

Artificial Intelligence

DT8012

Introduction
Chapter 1, AIMA

What you'll learn from this course

An overview course – an introduction to AI technologies

- What is meant by Artificial Intelligence
 - what tools are used
 - what problems are targeted
- What problems can be solved with search
 - exactly or approximately
 - in dynamic or adversarial environment (game playing)
- How computers can represent knowledge
 - symbolic (logic) & non-symbolic (neural networks)
- How reasoning can be done with a machine
 - given knowledge that's certain & under uncertainty
- How a machine can learn & generalise

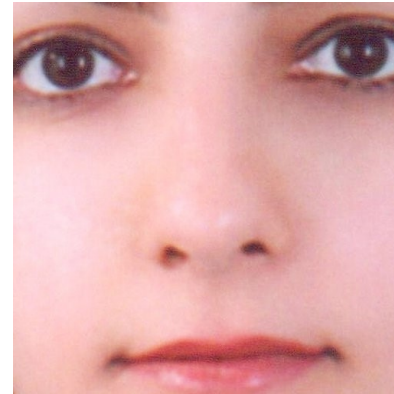
People



Slawomir Nowaczyk
Associate Professor
Course responsible



Taha Khan
Postdoc



Farzaneh Etminani
Postdoc



Hassan Nemati
PhD student

Labs and project



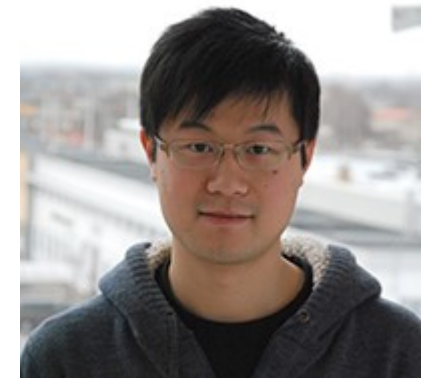
Stefan Byttner
Associate Professor



Reza Khoshangiz
Postdoc



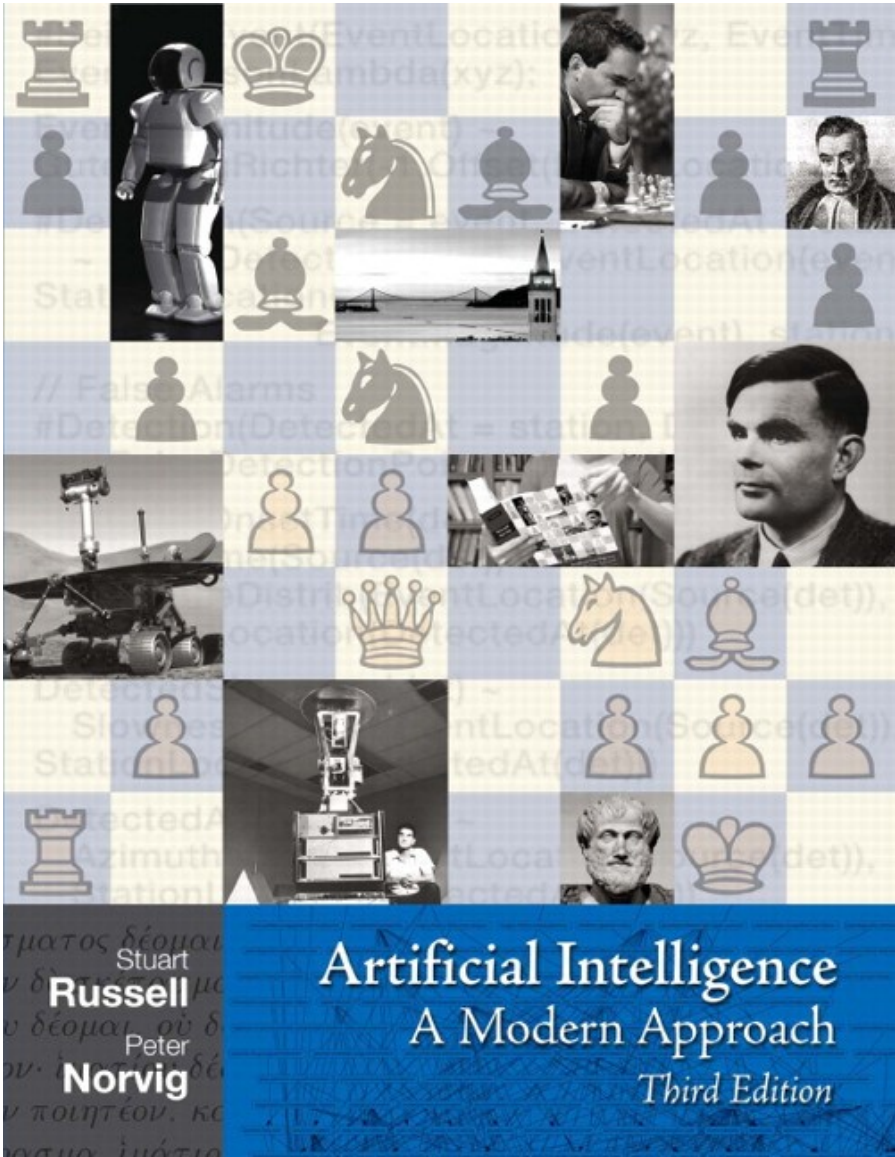
Onur Dikmen
Senior Lecturer



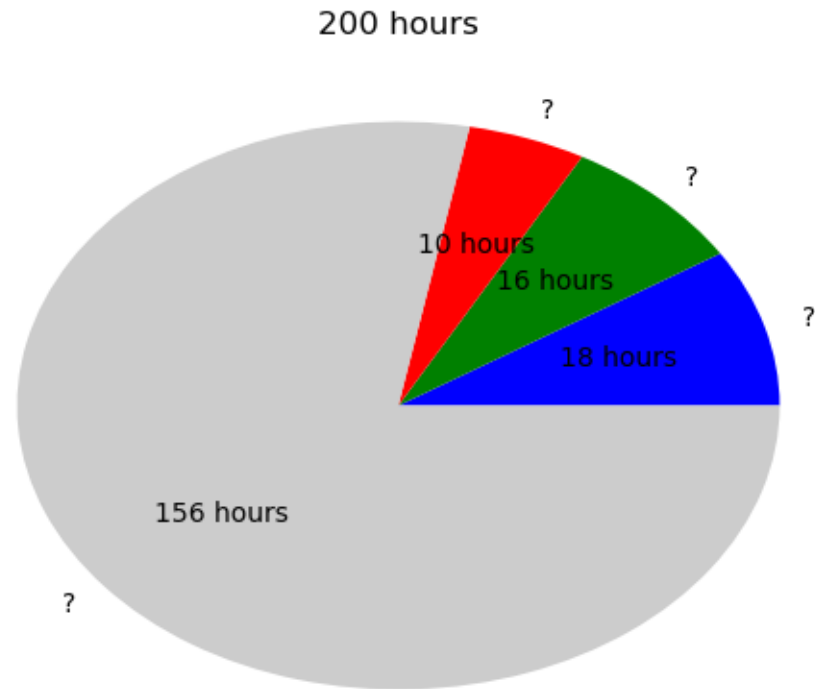
Yuantao Fan
PhD student

Labs

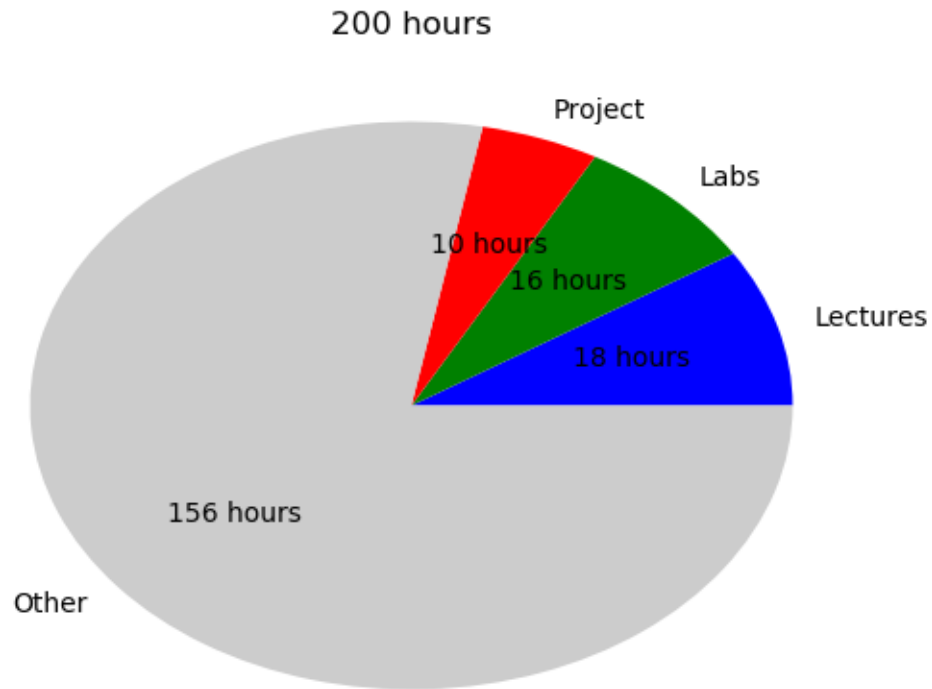
Course content follows the AIMA book closely



Time Management



Time Management



Course structure

7.5 credits course
10 weeks half-time
200 total work hours!

- Approximately 20 hours of lectures
- Lab work (4 labs, 4-8 hours each)
- Group project (40-80 hours)
 - implementation of poker-playing agents
 - tournament structure, two students per group
- Written + oral exam
- This is a difficult course, with a lot of material
 - it requires theory, practice & understanding

Course expectations

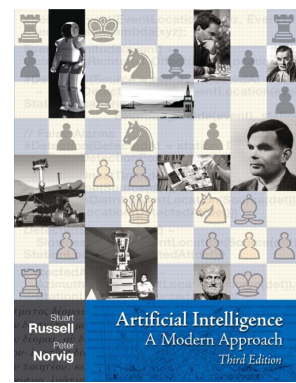
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200 total work hours!

- Topics are introduced during lectures & labs
 - AIMA book covers more topics than this course
- However not all details are given in the lectures
 - you need to read relevant book chapters in whole
 - and learn the complete material they cover
- The two exams have different focus
 - you need to both apply and explain what you know
 - memorisation is not enough, we aim for, and test during the exams, deep understanding of concepts

Course Plan



- Lecture 1: Introduction (chapters 1&2)
- Lecture 2: Informed Search (chapter 3)
- **SEARCH** Lecture 3: Adversarial Search (chapter 5)
- Lecture 4: Propositional Logic (chapter 7)
- **LOGIC** Lecture 5: First-Order Logic (chapters 8&9)
- Lecture 6: Uncertainty/Probability (ch. 13&16)
- **PROBABILITY** Lecture 7: Bayesian Networks (chapter 14)
- Lecture 8: Machine Learning 1 (chapter 18)
- **LEARNING** Lecture 9: Machine Learning 2 (chapter 18)

Course Material

- Course contents and relevant materials (e.g. lab descriptions) are available in Blackboard
- In particular, we will provide materials for you to prepare before each lecture (use it!)
- Lecture slides will be uploaded to Blackboard

Contact information

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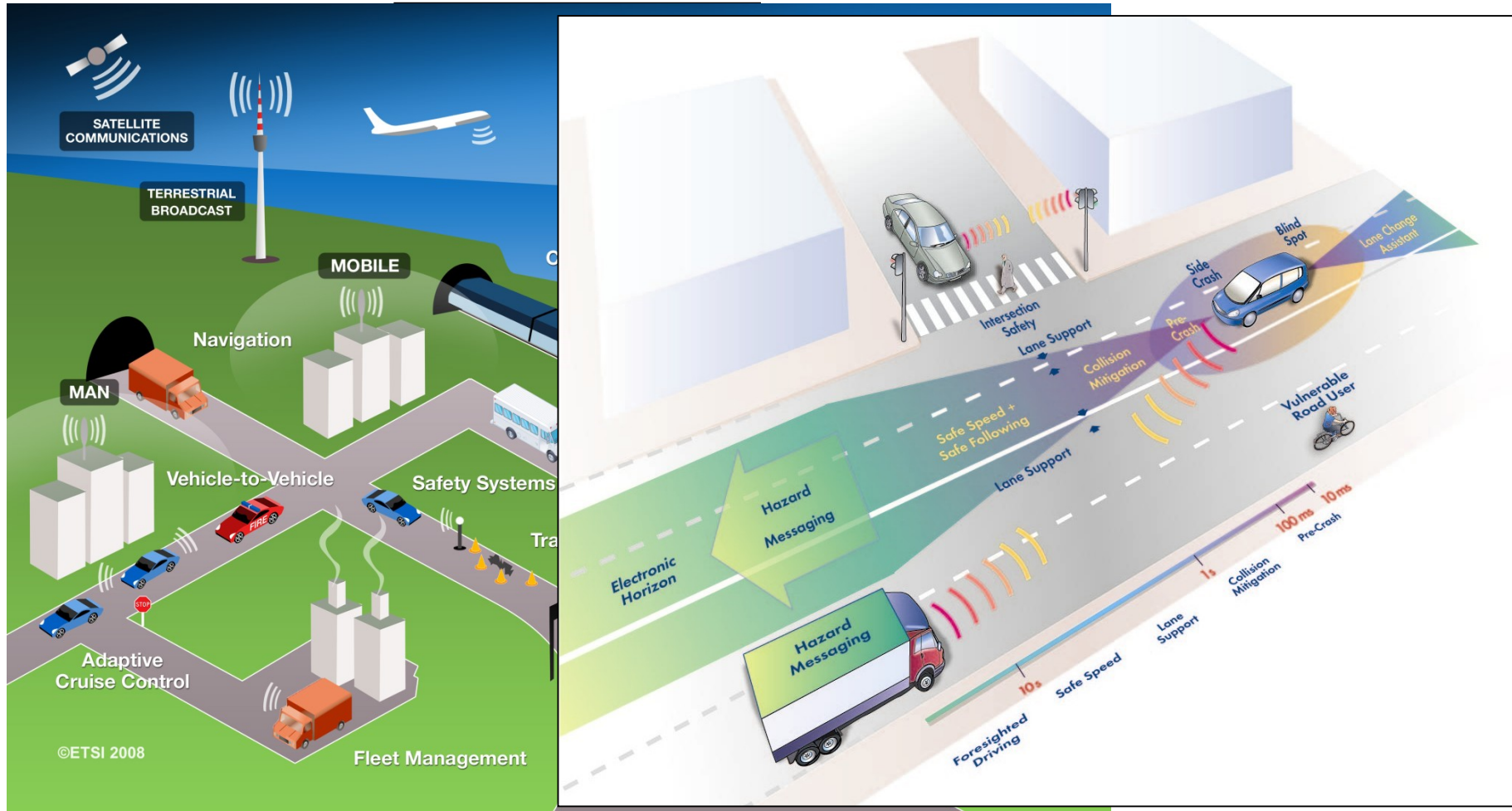
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Questions?

Artificial Intelligence for (cooperating) Embedded Systems



Intelligent embedded software and hardware for traffic control, safety, security, ...

Artificial Intelligence for (cooperating) Embedded Systems

University of Michigan and US Army

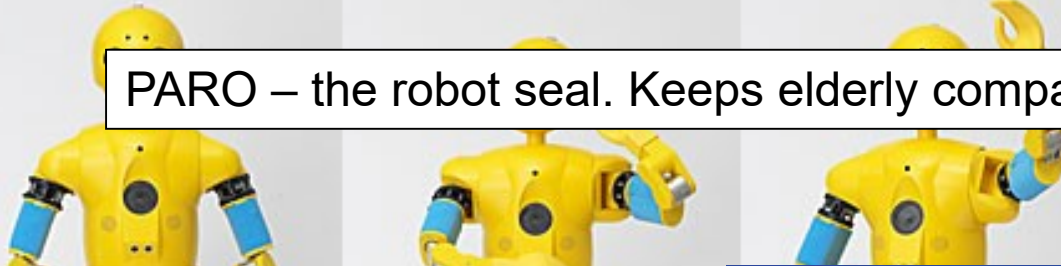
The Com-Bat: scavenge for power, stereoscopic cameras, microphones, detect radiation and airborne poisons.



Embedded intelligent systems for control of unmanned aerial vehicles

Artificial Intelligence for (cooperating) Embedded Systems

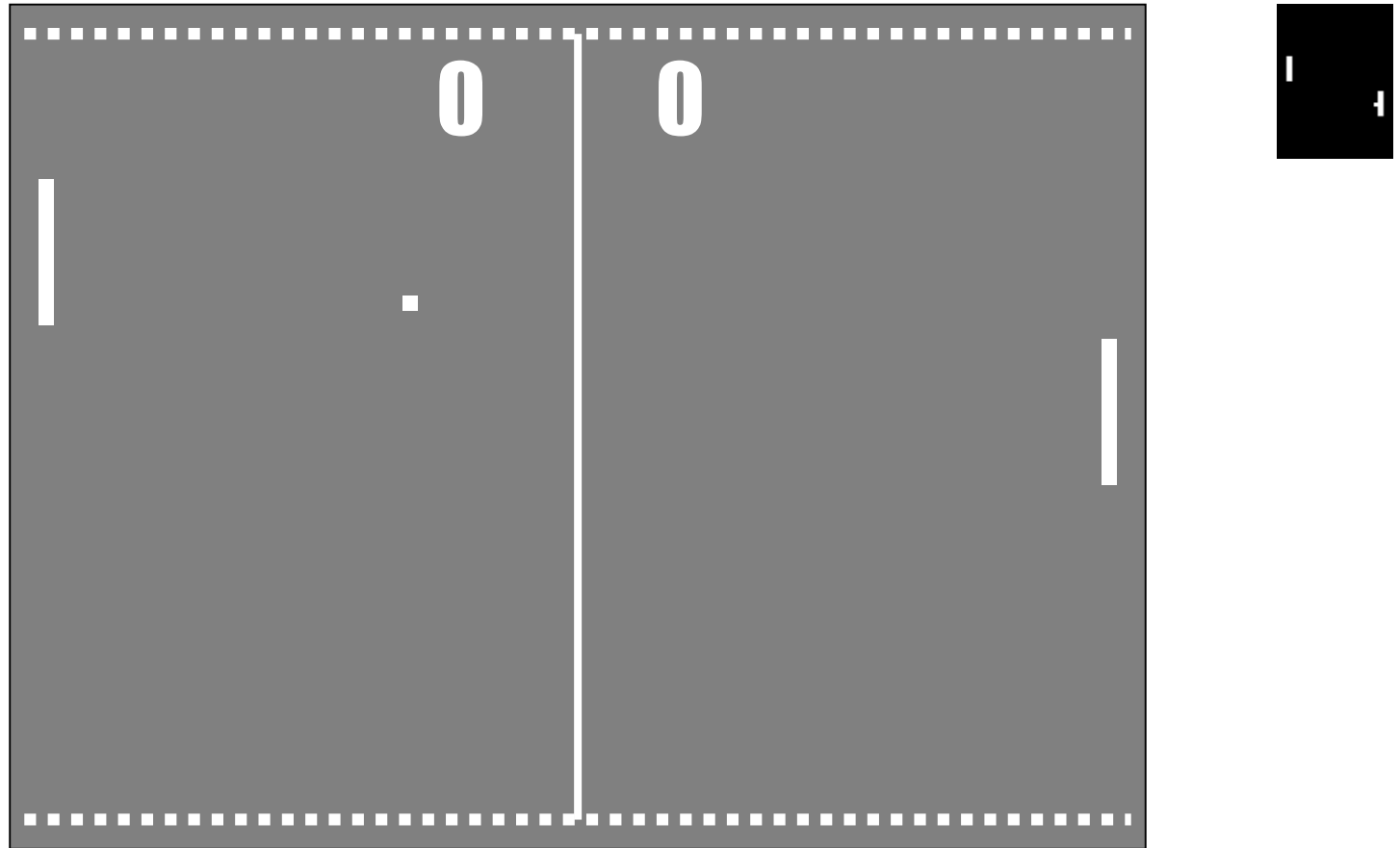
PARO – the robot seal. Keeps elderly company, like a pet.



to other persons. It recognizes approximately 10,000 words and speaks spontaneously. Can perceive when something unusual occurs (alarm).



The "pong" video arcade game



First public in 1972. The computer moves by calculating where the ball will cross the goal line and move the paddle there. Depending on difficulty, it sometimes does not move fast enough or moves to the wrong spot with some probability.

Games: Chess & IBM deep blue

- Deep Blue relies on computational power, search and evaluation.
- Deep Blue evaluates 200×10^6 positions per second. (Garry Kasparov evaluates 3 positions per second)
- The Deep Blue is a 32-node IBM RS/6000 SP with P2SC processors. Each node of the SP employs a single micro-channel card containing 8 dedicated VLSI chess processors, for a total of 256 processors working in tandem.
- Deep Blue calculates 100-200 billion (10^9) moves in three minutes.
- Deep blue typically searches 6 moves ahead but can go as far as 10-20 moves.
- Deep Blue beat the world champion Garry Kasparov in 1997
"quantity has become quality".



Deep Blue is "brute force".
Humans (probably) play chess differently...

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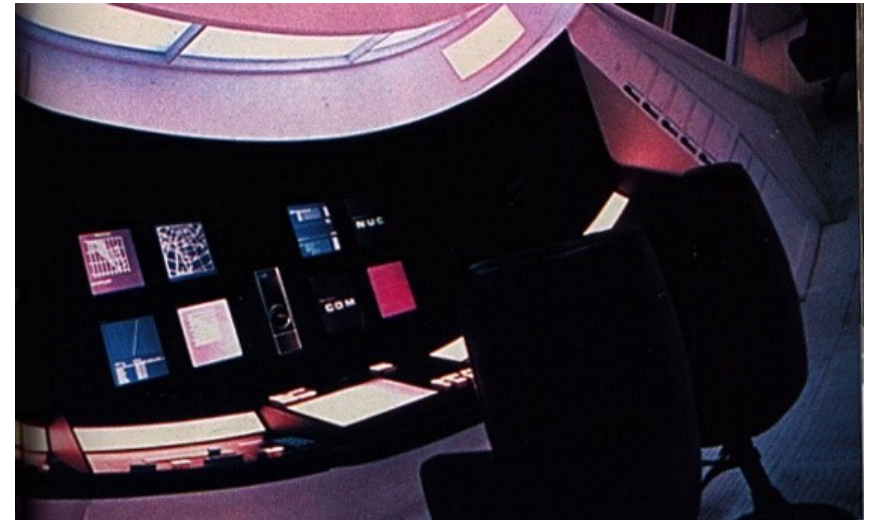


Deep Blue is "brute force".
Humans (probably) play chess differently...

Note: in 1957, AI researchers thought that computers would beat the world chess champion within 10 years.

Do humans play chess differently?

Compare with HAL (the computer in "2001: A Space Odyssey"). HAL plays "tricky" and exploits the lower level of the opponent (the Astronaut Poole).



This is not "computer-like", but "human-like".

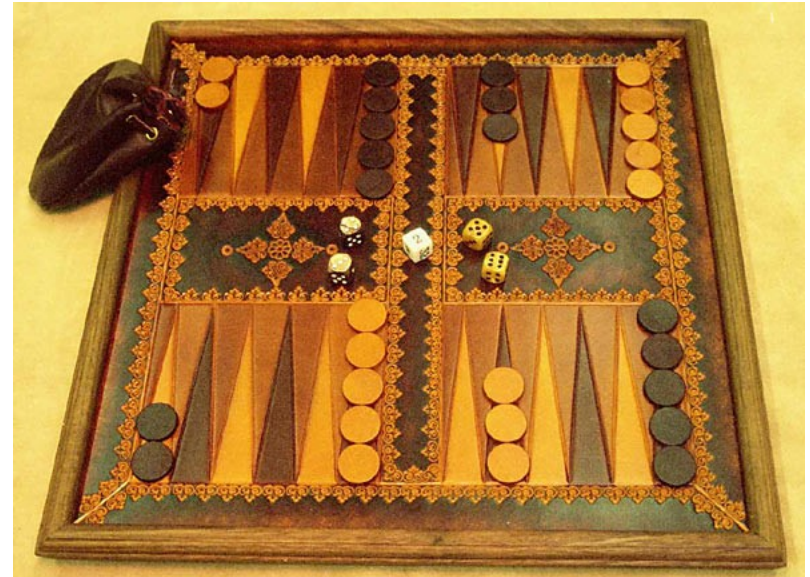
Computers, on the other hand, assume that the opponent will make the best possible move.

This is the minimax rule

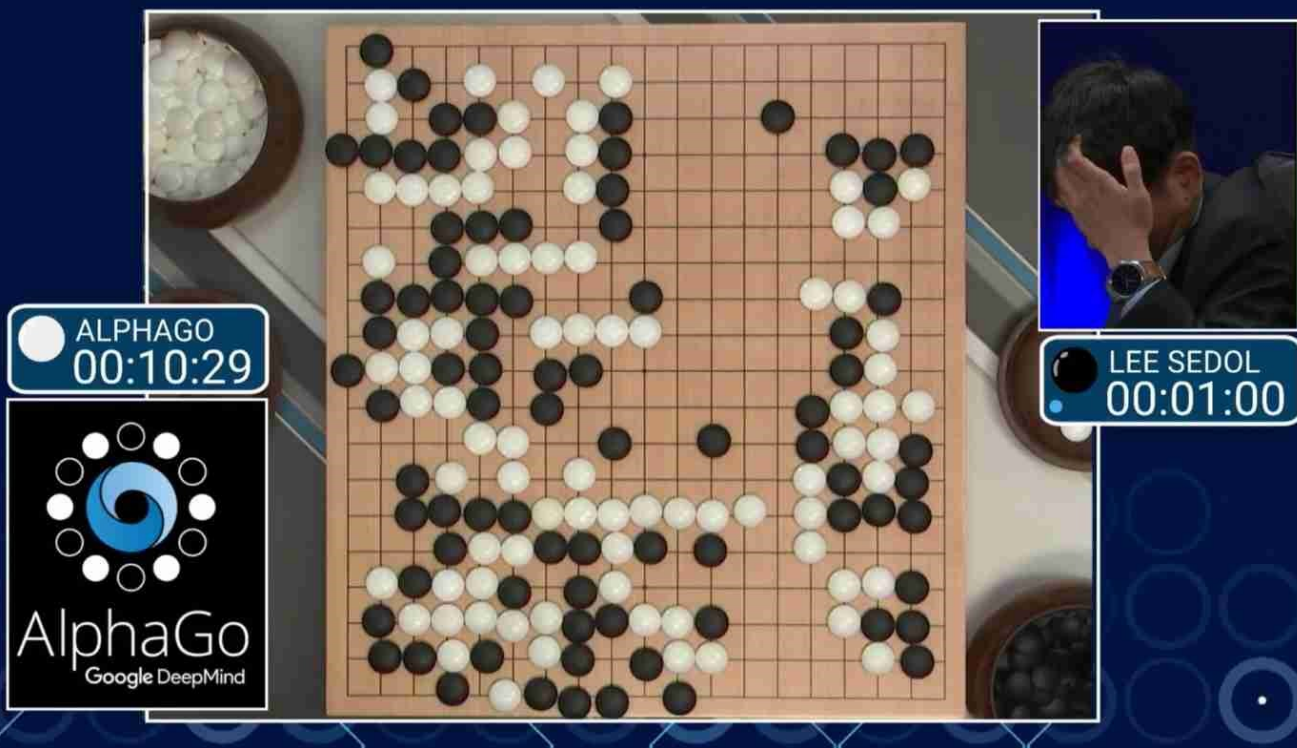
Check out "How HAL plays chess:
<http://mitpress.mit.edu/e-books/Hal/chap5/five1.html>

TD-Gammon

- The best backgammon programs use temporal difference (TD) algorithms to train a back-propagation neural network by self-play. The top programs are world-class in playing strength.
- 1998, the American Association of Artificial Intelligence meeting: NeuroGammon won 99 of 100 games against a human grand master (the current World Champion).
- TD-Gammon is based more on pattern recognition than search.



TD-Gammon is an example of machine learning. It plays itself and adapts its "rules" after each game depending on wins/losses.



The story of AlphaGo so far

AlphaGo is the first computer program to defeat a professional human Go player, the first program to defeat a Go world champion, and arguably the strongest Go player in history.

AlphaGo's first formal match was against the reigning 3-times European Champion, Mr Fan Hui, in October 2015. Its 5-0 win was the first ever against a Go professional, and the results were published in full technical detail in the international journal, [Nature](#). AlphaGo then went on to compete against legendary player Mr Lee Sedol, winner of 18 world titles and widely considered to be the greatest player of the past decade.

AlphaGo's 4-1 victory in Seoul, South Korea, in March 2016 was watched by over 200 million people worldwide. It was a landmark achievement that experts agreed was a decade ahead of its time, and earned AlphaGo a 9 dan professional ranking (the highest certification) - the first time a computer Go player had ever received the accolade.



[> More on The Future of Go Summit in this video](#)

AlphaZero is a computer program developed by research company DeepMind, which uses an approach similar to AlphaGo Zero's to master not just *Go*, but also *chess* and *shogi*. On December 5, 2017 DeepMind team introduced AlphaZero, which, within 24 hours, achieved a superhuman level of play in these games by defeating world-champion programs.

AlphaZero

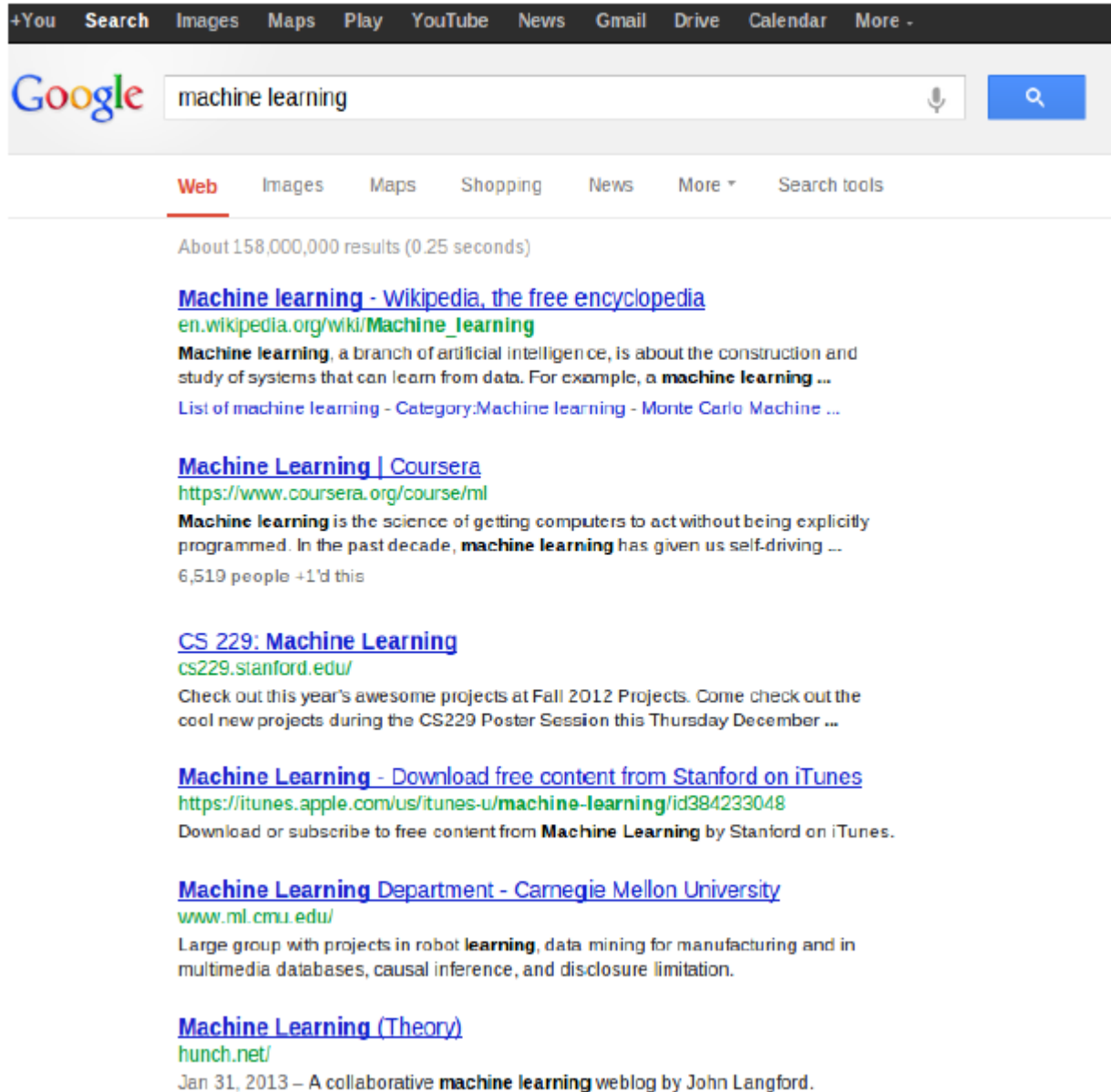
From Wikipedia, the free encyclopedia



AI in video games

- "Pong" was a first version...
- See online talk (Boston University) at <http://www.bu.edu/buniverse/view/?v=1SaUoj65>
- And at (UC Berkeley) <http://www.youtube.com/watch?v=PsvsZuFgBzc>
- Read tutorial (and watch slides) from Microsoft at <http://research.microsoft.com/en-us/projects/ijcaiigames/>
- Façade demo at <http://www.youtube.com/watch?v=GmuLV9eMTkg>

Search/query applications



The image shows a screenshot of a Google search results page. At the top, there is a navigation bar with links for '+You', 'Search', 'Images', 'Maps', 'Play', 'YouTube', 'News', 'Gmail', 'Drive', 'Calendar', and 'More -'. Below this is the Google logo and a search bar containing the text 'machine learning'. To the right of the search bar is a microphone icon and a blue search button with a magnifying glass icon. Below the search bar, there are tabs for 'Web', 'Images', 'Maps', 'Shopping', 'News', 'More ▾', and 'Search tools'. The 'Web' tab is selected and underlined. Below the tabs, the search results are displayed. The first result is 'Machine learning - Wikipedia, the free encyclopedia' with a URL 'en.wikipedia.org/wiki/Machine_learning'. The second result is 'Machine Learning | Coursera' with a URL 'https://www.coursera.org/course/ml'. The third result is 'CS 229: Machine Learning' with a URL 'cs229.stanford.edu/'. The fourth result is 'Machine Learning - Download free content from Stanford on iTunes' with a URL 'https://itunes.apple.com/us/itunes-u/machine-learning/id384233048'. The fifth result is 'Machine Learning Department - Carnegie Mellon University' with a URL 'www.ml.cmu.edu/'. The sixth result is 'Machine Learning (Theory)' with a URL 'hunch.net/'.

+You Search Images Maps Play YouTube News Gmail Drive Calendar More -

Google machine learning

Web Images Maps Shopping News More ▾ Search tools

About 158,000,000 results (0.25 seconds)

[Machine learning - Wikipedia, the free encyclopedia](#)
en.wikipedia.org/wiki/Machine_learning
Machine learning, a branch of artificial intelligence, is about the construction and study of systems that can learn from data. For example, a **machine learning** ...
List of machine learning - Category:Machine learning - Monte Carlo Machine ...

[Machine Learning | Coursera](#)
<https://www.coursera.org/course/ml>
Machine learning is the science of getting computers to act without being explicitly programmed. In the past decade, **machine learning** has given us self-driving ...
6,519 people +1'd this

[CS 229: Machine Learning](#)
cs229.stanford.edu/
Check out this year's awesome projects at Fall 2012 Projects. Come check out the cool new projects during the CS229 Poster Session this Thursday December ...

[Machine Learning - Download free content from Stanford on iTunes](#)
<https://itunes.apple.com/us/itunes-u/machine-learning/id384233048>
Download or subscribe to free content from **Machine Learning** by Stanford on iTunes.

[Machine Learning Department - Carnegie Mellon University](#)
www.ml.cmu.edu/
Large group with projects in robot **learning**, data mining for manufacturing and in multimedia databases, causal inference, and disclosure limitation.

[Machine Learning \(Theory\)](#)
hunch.net/
Jan 31, 2013 – A collaborative **machine learning** weblog by John Langford.

Machine translation

The image shows a screenshot of the Google Translate web interface. At the top, there is a navigation bar with links to '+You', 'Search', 'Images', 'Maps', 'Play', 'YouTube', 'News', 'Gmail', 'Drive', 'Calendar', and 'More'. Below this is the Google logo and a 'SIGN IN' button. The main area is titled 'Translate' and features a 'From: French - detected' dropdown, a swap button, a 'To: English' dropdown, and a blue 'Translate' button. Below the input fields, there are tabs for 'English', 'Spanish', 'French', and 'French - detected'. The input text in French is: "Le premier ministre a lancé une autre piste – sans l'expliquer et beaucoup des experts présents à la conférence environnementale n'ont pu le faire - : la mobilisation d'une partie des gains financiers perçus sur le parc nucléaire français. "Pendant toute la durée de vie restante de nos centrales, et tout en assurant une sécurité maximale, a déclaré Jean-Marc Ayrault, notre parc nucléaire sera mis à contribution sans rupture d'approvisionnement".

The output text in English is: "The Prime Minister has launched another track - without explaining and many experts at the environmental conference could not do -: the mobilization of some of the financial gains earned on the French nuclear fleet. "Throughout the remaining life of our plants, and while ensuring maximum security, said Jean-Marc Ayrault, our nuclear fleet will be involved without supply disruption."

At the bottom of the interface, there are links for 'Turn off instant translation', 'About Google Translate', 'Mobile', 'Privacy', 'Help', and 'Send feedback'.

Route planning



Personal assistant

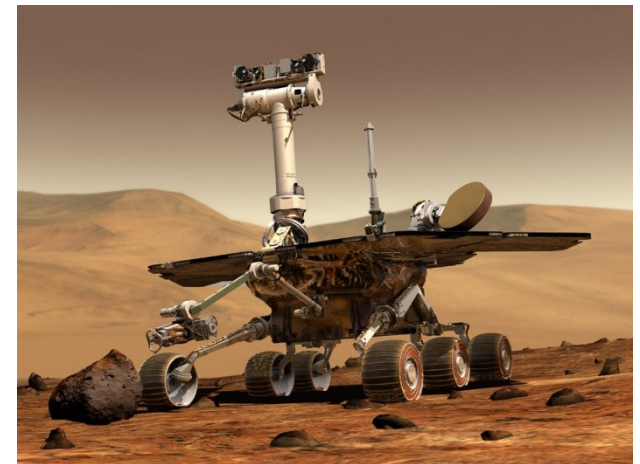
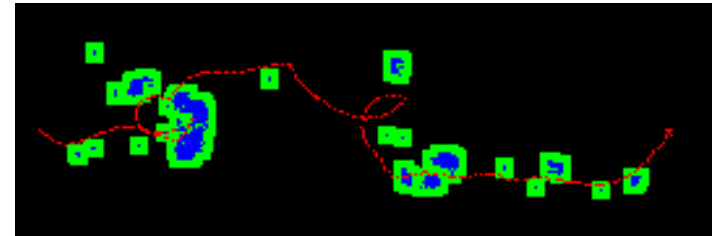


Navigating: Mars Autonomy Project

<http://www.frc.ri.cmu.edu/projects/mars/dstar.html>



Project at Carnegie Mellon, Pittsburgh



Project at JPL, Pasadena

Navigating: Under water



...and in the forest...

Autonomous driving



Stanley: The first car to finish the 2005 DARPA grand challenge.

Autonomous driving, 350 km in the desert.

It took 6 hrs and 54 min, with an average speed of about 50 km/h.

Stanford-group, lead by Prof. Sebastian Thrun.

Second was CMU, 10 minutes slower.

Nobody managed the similar task in 2004... the best car managed 11.78 km!

2007: Urban Challenge

- Autonomous driving 100 km in city environment in max 6 hours (about 15 km/h on average).
- Follow all traffic rules
- Manage other vehicles



2012: DARPA Robotics challenge

”... to develop ground robotic capabilities to execute complex tasks in dangerous, degraded, human-engineered environments.”

Unlike prior challenges, construction of the vehicles will not be part of the scope of the Robotics challenge. Boston dynamics have been contracted for developing 8 identical robots for the software teams. Robots are expected to be complete by Aug 2014.



Self-driving cars



\$150,000 worth of equipment (including \$70,000 LIDAR scanner)

Self-driving cars



The Drive Me trial starts in 2018 when 100 of our customers will drive XC90s equipped with the technology which will result in the IntelliSafe Autopilot, on Swedish roads

Self-driving cars



Grand Cooperative Driving Challenge (GCDC 2011)



11 teams from all over the world, Halmstad University took 2nd place

Grand Cooperative Driving Challenge (GCDC 2016)



10 teams from all over the world, this time Halmstad University won

AI fork-lift trucks (Halmstad)



Navigating: Vacuum cleaners



How do you guarantee that the vacuum cleaner doesn't get stuck and that it cleans the entire floor?

Small programs ~ 256 B

Navigating: helping elderly

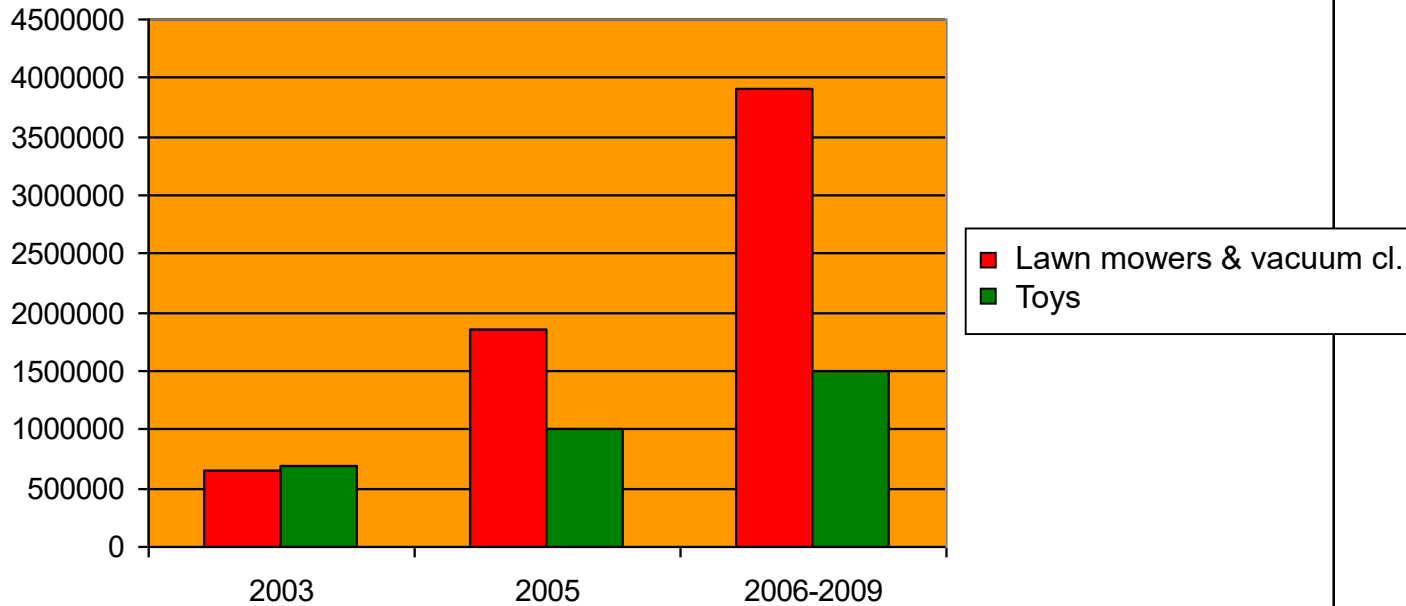


And just helping out (housekeeping): http://www.youtube.com/watch?v=Uoq_r2dUf8g

Robots at home



Robots in the homes

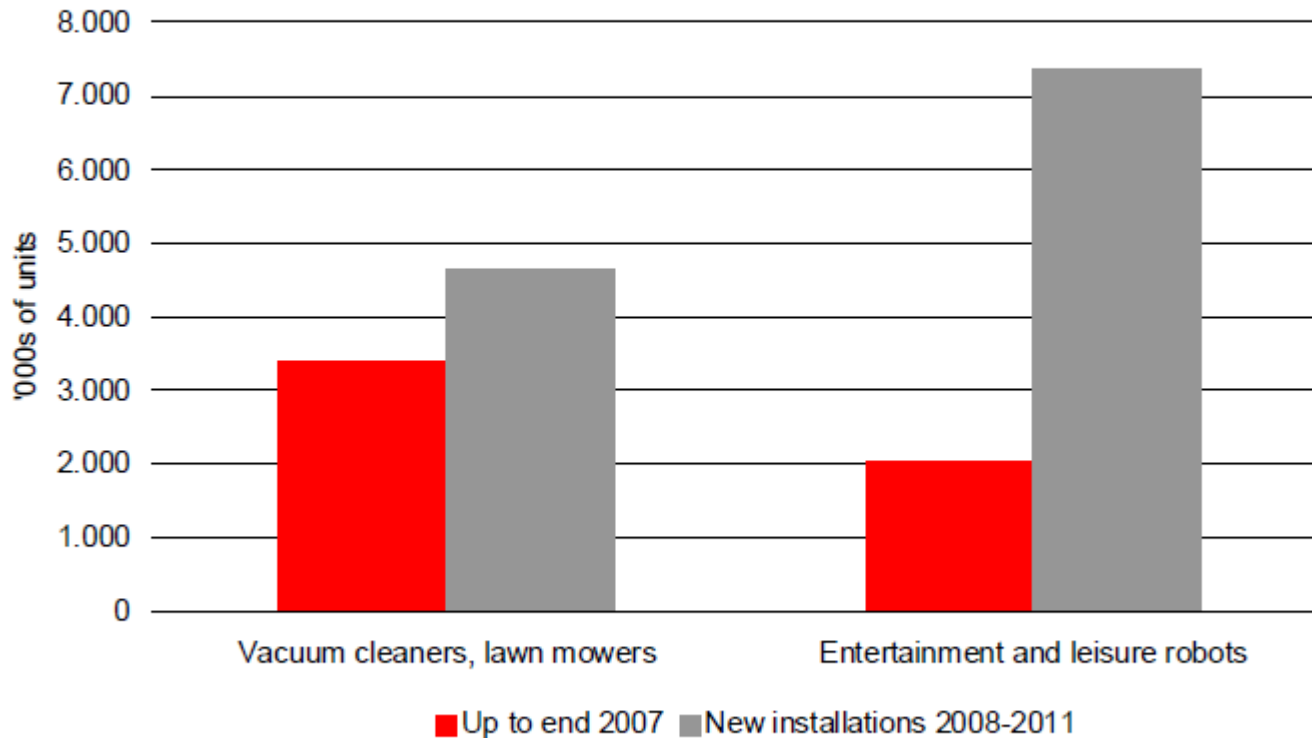


World Robotics Report 2004 & 2006

Robots at home

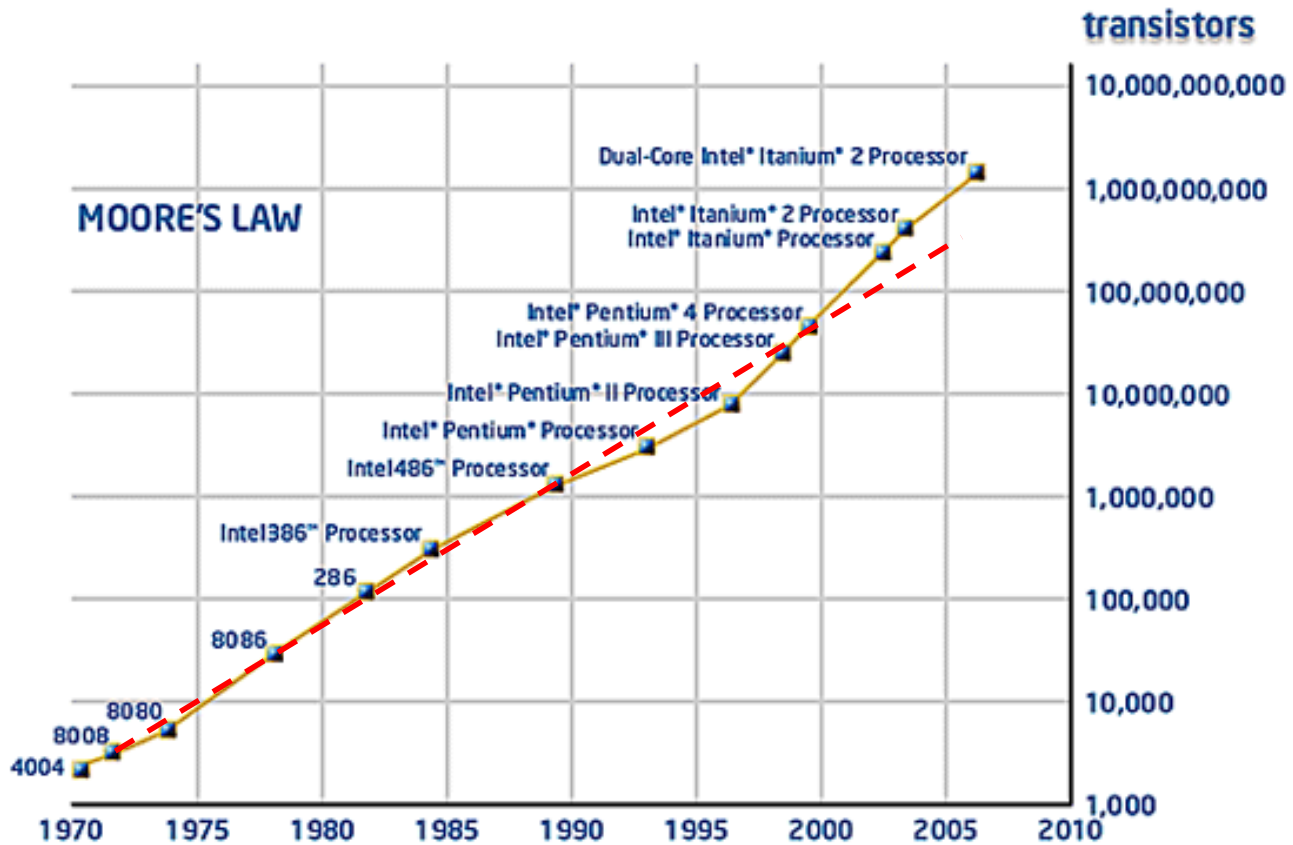


Service robots for personnel/domestic use. Stock at the end of 2007 and projected installations in 2008-2011



Source: World Robotics 2008

Computers...



...become cheaper and cheaper

A "MIPS" becomes 1,000,000 cheaper in 40 years.

About half the price in one year.

(1 MIPS = 1 million "instructions" per second)

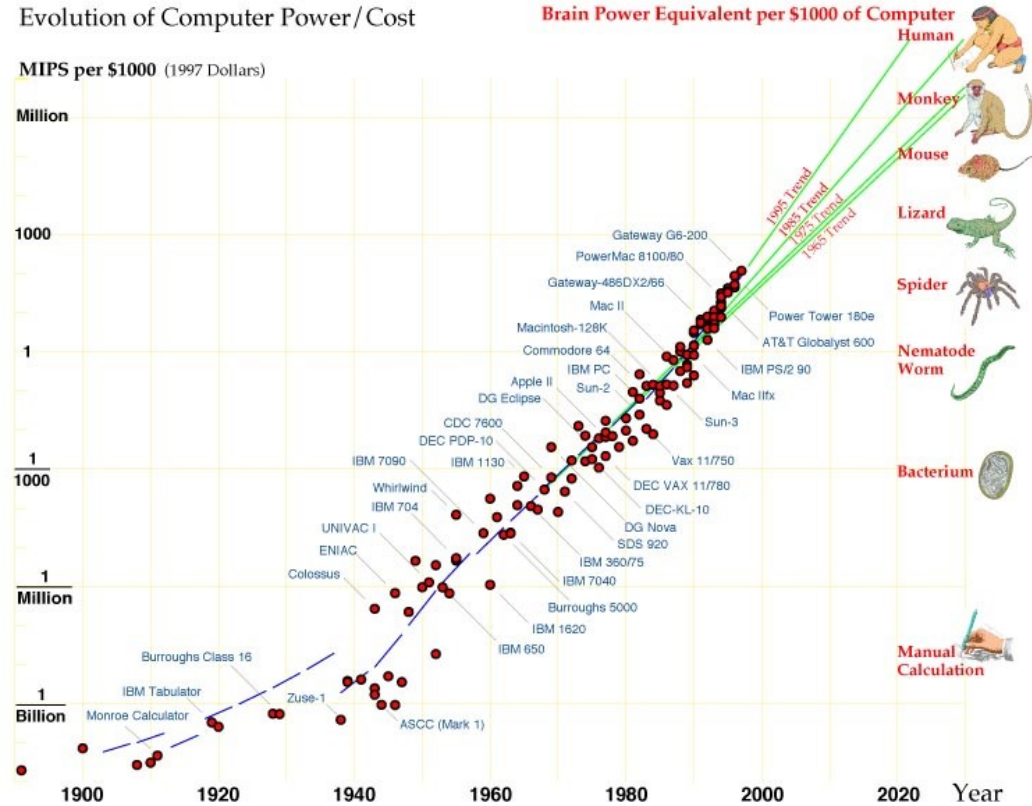


Image from Moravec

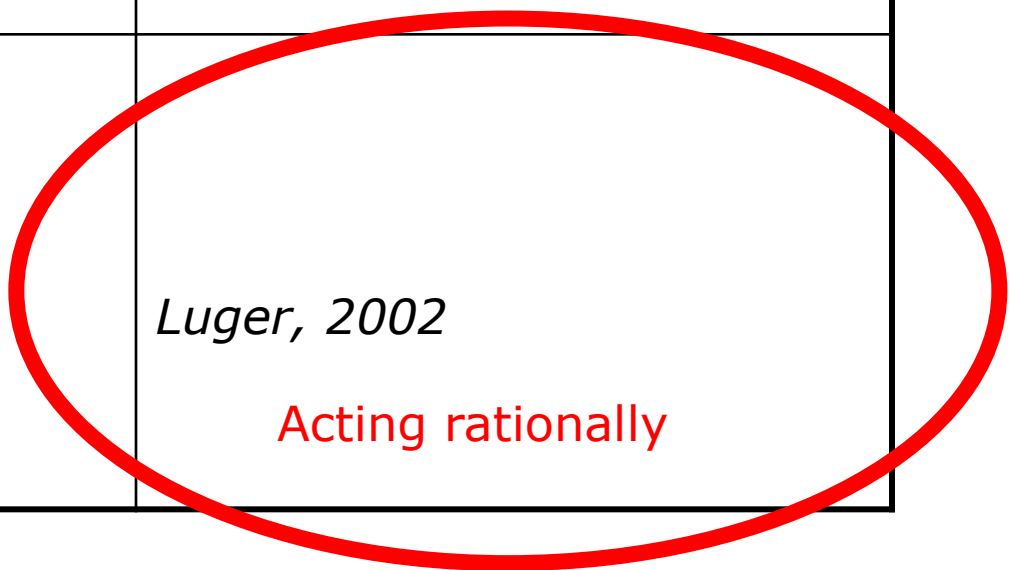
Computer memory becomes cheaper at a similar rate; half as expensive in two years.

What is AI?

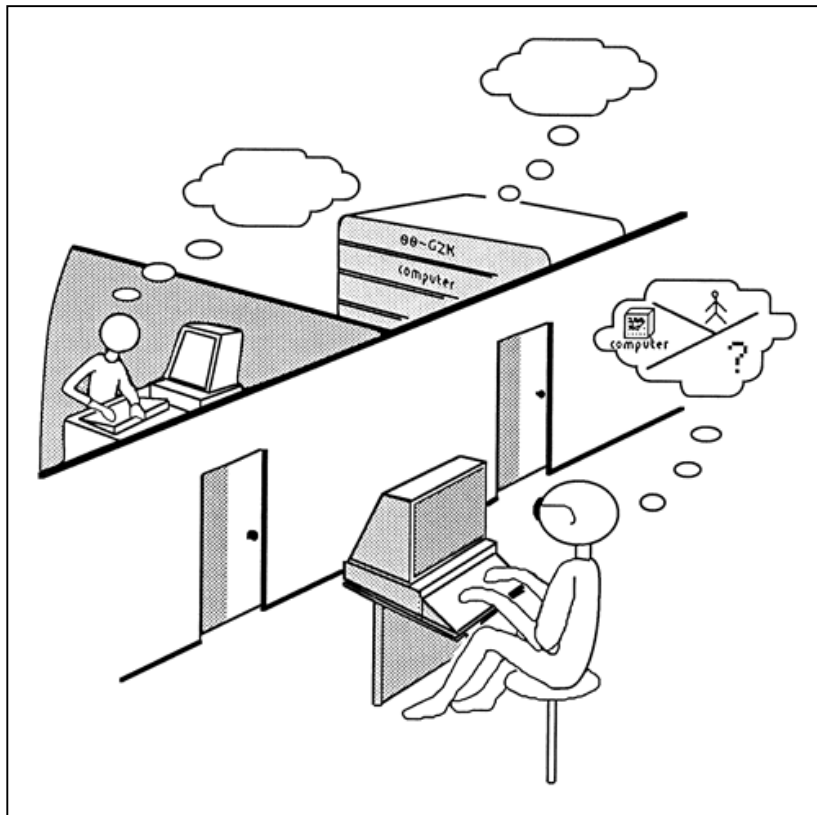
- “The study of [rational] agents that exist in an environment and perceive and act.” [Russell & Norvig]

What is AI?

<p><i>Bellman, 1978</i></p> <p>Thinking like a human</p>	<p><i>Charniak & McDermott, 1985</i></p> <p>Thinking rationally</p>
<p><i>Kurzweil, 1990</i></p> <p>Acting like a human</p>	<p><i>Luger, 2002</i></p> <p>Acting rationally</p>



The Turing test – acting like a human



© B.J. Copeland 2000

Suggested by Alan Turing in 1950.

If the interrogator cannot distinguish the human from the machine (robot), solely on the basis of their answers to questions, then the machine can be assumed intelligent.



Alan Turing

The Turing test provides...

- An objective notion of intelligence
 - no discussion on the "true" nature of intelligence
- A way to avoid confusion by looking at how the computer reasons, or if it is conscious
- A way to avoid bias in favour of the human, by just focusing on the written answers

The Turing test can of course be generalized to other fields besides conversation

But it focuses too much on human behaviour.
We are not trying to build humans (we already know how to do this...)

Problems with Turing test

- A test of the judge as well that of the actual AI machine
- Promotes imitators (con-artists)

See www.loebner.net

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

Chat bots:

<http://www.abenteuermedien.de/jabberwock/index.php>

<http://www.alicebot.org/>

http://www-ai.ijs.si/eliza-cgi-bin/eliza_script

<http://www.simonlaven.com/>

AI as "rational agent"

- We will mainly focus on general principles of rational agents, in particular how can one approach constructing them
 - We define *rational* as "achieving the best possible outcome"
 - It assumes the outcome is *measurable*
 - This definition is objective, and also general
 - We don't have to meddle with what is "human"

Fundamental issues in AI

- Sensing

- How to extract relevant information from sensory input

- Representation

- Facts about the world have to be represented in some way. Logic is one language that is used in AI. How should knowledge be structured? What is explicit, and what must be inferred? How to encode "rules" for inference so as to find information that is only implicitly known? How deal with incomplete, inconsistent, and probabilistic knowledge?

- Search

- Many tasks can be viewed as searching a very large problem space for a solution. Use of heuristics and constraints.

- Inference

- Some facts can be inferred from other facts.

- Learning

- Learning is essential in an intelligent system.

- Planning

- Starting with general facts about the world, about the effects of basic actions, about a particular situation, and a statement of a goal, generate a strategy for achieving the goal.