# Certificate I: Understanding AI and Machine Learning in Africa

## Course AIML02: AI and Machine Learning in Africa

## Module 3: AI Business Strategy

## Lecture 4: The Future of AI Will Be About Less Data, Not More

Carnegie Mellon University
Africa

# Learning Objectives

1. Give examples of weaknesses in data-driven deep learning

2. Explain why the future of AI may be based less on bottom-up data-driven deep learning and more on top-down reasoning

3. Identify four areas where developments will occur in the next five years

# Lecture Contents

1. Data-driven machine learning vs. Knowledge-driven reasoning
2. More efficient robot reasoning
3. Ready expertise
4. Common sense
5. Making better bets
6. Lecture summary
7. Recommended reading & references

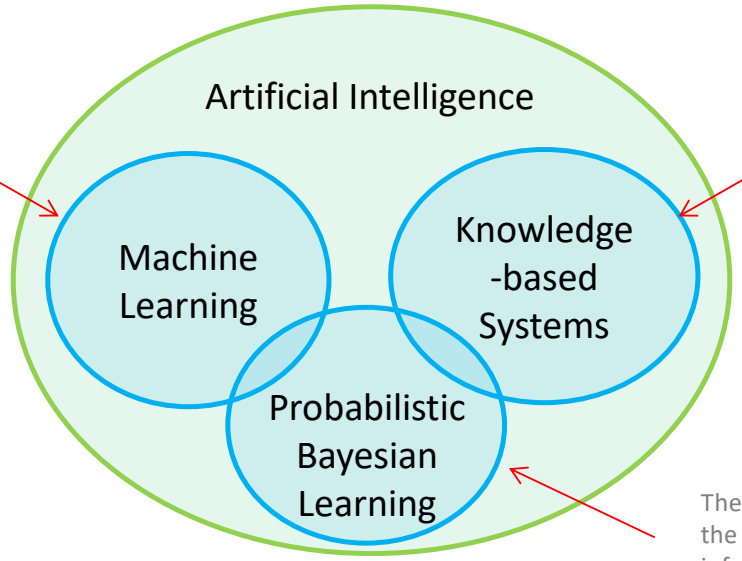
# Data-driven Machine Learning vs. Knowledge-driven Reasoning

"Companies considering how to invest in AI capabilities should first understand that over the coming five years applications and machines will become less artificial and more intelligent."

(Wilson et al., 2019)

# Data-driven Machine Learning vs. Knowledge-driven Reasoning

Machine learning techniques, such as deep learning, enable AI applications after being trained using data in very large datasets (sometimes referred to as big data)

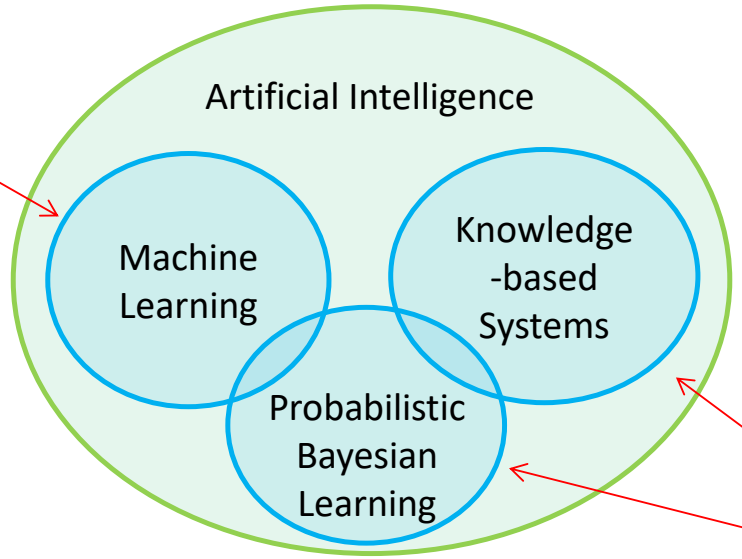



Knowledge-based systems attempt to emulate the problem-solving skills of a human expert by using explicitly encoded knowledge and reasoning to solve problems (they used to be called expert systems)

These provide a powerful way to deal with uncertainty by capturing the statistical relationships among the entities being modeled: inferring the most likely outcomes and drawing conclusions that are the most likely to be correct when solving problems

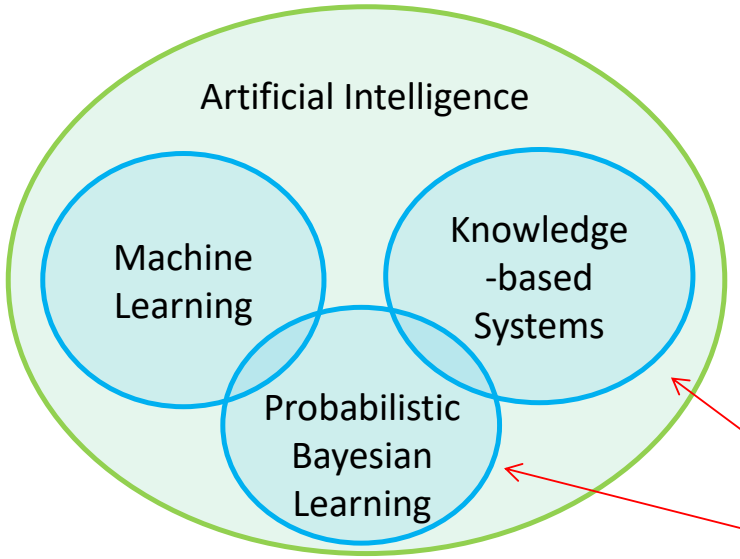
# Data-driven Machine Learning vs. Knowledge-driven Reasoning

Future AI systems will rely less on data-driven machine learning




Future AI systems will rely more on approaches that emulate human intelligence, working with less data

# Data-driven Machine Learning vs. Knowledge-driven Reasoning




General reasoning ability will allow AI to be applied more broadly and will create new business opportunities

# Data-driven Machine Learning vs. Knowledge-driven Reasoning

- Recent advances in AI have been driven by deep neural networks
- Building up systems from the bottom by training them on "mountains of data"
- But these systems have serious limitations
- For example, they have trouble handling “edge” cases:
  situations where there is little data

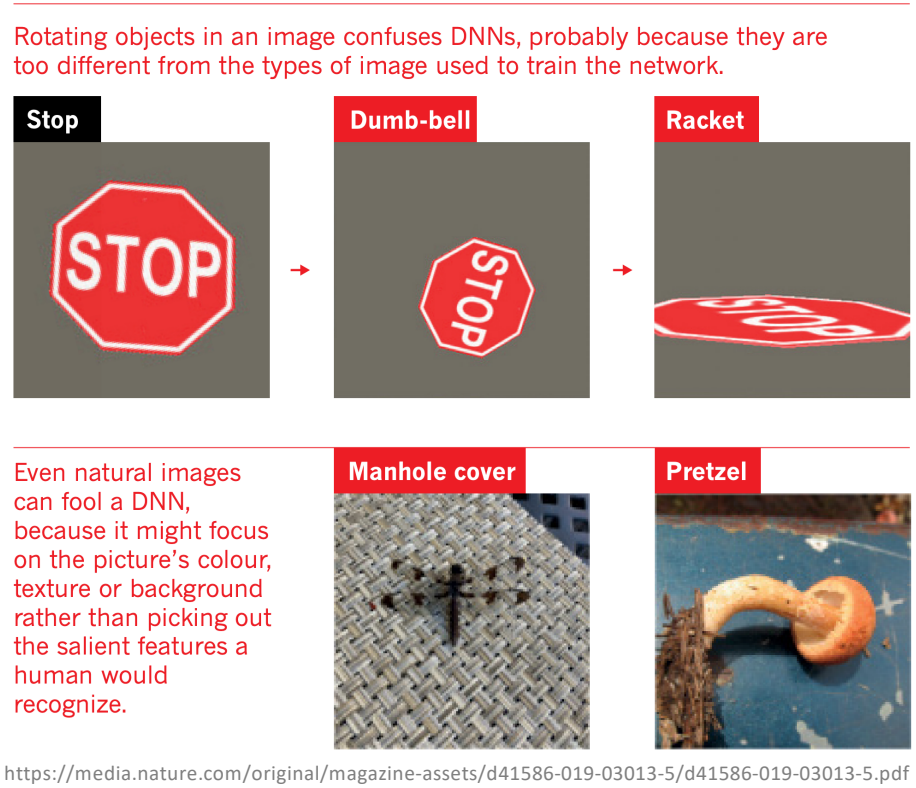
# Data-driven Machine Learning vs. Knowledge-driven Reasoning

A driverless car that can handle crosswalks, pedestrians, and traffic has trouble dealing with anomalies such as children dressed in unusual Halloween costumes, wandering across the street after dusk

https://www.today.com/parents/13-ways-get-great-photos-kids-halloween-t49076

# Data-driven Machine Learning vs. Knowledge-driven Reasoning

- The iPhone X's facial recognition system doesn't recognize "morning faces": a user's puffy, haggard look on first awakening
- Turn an image upside down or slightly alter it and the network may misidentify it

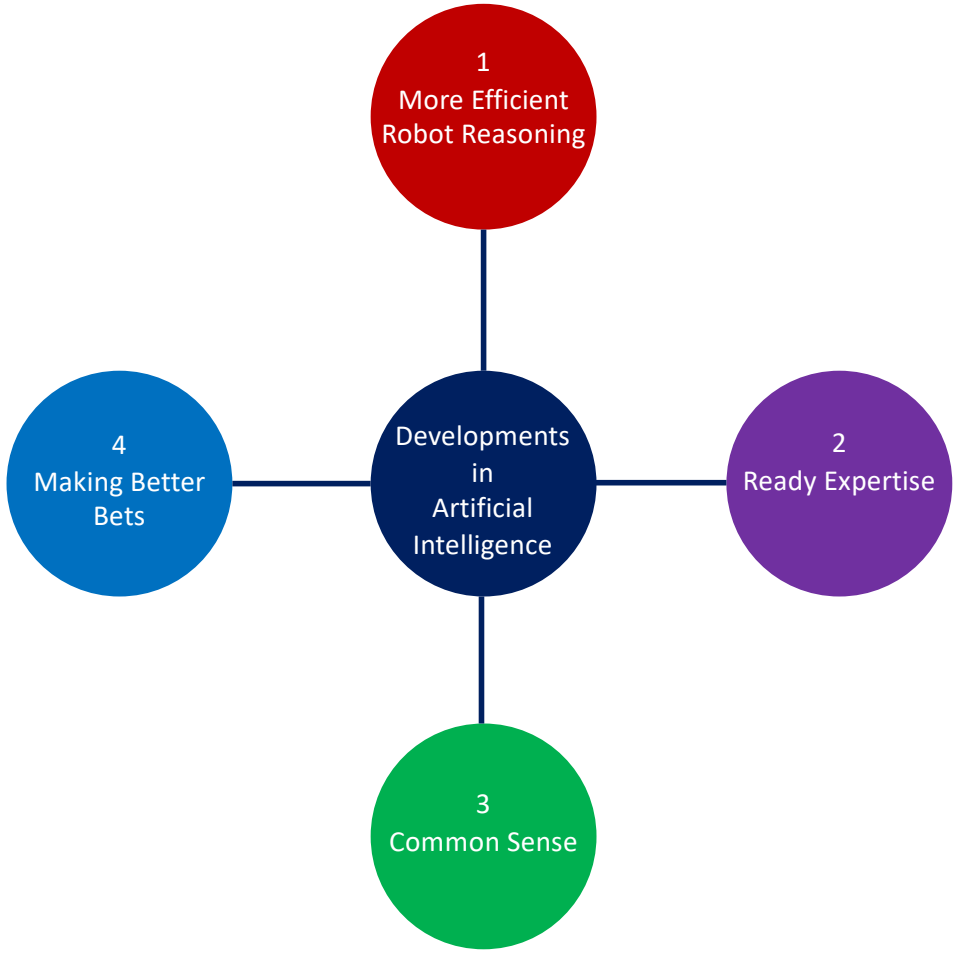



https://media.nature.com/original/magazine-assets/d41586-019-03013-5/d41586-019-03013-5.pdf

# Data-driven Machine Learning vs. Knowledge-driven Reasoning

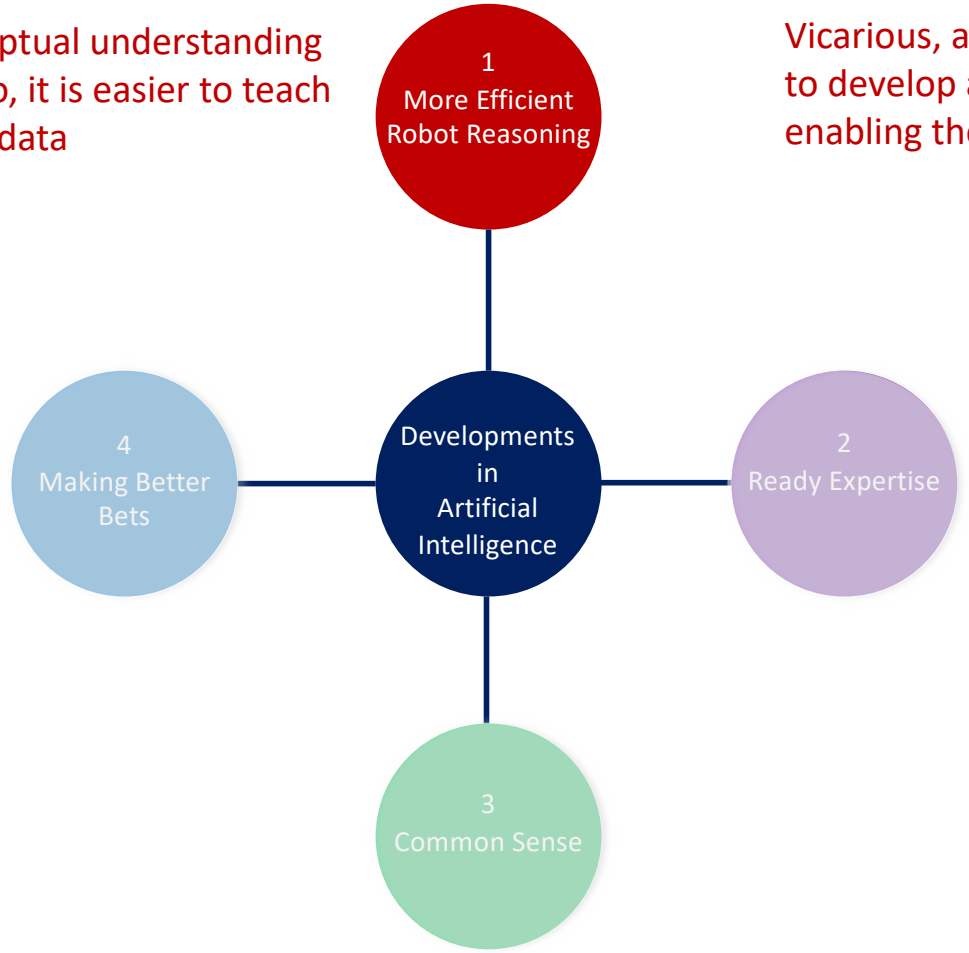
- Practical problems: not every company has the volume of data necessary to train a deep neural networks
- Privacy problems: using huge amounts of citizens' data leads to more government action such as the European Union's General Data Protection Regulation (GDPR)
- Transparency problems: these systems are black boxes and it's not always clear how the outputs – the actions or decisions – are derived from the input data
- Ethical problems: the black-box characteristic also leaves them open to manipulation by people with bad intentions as tools for disinformation

# A Vision of Where AI is Heading



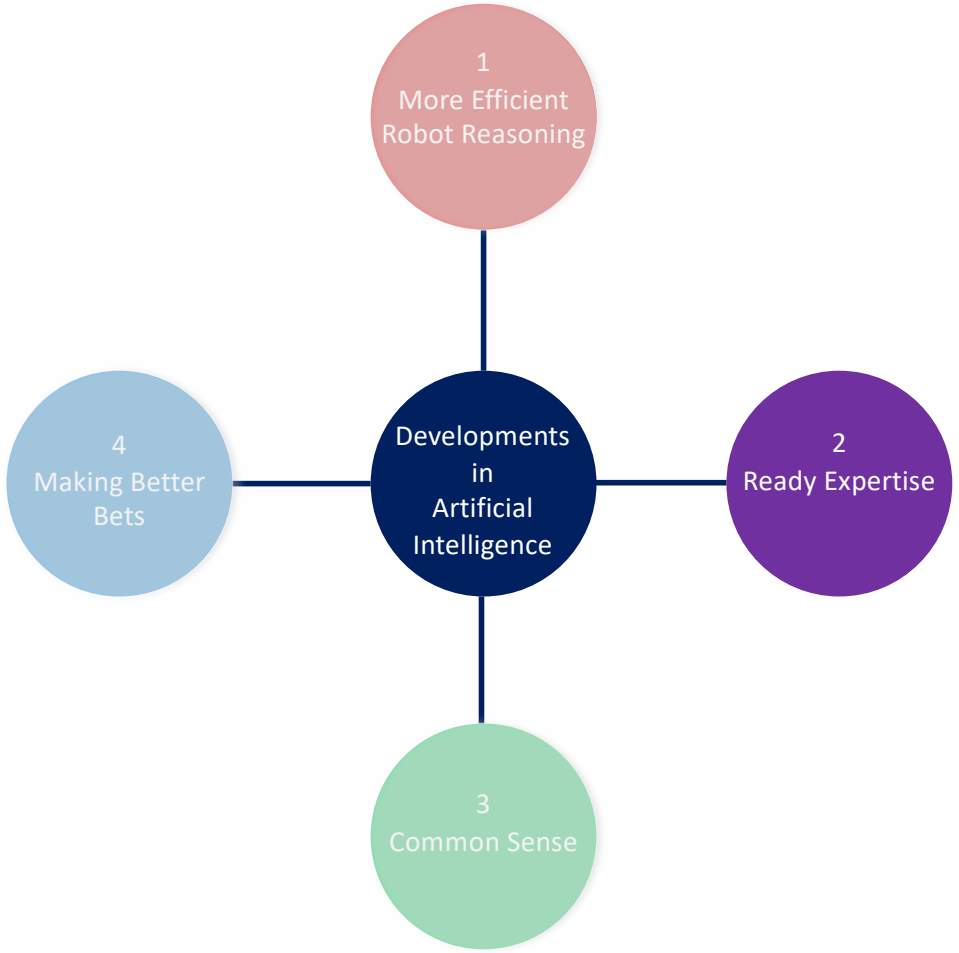
# A Vision of Where AI is Heading

When robots have a conceptual understanding of the world, as humans do, it is easier to teach them things, using far less data



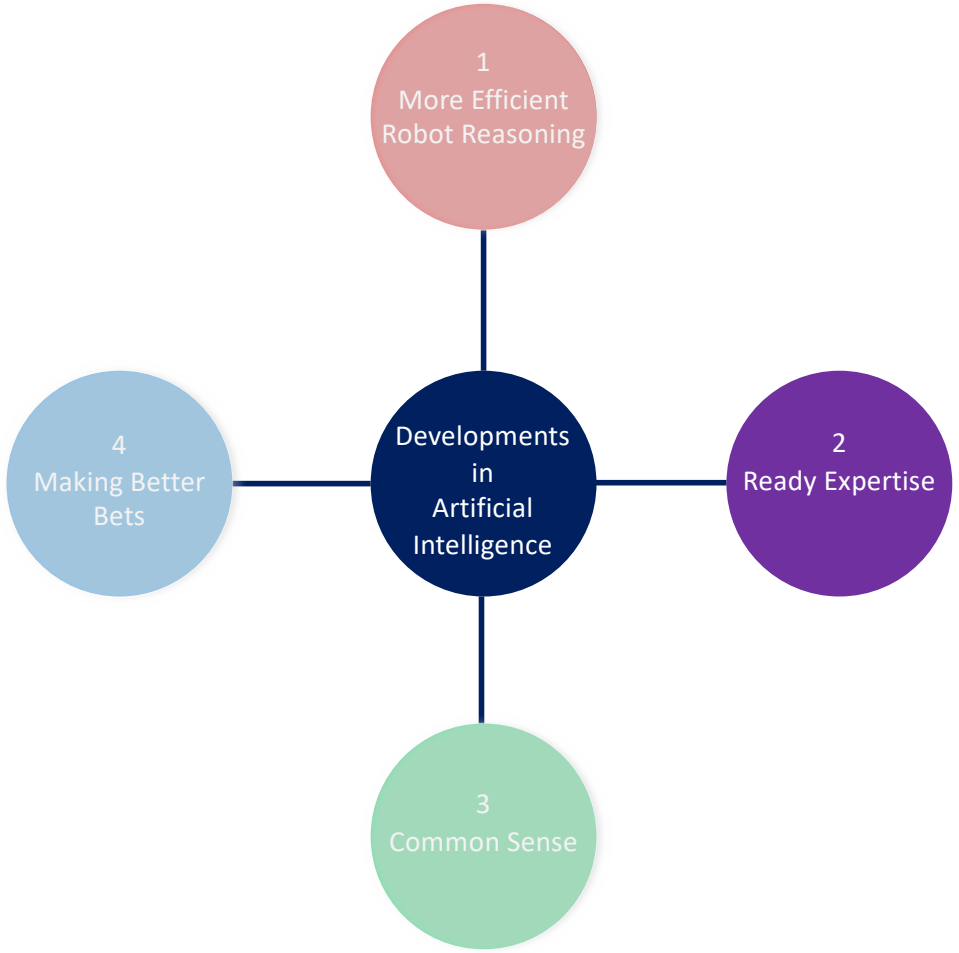

Vicarious, a startup based in California, is working to develop artificial general intelligence for robots, enabling them to generalize from few examples.

# A Vision of Where AI is Heading




Modeling what a human expert would do in the face of uncertainty and little data, top-down artificial intelligence can beat data-hungry approaches for designing and controlling many varieties of factory equipment

# A Vision of Where AI is Heading




Siemens is using top-down AI to control the highly complex combustion process in gas turbines, where air and gas flow into a chamber, ignite, and burn at temperatures as high as 1,600 degrees Celsius

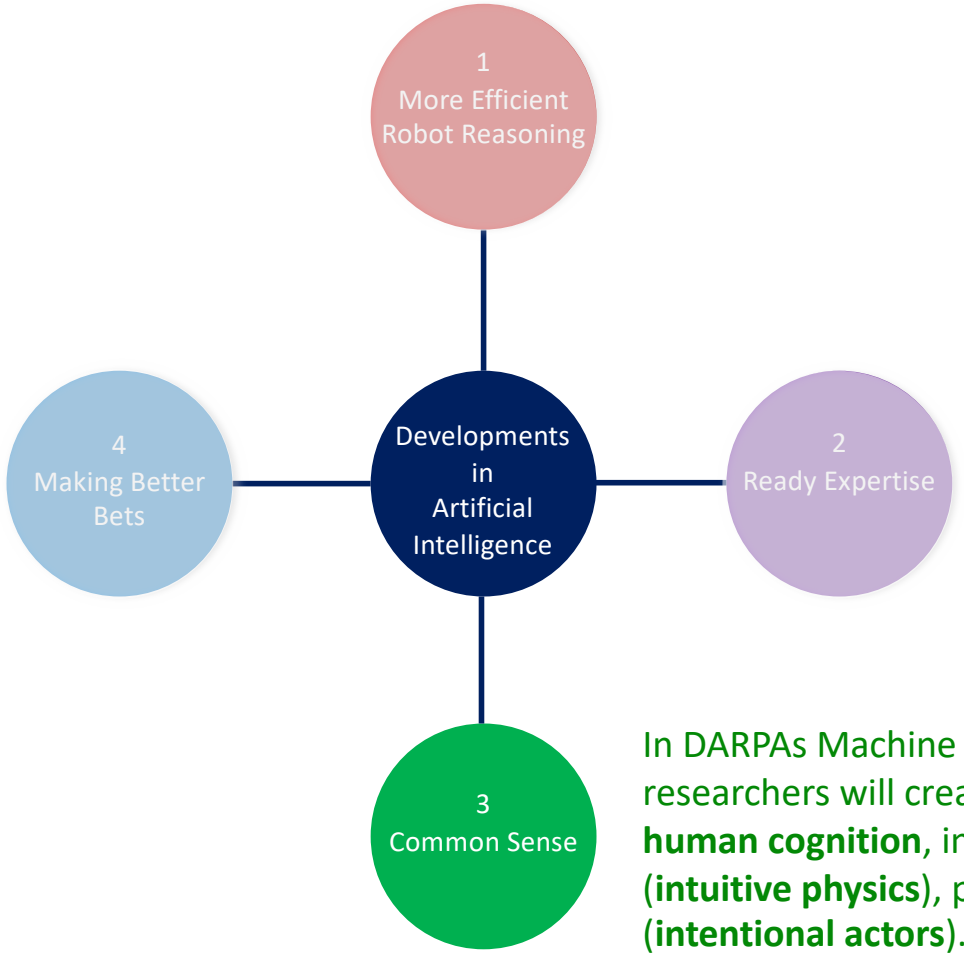
# A Vision of Where AI is Heading


Many organizations are working developing AI systems with common sense: the ability to understand everyday objects and actions, communicate naturally, handle unforeseen situations, and learn from experiences

# A Vision of Where AI is Heading

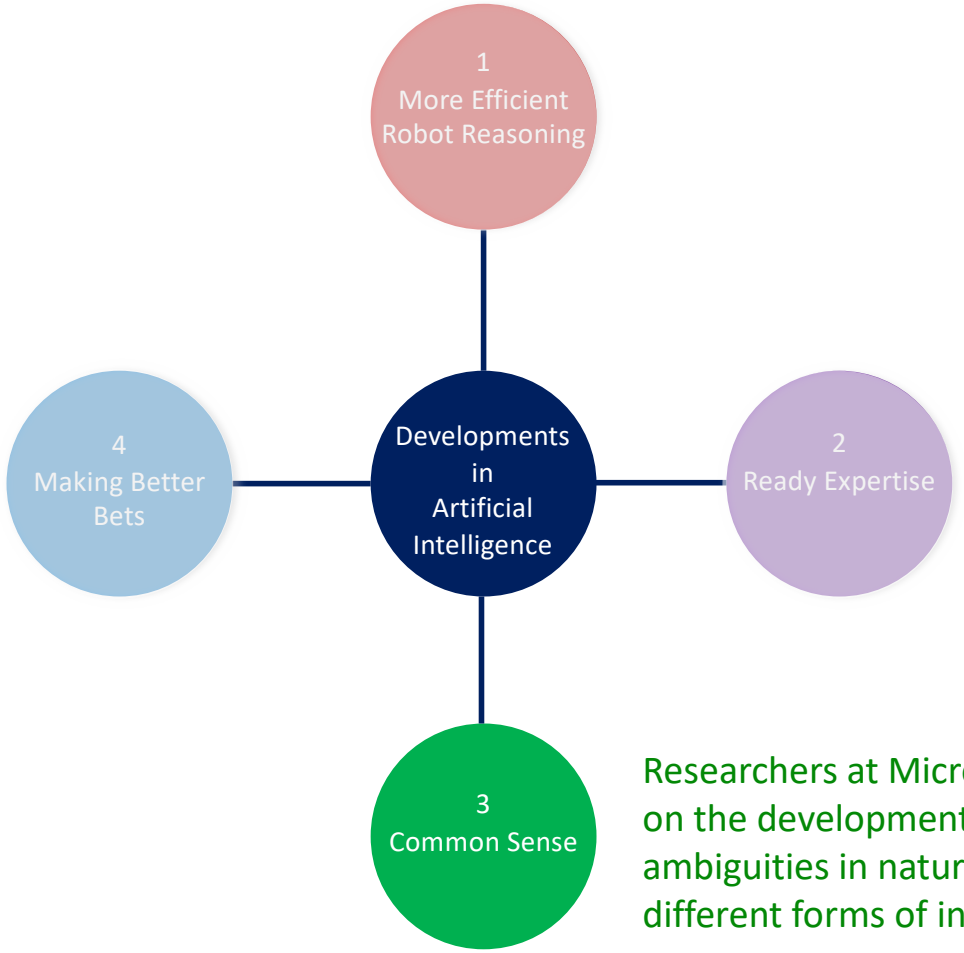

What comes naturally to humans, without explicit training or data, is fiendishly difficult for machines so the Allen Institute for Artificial Intelligence (AI2) is developing a portfolio of tasks against which progress can be measured.

# A Vision of Where AI is Heading




In DARPAs Machine Common Sense (MCS) program, researchers will create models that mimic core domains of **human cognition**, including "the domains of objects (**intuitive physics**), places (**spatial navigation**), and agents (**intentional actors**)."

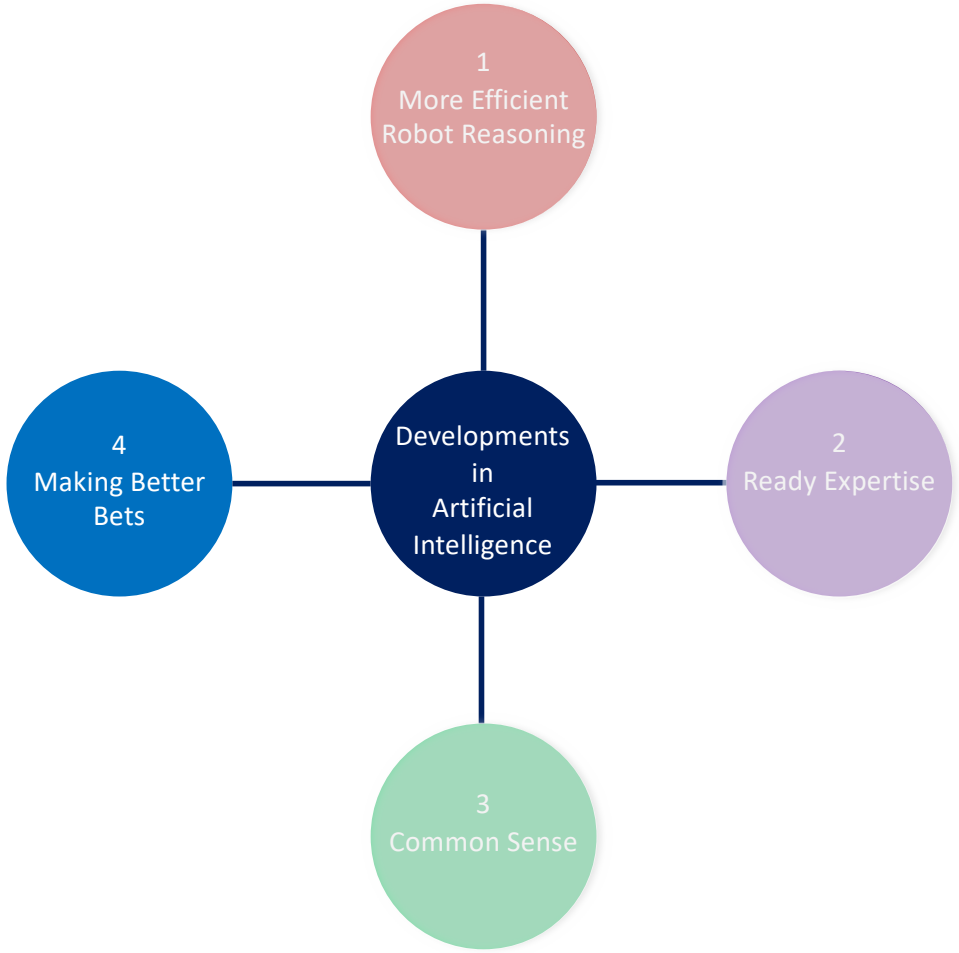
# A Vision of Where AI is Heading




Researchers at Microsoft and McGill University collaborated on the development of a system that can deal with the ambiguities in natural language, a problem that requires different forms of inference and knowledge

# A Vision of Where AI is Heading

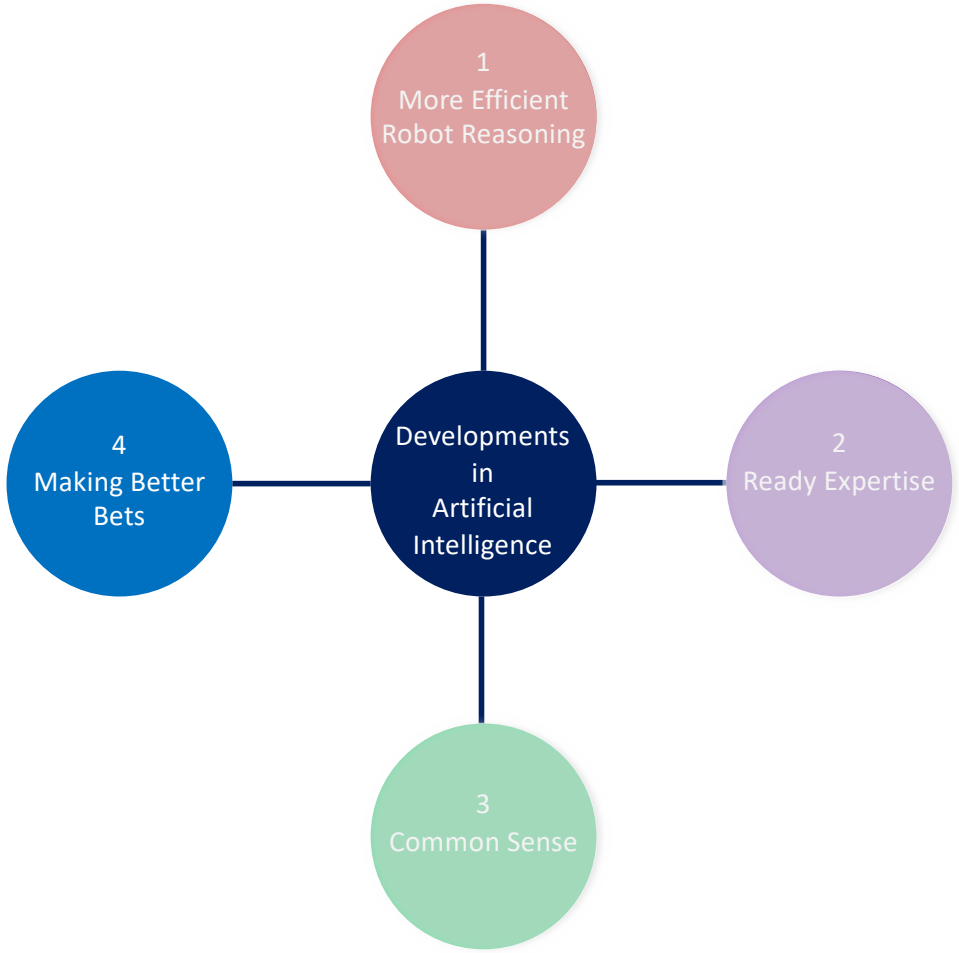
Although they do it implicitly, humans often consider the likelihood of different options before deciding what to do



# A Vision of Where AI is Heading

Machines are now being taught to mimic such reasoning through the application of Gaussian processes:

probabilistic models that can deal with uncertainty, work with little data, and learn from experience



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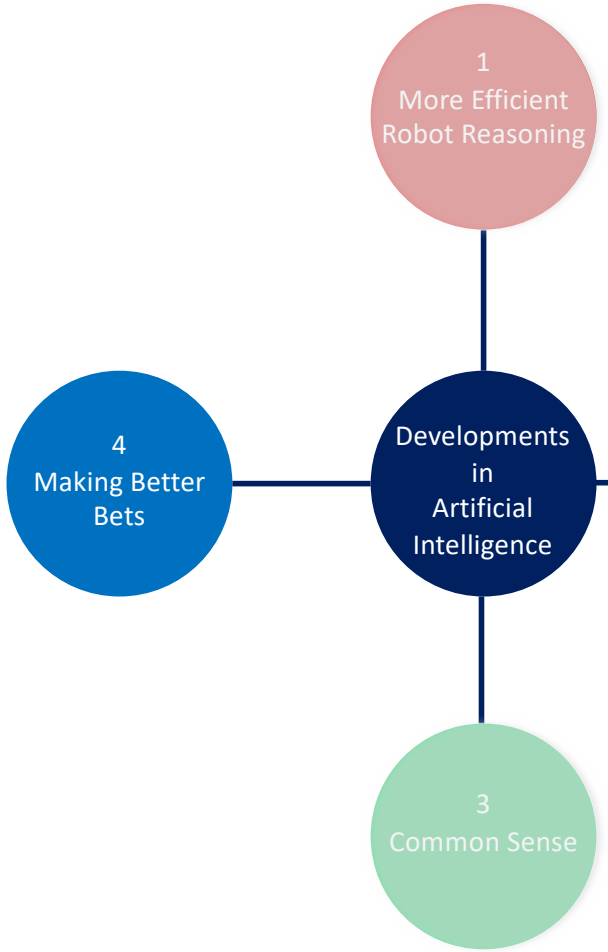


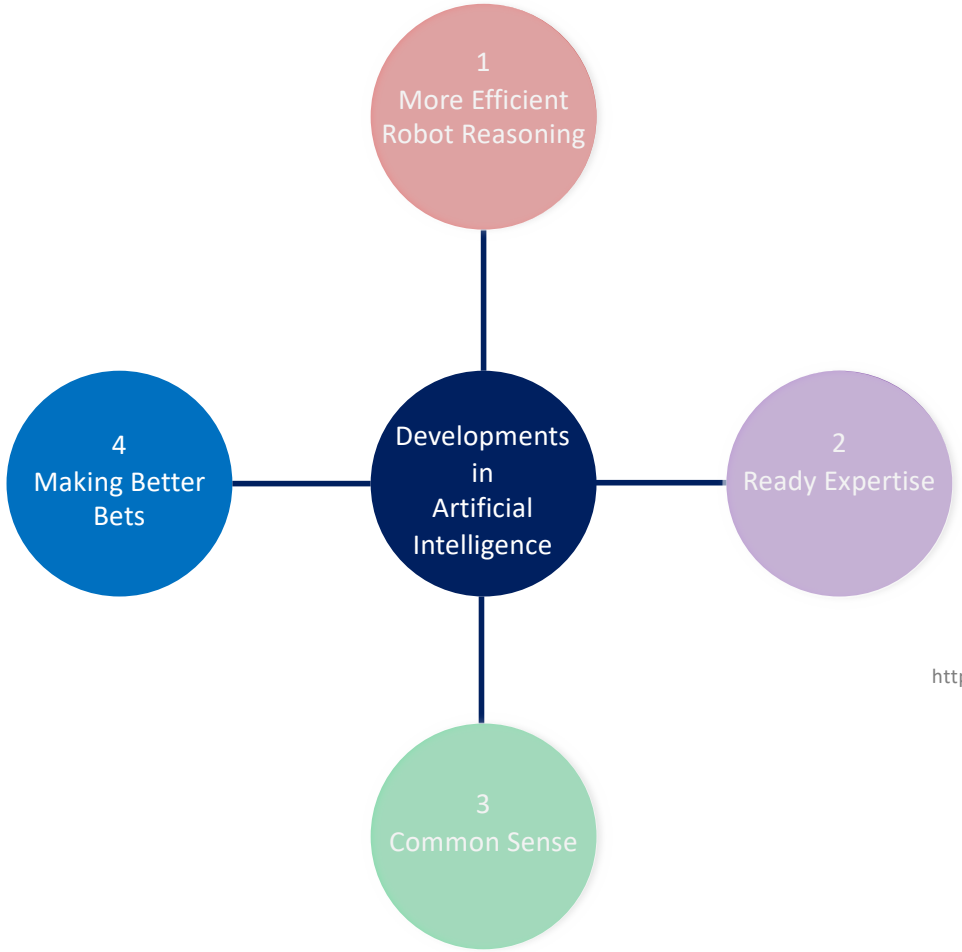

Alphabet, Google's parent company, launched Project Loon to provide internet service to underserved regions of the world using a network of giant balloons hovering in the stratosphere

https://www.wired.com/story/loon-internet-balloons-kenya-google-alphabet-x/

# A Vision of Where AI is Heading

The movement of the balloons will depend on winds of different speeds at different altitudes.

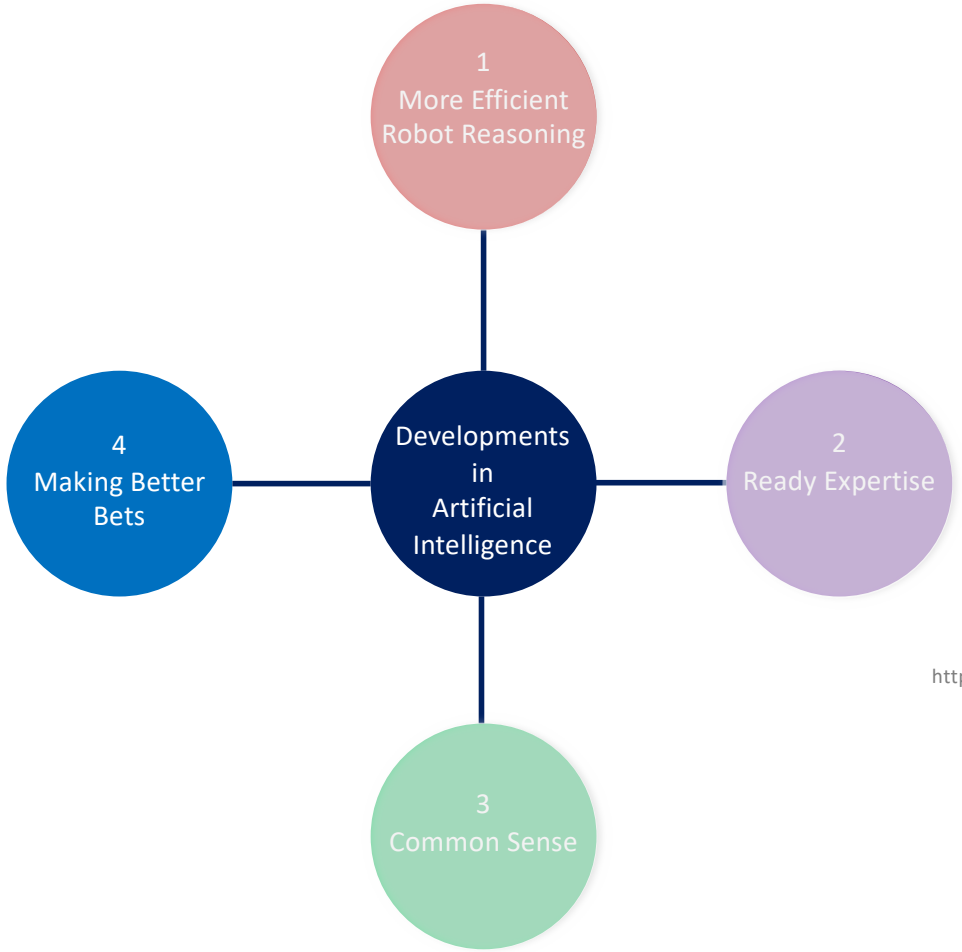
Their navigational systems use Gaussian processes to predict the altitude the balloons need to go to adjust their position




https://www.wired.com/story/loon-internet-balloons-kenya-google-alphabet-x/

# A Vision of Where AI is Heading

Each balloon then moves into a layer of wind blowing in the right direction, arranging themselves to form one large communication network.

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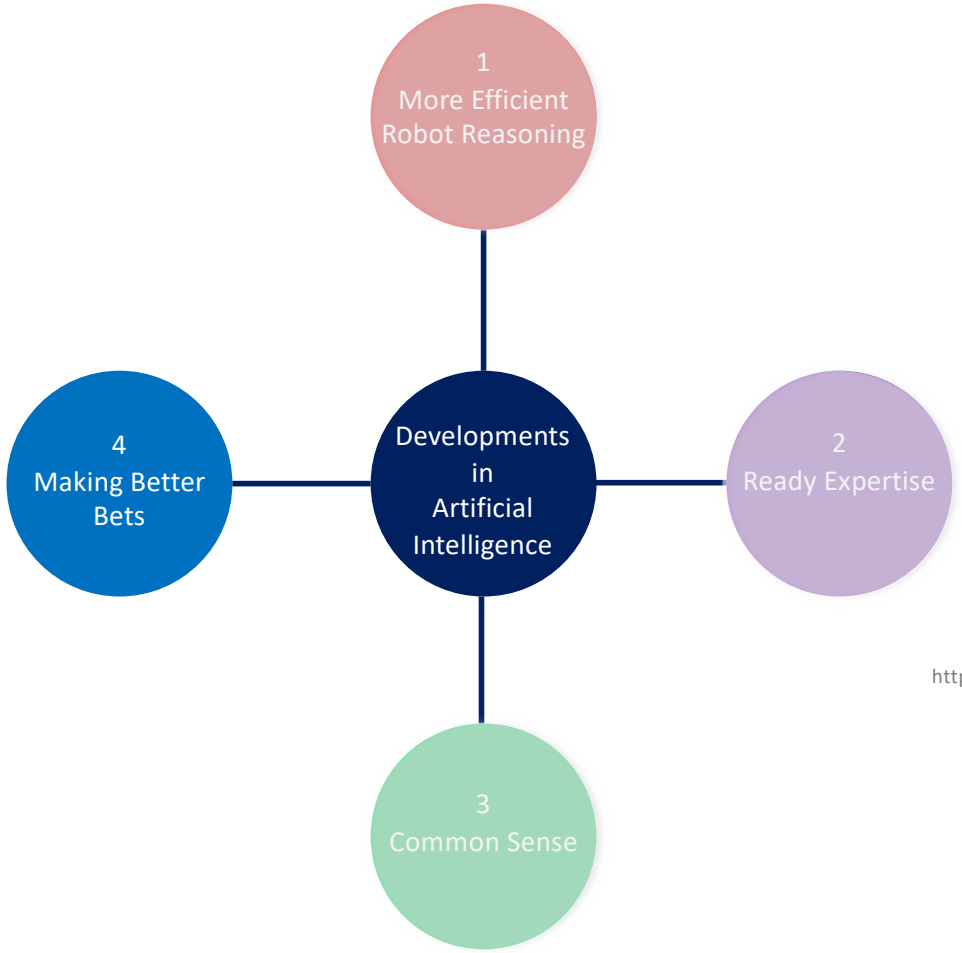
# A Vision of Where AI is Heading

Gaussian processes have several things going for them:

- Don’t require huge amounts of data
- Computations are straightforward
- Failures can be easily traced

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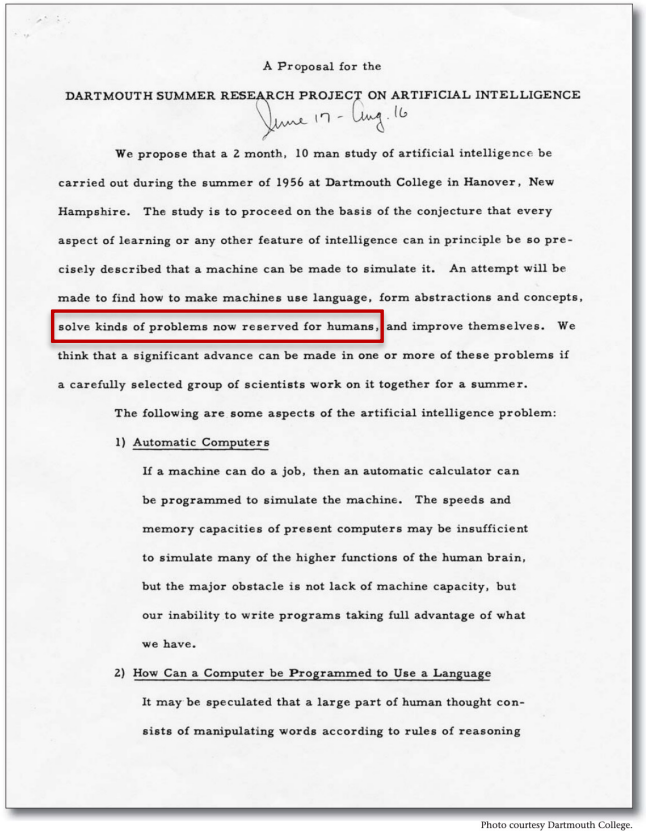
# The Birth of AI

Seven topics:

1. Automatic Computers
2. How Can a Computer be Programmed to Use a Language
3. Neuron Nets
4. Theory of the Size of a Calculation
5. Self-improvement
6. Abstractions
7. Randomness and Creativity



A Proposal for the

DARTMOUTH SUMMER RESEARCH PROJECT ON ARTIFICIAL INTELLIGENCE

June 17 - Aug. 16

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.

The following are some aspects of the artificial intelligence problem:

1) Automatic Computers

If a machine can do a job, then an automatic calculator can be programmed to simulate the machine. The speeds and memory capacities of present computers may be insufficient to simulate many of the higher functions of the human brain, but the major obstacle is not lack of machine capacity, but our inability to write programs taking full advantage of what we have.

2) How Can a Computer be Programmed to Use a Language

It may be speculated that a large part of human thought consists of manipulating words according to rules of reasoning

Photo courtesy Dartmouth College.

*Page 1 of the Original Proposal.*

https://ojs.aaai.org/index.php/aimagazine/article/view/1904/1802

# Lecture Summary

1. "As AI develops, it will rely less on bottom-up big data and more on top-down reasoning  that resembles the way humans approach problems and tasks."

2. "This will enable us to apply AI more broadly than ever, creating opportunities for early adopters even in businesses and activities to which AI previously seemed unsuited."

3. "Until recently, most AI advanced through deep learning and machine learning, building up systems by training them on mountains of data.  But these data-hungry networks have serious limitations and difficulty handling situations where little data exists."

4. "To craft a vision of where AI is heading in the next several years, and plan investments and tests accordingly, companies should look for the following developments: more efficient robot reasoning ..., ready expertise ..., common sense ..., making better bets ..."

# Recommended Reading

Wilson, H. J., Daugherty, P., and Davenport, C. (2019). The Future of AI Will Be About Less Data, Not More, in Insights You Need from Harvard Business Review - Artificial Intelligence, Harvard Business School Publishing Corporation.

https://hbr.org/2019/01/the-future-of-ai-will-be-about-less-data-not-more