



AI History

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Discussion 1



- How you define “Intelligence” and “knowledge” in computers ?
- What do you expect “Intelligence” and “Knowledge” of computers ?

AI Capabilities



- Turing Test (Alan Turing 1950)
⇒ Satisfactory operational definition of intelligence.
- AI Capabilities:
 - Natural Language Processing
 - Knowledge Representation
 - Automated Reasoning
 - Machine Learning
- Total Turing Test (w/ Interaction)
 - Computer Vision
 - Computer Audition*
 - Robotics



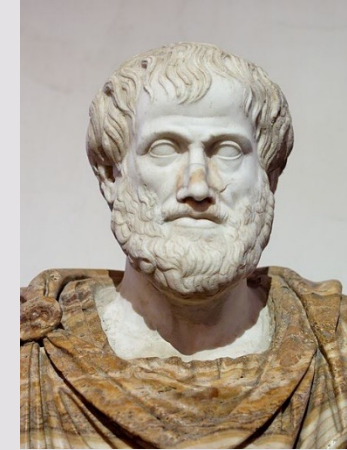
Alan Turing
(1912-1954)



Thinking Rationally: The “laws of thought” approach




- Aristotle : “Right thinking”
 - Syllogisms
 - “Socrates is a man; all men are mortal; therefore, “Socrates is mortal”
 - Logic \Rightarrow Logicist
 - Two main obstacles,
 - Informal knowledge with less than 100% certain
 - Difference solving problems “in principle” and “in practice”



Aristotle
384BC-322BC

Acting Rationally: The rational agent approach



- Computer Agents:
 - Operate autonomously
 - Perceive environments
 - Persist over prolonged time period
 - Adapt to change
 - Create and pursue goals
- Rational Agent \Rightarrow Best Acting Agent  ! Cognitive Science
- Two advantages:
 - More general than the “laws of thought” approaches
 - More amendable to scientific development

The foundations of AI



- Philosophy
- Mathematics
- Economics
- Neuroscience
- Psychology
- Computer Engineering
- Control theory and cybernetics
- Linguistics



- Questions
 - Can formal rules be used to draw valid conclusions?
 - How does the mind arise from a physical brain?
 - Where does knowledge come from?
 - How does knowledge lead to action?
- Aristotle (384-332 B.C.): Syllogisms
- Thomas Hobbes (1588-1679): “We add and subtract in our silent thoughts”
- Blaise Pascal (1623-1662) : “The arithmetical machine produces effects which appear nearer to thought than all the actions of animals.”

Philosophy -2



- Rationalism: René Decartes (1596-1650)
- “cogito ergo sum”
(English: "I think, therefore I am").
- Descartes proceeds to construct a system of knowledge, discarding perception as unreliable and instead admitting only deduction as a method
- One problem with a purely physical conception of the mind is that it seems to leave little room for free will.
- Dualism: “A part of human mind (or soul or sprit) that is outside of nature, exempt from physical laws.
- Materialism: “The brain’s operation according to the laws of physics constitutes the mind. Free will is simply the way that perception of available choices.



Philosophy -3



- Empiricism:
 - Francis Bacon (1561-1626) :
Empiricism by “Novum Organum”
 - John Locke(1632-1704): “Nothing is in the understanding, which was not first in the senses.”
- Logical Positivism: “All knowledge can be characterized by logical theories connected, ultimately, to observation sentences that correspond to sensory inputs”
- Confirmation Theory: “The Logical Structure of the World” defines an explicit computational procedure for extracting knowledge from elementary experiences.
- ⇒ First theory of mind as a computational process.



- Questions:

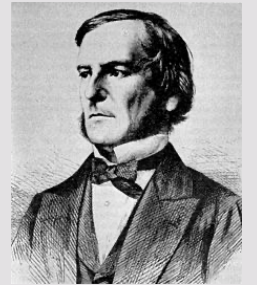
- What are the formal rules to draw valid conclusions?
- What can be computed?
- How do we reason with uncertain information?

- Mathematics formulation;

⇐ Logic, Computation, and Probability

- Logic:

- Propositional, Formal Logic, or Boolean Logic
(1847) : George Boole (1815-1864)
- First Order Logic : Gottlob Frege (1848-1925) extended Boolean logic to include objects and relations



George Boole
1815-1864

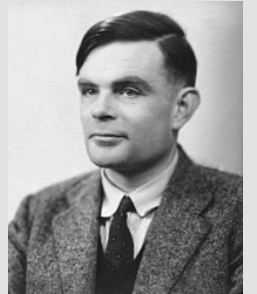


Gottlob Frege
1848-1925



- Computation:
 - Determine the limits of logic and computation
⇒ Algorithm: Euclid's algorithm for computing greatest common divisors by Kurt Gödel.
 - Incompleteness Theorem: Kurt Gödel (1906-1978)
Some functions on the integers cannot be represented by an algorithm.
 - Entscheidungs Problem = Computability :
David Hilbert (1862-1943)

⇒ Alan Turing defines computability.



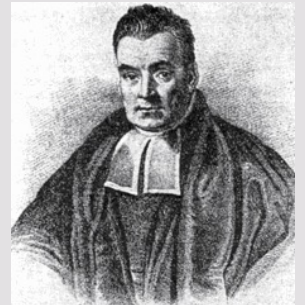
Alan Turing
(1912-1954)



- Computation:
 - Computable: Alan Turing (1912-1954) tried to characterize exactly which functions are computable. \Rightarrow Turing Machines
 - Tractability, Intractability:
 - Intractable \Rightarrow if the time required to solve instances of the problem grows exponentially with the size of the instances.
 - NP-completeness:
 - Steven Cook(1971), Richard Karp(1972)
 - Any problem class to which the class of NP-complete problems can be reduced is likely to be intractable.



- Probability:
 - Probability Theory: Gerolamo Cardano (1501-1576)
 - New Statistical methods: James Bernoulli, Pierre Laplace
 - Bayes' Rule: Thomas Bayes (1701-1761) Bayes' rule underlies most modern approaches to uncertain reasoning AI systems
- Bayesian probability is the name given to several related interpretations of probability, which have in common the notion of probability as something like a partial belief, rather than a frequency. This allows the application of probability to all sorts of propositions rather than just ones that come with a reference class. "Bayesian" has been used in this sense since about 1950.



Thomas Bayes
1701-1761



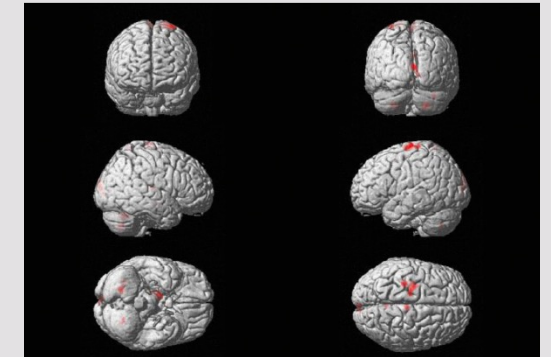
- Questions:
 - How do brains process information?
- Neuroscience: The study of the nervous system, Brain.
- Paul Broca (1824-1880):
 - Localization responsible for specific cognitive functions
 - Broca's area: The portion of the left hemisphere localized for Speech production.



Neuroscience -2



- Neurons: A staining technique enabled observation by Camillo Golgi(1934).
- Electroencephalograph(EEG):
Hans Berger(1929)
- Functional magnetic resonance imaging
(fMRI): Ogawa (1990), Cabeza and Nyberg(2001)
- Collection of simple cells can lead to thought,
action, and consciousness.
“Brains cause minds.”

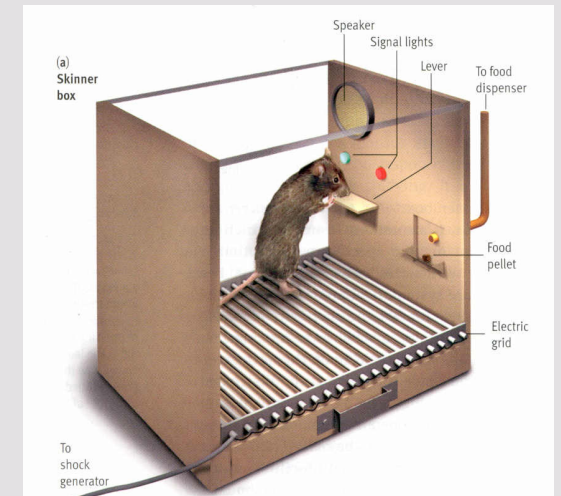


Psychology -1



- Questions:
 - How do humans and animals think and act?
- Herman von Helmholtz(1821-1894), Wilhem Wundt(1832-1920) “Handbook of Physiological Optics”
- Behaviorism: John Watson(1878-1958)

They insisted **only** on the study of objective measures of **the percepts** (or stimulus) given to an animal and its **resulting actions** (or response). They reject any internal mental process.
- Behaviorism discovered a lot about rats and pigeons but had less success at understanding humans. (US)



Psychology -2



- Cognitive Psychology: William James (1842-1910) .
Brain is a information processing machine.
Frederic Bartlett at Cambridge Applied Psychology Unit.
The three key steps of a knowledge-based agent.
 - 1) Stimulus must be translated into an internal representation
 - 2) Representation is manipulated by cognitive processes to derive new internal representations
 - 3) These are in turn retranslated back into action



Cognitive Science



- 1943-1955: The gestation of AI
 - Artificial Neuron Model: W. McCulloch, W. Pitts
 - First work of AI, based on
 - Knowledge of the basic physiology and function of neurons in the brain
 - Formal analysis of propositional logic
 - Turing's theory of computation
 - They showed any computable function could be computed by some network of connected neurons.
 - Hebbian Learning: D. Hebb (1949)
 - First neural computer SNARC (1950): M. Minsky, D. Edmond at Harvard.
 - Turing Test, Genetic Algorithm, Reinforcement Learning (1950) : A. Turing "Computing Machinery and Intelligence" at UK

History of Intelligent Systems (AI) -2



- 1956: The birth of AI
 - John McCarthy at Stanford and Dartmouth College
 - Two months workshop at Dartmouth in summer 1956
 - With M. Minsky, C. Shannon, N. Rochester
 - Logic Theorist(LT): Newell, Simon
 - Shorter proof for Mathematics
- Why AI is separate field?
 - Idea of duplicating human faculties such as creativity, self-improvement, and language use
 - Attempt to build machines that function autonomously in complex, changing environments

History of Intelligent Systems (AI) -3



- 1952-1969: Early enthusiasm, great expectations
 - Success in a limited way
 - General Problem Solver: Newell, Simon imitates human problem-solving protocols.
 - J.McCarthy at MIT, AI lab
 - LISP (1958)
 - Time sharing (1958)
 - “Programs with Common Sense” was published. Use general world knowledge.
 - M. Minsky moved to MIT (1958)
 - J.McCarthy at Stanford (1963)
 - Stressed representation and reasoning in formal logic
 - M.Minsky at MIT supervised students on limited problems.

History of Intelligent Systems (AI) -4



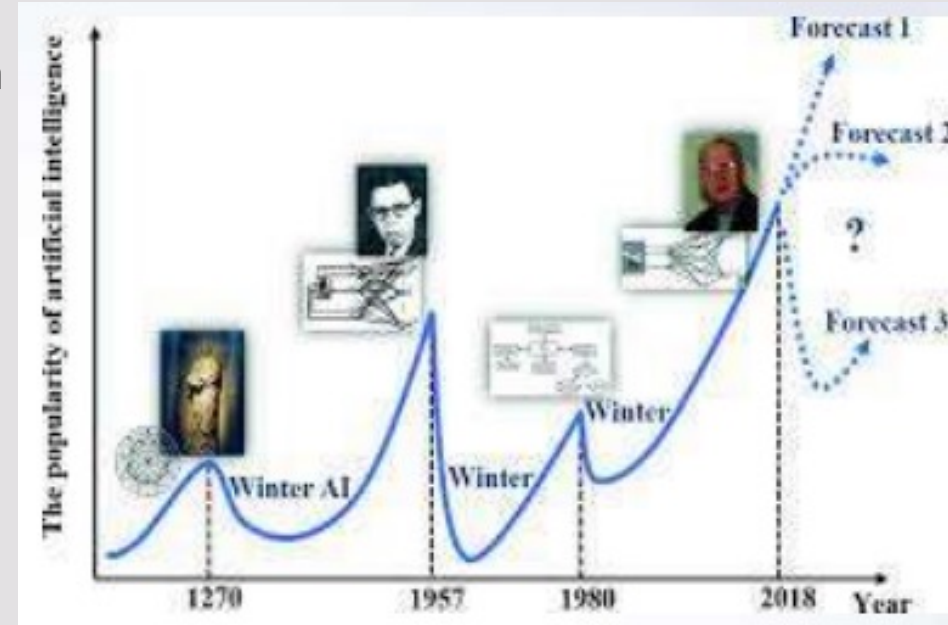
- 1966-1973: A dose of reality, but...
 - Visible future (1957) by Simon
 - Early system turned out to fail miserably on wider selections of problems and on more difficult problems.
 - Machine translation: U.S. National Research Council.
 - Translation of Russian scientific papers. “Sputnik” launch in 1957
 - Simple syntactic transformations based of the grammars of Russian and English?
 - Need background knowledge!
 - “The spirit is willing but the flesh is weak”
⇒ “The vodka is good but the meat is rotten”
 - Advisory committee “There has been no machine translation of general scientific text, and non is in immediate prospect”

⇒ Project was cancelled.

AI Winter



- The Winter: After expansion, there's always a contraction
 - First **doubts** on the **feasibility** of all the approach
 - Problems:
 - **Limited computer power**
 - Combinatorial explosion (**exponential time**)
 - Commonsense knowledge and reasoning
 - Moravec's paradox
 - The **Chinese room argument** undermined the goal of building intelligent machines
 - **END OF FUNDING**



History of Intelligent Systems (AI) -5



- 1969-1979: Knowledge-based systems:
The key to power
 - Weak methods: use more domain knowledge
 - DENDRAL: Ed. Feigenbaum
Inferring molecular structure
 - MYCIN: Expert System,
450 rules. Better than junior doctors.
Extensive interview of experts and handling uncertainty.
 - SHRDLU: T. Winograd
Understanding natural language in a small world
 - “General knowledge required.” E. Charniak
 - Minsky “Plan”, Shank “Script”

Brief History of AI: Expert System

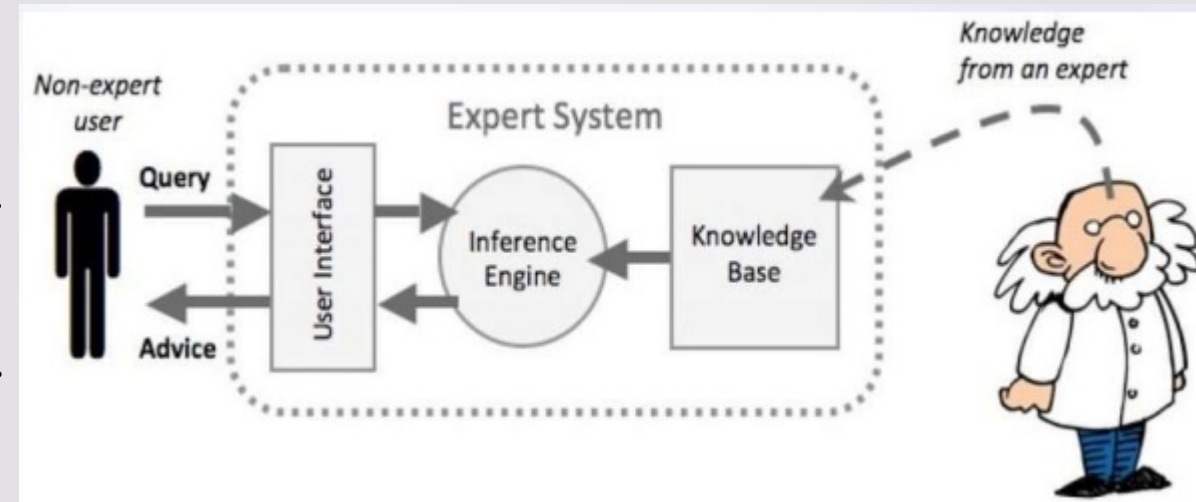


■ MYCIN(1972):

- Diagnosed infection (感染) blood diseases.
- About 600 rules & started to ask questions.
- In some cases, better than human experts.

■ XCON (1980):

- Production-rule-based system that assisted the ordering of a type of computers systems by automatically selecting the computer systems components based on the customers requirements.
- Saving \$40 million dollars to the company. 2500 rules and processed 80,000 orders with 95%-98% accuracy.
- The gain in money was because it reduced the need to give free components when the technicians made errors, by speeding the assembly process and by increasing customer satisfaction.





Brief History of AI: Expert System

- PROSPECTOR (1981)
 - A computer-based consultation system for mineral exploration(礦產勘探諮詢系統).
 - Recommending exploratory drilling(探索性鑽探)
- New funding due to this success
 - AI groups were formed in many large companies to develop expert systems.
 - 1986 sales of AI-based hardware and software were \$425 million.



History of Intelligent Systems (AI) -6

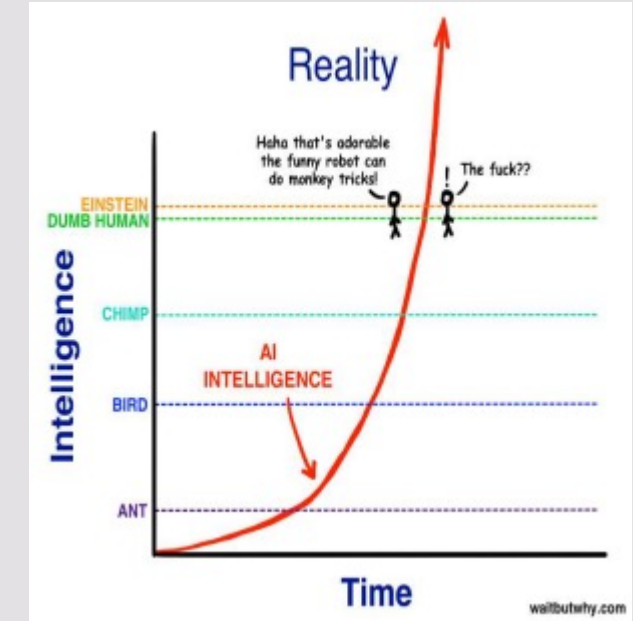


- Present
 - The return of neural networks
 - Back-propagation reinvented by Rumelhart and McClelland. Originally by Bryson and Ho (1969)
 - Isolation from other area was abandoned.
 - HMMs in Speech Recognition, and handwritten characters
 - Data Mining
 - Bayesian Network: Judia Pearl (1988) “Probabilistic Reasoning in Intelligent Systems”
 - Other revolutions in robotics, computer vision, knowledge representation research
 - From weak methods to “Human-level AI”, and “Artificial General Intelligence”

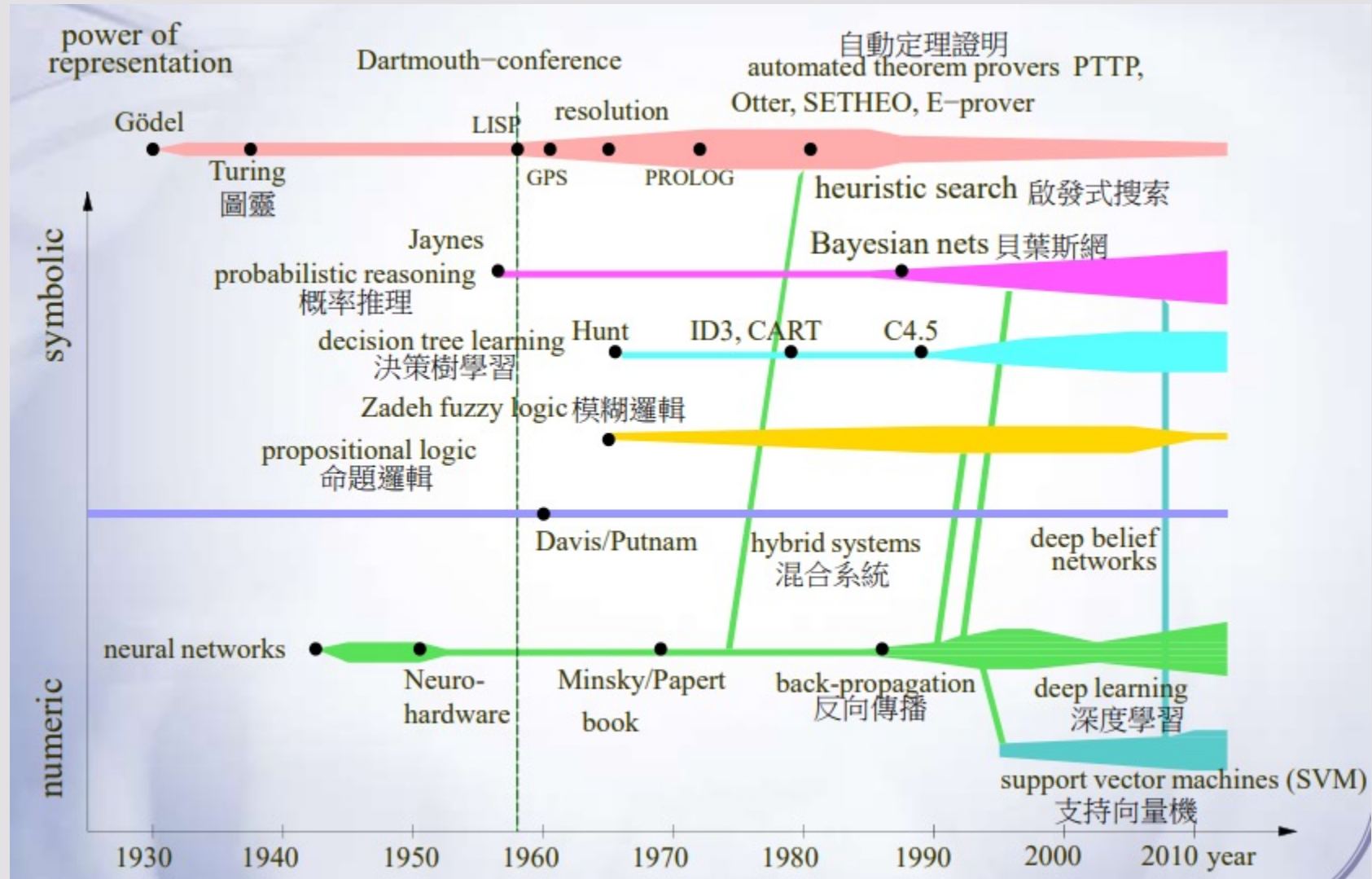
Brief History of AI



- Quick pace in the '90s
 - NCSA releases the **first web browser**, Mosaic
 - **Deep Blue beats** Gary Kasparov
 - **Robotic soccer players**(機器人足球運動員) in RoboCup
 - Sony corporation introduced the **robotic dog**(機器人狗) AIBO
 - Remote agent autonomously drive deep space
- Even moving faster in the 00's
- Now the intelligence explosion



Brief History of AI: Summary



History of Intelligent Systems (AI) -7

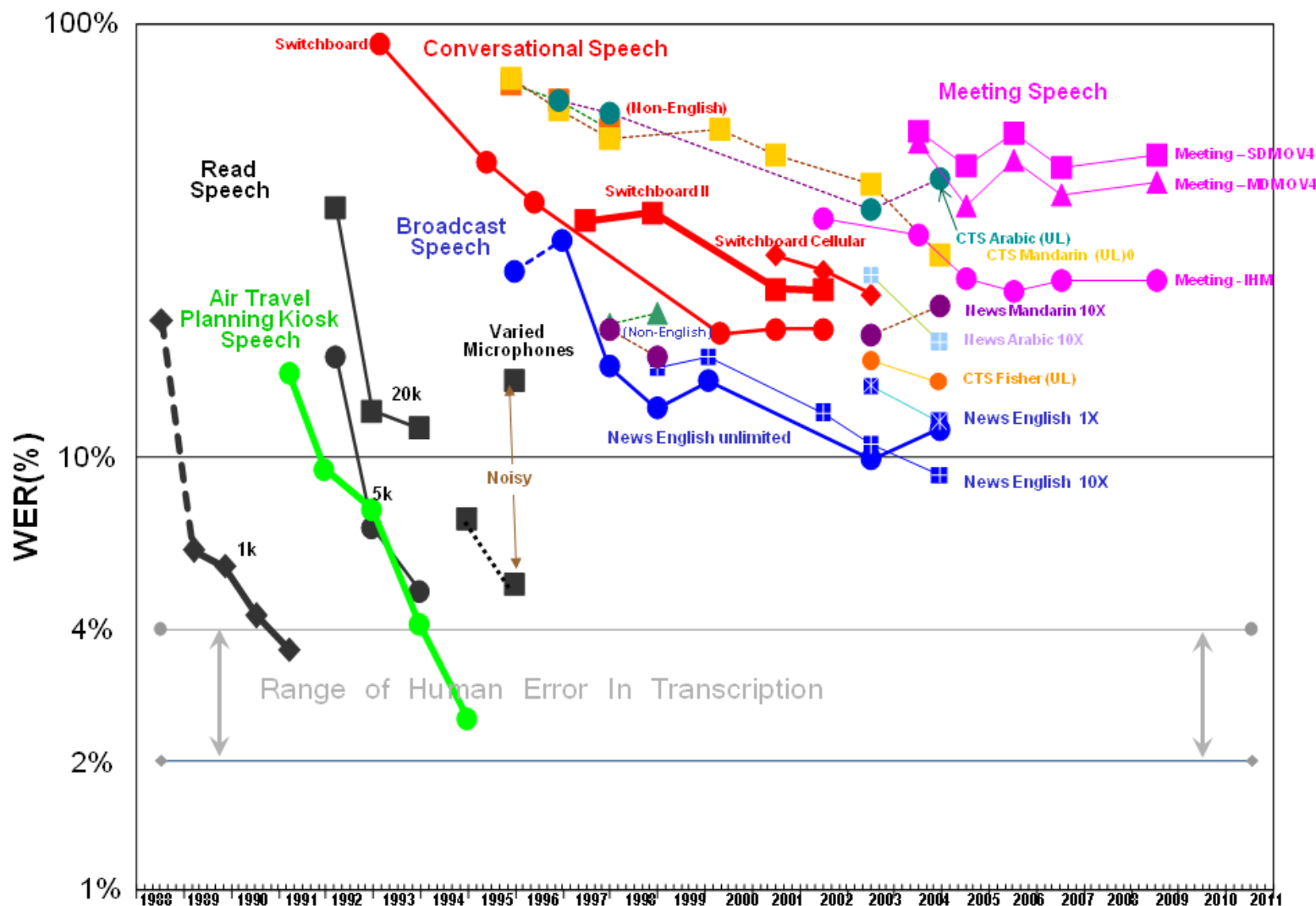


- Present: Very Large Data Sets “Massive Data AI”
 - More than a zeta byte data on the WEB
 - Trillions of words of English
 - Billions of images
 - Billions of base pairs of genomic sequences
 - Word-sense disambiguation: Yarowsky (1995)
“plant” : flora or factory? 96% accurate estimation by very large corpora with no annotation
 - Knowledge Bottleneck are going to be solved !
- Examples:
 - Robotic Vehicles: DARPA Grand Challenge
 - Speech Recognition : United Airline
 - Machine Translation : Google, VoiceTra@NICT
 - NASA remote agent program
 - Game playing, SPAM filtering, Logistics planning
 - iRobot: Roomba robotic vacuum cleaners

DARPA Speech Recognition



NIST STT Benchmark Test History – May. '09



Discussion 2



- Introduce “Massive Data AI” examples in your research area.
- Discuss recent progress what have been done and haven't done.
What is the most serious problem??