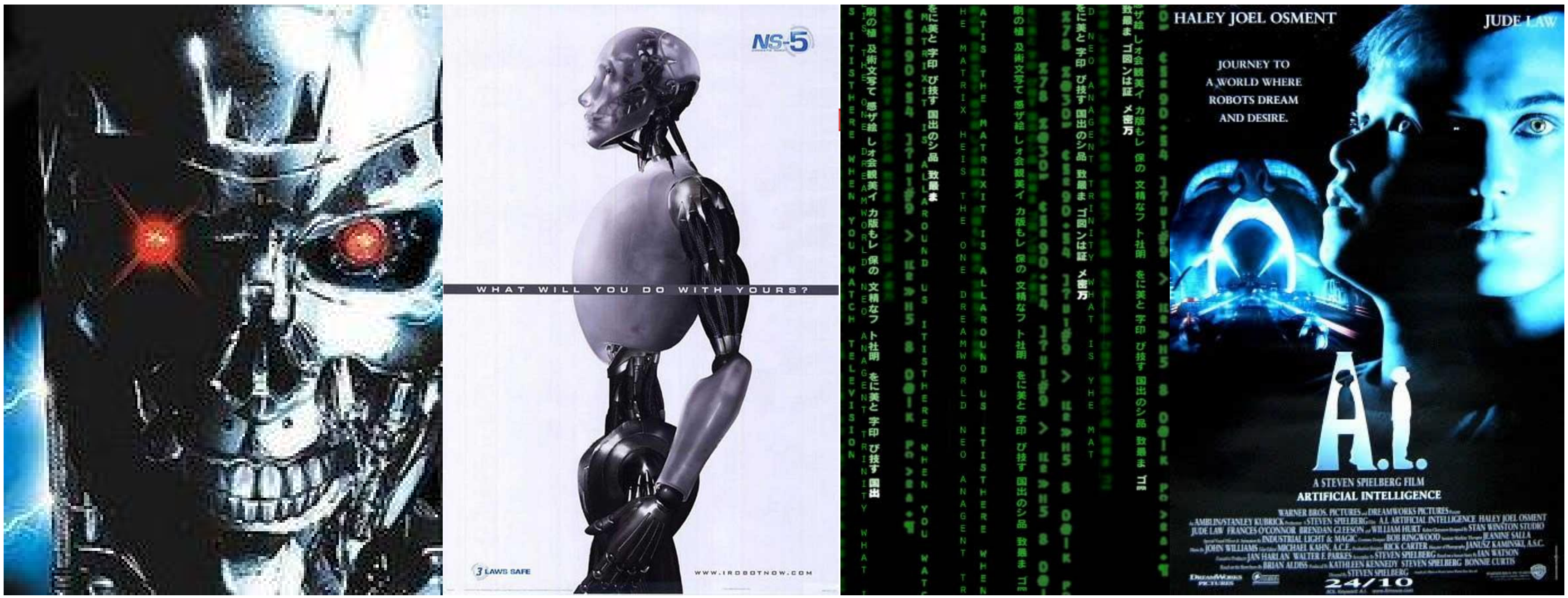
Is (strong) AI possible ?



Strong and Weak AI

- **Strong AI** makes the bold claim that computers can be made to think on a level (at least) equal to humans and possibly even be conscious of themselves.

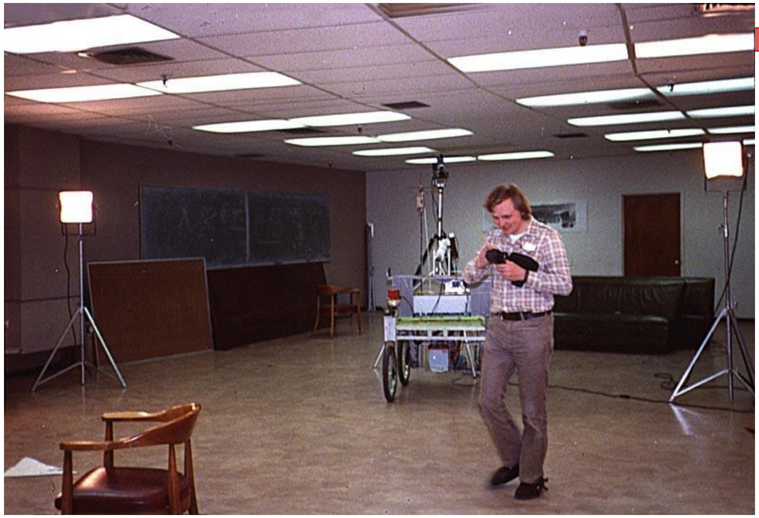
- **Weak AI** simply states that some "thinking-like" features can be added to computers to make them more useful tools... and this has already started to happen.

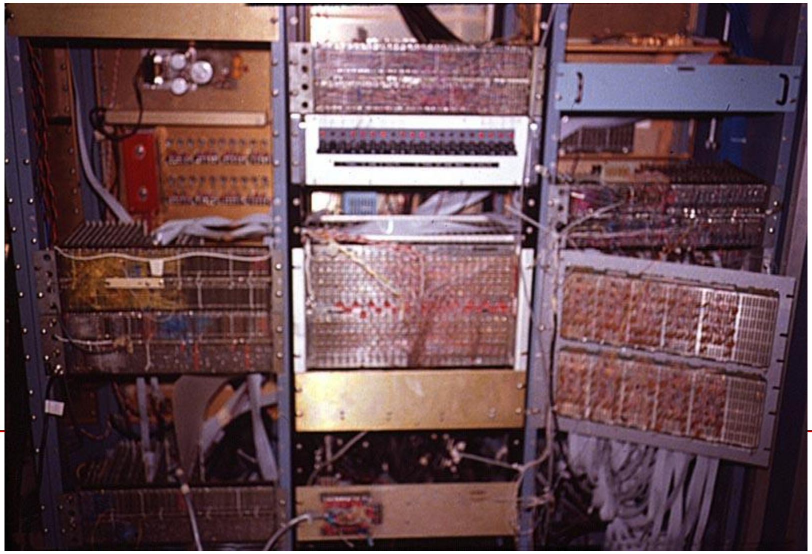
Why not possible ?

- Reasons:

- Not enough computational power
- Not good-enough algorithms
- Not enough time to research
- Analogue shell

Hans Moravec





Moravec's paradox

- high-level reasoning requires very little computation, but low-level sensorimotor skills require enormous computational resources
- "it is comparatively easy to make computers exhibit adult level performance on intelligence tests or playing checkers, and difficult or impossible to give them the skills of a one-year-old when it comes to perception and mobility."

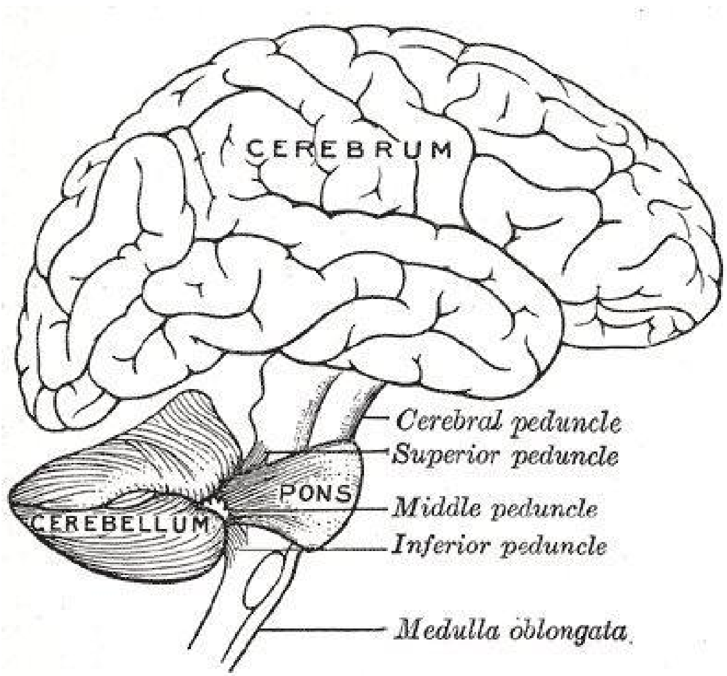
INSTRUCTIONS

- 1 MIPS = millions of (basic) operations per second.

- Basic operations = addition, subtraction, multiplication etc

Why not enough computational power?

Compare the human brain with a computer!



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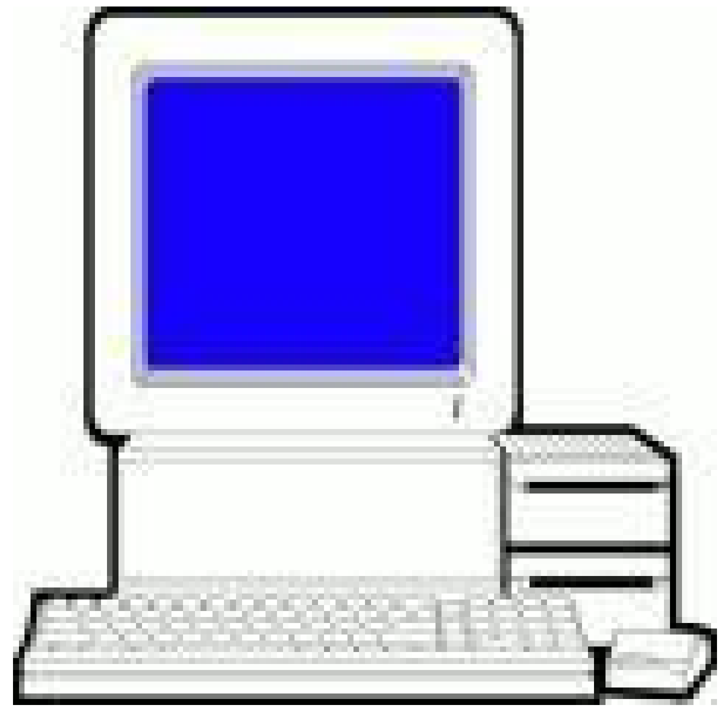


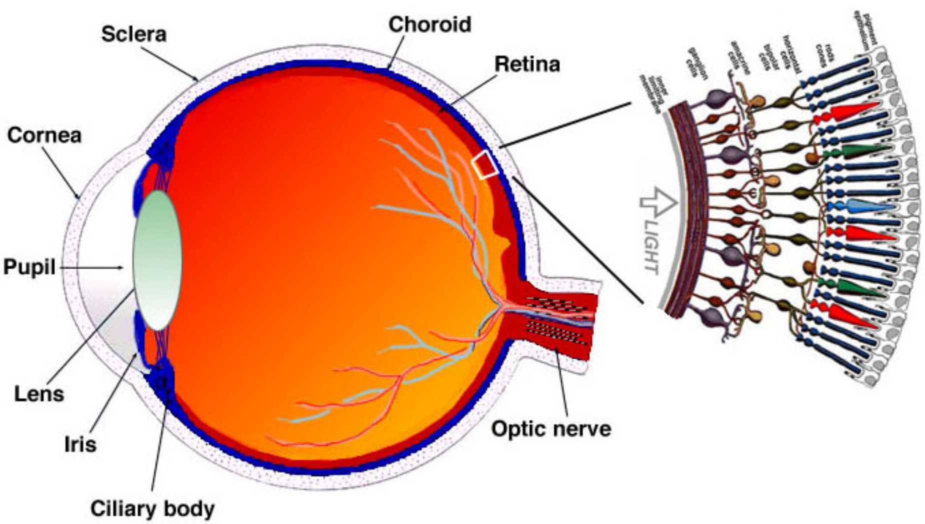
Brains, Eyes and Machines

Human and animal brain can suggest how much power is needed, if we can relate nerve volume to computations.

Human retina

Structurally and functionally, one of the best understood neural assemblies is the retina of the vertebrate eye.

Similar operations have been developed for robot vision, handing us a rough conversion factor.



- Transparent
- Connected to an optic nerve (1 million-fiber cable)
- 1 cm^2
- ½ mm thin
- 100 millions neurons
- 5 types of neurons

How many instructions runs the retina ?

- It takes robot vision programs about 100 computer instructions to derive single edge or motion detections from comparable video images.
- 100 MIPS are needed to do a million detections.
- 1000 MIPS to repeat them ten times per second to match the retina.

The speed of the human brain

- Volume ~ 1500 cm^3
- Brain ~ 10^5 retina
- Brain ~ 100 million MIPS

- Deep Blue ~ 3 million MIPS (chess only !)

- A typical PC would have to be at least a 10^5-10^6 times more powerful to perform like a human brain.

Confirmation
Deep Blue vs. Kasparov

- Kasparov, can apply his brainpower to chess problems with an efficiency of 1/30.
- Deep Blue ~ 3 million MIPS (chess only !)

- Deep Blue's near parity with Kasparov's chess skill supports the retina-based extrapolation.

The storage capacity

- Human brain ~ 10^{15} synapses
- Each synapse could store 1 byte
- Human brain ~ 10^{15} bytes

Speed of a neuron

- 100 million MIPS could do the job of the human brain's 100 billion neurons.
- One neuron is worth about 1/1000 MIPS, i.e., 1000 instructions per second.
- not enough to simulate an actual neuron, which can produce 1,000 finely timed pulses per second.
  - But we are talking about highly tuned programs.

Other differences between computers and brains

Modern Computers

- One or a few high speed (ns) processors with considerable computing power
- One or a few shared high speed buses for communication
- Sequential memory access by address
- Problem-solving knowledge is separated from the computing component
- Hard to be adaptive

Human Brain

- Large # (10^{11}) of low speed processors (ms) with limited computing power
- Large # (10^{15}) of low speed connections
- Content addressable recall (CAM)
- Problem-solving knowledge resides in the connectivity of neurons
- Adaptation by changing the connectivity

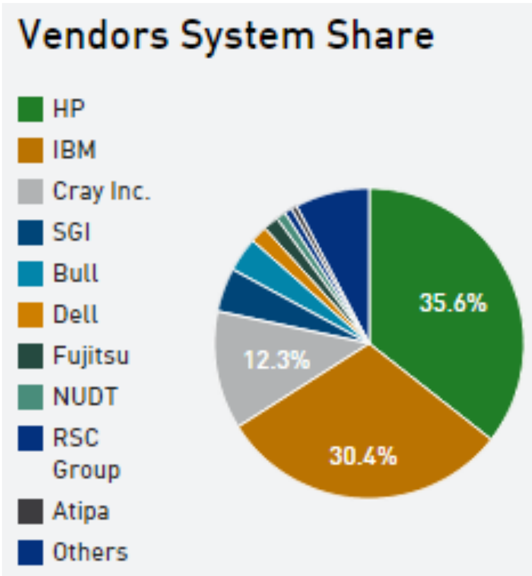
History of evolution of brains and computers

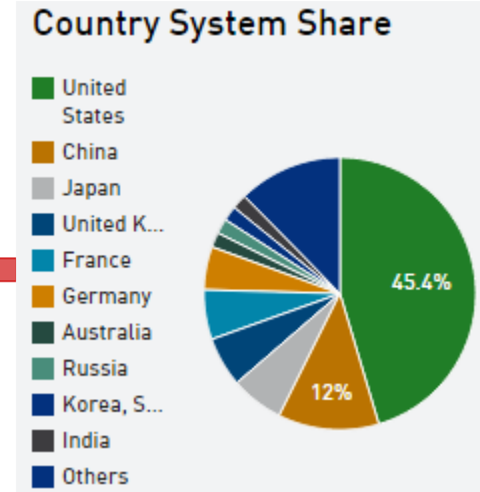
- Wormlike animals with perhaps a few hundred neurons evolved early in the Cambrian, over 570 million years ago.
- Earliest vertebrates, very primitive fish with nervous systems perhaps 100,000 neurons, appeared about 470 million years ago.
- Amphibians with few million neurons crawled out of the water 370 million years ago.
- Small mammals showed up about 220 million years ago, with brains ranging to several hundred million neurons, while enormous dinosaurs around them bore brains with several billion neurons, a situation that changed only slowly until the sudden extinction of the dinosaurs 65 million years ago.
- Our small primate ancestors arose soon after, with brains ranging to several billion neurons.
- Hominid apes with 20 billion neuron brains appeared about 30 million years ago.
- Humans have approximately 100 billion neurons.

- The first electromechanical computers, with a few hundred bits of telephone relay storage, were built around 1940.
- Computers acquired 100,000 bits of rotating magnetic memory by 1955.
- Computers with millions of bits of magnetic core memory were available by 1965.
- By 1975, many computer core memories had exceeded 10 million bits and by 1985 100 million bits was common.
- Larger computer systems had several billion by 1995.
- In 2005, some personal computer systems have 1 billion of bits of RAM.

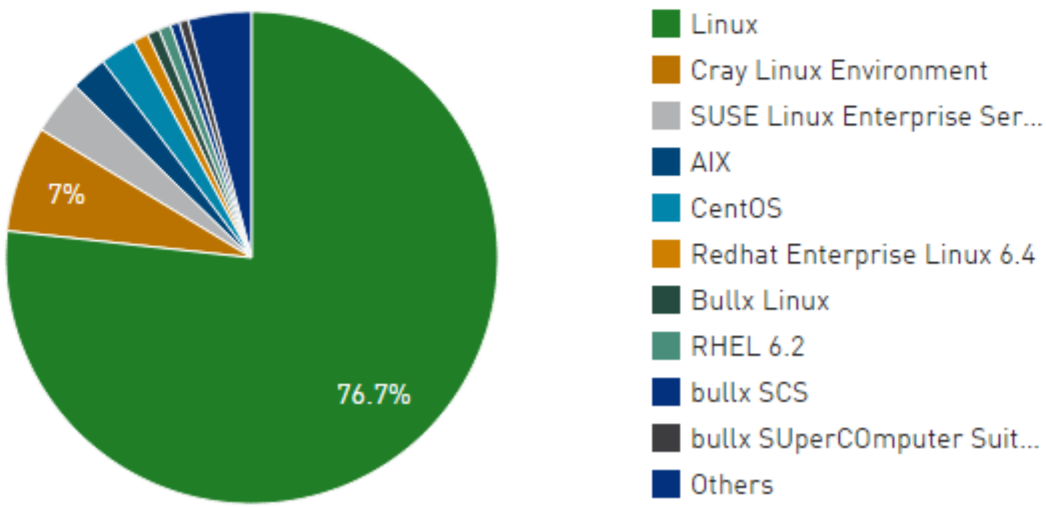
TOP500 List – November 2011

RANK	SITE	SYSTEM	CORES	RMAX (TFLOP/S)	RPEAK (TFLOP/S)	POWER (KW)
1	National Super Computer Center in Guangzhou China	**Tianhe-2 (MilkyWay-2)** - TH-IVB-FEP Cluster, Intel Xeon E5-2692 12C 2.200GHz, TH Express-2, Intel Xeon Phi 31S1P NUDT	3,120,000	33,862.7	54,902.4	17,808
2	DOE/SC/Oak Ridge National Laboratory United States	**Titan** - Cray XK7 , Opteron 6274 16C 2.200GHz, Cray Gemini interconnect, NVIDIA K20x Cray Inc.	560,640	17,590.0	27,112.5	8,209
3	DOE/NNSA/LLNL United States	**Sequoia** - BlueGene/Q, Power BQC 16C 1.60 GHz, Custom IBM	1,572,864	17,173.2	20,132.7	7,890
4	RIKEN Advanced Institute for Computational Science (AICS)	K computer, SPARC64 VIIIfx 2.0GHz, Tofu interconnect Fujitsu	705,024	10,510.0	11,280.4	12,660

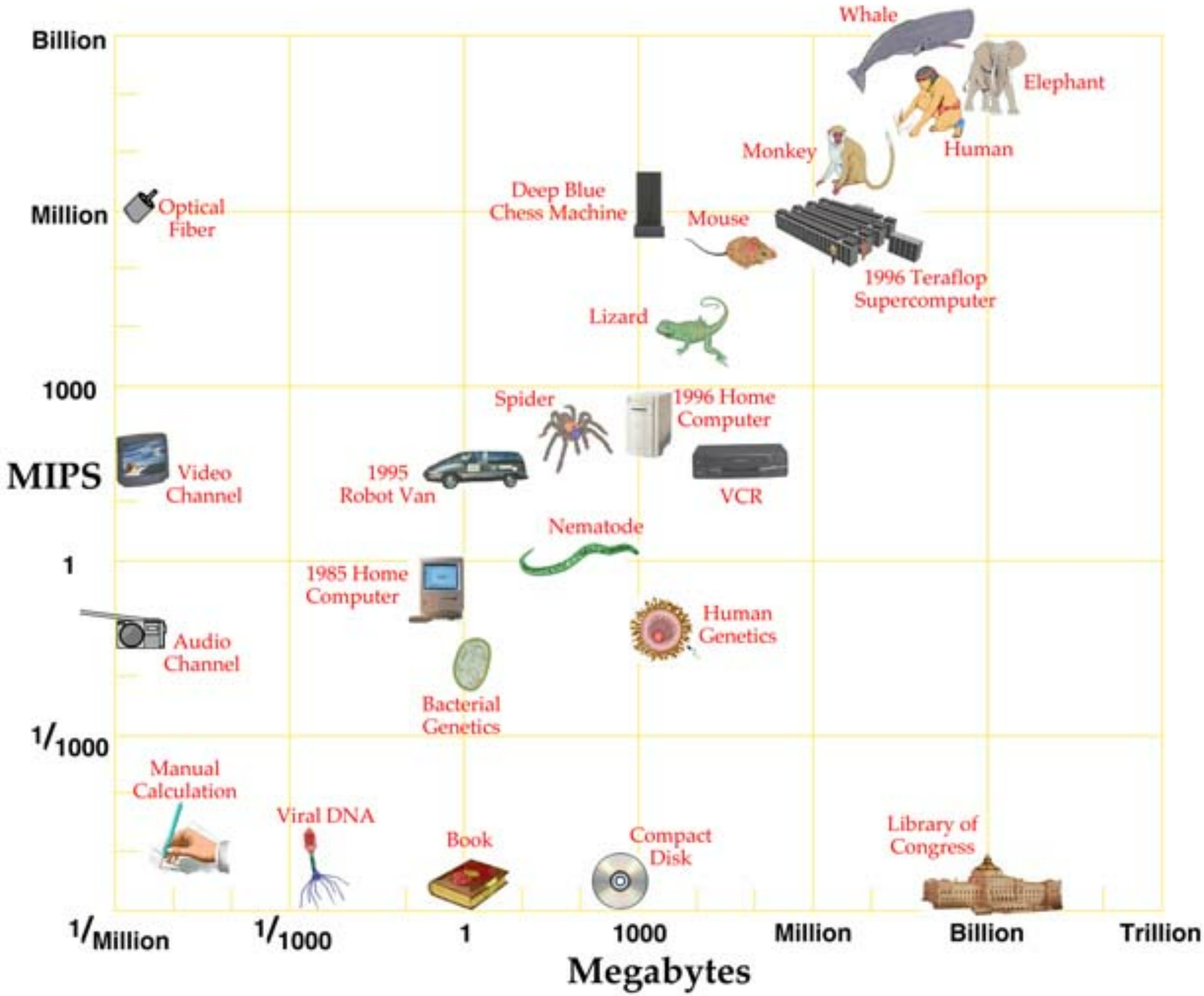




Operating System System Share



All Thinks, Great and Small

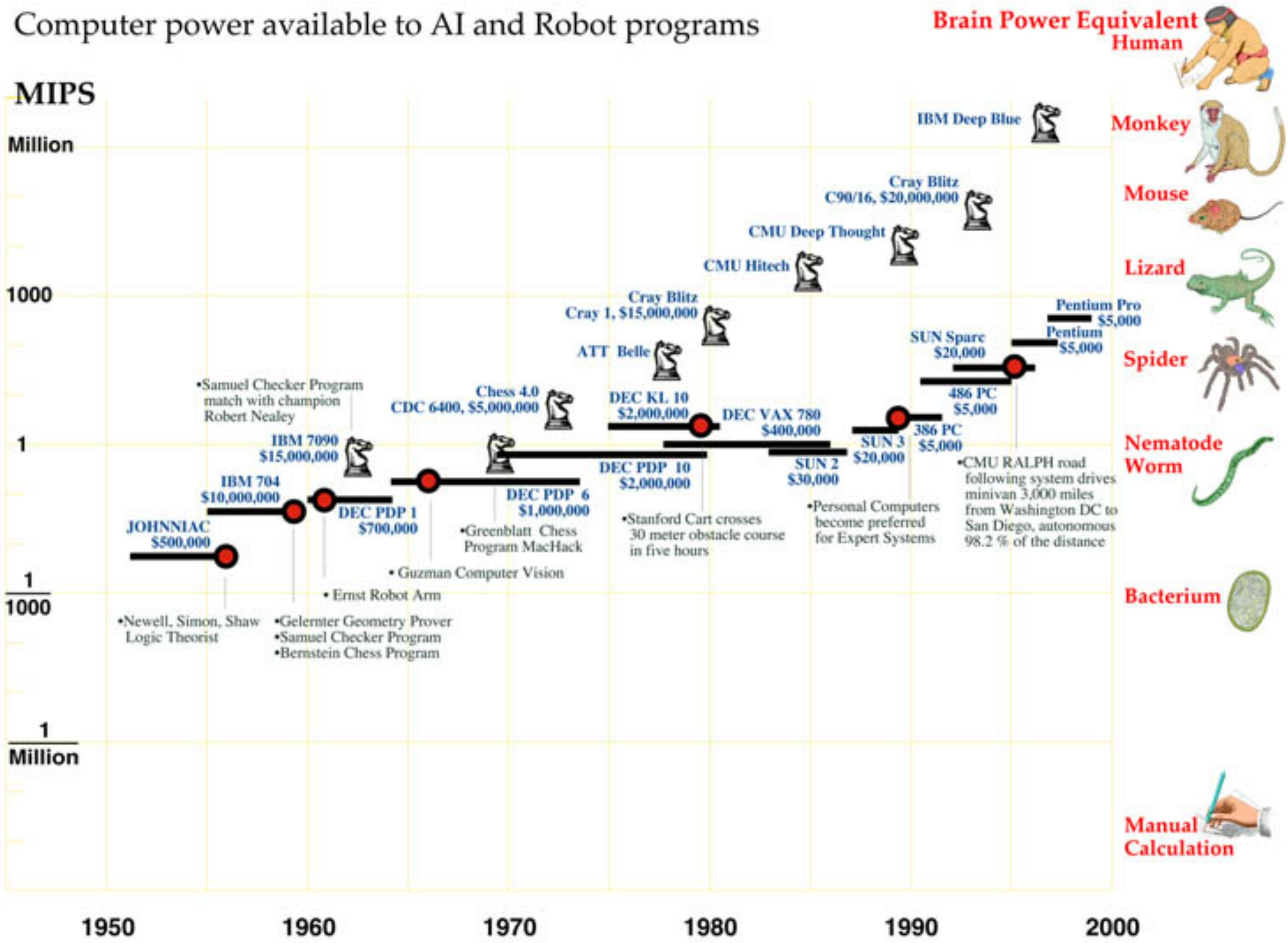


Made by Hans Moravec

More

- few KHz – few KB
- few MHz – few MB
- few GHz – few GB

- Dividing memory by speed defines a "time constant," roughly how long it takes the computer to run once through its memory.
- The megabyte/MIPS ratio seems to hold for nervous systems too!
- Flying insects seem to be a few times faster than humans, so may have more MIPS than megabytes.



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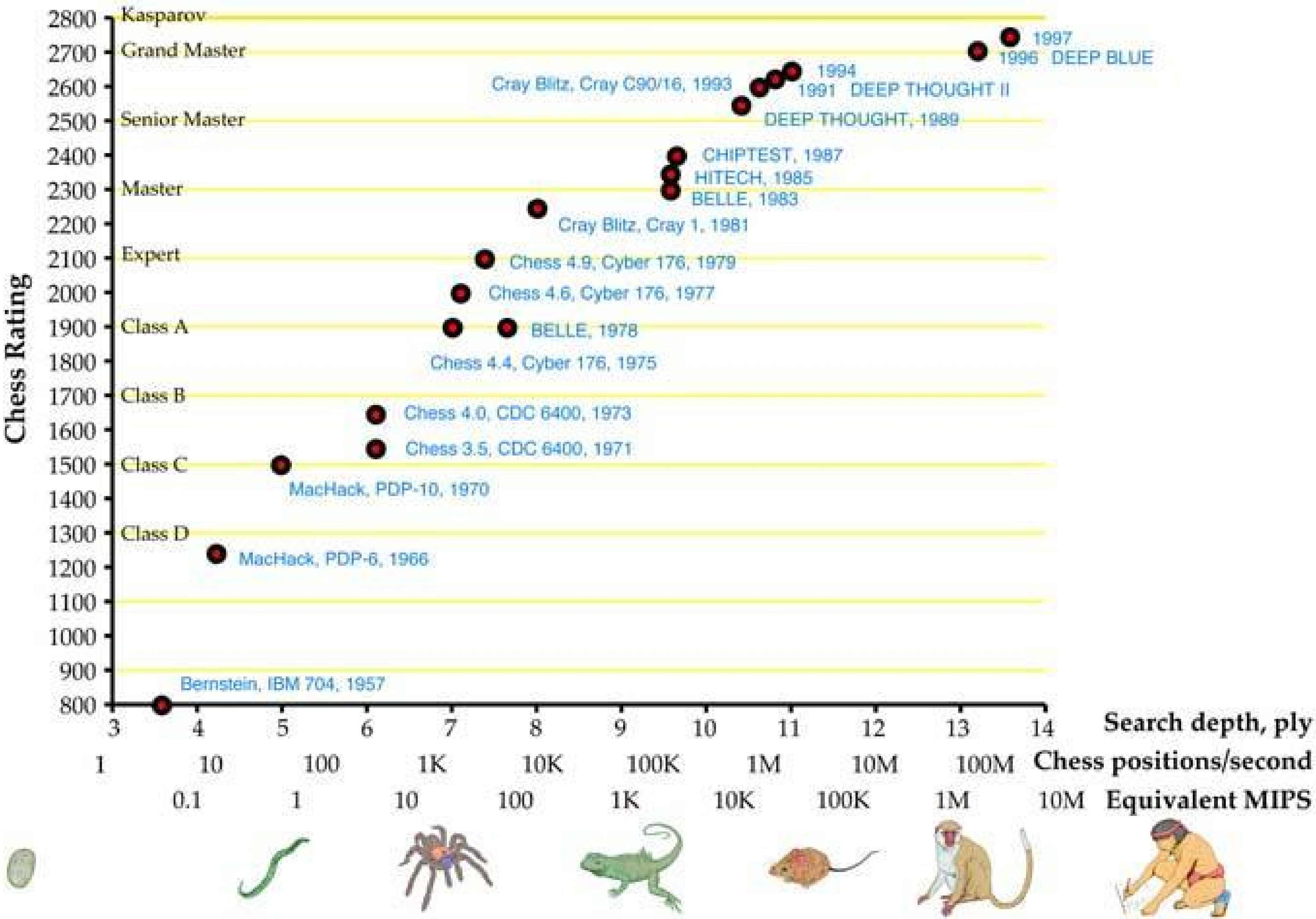
Human Brain & Super Computers

- The most powerful experimental supercomputers can do million MIPS.
- They are very close of being powerful enough to match human brainpower,
- No way to be applied to AI projects. Why?
  - Why to use a million-dollar computer to develop one stupid-human, when millions of inexpensive original-model humans are available?
  - Such machines are needed for high-value scientific calculations, mostly physical simulations, having no cheaper substitutes.
- “Smarter than humans” machines will be interesting only when they will be very cheap.

Chess Machine Performance versus Processing Power



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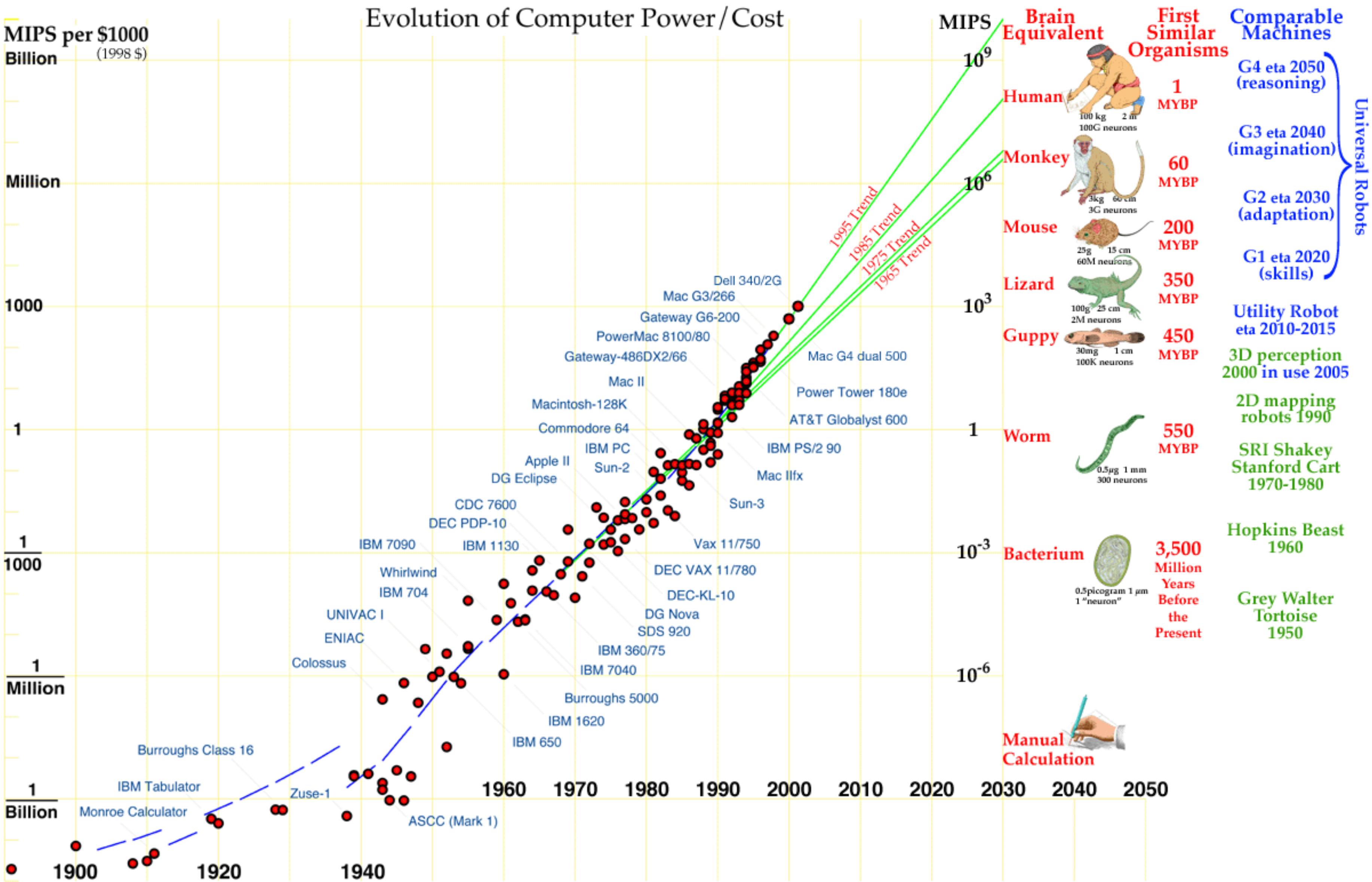
Why computers are still better ?

- There is a big practical difference between animal and robot learning.
  - Animals learn individually.
  - Robot learning can be copied from one machine to another.
  - Decoupling training from use will allow robots to do more with less.
  - Big computers at the factory--maybe supercomputers with 1,000 times the power of machines that can reasonably be placed in a robot--will process large training sets under careful human supervision, and distill the results into efficient programs and arrays of settings that are then copied into myriads of individual robots with more modest processors.



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Why not good-enough algorithm?

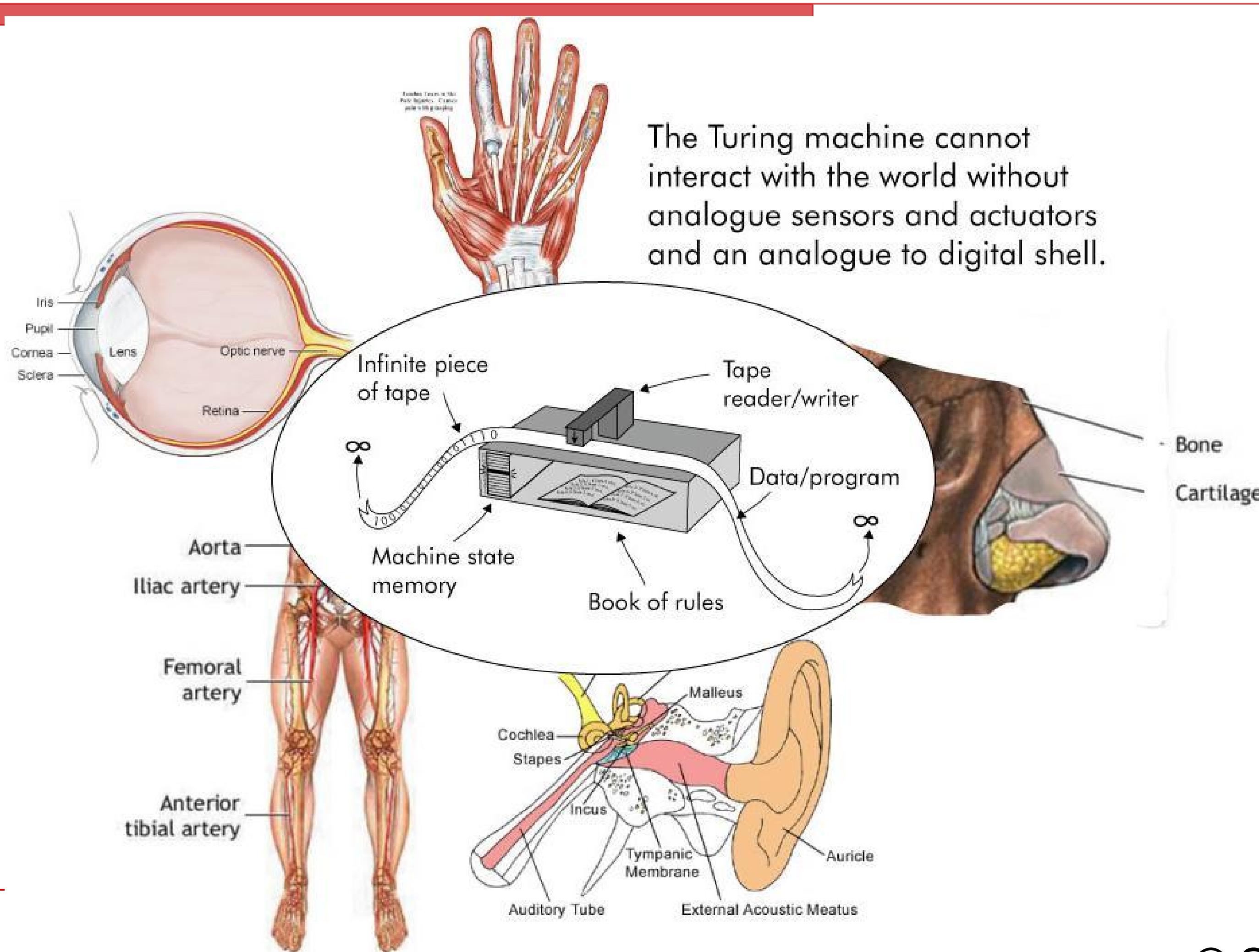
- “AI will be achieved one-day, but right now we are still unable to write a correct 10-lines computer program.”
- John McCarthy – 30 years ago we had good enough hardware, but poor algorithms.

Not enough time to research

Other considerations - Efficiency of software

- At 1 MIPS the best results come from finely hand-crafted programs that distill sensor data with utmost efficiency.
- 100-MIPS processes weigh their inputs against a wide range of hypotheses, with many parameters, that learning programs adjust better than the best programmers.

THE ANALOG SHELL



Loose of information

- We loose information from A/D conversion
- Some body parts can act as sensors even if they are not!
  - Evelyn Glennie (scottish artist)
    - Profundly deaf since 12
    - Hears with the body parts
      - Low sounds – feets and legs
      - High sounds – face, neck, chest.

What's next?

- 4 generations of robots by 2050

… according to Hans Moravec …

Generation 1 - by 2020

- First-generation universal robots will handle only contingencies explicitly covered in their current application programs.
- Unable to adapt to changing circumstances, they will often perform inefficiently or not at all.
- Physical work: businesses, streets, fields and homes that robotics could begin to overtake pure information technology commercially.

Generation 2 – by 2030

- Universal robot with a mouselike mind will adapt as the first generation does not, and even be trainable.
- Besides application programs, the robots would host a suite of software "conditioning modules" that generate positive and negative reinforcement signals in predefined circumstances.
- Application programs would have alternatives for every step small and large (grip under/over hand, work in/out doors). As jobs are repeated, alternatives that had resulted in positive reinforcement will be favored, those with negative outcomes shunned.
- With a well-designed conditioning suite (e.g. positive for doing a job fast, keeping the batteries charged, negative for breaking or hitting something) a second-generation robot will slowly learn to work increasingly well.

Generation 3 - by 2040

- Monkeylike think power by 2040 will permit a third generation of robots to learn very quickly from mental rehearsals in simulations that model physical, cultural and psychological factors.
- It should let a robot learn a skill by imitation, and afford a kind of consciousness.
- Asked why there are candles on the table, a third generation robot might consult its simulation of house, owner and self to honestly reply that it put them there because its owner likes candlelit dinners and it likes to please its owner.
- Further queries would elicit more details about a simple inner mental life concerned only with concrete situations and people in its work area.

Generation 4 – by 2050

- Fourth-generation universal robots with humanlike mental power will be able to abstract and generalize.
- Fourth-generation machines result from melding powerful reasoning programs to third-generation machines. They may reason about everyday actions with the help of their simulators.
- Properly educated, the resulting robots are likely to become intellectually formidable, besides being soccer stars.

MORE DETAILS …

- *When will computer hardware match the human brain*?
- Hans Moravec
- **Journal of Evolution and Technology. 1998. Vol. 1**