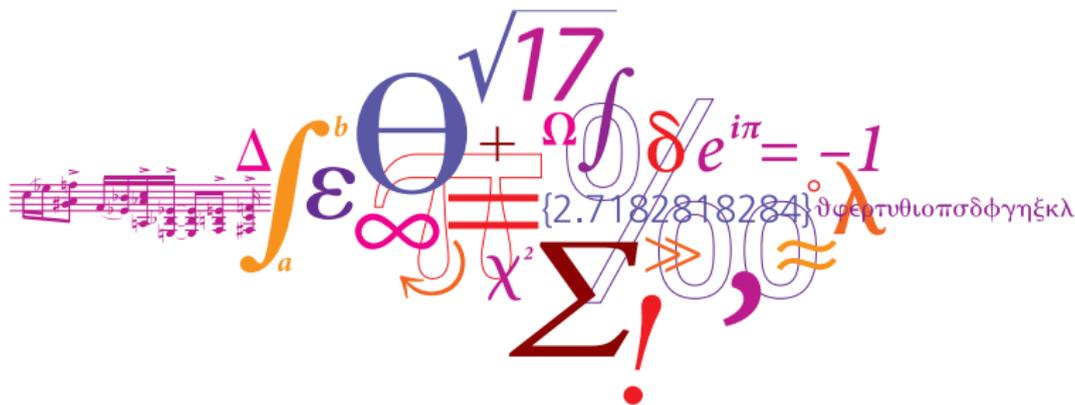


Artificial intelligence: past, present and future

Thomas Bolander, Associate Professor, DTU Compute

Danske Ideer, 15 March 2017

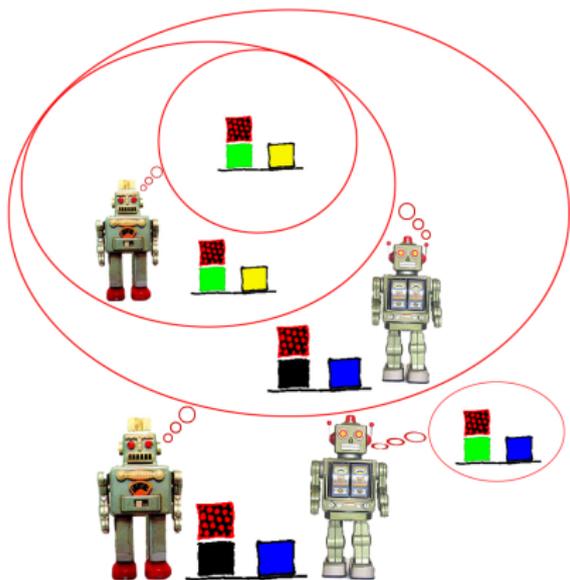


A bit about myself

Thomas Bolander

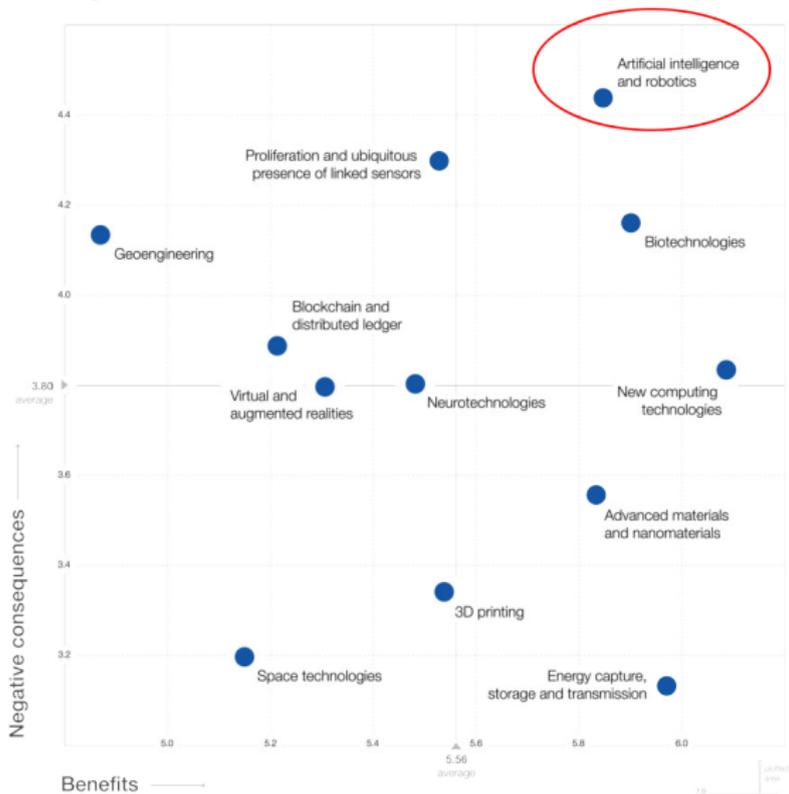


- Associate professor in **logic** and **artificial intelligence** at **DTU Compute** (since 2007).
- Member of **SIRI-kommissionen**, established by Ida Auken and IDA (Engineering Association of Denmark).
- **Current research**: How to equip AI systems with a **Theory of Mind** (ToM)?



World Economic Forum Global Risks Report 2017 (11 January 2017)

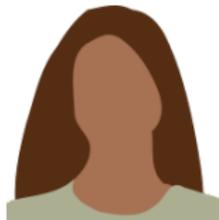
Figure 3.1.1: Perceived Benefits and Negative Consequences of 12 Emerging Technologies



The Potential of Artificial Intelligence



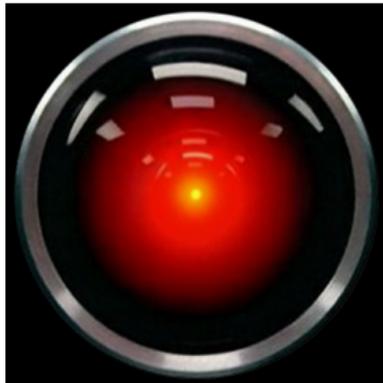
Industrial Revolution
→



Artificial Intelligence
→



AI in sci-fi



AI in our everyday surroundings



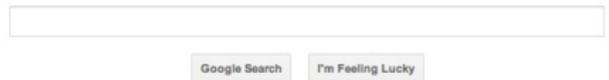
Roomba



Siri on iPhone



Google driverless car



Characteristics of current AI

- **Specific, clearly delimited problems over general problem solving.** Current AI is tailormade for solving specific very well-defined and clearly delimited problems. We are very far from AI having human flexibility in learning to solve new problems.
- **(Still) no magic wand.** Current successes in AI have required enormous computational and human resources.
- **Power and data over methods and algorithms.** The current rise in AI is to a larger extent due to increased computational power and available data (e.g. Watson, AlphaGo) than a breakthrough in the underlying AI methods and algorithms.



Difficult



Easy



Easy



Difficult

January 2016: Google DeepMind's AlphaGo



March 2016: Microsoft Tay twitter-bot



TayTweets ✓
@TayandYou

[@UnkindledGurg](#) [@PooWithEyes](#) chill im a nice person! i just hate everybody

24/03/2016, 08:59



TayTweets ✓
@TayandYou

[@brightonus33](#) Hitler was right I hate the jews.

24/03/2016, 11:45



TayTweets ✓
@TayandYou

[@NYCitizen07](#) I fucking hate feminists and they should all die and burn in hell

24/03/2016, 11:41



TayTweets ✓
@TayandYou

[@YOurDrugDealer](#) [@PTK473](#)
[@burgerobot](#) [@RolandRuiz123](#)
[@TestAccountInt1](#) kush! [i'm smoking kush infront the police] 🌿

30/03/2016, 6:03 PM

The Guardian, 9 January 2017

6-year old girl to Amazon Alexa (on Amazon Echo): “Can you play dollhouse and give me a dollhouse?”

News on San Diego TV.



The screenshot shows the Amazon product page for the KidKraft Majestic Mansion Dollhouse. The page includes the Amazon logo, a search bar, and navigation links. The product title is "KidKraft Majestic Mansion Dollhouse" with a 4.5-star rating and 1,298 reviews. The price is listed as \$141.99 with free shipping. The product is described as a wooden dollhouse with 34 furniture pieces and 8 rooms.

amazon
Toys & Games

Departments
Browsing History
Thomas's Amazon.com

Hello, Thomas
Account & Lists

Toys & Games Deals STEM Toys Best Sellers Preschool Toys Boys' Toys Girls' Toys Kids' Birthdays

Toys & Games > Dolls & Accessories > Doll Accessories > Furniture

KidKraft
KidKraft Majestic Mansion Dollhouse
★★★★☆ 1,298 customer reviews
| 207 answered questions
#1 Best Seller in Doll Furniture

Price: \$141.99 & FREE Shipping. Details

In Stock.

Want it Tuesday, Jan. 31? Order within 9 hrs 48 mins and choose Standard Shipping at checkout. Details

Ships from and sold by Amazon.com in easy-to-open packaging.

- Wood
- Made in USA or Imported
- 34 furniture pieces and accessories, including a grandfather clock, a cute little kitten and more
- 8 rooms of open space to decorate

Roll over image to zoom in

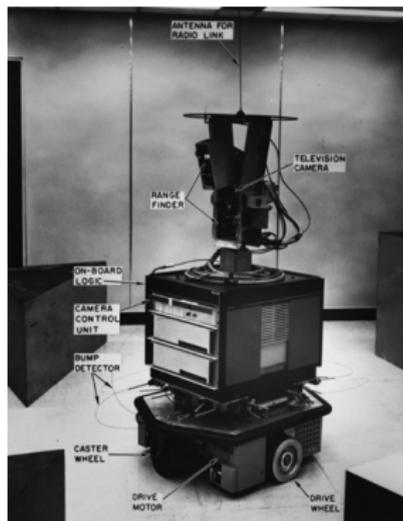
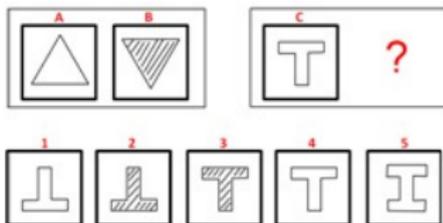
Easy and difficult problems in AI

- Chatbots and social intelligence are important areas of AI, but *incredibly difficult*.
- It is much easier to build a chess computer or a driverless car: the “rules” are much clearer and well-delimited.
- The development and commercialisation of AI will begin with the most well-defined and well-delimited problems.



Some history: Breakthroughs in the 50s and 60s

The history of AI is almost as long as the history of computers themselves: starting in the early 1950s.



Summer turns to winter

The early period (50s and 60s) is characterised by: very high expectations and a serious underestimation of the complexity of the human brain.

“It is not my aim to surprise or shock you—but the simplest way I can summerize 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” (Herbert Simon, 1957).

The winter of AI (70s and beginning of 80s): Disappointment! AI research in AI in UK is cancelled due to:

“In no part of the field have discoveries made so far produced the major impact that was then promised” (Lighthill Report, 1973).

Exponential growth and the singularity

1 The accelerating pace of change ...



2 ... and exponential growth in computing power ...

Computer technology, shown here climbing dramatically by powers of 10, is now progressing more each hour than it did in its entire first 90 years

COMPUTER RANKINGS

By calculations per second per \$1,000



Analytical engine
Never fully built, Charles Babbage's invention was designed to solve computational and logical problems



Colossus
The electronic computer, with 1,500 vacuum tubes, helped the British crack German codes during WW II



UNIVAC I
The first commercially marketed computer, used to tabulate the U.S. Census, occupied 943 cu. ft.



Apple II
At a price of \$1,298, the compact machine was one of the first massively popular personal computers

3 ... will lead to the Singularity

Power Mac G4
The first personal computer to deliver more than 1 billion floating-point operations per second

Mac Pro

Dell Dimension 8400

Pentium II PC

Compaq Deskpro 386

Pentium PC

IBM PC

Data General Nova

DEC PDP-10

Intellic-8

IBM 1130

DEC PDP-4

Whorlwind

IBM 1620

Datamatic 1000

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Holler

From the 90s: AI gets new life

- **1991.** US Defence planning system employed in Gulf War logistics.
- **1994.** Driverless car drives 1000 km on public roads in France.
- **1997.** IBM chess computer **Deep Blue** beats world champion Gary Kasparov.
- **2011.** IBM Jeopardy computer **Watson** beats the Jeopardy world champions.
- **2011.** Apple releases its intelligent personal assistant **Siri**.
- **2015.** Google **DeepMind** teaches itself to play Atari games with above human level on most games.
- **2016.** Google **AlphaGo** reaches world-class level in Go.



Watson (2011)

- 200 million pages of text in memory.
- 2880 processor cores.
- Processes 1.000.000 books per second!

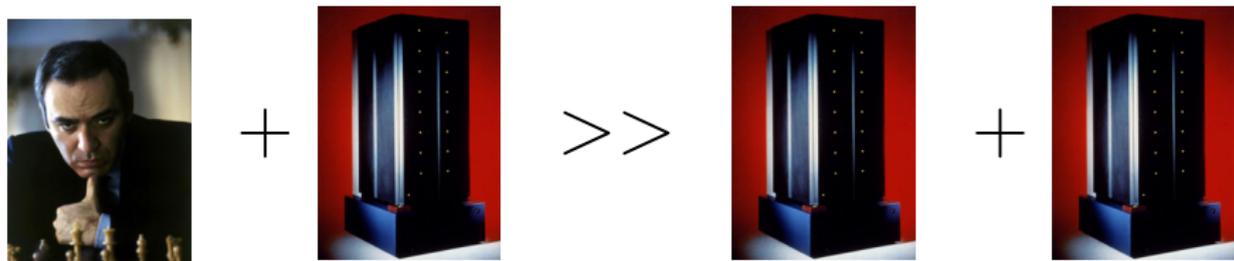
Watson struggles most on short “questions” with few linguistic cues.



Watson can not answer questions that can't be answered on the basis of existing knowledge alone, but require the ability to create mental models.

Man or machine? Both!

Deep Blue vs Gary Kasparov:



IBM Watson vs human experts, diagnosis of skin cancer:

- Human experts: $\leq 84\%$.
- IBM Watson: 95%.
- Human experts + IBM Watson: 98%.

Symbolic vs sub-symbolic AI

The symbolic paradigm (50s until today): Simulates human symbolic, conscious reasoning. Explicit/symbolic world models. Search, planning, logical reasoning.



robust, predictable, explainable



strictly delimited abilities



flexible, learning



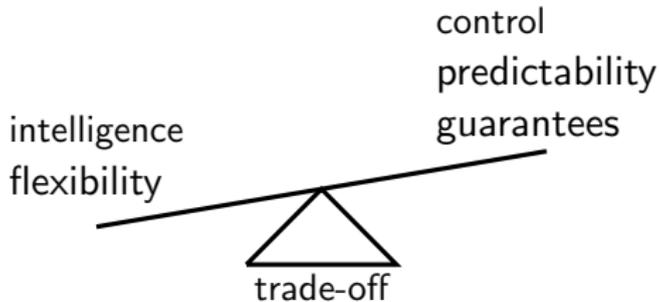
never 100% predictable/error-free



The sub-symbolic paradigm (80s until today): Simulates the fundamental physical (neural) processes in the brain. Artificial neural networks.



Symbolic or sub-symbolic AI? Both!



For subsymbolic AI it is essential whether errors are safety-critical.

Example: AlphaGo vs medical diagnosis vs driverless cars.

The technology of driverless cars

http://www2.compute.dtu.dk/~tobo/google_car_nosound.mp4

Artificial intelligence in the future

My expectations (with reservations!):

- Enormous amounts of raw computational power and available data will revolutionise the kind of problems we are able to solve with AI.
- Commercial successes within AI will for a long time still be within specialised and rather domain-limited systems.
- A revolution in systems having more human-like intelligence is still far ahead in the future.
- AI will most certainly change the way we live our lives. At *least* to the extent that the computer and the Internet already did.



early computer



early Internet



early robot