# Artificial Intelligence

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What is A.I

- **It's a lot of different things to a lot of different people**:

- **Computational models of human behaviour**
  - Programs that behave (externally) like humans.
  - This is the original idea from Turing and the well known **Turing Test** is to use to verify this
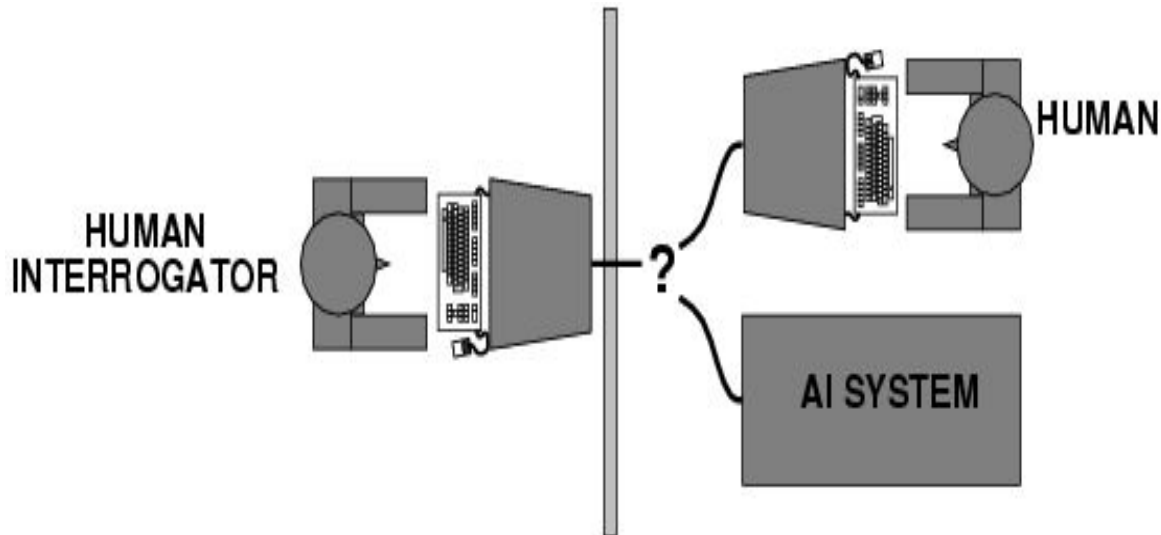
It's a lot of different things to a lot of different people:

- **Computational models of human "thought"**
  - Programs that operate (internally) the way humans do
- **Computational systems that behave intelligently?**
  - But what does it mean to behave intelligently?

- **Computational systems that behave rationally**
 - More widely accepted view

- **What means "behave rationally" for a person/system:**
  - Take the right/ best action to achieve the goals, based on his/its knowledge and belief
- **Example**. Assume I don't like to get wet (my goal), so I bring an umbrella (my action). Do I behave rationally?
  - The answer is dependent on my knowledge and belief
  - If I've heard the forecast for rain and I believe it, then bringing the umbrella is rational.
  - If I've not heard the forecast for rain and I do not believe that it is going to rain, then bringing the umbrella is not rational.

Note on behave rationally or rationality

- **"Behave rationally" does not always achieve the goals successfully**
  - Example.
    - My goals – (1) do not get wet if rain; (2) do not be looked stupid (such as bring an umbrella when no raining)
    - My knowledge/belief – weather forecast for rain and I believe it
    - My rational behaviour – bring an umbrella
    - The outcome of my behaviour: If rain, then my rational behaviour achieves both goals; If not rain, then my rational behaviour fails to achieve the 2nd goal
- **The successfulness of "behave rationally" is limited by my knowledge and belief**

Brief history of AI

- The history of AI begins with the following articles:
  - Turing, A.M. (1950), Computing machinery and intelligence, Mind, Vol. 59, pp. 433-460.

MIND

A QUARTERLY REVIEW

OF

PSYCHOLOGY AND PHILOSOPHY

I.—COMPUTING MACHINERY AND INTELLIGENCE

BY A. M. TURING
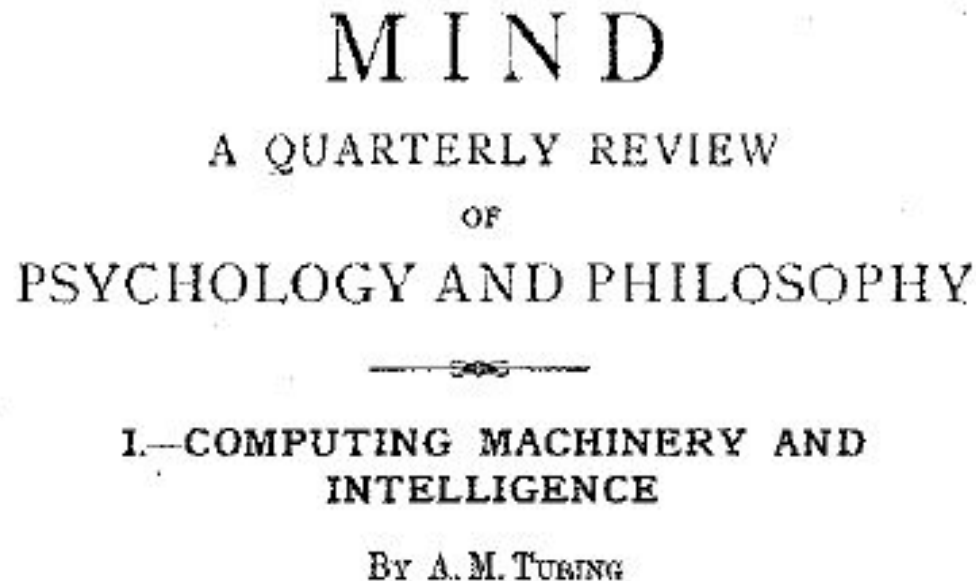
I propose to consider the question, 'Can machines think?' ...

Alan Turing - Father of AI

Alan Turing - Father of AI

Alan Turing (OBE, FRS)
- Born 23 June 1912, Maida Vale, London, England
- Died 7 June 1954 (aged 41), Wilmslow, Cheshire, England
- Fields: Mathematician, logician, cryptanalyst, computer scientist
- Institutions:
  - University of Manchester
  - National Physical Laboratory
  - Government Code and Cypher School (Britain's codebreaking centre)
  - University of Cambridge

The birth of artificial intelligence

– 1950: Turing's landmark paper "Computing machinery and intelligence" and **Turing Test**
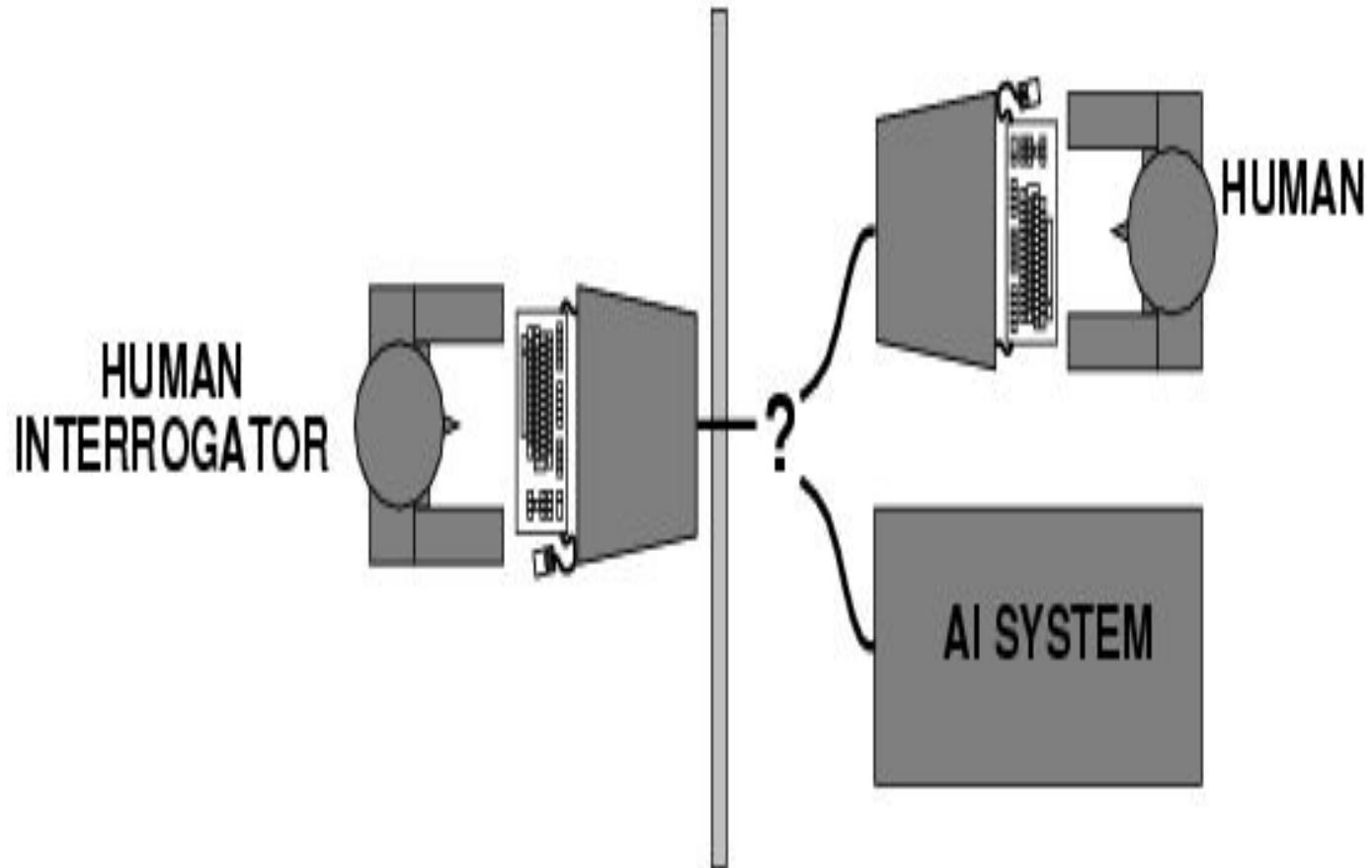
History of AI

- 1951: **AI programs** were developed at **Manchester**:
    - A draughts-playing program by **Christophe**r Strachey
    - A chess-playing program by Dietrich **Prinz**
    - These ran on the Ferranti Mark I in 1951.
- 1955: **Symbolic reasoning and the Logic Theorist**
    - Allen Newell and (future Nobel Laureate) Herbert Simon created the "Logic Theorist". The program would eventually prove 38 of the first 52 theorems in Russell and Whitehead's Principia Mathematica
- 1956: Dartmouth **Conference** - "Artificial Intelligence" adopted

Deep blue by IBM

- In 1996 IBM Deep Blue beat Gary Kasparov for the first time. and in 1997 an upgraded version won an entire match against the same opponent.

Logic

- Another of the early research in AI was applied the similar idea to **deductive logic**:

  All men are mortal   x (man(x) -> mortal(x))

  Socrates is a man   man(Socrates)

  Socrates is mortal   mortal(Socrates)

- The discipline of developing programs to perform such logical inferences is known as (automated) **theorem-proving**

- Today, theorem-provers are highly-developed . .

Networks

- ## Semantic Networks
  - A semantic net is a network which represents semantic relations among concepts. It is often used as a form of knowledge representation.
  - Nodes : used to represent objects and descriptions.
  - Links : relate objects and descriptors and represent relationships
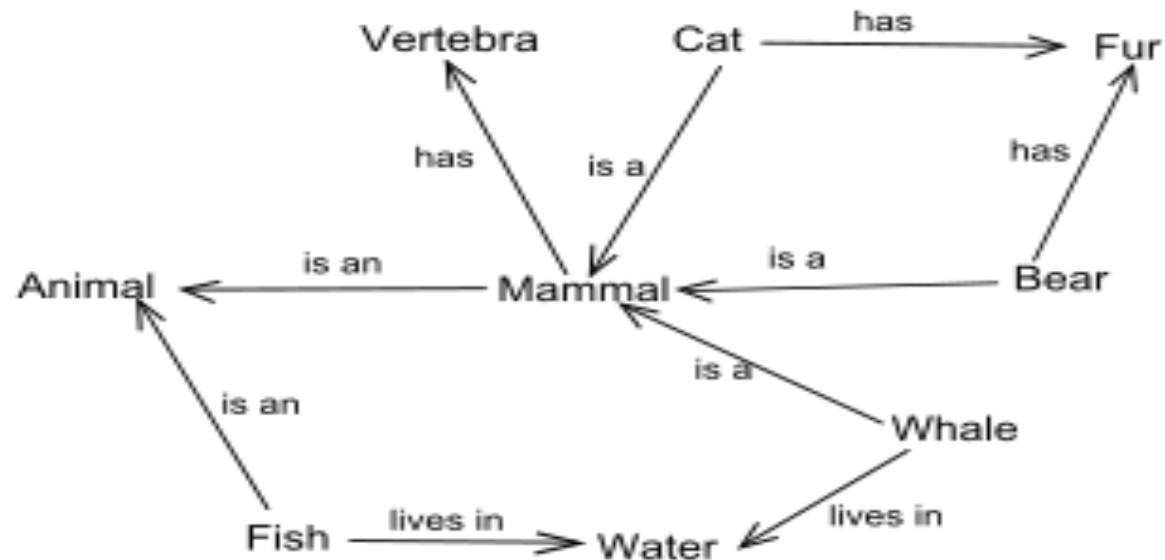
Mathematics

- 1956   Logic Theorist (the first running AI program?)

- 1961   SAINT **solved calculus problems** at the college freshman level

- 1967   Macsyma

  Gradually **theorem proving** has become well enough understood that it is usually no longer considered AI

- 1996   J Moore and others verified the correctness of the AMD5k86 **Floating-Point Division algorithm**

The Silver Bullet?

Is there an "intelligence algorithm"?

1957   GPS (General Problem Solver)

Start   Goal

Representing Knowledge – Capturing Experience

Representing Experience with Scripts, Frames, and Cases

1977 Scripts

Joe went to a restaurant. Joe ordered a hamburger. When the hamburger came, it was burnt to a crisp. Joe stormed out without paying.

The restaurant script:

Did Joe eat anything?

Representing Knowledge – Probabilistically

1975   Mycin attaches **probability-lik**e numbers to rules

If: (1) the stain of the ogranism is gram-positive, and
(2) the morphology of the organism is coccus, and
(3) the growth conformation of the organism is clumps

Then: there is suggestive evidence (0.7) that the identity of the organism is stphylococcus.

1970s   Probabilistic models of speech recognition

1980s   Statistical Machine Translation systems

1990s   large scale neural nets

The Rise of Expert Systems

1967   Dendral – a rule-based system that **infered molecular structure** from mass spectral and NMR data

1975   Mycin – a rule-based system to recommend **antibiotic therapy**

1975   Meta-Dendral learned new rules of **mass spectrometry**, the first discoveries by a computer to appear in a refereed **scientific journal**

1979   EMycin – the first expert system shell

1980's   The Age of Expert Systems

Expert Systems – The Heyday

1979   Inference

1980   IntelliCorp   Selling expert system shells

1981   Teknowledge

1983   Carnegie Group

1980   XCON (R1) – first real commercial expert system at   DEC, configures VAX systems

1981   Japanese Fifth Generation project launched as the
        Expert Systems age blossoms in the US.

1984   Gold Hill Common Lisp

1986   **neural net** start up companies appear

1988   AI revenues peak at $1 billion. AI Winter begins.

Expert Systems – Today: Medicine

One example domain, medicine, has expert systems whose tasks include:

- arrhythmia recognition from electrocardiograms

- coronary heart disease risk group detection

- monitoring the prescription of restricted use antibiotics

- early melanoma diagnosis

- gene expression data analysis of human lymphoma

- breast cancer diagnosis

Expert Systems – Today: Build Your Own

eXpertise2Go: http://www.expertise2go.com/

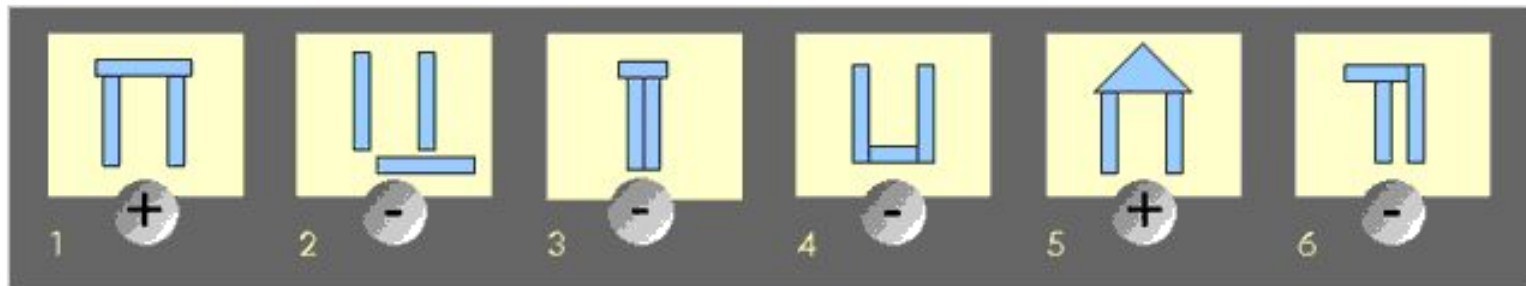AcquiredIntelligence: http://www.aiinc.ca/demos/

   (whales, graduate school)

Hand-Coded Knowledge vs. Machine Learning

• How much work would it be to enter knowledge by hand?

• Do we even know what to enter?

    1952-62   Samuel's checkers player learned its evaluation
                 function

1975   Winston's system learned structural descriptions
                 from examples and near misses

1984   Probably Approximately Correct learning offers a
             theoretical foundation

mid 80's The rise of neural networks

Robotics - Tortoise

1950 W. Grey Walter's light seeking tortoises. In this picture, there are two, each with a light source and a light sensor. Thus they appear to "dance" around each other.
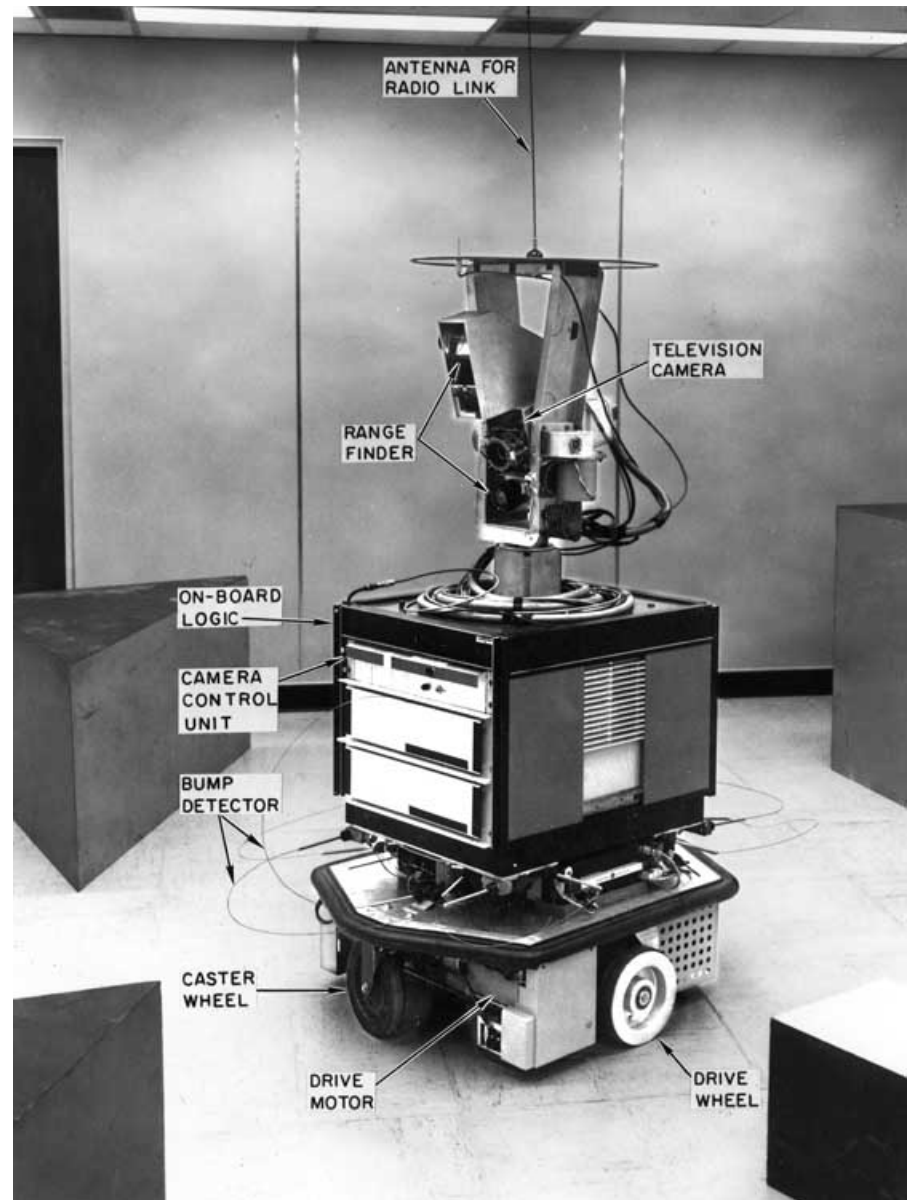
Robotics – Hopkins Beast

1964   Two versions of the Hopkins beast, which used sonar to guide it in the halls. Its goal was to find power outlets.

Robotics - Shakey

1970   Shakey (SRI) was driven by a remote-controlled computer, which formulated plans for moving and acting. It took about half an hour to move Shakey one meter.

SOPHIA
Hanson Robotic

Robotics – Stanford Cart

1971-9 Stanford cart. Remote controlled by person or computer.

1971 follow the white line

1975 drive in a straight line by tracking skyline

1979 get through obstacle courses. Cross 30 meters in five hours, getting lost one time out of four
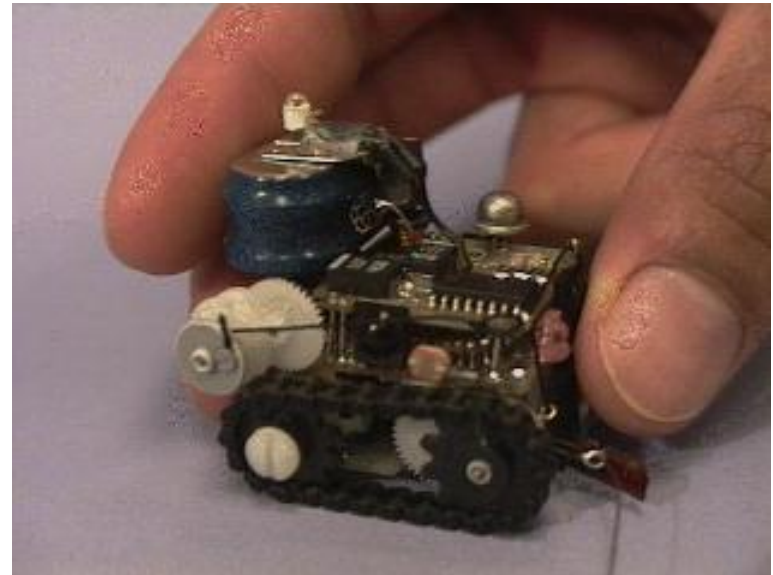
Planning vs. Reacting

In the early days: substantial focus on planning (e.g., GPS)

1979 – in "Fast, Cheap and Out of Control", Rodney Brooks argued for a very different approach. (No, I'm not talking about the 1997 movie.)

The Ant, has 17 sensors. They are designed to work in colonies.

http://www.ai.mit.edu/people/brooks/papers/fast-cheap.pdf

http://www.ai.mit.edu/projects/ants/

Robotics - Dante

1994 Dante II (CMU) explored the Mt. Spurr (Aleutian Range, Alaska**) volcano. High-temperature**, fumarole gas samples are prized by volcanic science, yet their sampling poses significant challenge. In 1993, eight volcanologists were killed in two separate events while sampling and monitoring volcanoes.

Using its tether cable anchored at the crater rim, Dante II is able to descend down sheer crater walls in a rappelling-like manner to gather and analyze high temperature gasses from the crater floor.

Robotics - Sojourner

Oct. 30, 1999 Sojourner **on Mars**. Powered by a 1.9 square foot solar array, Sojourner can negotiate obstacles tilted at a 45 degree angle. It travels at less than half an inch per second.

http://antwrp.gsfc.nasa.gov/apod/ap991030.html

Robotics – Mars Rover

Tutorial on Rover:

http://marsrovers.jpl.nasa.gov/gallery/video/animation.html
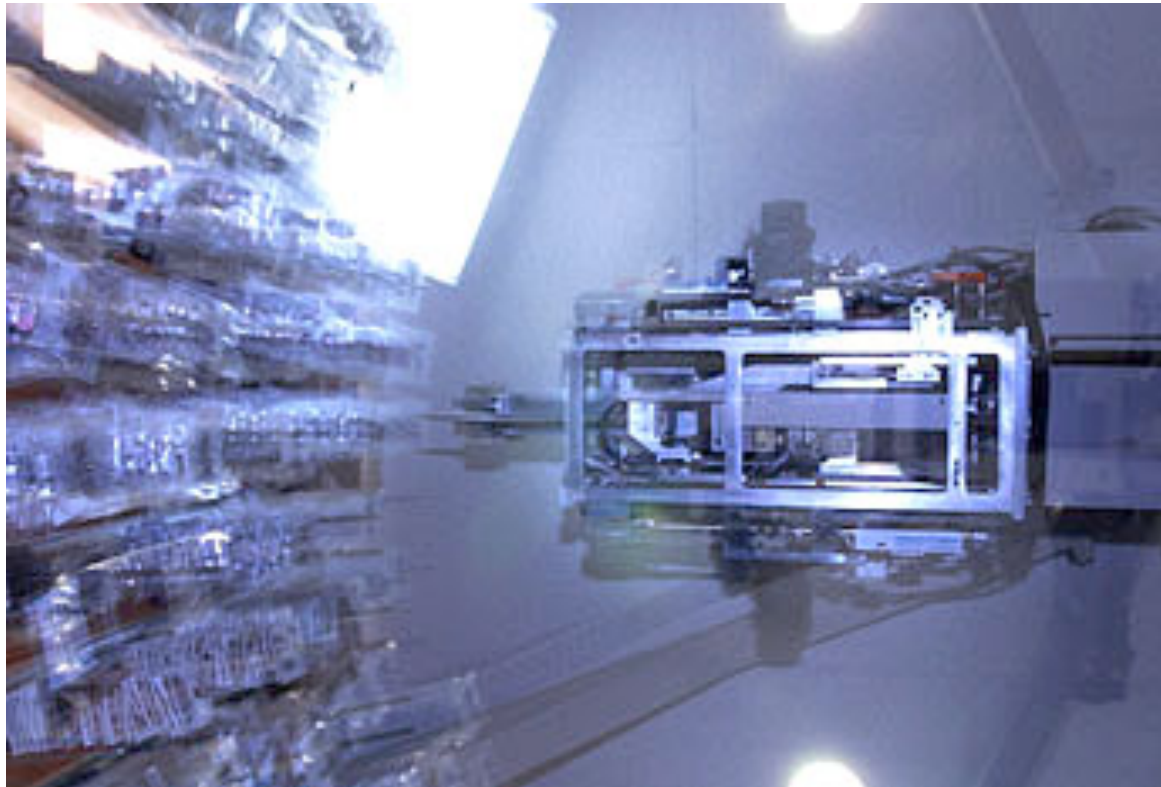
Sandstorm

March 13, 2004 - A DARPA Grand Challenge: an unmanned offroad race, 142 miles from Barstow to Las Vegas.

Moving Around and Picking Things Up

Phil, the drug robot, introduced in 2003

Robotics - Aibo

1999 Sony's Aibo
pet dog

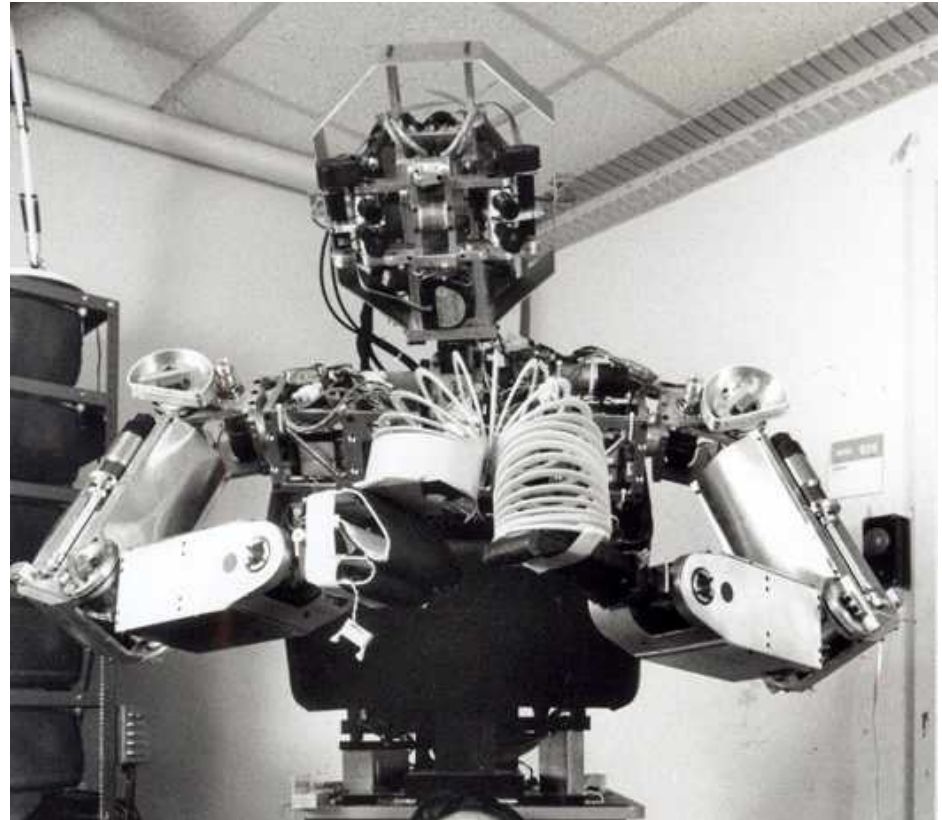# What Can You Do with an Aibo?

1997 – First official Rob-Cup soccer match

Picture from 2003 competition

Robotics - Cog

1998 – now   Cog

Humanoid intelligence requires humanoid interactions with the world.

http://www.eecs.mit.edu/100th/images/Brooks-Cog-Kismet.html

At the Other End of the Spectrum - Roomba

2001   A robot vacuum cleaner

Natural Language Processing

1964   **STUDENT solves algebra word problems**

The distance from New York to Los Angeles is 3000 miles. If the average speed of a jet plane is 600 miles per hour, find the time it takes to travel from New York to Los Angeles by jet.

1965   ELIZA models a Rogerian therapist

young woman: *Men are all alike.*

eliza: *In what way?*

young woman: *They're always bugging us about something specific or other.*

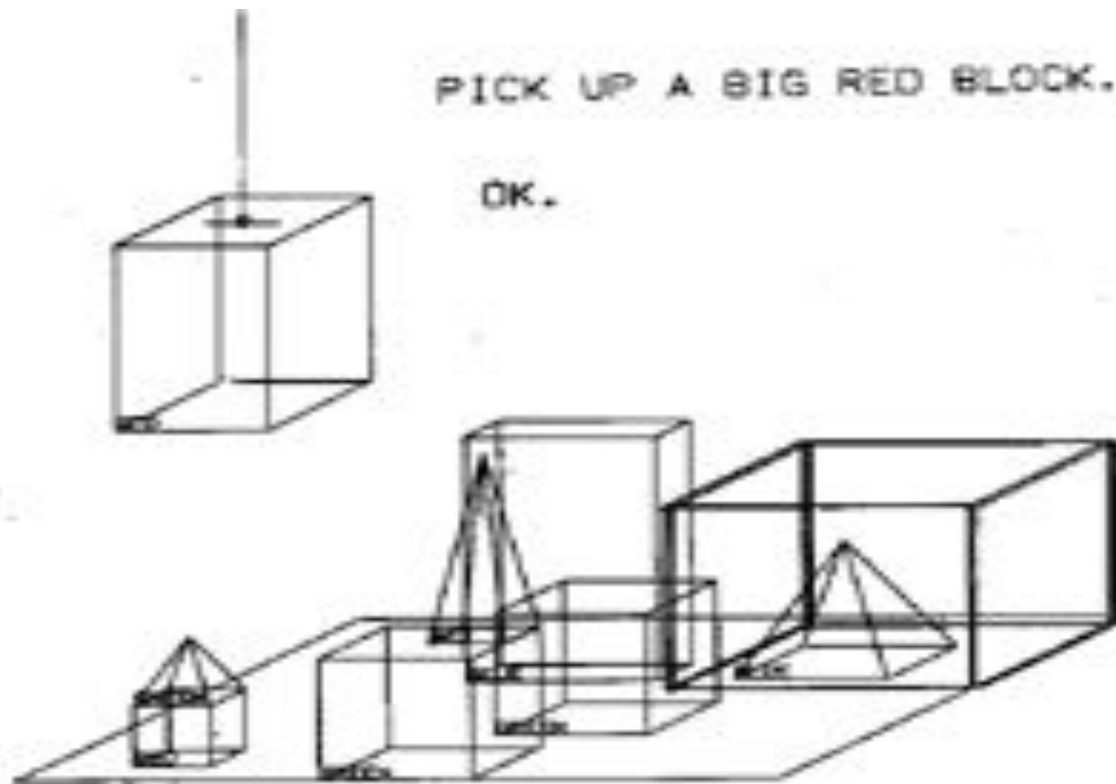*eliza:* *Can you think of a specific example?*

young woman: *Well, my boyfriend made me come here.*

eliza: *Your boyfriend made you come here?*

NLP, continued

1966   Alpac report kills work on MT

1971   SHRDLU

NLP, continued

1973   **Schank – a richer limited domain: children's stories**

   Suzie was invited to Mary's birthday party. She knew she wanted a new doll so she got it for her.

1977   Schank – scripts add a knowledge layer – restaurant stories

1970's and 80's   sophisticated grammars and parsers

But suppose we want generality? One approach is "shallow" systems that punt the complexities of meaning.

NLP Today

- Grammar and spelling checkers

  - Spelling: http://www.spellcheck.net/

- Chatbots

  - See the list at:
    http://www.aaai.org/AITopics/html/natlang.html#chat/

- Speech systems

  - Synthesis: The IBM system:
    - http://www.research.ibm.com/tts/coredemo.html

Machine Translation: An Early NL Application

1949   Warren Weaver's memo suggesting MT

1966   Alpac report kills government funding

Early 70s SYSTRAN develops direct Russian/English system

Early 80s knowledge based MT systems

Late 80s   statistical MT systems

Why Is It So Hard?

Olive oil

Why Is It So Hard?

Peanut oil

Why Is It So Hard?

Coconut oil

Why Is It So Hard?

Baby   oil

Why Is It So Hard?

Cooking oil

Programming Languages

1958   Lisp – a functional programming language with a
           simple syntax.

           (successor SitA ActionP)

1972   PROLOG - a logic programming language whose
      primary control structure is depth-first search

          ancestor(A,B) :- parent(A,B)
          ancestor(A,B) :- parent(A,P), ancestor(P,B)

1988   CLOS (Common Lisp Object Standard) published.
      Draws on ideas from Smalltalk and semantic nets

Cognitive Modeling

Symbolic Modeling

1957   GPS

1983   SOAR

Neuron-Level Modeling

McCulloch Pitts neurons: all or none response

More sophisticated neurons and connections

More powerful learning algorithm

Making Money - Robots

1962   Unimation, first industrial robot company, founded. Sold a die casting robot to GM.

1990   iRobot founded, a spinoff of MIT

2000   The UN estimated that there are 742,500 industrial robots in use worldwide. More than half of these were being used in Japan.

2001   iRobot markets Roomba for $200.