

30 YEARS DFKI Human Centric AI.

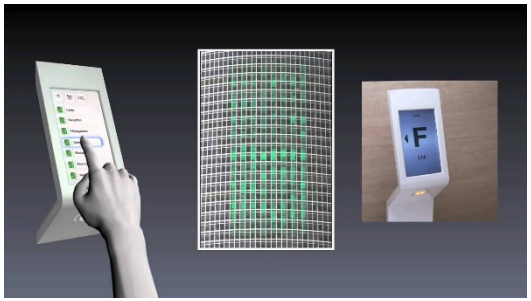
Artificial Intelligence – What is it?

Prof. Dr. habil. Jana Koehler

Artificial Intelligence - Summer 2019

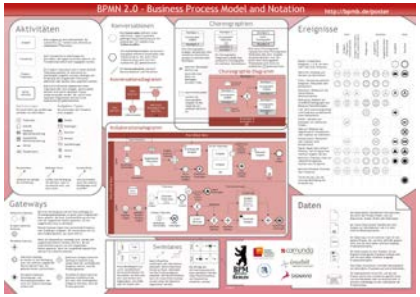
About Myself

- Education
  - Computer Science in Berlin
  - PhD in AI Planning at DFKI
  - Visiting Professor: U Linköping, U Maryland
  - ICSI Berkeley, U Freiburg (Habilitation)



https://www.theporttechnology.com/

- Schindler AG Switzerland 1999 -2001
- IBM Research Zurich 2001-2010
  - WebSphere BPM Suite & SOA & EA
  - Contributor BPMN 2.0 Standard
- Hochschule Luzern 2010-2018
  - Industry projects, SNF, SGAICO, own company



https://www.omg.org/spec/BPMN/2.0/
(poster from signavio.com)

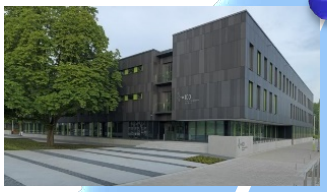
- DFKI CEO since 2/2019
  - Having it all? … Best paper awards, managerial experience, patents, ….

About DFKI

Bremen

Berlin

Osnabrück



Kaiserslautern

Saarbrücken

- Est. 1988
- >1000 people
- 29 professors
- 50 Mio in projects
- 25 % from industry

Living Labs, Competence Centers, Transfer Labs, ...

Innovative Retail Lab (IRL)

Advanced Driver Assistance Systems Living Lab (ADAS)

Bremen Ambient Assisted Living Lab (BAALL)

Smart Factory

Robotics Exploration Lab (RIC)

Smart City Living Lab

Smart Office Space

Achieving Innovation

The Beginnings of Artificial Intelligence

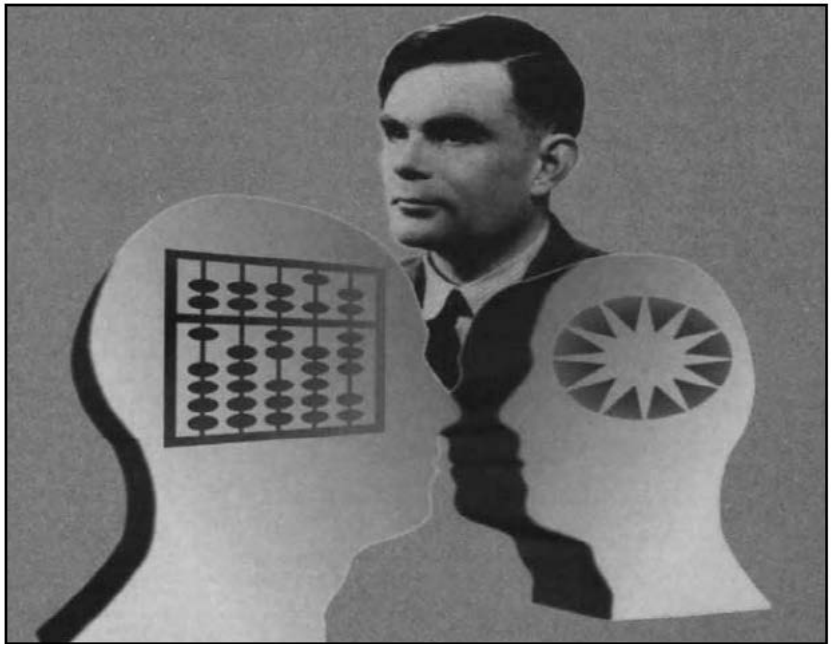
Alan Turing
Can Machines Think?

A. M. Turing (1950)
Computing Machinery and Intelligence
Mind 49: 433-460

AI Magazine Volume 13 Number 2 (1992) (© AAAI)

Can Machines Think?

Computers Try to Fool Humans at the First Annual Loebner Prize Competition Held at The Computer Museum, Boston



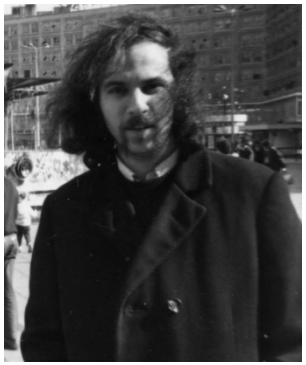
1956 Dartmouth College Summer Workshop

- «Complex Computer Applications»
- «Artificial Intelligence»

John McCarthy
4.9. 1927 - 23. 10. 2011

"Stanford School"
thinking rationally

„Symbolic“



Marvin L. Minsky
9.8.1927 - 24.1.2016

"MIT School"
thinking humanly

„Subsymbolic“

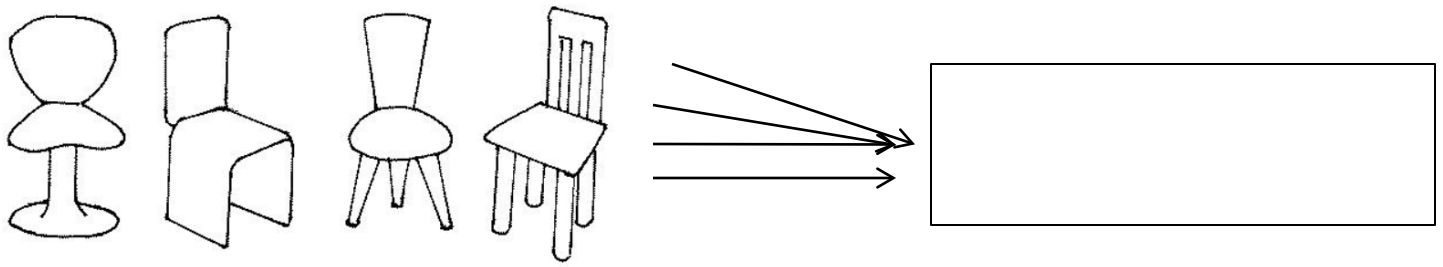
Symbolic Representations

A chair

- is a portable object
- has a horizontal surface at a suitable height for sitting
- has a vertical surface suitably positioned for leaning against

- Find a definition
  - using symbols, concepts, rules, some formalism
  - apply automated reasoning procedures

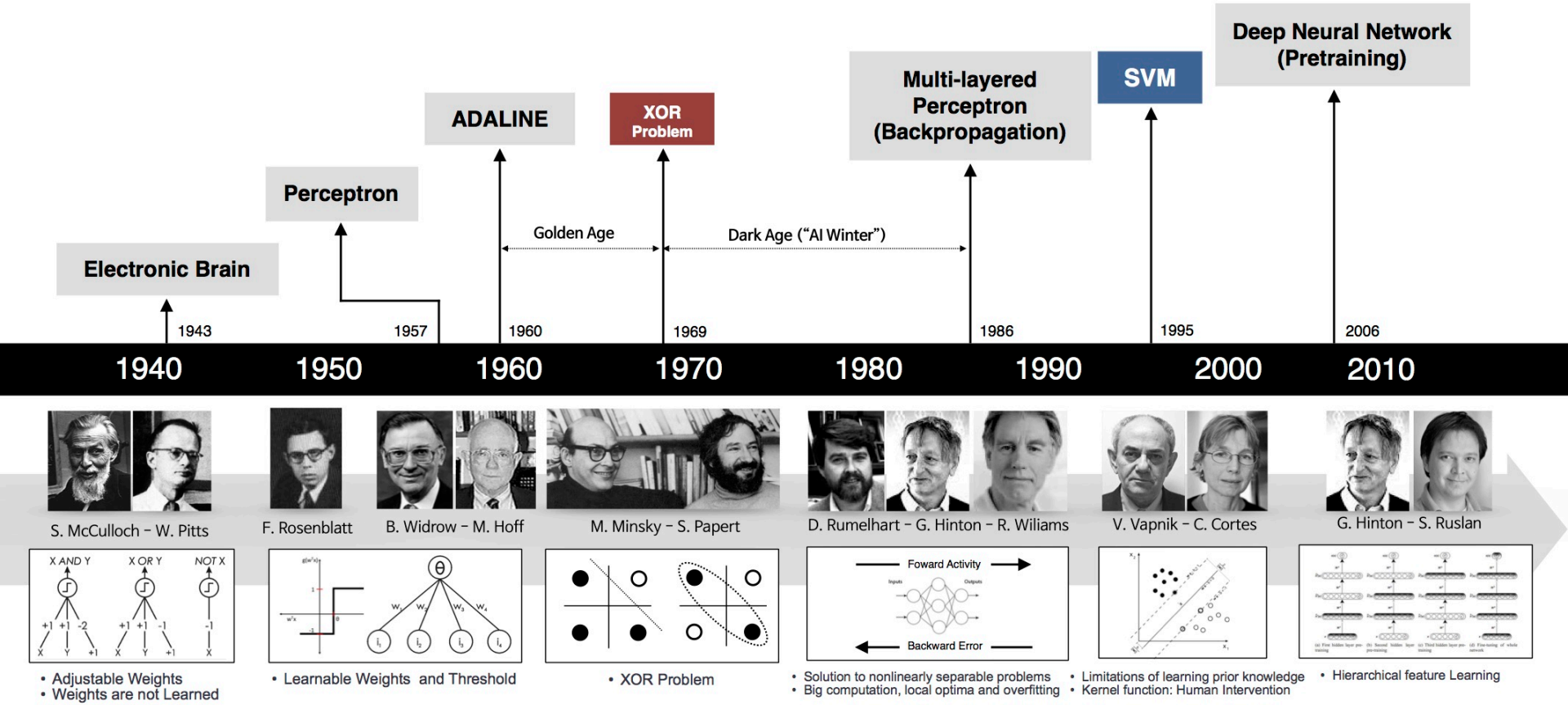
Subsymbolic Representations



- Use many different (arbitrary) features to describe the object
  - low-level inputs bits, encoding of neurons
  - show examples to the system and let it learn a generalization pattern

- If the pattern is correct, the system has «learned» the concept without using an explicit definition

Dramatic Progress over the Last Decade in Key Fields

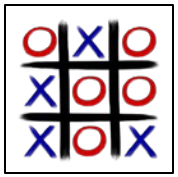


https://beamandrew.github.io/deeplearning/2017/02/23/deep_learning_101_part1.html

Progress in Search Algorithms and Game Playing

2008 - 2018

10^3	10^{13}	10^{47} 10^{20}	10^{170}		
Rules	Complete Search	Heuristic Search	Monte Carlo Search	Supervised Machine Learning	Reinforcement Machine Learning






https://en.wikipedia.org/wiki/Game_complexity

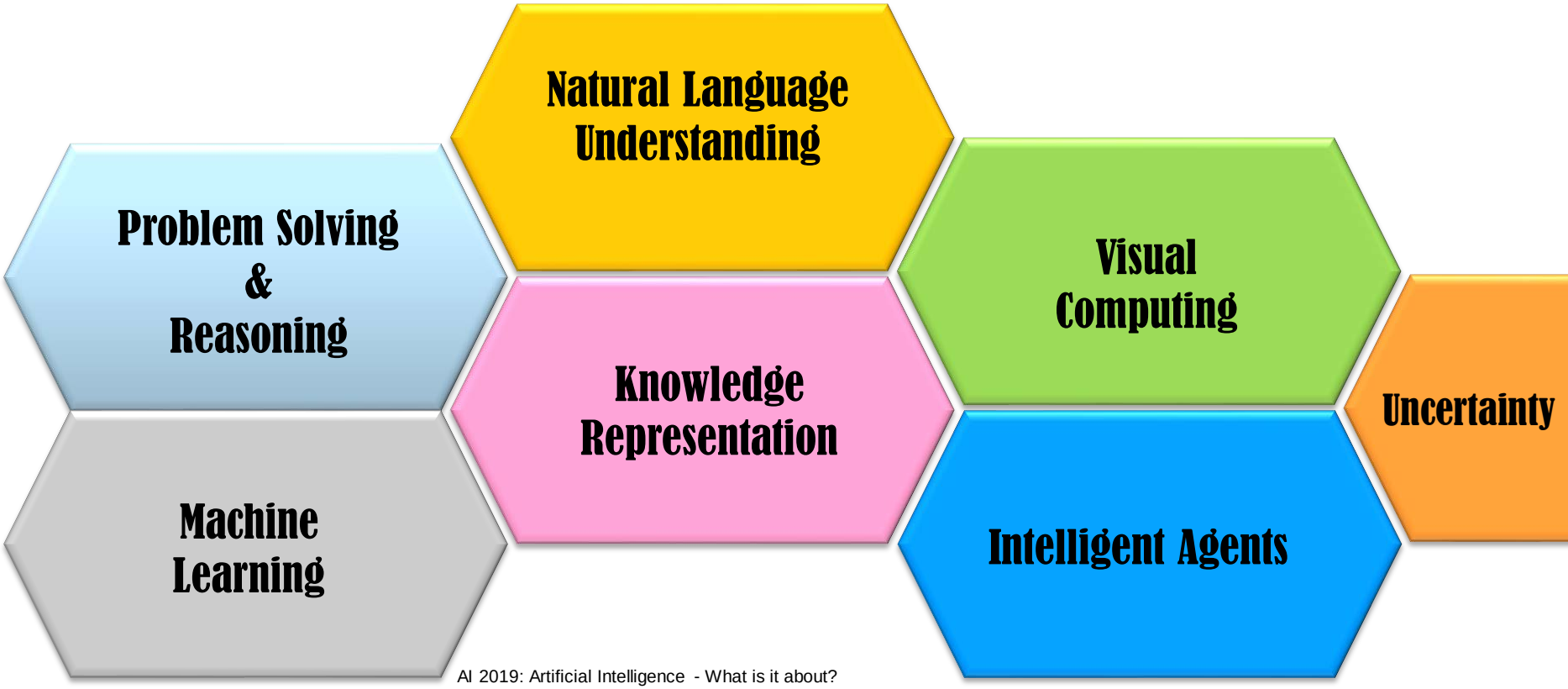
11

AI – An Interdisciplinary Research Area rooted in Computer Science

We propose that a 2 month, 10 man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer.

Important Research Areas

- *1956: automatic computers (simulations), use language, neuron nets, theory of the size of a computation, self-improvement, abstractions, randomness and creativity*



Artificial Intelligence vs. Cognitive Science

Build Intelligent Software Systems

- algorithms to achieve intelligent behavior
- problems that only humans can solve are solved by computers
- do not mimic/replicate human intelligence

➢ part of computer science, links to mathematics, economics

Understand Human Intelligence

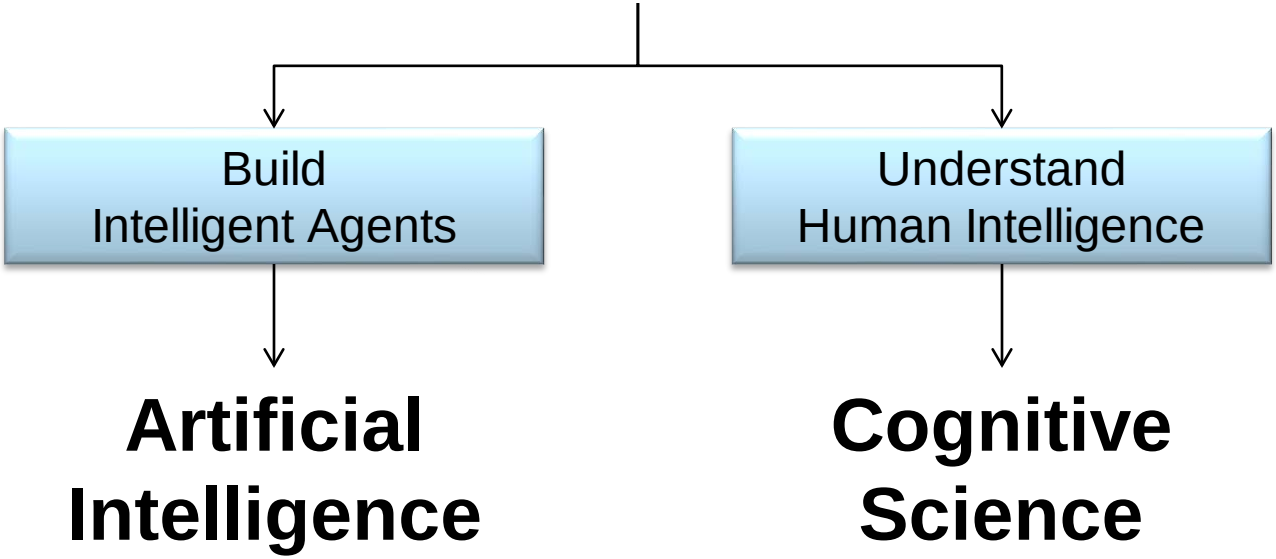
- what constitutes (human) intelligence?
- how do people solve problems?
- build models of human intelligence/the brain

➢ part of neuro & brain sciences, links to psychology

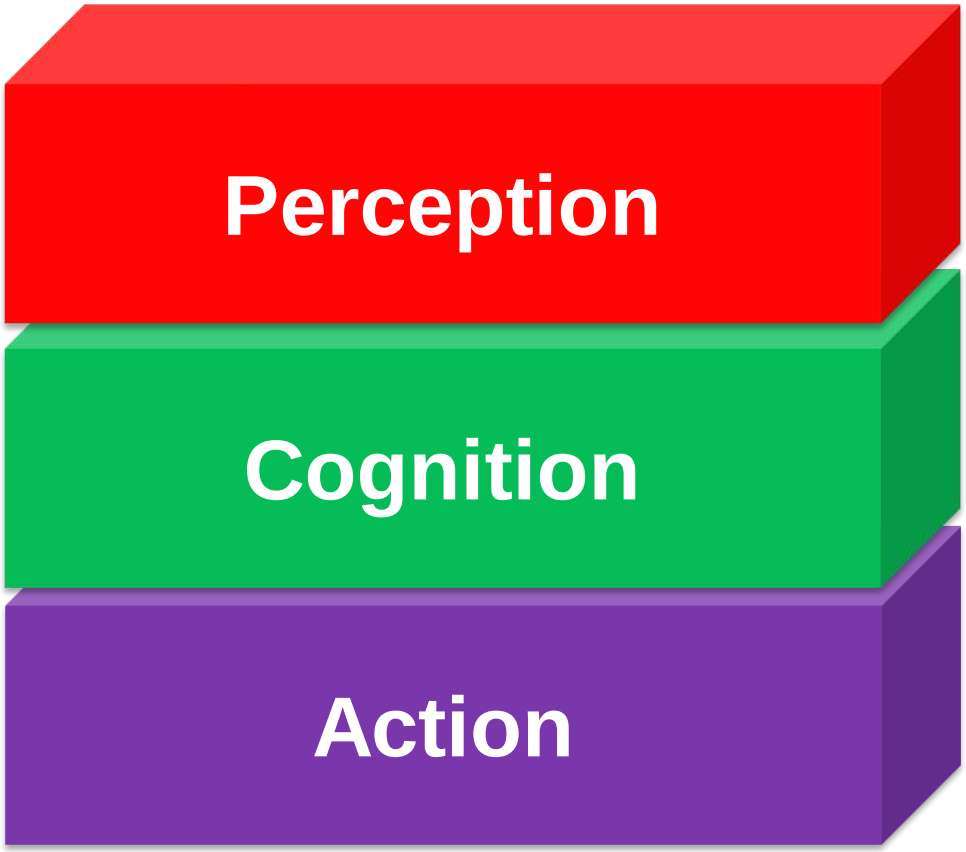
My Definition

Intelligence

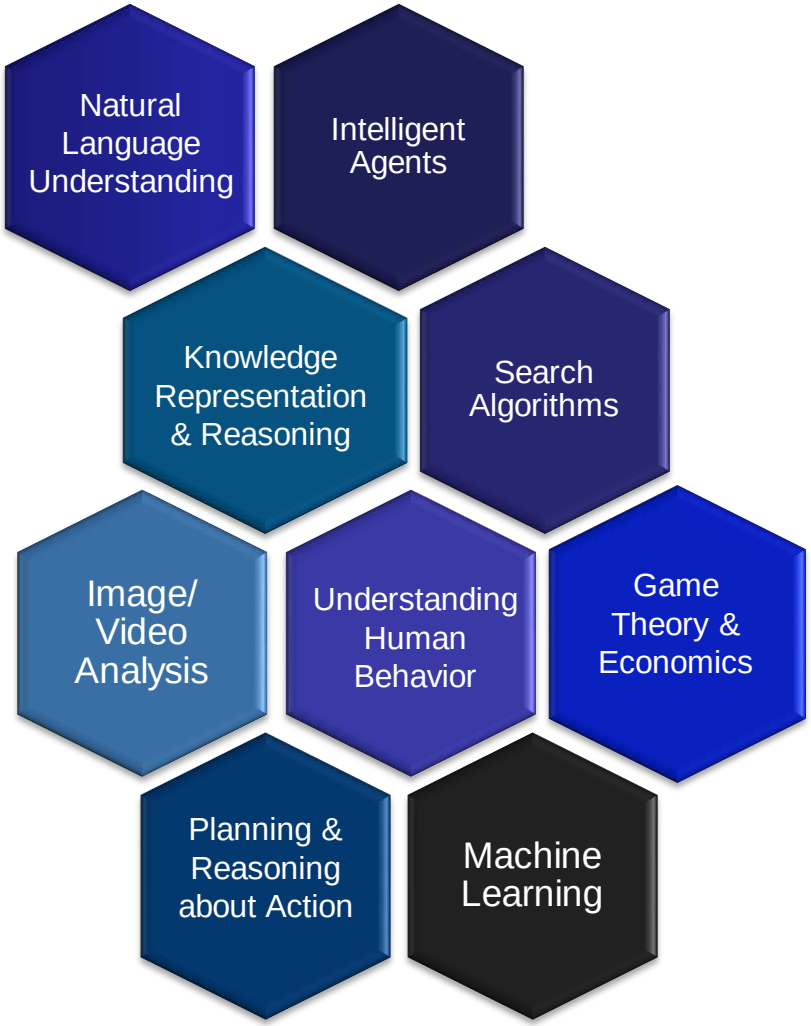
… is the ability to define and set goals and to develop behavior to achieve these goals …



AI is about

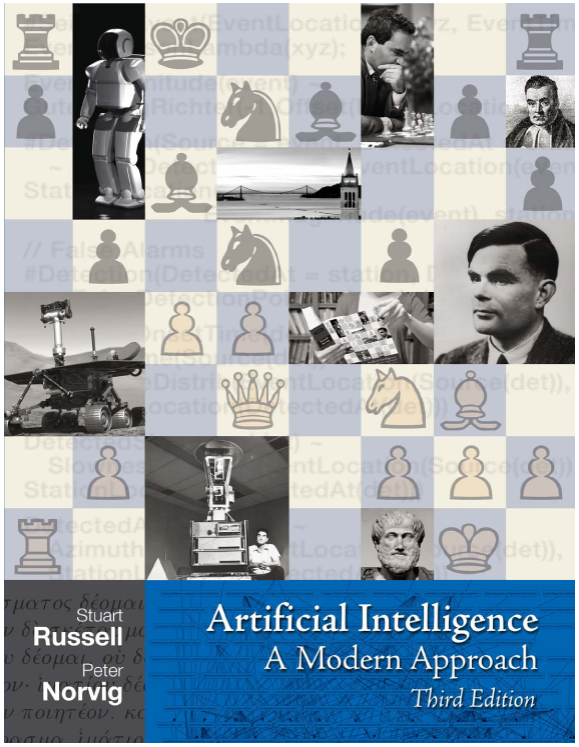


Major Technologies & Application Areas

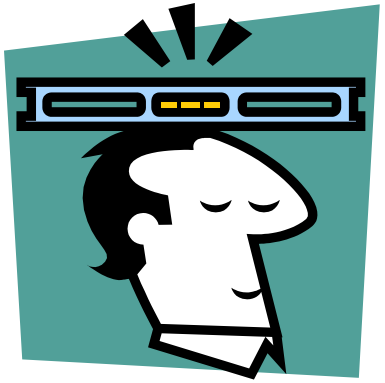


Textbook – The Famous AIMA Book

- http://aima.cs.berkeley.edu



Stuart Russell
Peter Norvig
Artificial Intelligence – A Modern Approach
3rd Edition, 2016



Metaphor of the Rational Agent

Models and Algorithms – 3 Types of Systems

Training
Generalization of annotated examples via statistical pattern recognition
Machine Learning

Exploration
Experience generated from active experimentation and environmental feedback
Reinforcement Learning

Engineering
Human knowledge and expertise captured in formal models
Solver

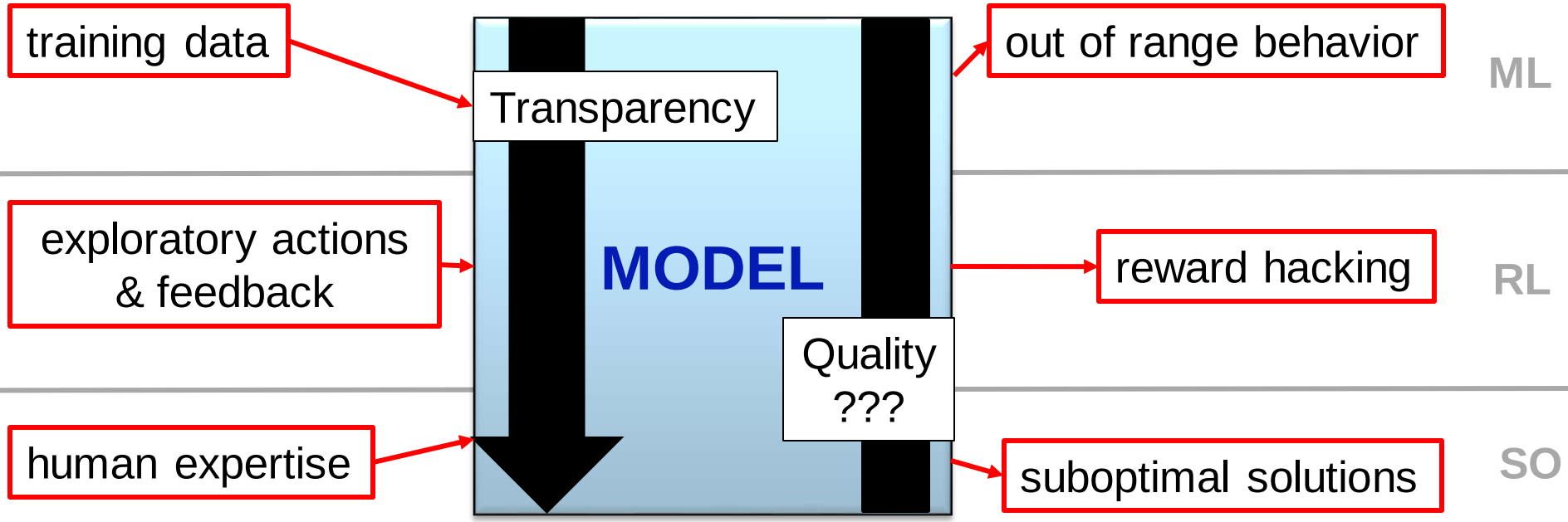
+

=

intelligent behavior in modeled situations and applications (and only there!)

See also Hector Geffner, IJCAI 2018
http://www.tecn.upf.es/~hgeffner/
https://www.youtube.com/watch?v=e8H7mAnJZ5g

Transparency and Quality of Models influence Risks



Digital Transformation Enables + Needs AI

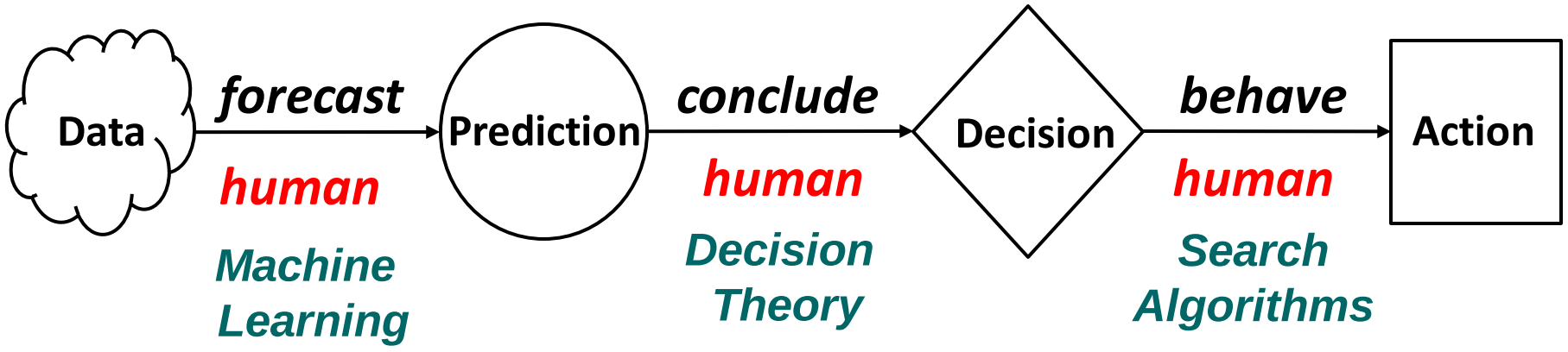
since 00s: arbitrary data in massive amounts

- revolutionize business models and processes

60/70s: selected data in small amounts

- support business processes

Prediction - Decision - Action



"Big data" is high-volume, -velocity and -variety information assets that demand

- *cost-effective, innovative forms of information processing*
- *for enhanced insight and decision making*

Gartner 2011

What is Artificial Intelligence?

- The attempt to make computers more "intelligent"?
- The attempt to better understand human intelligence?
- Four approaches:
  - is it about thought thinking . . .
  - or acting?
  - oriented towards a human model (with all its defects) . . .
  - or normative (how should a rational being think/act)?

Selected Definitions

Thinking Humanly	Thinking Rationally
"The exciting new effort to make computers think . . . machines with minds, in the full and literal sense." (Haugeland, 1985) "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . ." (Bellman, 1978)	"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985) "The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992)
Acting Humanly	**Acting Rationally**
"The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990) "The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)	"Computational Intelligence is the study of the design of intelligent agents." (Poole et al., 1998) "AI . . . is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

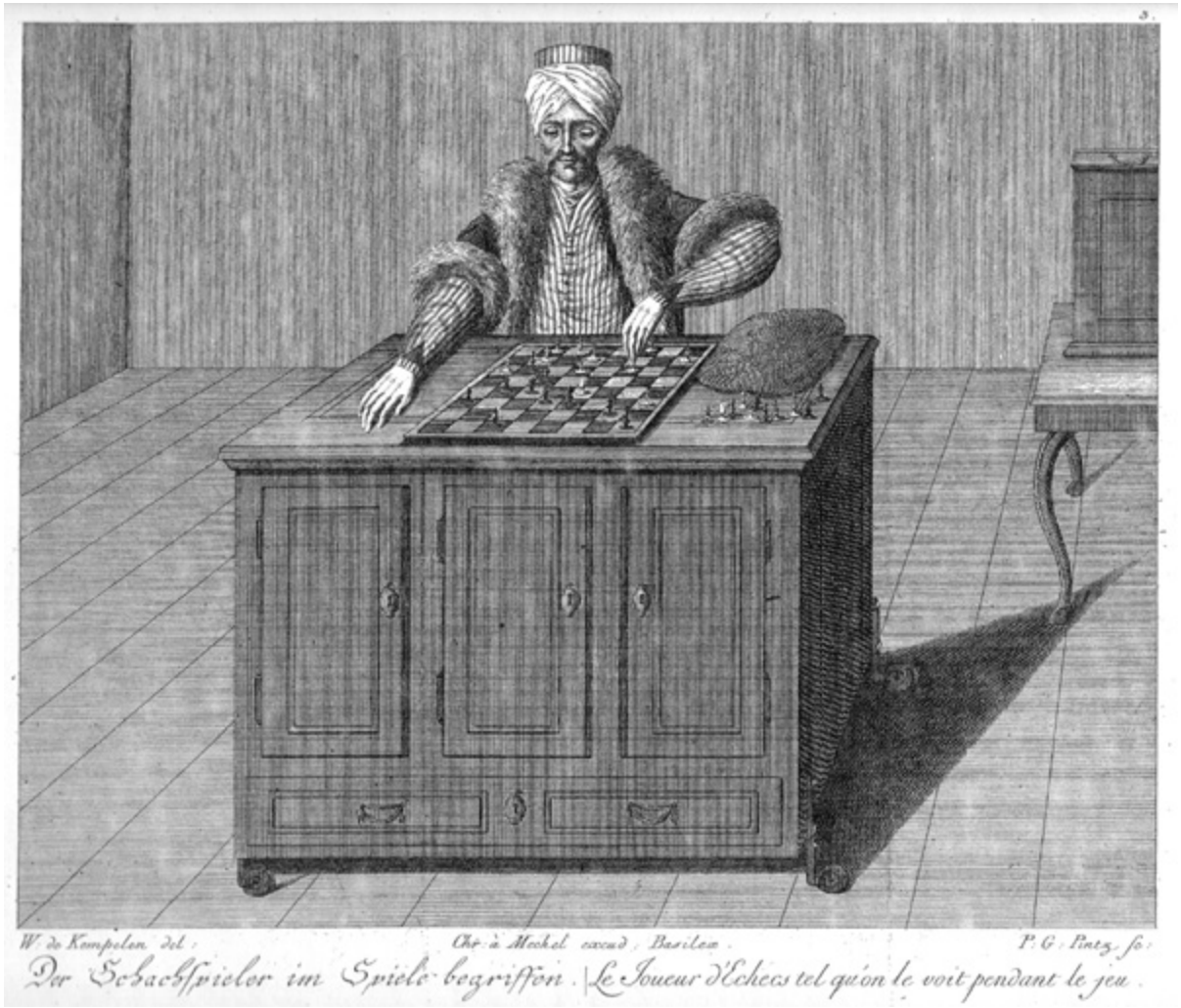
Thinking Humanly

- What cognitive capabilities are necessary to produce intelligent performance?
- Not important: Being able to solve problems correctly
- Important: Being able to solve problems like a human would

- **Cognitive science and cognitive psychology**
  - **Introspection (observing ourselves)**
  - **Psychological experiments**
  - **Brain research**

- . . . will not be discussed in this course

Acting Humanly: The Mechanical Turk 1770 - 1854



Wolfgang von Kempelen

Thinking Rationally

"Socrates is a man, all men are mortal, Socrates is mortal."

- What are the laws of thought?
- How should we think?

- Represent problems using a formal notation
- Use computational laws to derive conclusions

- Early greek philosophers, e.g. Aristoteles
  - Drawing correct conclusions using logical rules
  - Logical formalisms play a major role in AI although commonsense and everyday knowledge cannot be captured in logic alone

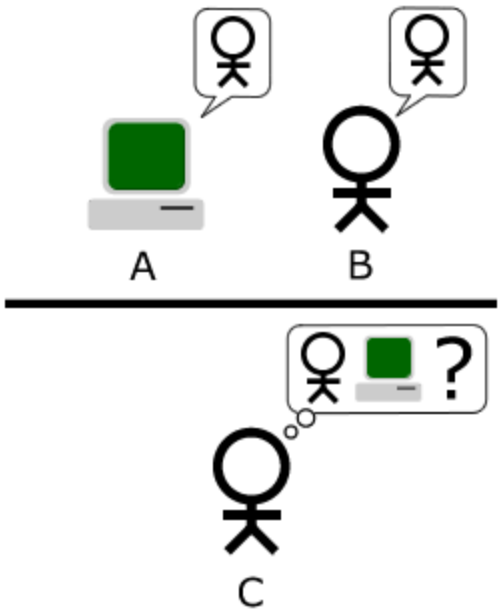
Acting Rationally

- Rational agents (or rational actors)
- A rational agent acts so as to achieve its given goals, under the assumption that its impressions of the world and its convictions are correct
- Rational thinking is a prerequisite for rational acting, although it is not a necessary condition
  - what to do, for example, when we must make a decision faced with insufficient information?

➢ We look at the concept of a rational agent in more detail later …

Turing Test

- Turing envisioned a gender test
- Building or imitating a human is not a goal for most AI researchers



The immediate task of the judge is to decide which of the other two is the woman, and the task of each of the players is to persuade the judge that he or she is the woman and that the other is the man. Thus, the game is a test of the ability of a man to pretend to be a woman, and of a woman to resist being judged a man. To make the game more exact, Turing proposes to use an average score over many conversations and to limit the length of each conversation to, say, 10 minutes. Turing then simply says that we should try to make a machine which could successfully "take the place of a man" in this game 70% of the time.

Ex Machina Trailer

A Bit of AI History

Major Phases

- 1943 – 1955
  - neural networks, basic learning mechanisms, genetic algorithms

- 1956 Darthmouth Conference
  - "Artificial Intelligence" as a research programme
  - AI as part of computer science
    - duplicating human skills such as creativity, self-improvement, use of language
    - building machines that will function autonomously in complex and changing environments

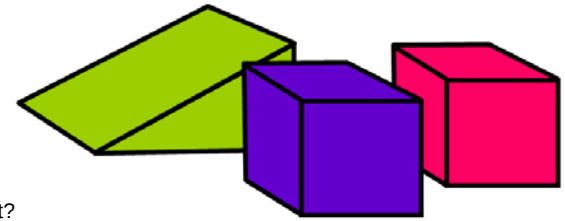
Early Successes

- 1952 – 1969
  - logical theorem proving, game playing programms,formal models of the world, various logic-based inference mechanisms
  - **Physical symbol system hypothesis**

"a physical symbol system has the necessary and sufficient means for general intelligent action"

  - **Microworlds**: small (toy) domains on which these systems operated

Shakey the Robot - Stanford Research Institute 1966 - 1972



"blocksworld"

Early Enthusiasm

"It is not my aim to surprise or shock you – but the simplest way I can summarize is to say that there are now in the world machines that think, that learn and that create.

Moreover, their ability to do these things is going to increase rapidly until – in a visible future – the range of problems they can handle will be coextensive with the range to which the human mind has been applied."

1957

Herbert Simon
Nobel prize 1978

"for his pioneering research into the decision-making process within economic organizations"

A Dose of Reality 1966 – 1973

- Pure syntatic manipulations led to infamous failures in language translation
  - "the spirit is willing, but the flesh is weak" = the vodka is good, but the meat is rotten
- Intractability of many problems
  - exhaustive enumeration of variants does not scale in exponential state spaces – ***combinatorial explosion***
- Limitations of many mechanisms only slowly understood
  - perceptrons can learn everything they can represent – but they can represent very little

LISP (1958 John McCarthy)
PROLOG (1972 Alain Colmerauer)

```
;; Addiere 2 und 3 und 4:
(+ 2 3 4)

;; Setze die Variable p auf den Wert 3,1415:
(setf p 3.1415)

;; Definiere eine Funktion, die ihr Argument quadriert:
(defun square (x)
  (* x x))

;; Quadriere die Zahl 3:
(square 3)
```

```
vater(adam,tobias).
vater(tobias,frank).
vater(tobias,ulrike).

grossvater(X,Y) :-
    vater(X,Z),
    vater(Z,Y).

grossvater(X,Y) :-
    vater(X,Z),
    mutter(Z,Y).
```

```
?- grossvater(adam,ulrike).
yes.
?- grossvater(X,frank).
X=adam
```

Modul Programming Concepts & Paradigms

Knowledge-Based Systems 1969 – 1985 – the Key to Power?

- Adding more domain knowledge to an AI system
  - learn from human experts
- Explicit representations of rules, plans, goals, states, objects, confidence/uncertainty
  - "frames" – concept logics – ontologies
- From "weak" to "strong" methods
- AI technology companies

Mycin 1973

An Artificial Intelligence Program to Advise Physicians Regarding Antimicrobial Therapy*

EDWARD H. SHORTLIFFE†, STANTON G. AXLINE, BRUCE G. BUCHANAN, THOMAS C. MERIGAN, AND STANLEY N. COHEN

Stanford University, Stanford, California 94305

LISP

```
PREMISE:
        ($AND   (SAME (VAL CNTXT GRAM) GRAMPOS)
                (SAME (VAL CNTXT MORPH) COCCUS)
                (SAME (VAL CNTXT CONFORM) CHAINS)
                3)
ACTION:
        (CONCLUDE CNTXT IDENT STREPTOCOCCUS TALLY .7)
```

ENGLISH TRANSLATION

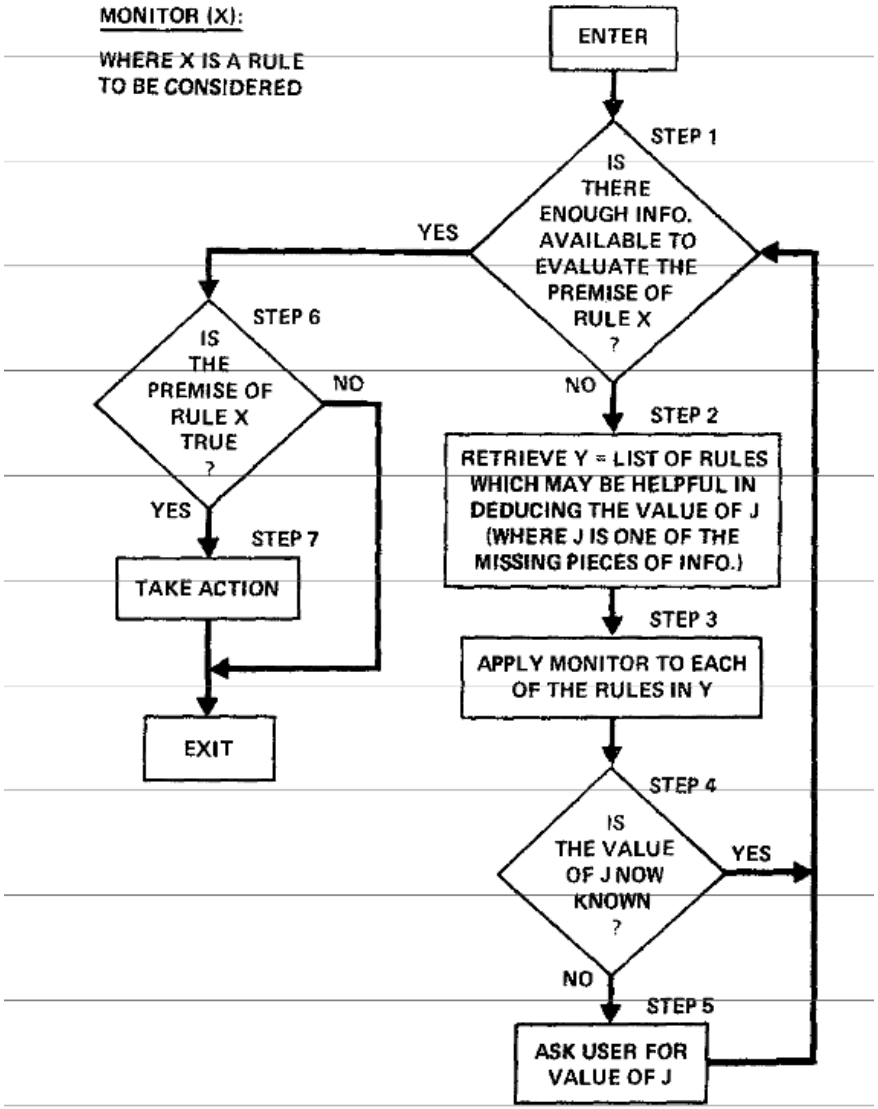
IF:

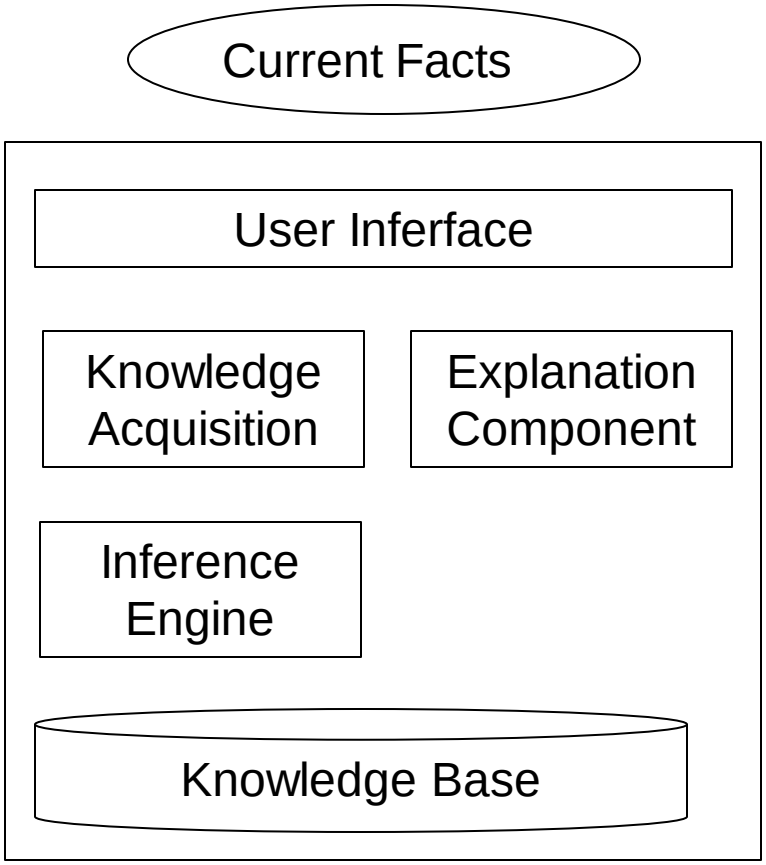
THE GRAMSTAIN OF THE ORGANISM IS GRAMPOS, AND THE MORPHOLOGY OF THE ORGANISM IS COCCUS, AND THE GROWTH CONFORMATION OF THE ORGANISM IS CHAINS

THEN:

CONCLUDE THAT THE IDENTITY OF THE ORGANISM IS STREPTOCOCCUS (MODIFIER: THE CERTAINTY TALLY FOR THE PREMISE TIMES .7)

Mycin Inference Engine





Knowledge-Intensive ("strong") versus Knowledge-Sparse Approaches ("weak")

- Knowledge-sparse: axioms, some facts + strong inference mechanisms
  - Google search uses indexing + the page rank
  - Deep Blue Chess Computer
  - Logic theorist

- Knowledge-intensive: domain ontologies and encoded knowledge bodies
  - Chess opening book
  - Expert systems, e.g. Mycin
  - Google user profiles

AI Winter (1987–93)

- Subsymbolic (connectionist) approaches remained vague
- Understanding Speech remains a challenge

- LISP machine market collapsed

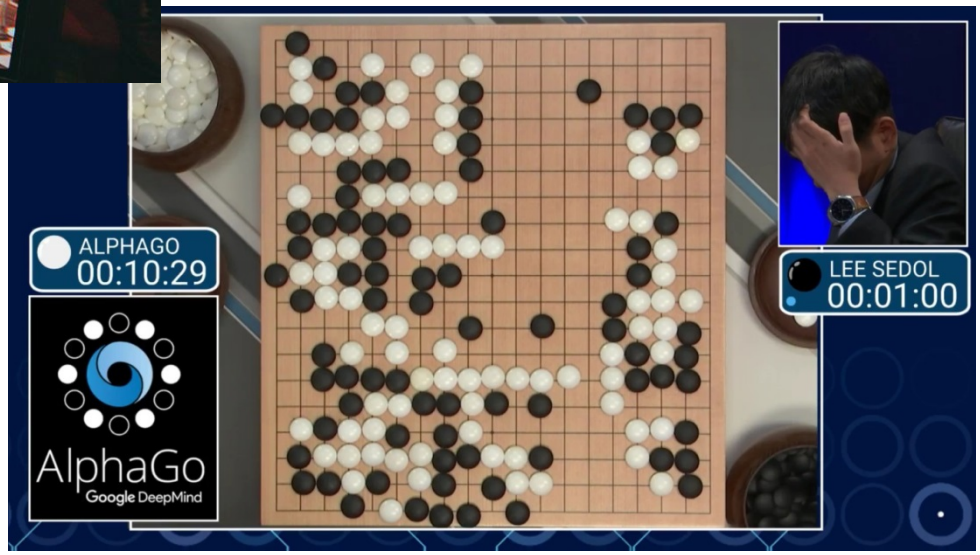
- Expert systems did not scale and could not handle contradictory knowledge and beliefs

- Japan's 5th generation computer systems project never managed to provide concurrent logic programming on special hardware

Deep Blue and AlphaGo – Important Milestones

1997

2016



Deep Blue 1996/97

- Winner against world champion Garri Kasparow
- Brute force computing power, written in C
- Massively parallel, RS/6000 SP Thin P2SC-based system with 30 nodes each node containing a 120 MHz P2SC, enhanced with 480 special purpose VLSI chess chips
- Capable of evaluating 200 million positions per second, 11.38 GFLOPS
- 259th on TOP500 supercomputer list in June 1997

Deep Blue's Opening Book and Evaluation Function

- Evaluation function was initially with many to-be-determined parameters, optimal values for these parameters were determined by the system itself b analyzing thousands of master games

- Opening book contained over 4,000 positions and 700,000 grandmaster games
  - provided by grandmasters Miguel Illescas, John Fedorowicz, Nick de Firmian
  - Chess knowledge finetuned by grandmaster Joel Benjamin

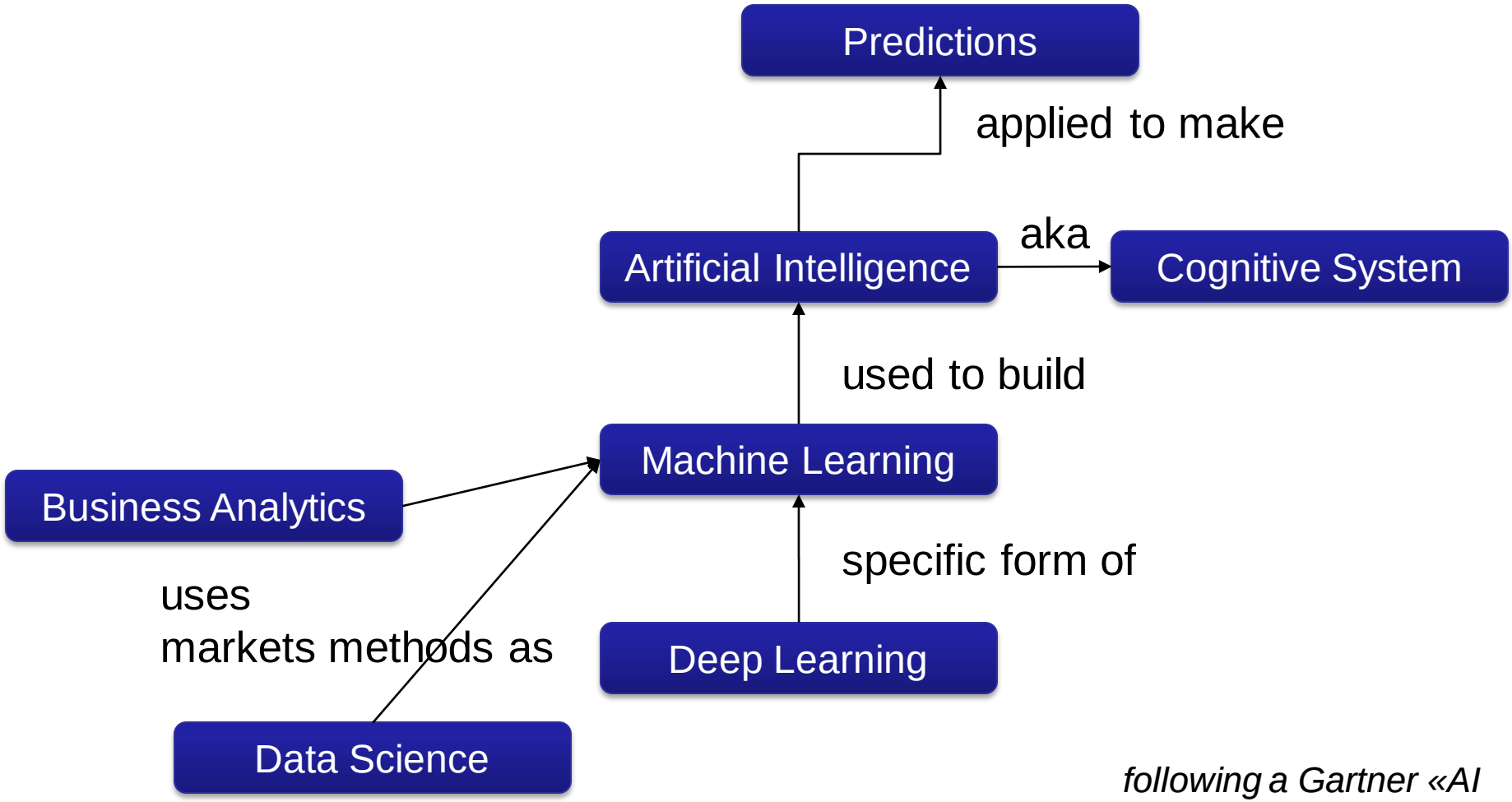
AI in the 90ies

Quote from 1st edition of Russel & Norvig's text book [1995]:

“Gentle revolutions have occurred in robotics, computer vision, machine learning, and knowledge representation. A better understanding of the problems and their complexity properties, combined with increased mathematical sophistication, has led to workable research agendas and robust methods."

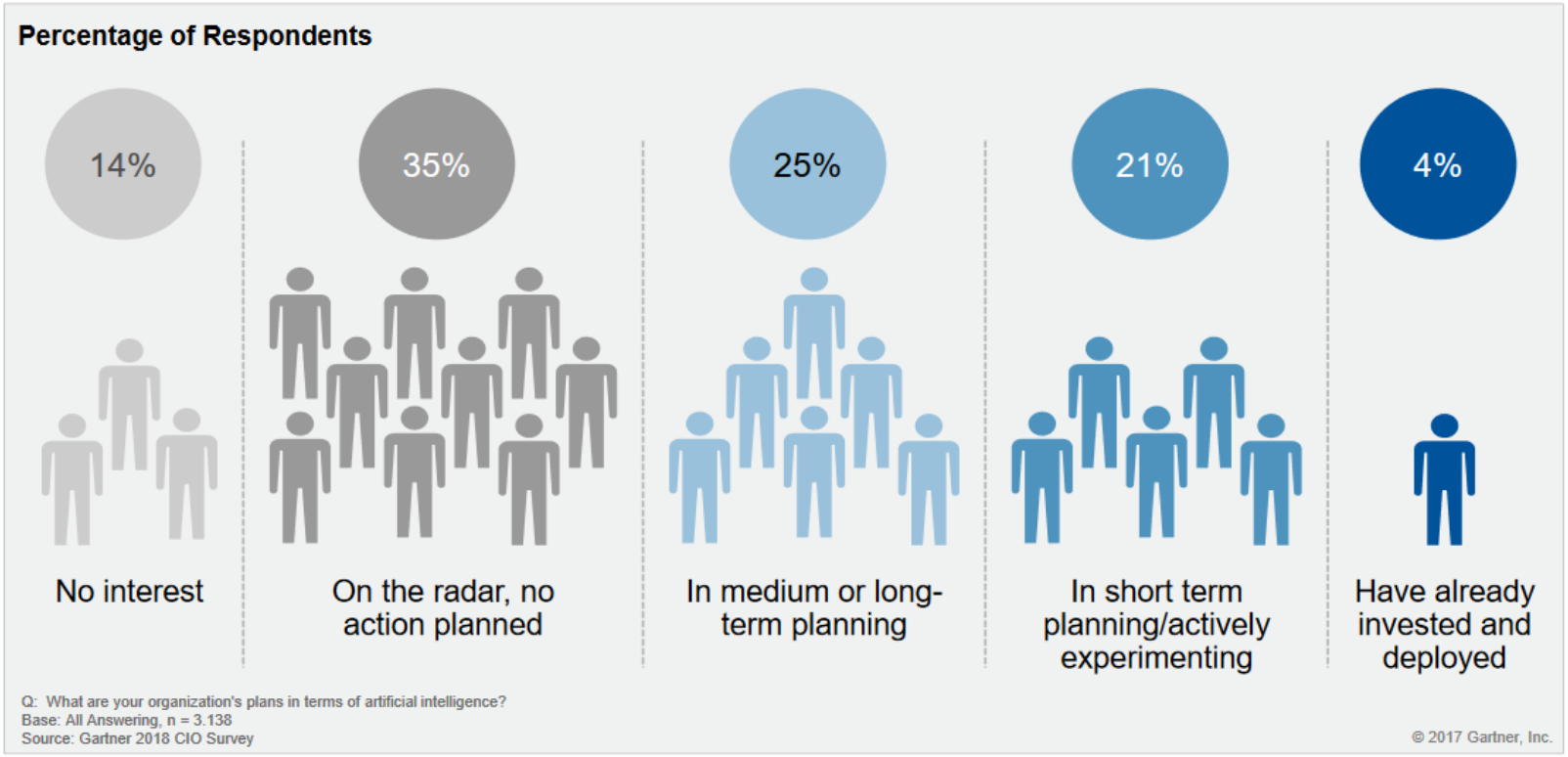
IBM Watson Triggers Renewed Interest in AI

Driving Forces Behind the Current AI Hype



following a Gartner «AI Landscape» slide

Artificial Intelligence is in early adoption



Gartner

Hype Hurts: Steering Clear of Dangerous AI Myths

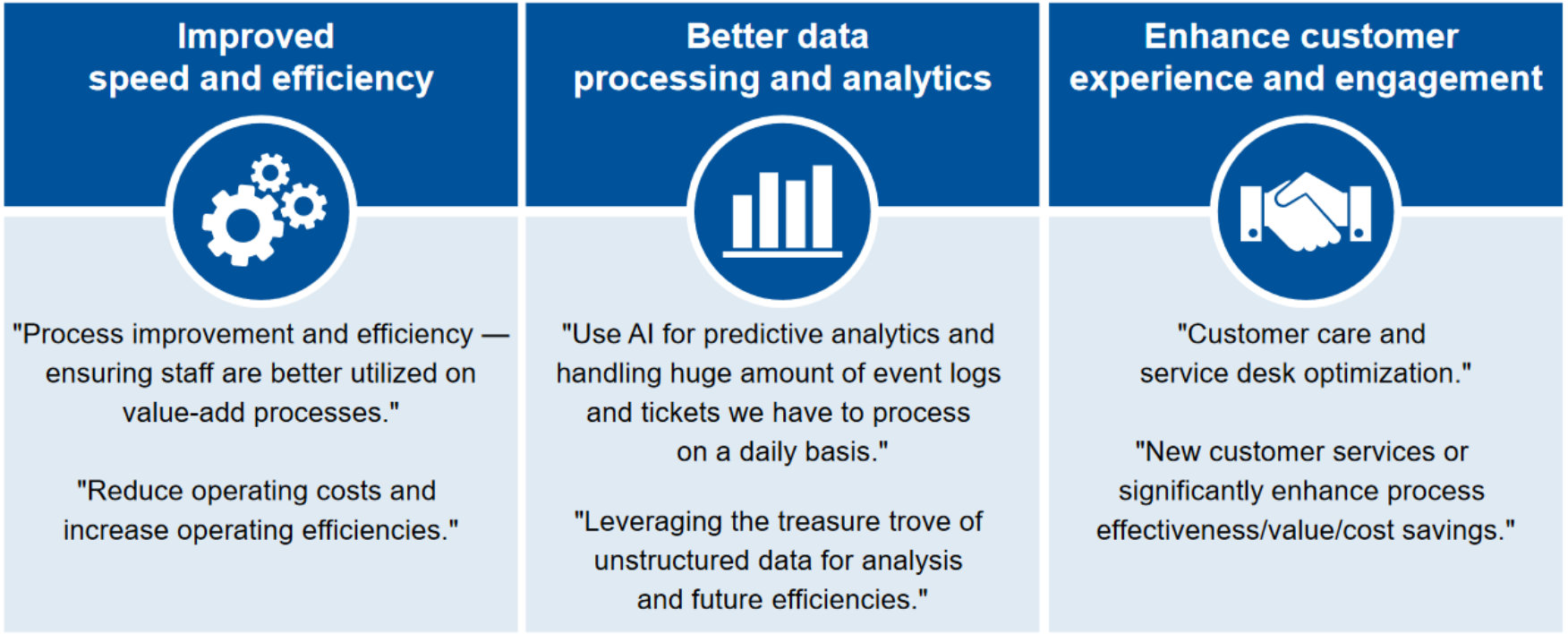
Published: 03 July 2017 **ID:** G00324274

Analyst(s): Tom Austin | Alexander Linden | Mike Rollings

https://www.gartner.com/smarterwithgartner/steer-clear-of-the-hype-5-ai-myths/

- Myth 1: Buy an AI to Solve Your Problems
- Myth 2: Everyone Needs an AI Strategy or a Chief AI Officer
- Myth 3: Artificial Intelligence Is Real
- Myth 4: AI Technologies Define Their Own Goals
- Myth 5: AI Has Human Characteristics
- Myth 6: AI Understands (or Performs Cognitive Functions)
- Myth 7: AI Can Think and Reason
- Myth 8: AI Learns on Its Own
- Myth 9: It's Easy to Train Applications That Combine DNNs and NLP
- Myth 10: AI-Based Computer Vision Sees Like we Do (Or Better)
- Myth 11: AI Will Transform Your Industry — Jump Now and Lead
- Myth 12: For the Best Results, Standardize on One AI-Rich Platform Now
- Myth 13: Maximize Investment in Leading-Edge AI Technologies
- Myth 14: AI Is an Existential Threat (or It Saves All of Humanity)
- Myth 15: There Will Never Be Another AI Winter

What Business Goals Are Organizations Pursuing With AI?



Base: n= 79 Gartner Research Circle Members/Excludes 'blanks'
Q09. Lastly, what specific business goal or objective is your organisation trying to address with AI?

Gartner

Selected Current Challenges in AI

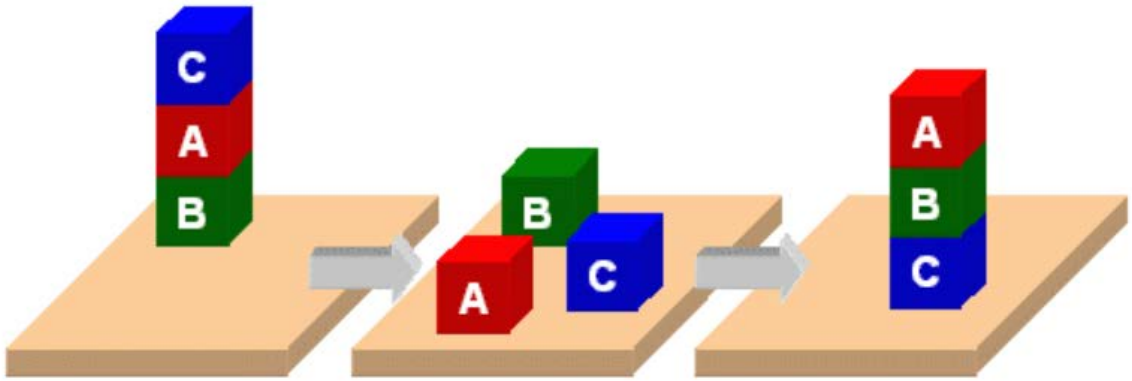
Gathering Training Data

https://www.youtube.com/watch?v=iaF43Ze1oeI

Designing the Objective Function

Atari Breakout after 600 training episodes

«Trivial» Problems Deep Learning cannot Solve



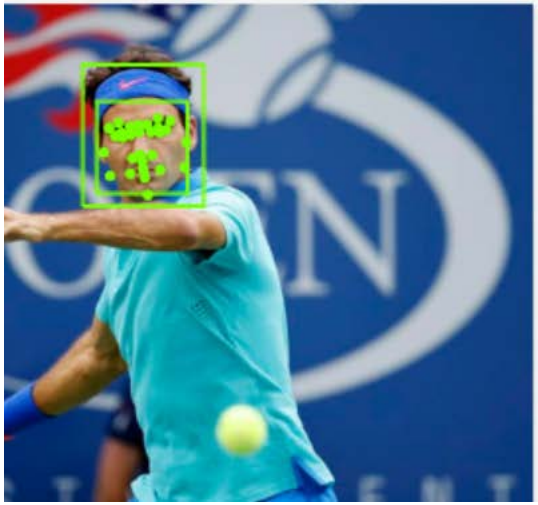
Find the shortest sequence of actions that transforms an **arbitrary** initial configuration of blocks into another **arbitrary** goal configuration

- This lecture looks deeply into this class of problems.

«Understanding» Images with Deep Learning

Sports	94%
Tennis	93%
Tennis Player	89%
Football Player	88%
Ball Game	86%
Racquet Sport	82%

Roger Federer	8.248
2015 US Open	2.87768
Tennis	2.03366
2016 US Open	1.72056
2014 US Open	1.49444
2012 US Open	1.48128
2011 US Open	1.44896
2013 US Open	1.40856
USTA Billie Jean King National T...	1.31064
Tennis player	0.52656
Forehand	0.33282



Joy	
Sorrow	
Anger	
Surprise	
Exposed	
Blurred	
Headwear	

Further Reading

- Chapter 1: Introduction in Russell and Norvig
- A. M. Turing (1950): Computing Machinery and Intelligence, Mind 49: 433-460
  - E.g. available here https://www.csee.umbc.edu/courses/471/papers/turing.pdf
- Patrick Hayes, Kenneth Ford: Turing Test Considered Harmful
  - https://www.researchgate.net/profile/Kenneth_Ford/publication/220813820_Turing_Test_Considered_Harmful/links/09e4150d1dc67df32c000000.pdf
- McCarthy, John; Minsky, Marvin; Rochester, Nathan; Shannon, Claude (1955), A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence
  - http://raysolomonoff.com/dartmouth/boxa/dart564props.pdf
- Rodney Brooks: The Seven Deadly Sins of AI Predictions, MIT Technology Review 2017
  - https://www.technologyreview.com/s/609048/the-seven-deadly-sins-of-ai-predictions/
- Watch Selected ICML/IJCAI 2018 videos on Youtube
  - https://www.youtube.com/channel/UCvqEpkx-HQ2nDMT-ob-AADg
  - My favorites are Yann Le Cunn´s and Hector Geffner´s invited talks
- Daniel Crevier: The Tumultuous History of the Search for Artificial Intelligence, Harper Collins, 1993.

Working Questions

1. What is Artificial Intelligence about?

2. What do we mean by a symbolic or subsymbolic representation?

3. What are weak (knowledge-sparse) and strong (knowledge-intensive) methods?

4. What characterizes the main historic phases of AI research?

5. Discuss risks and opportunities of AI technology in the light of your own opinion.

Steven Spielberg: Artificial Intelligence, 2001