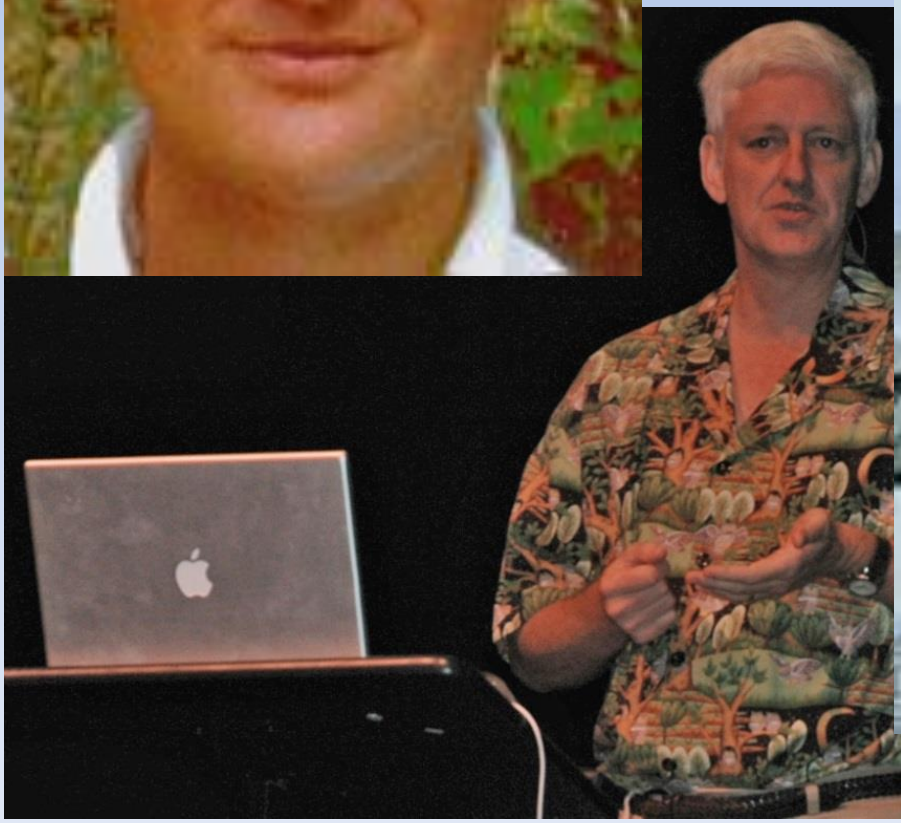
AI Programming

Chapter 1: What is AI ??



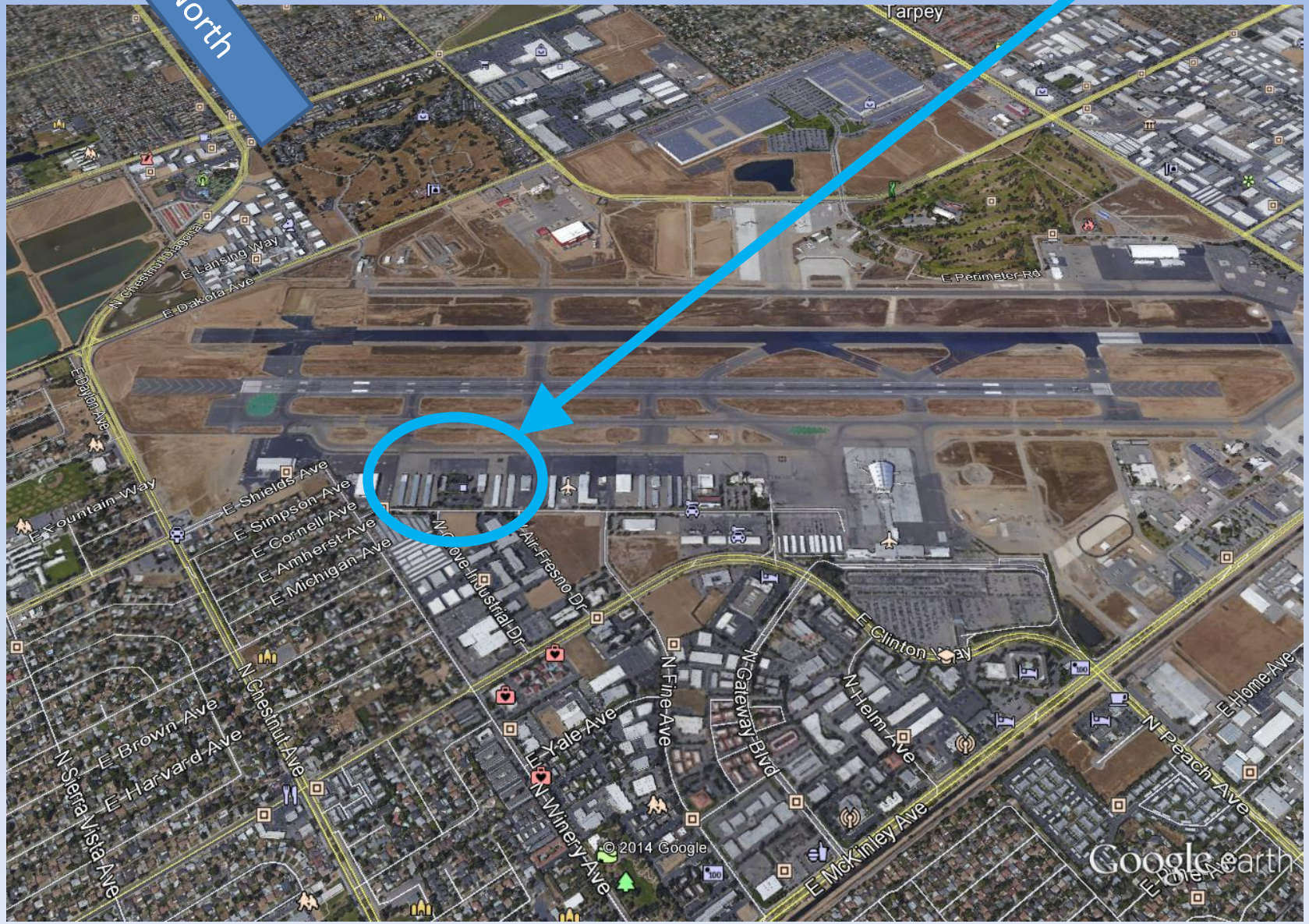
Lecture 2 : Chapter 1

- What is Artificial Intelligence?
- What is Intelligence?
- What is Thinking / Problem Solving
- Look @ Example: Locked Door

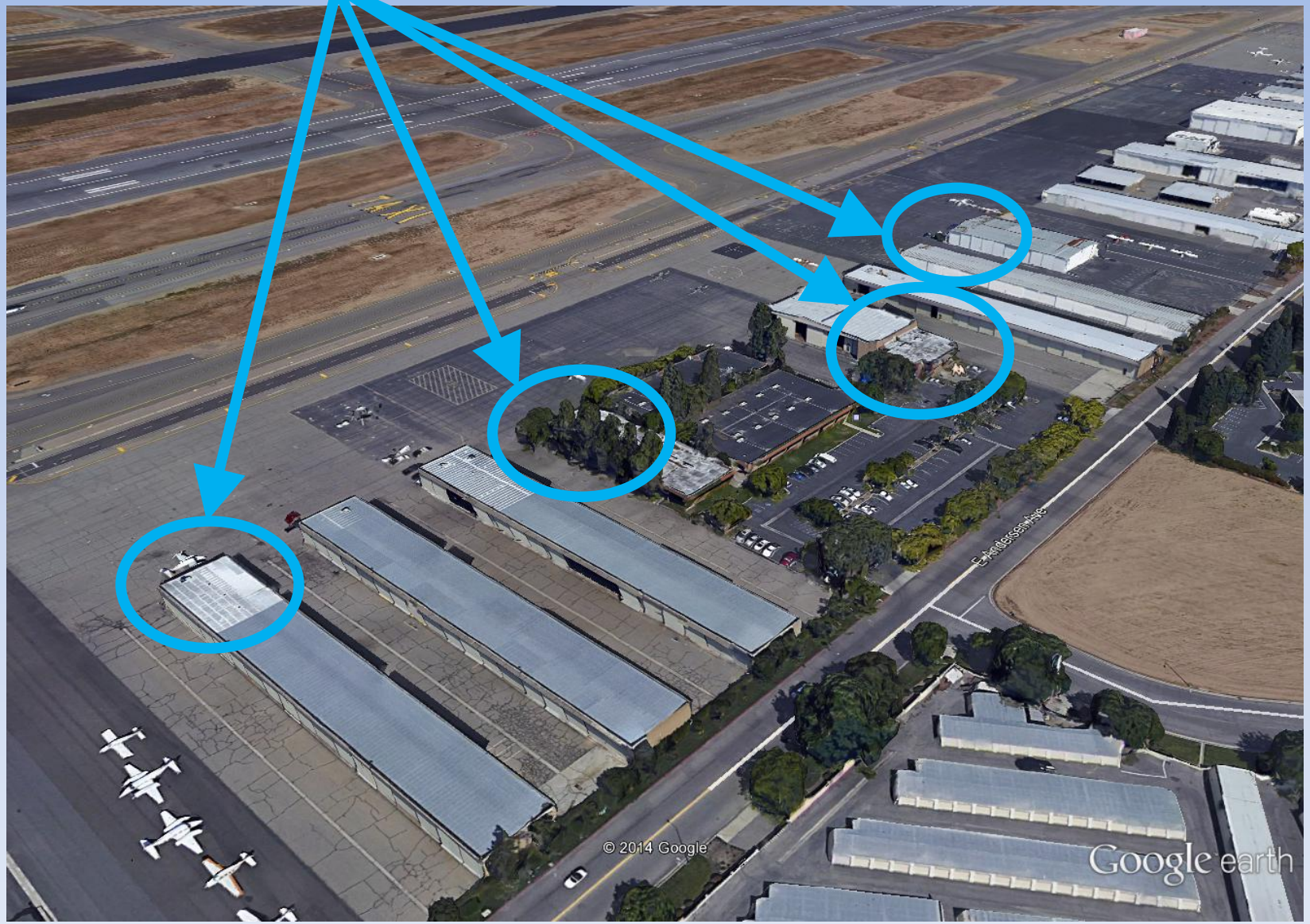
Chapter 1: Questions 1.7

- 1.7: To what extent are the following computer systems instances of artificial intelligence:
  - a) Supermarket bar code scanners.
  - b) Web search engines.
  - c) Voice-activated telephone menus.
  - d) Internet routing algorithms that respond dynamically to the state of the network.

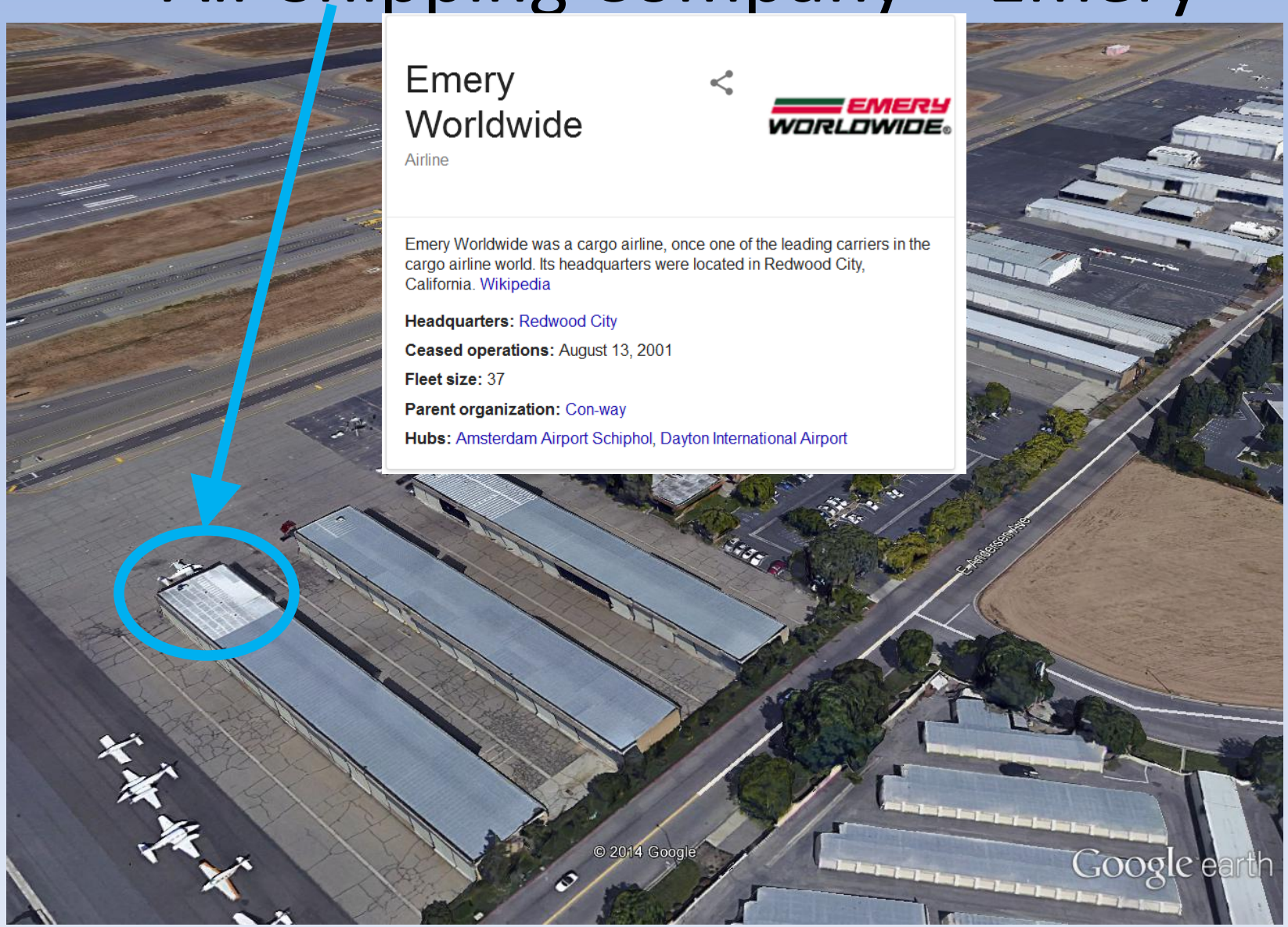
Locked Door Example: Environmental Control/1981



Locked Door Example: Environmental Control



Locked Door Example:
Air Shipping Company – Emery

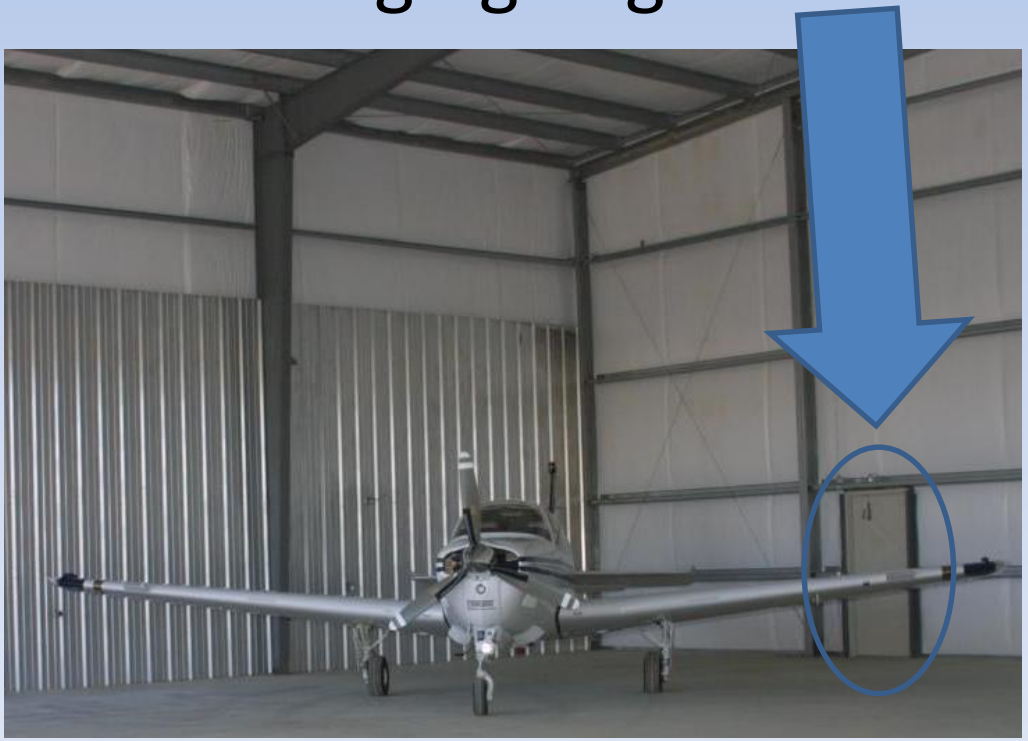


Interior Door w/ Lock
Trash Can

Photo Not Actual Hangar

Interior Door w/ Lock

- Usually just a few trash items
- This nite – bag needed replacement.
- This nite door closed while changing bag – Locked!



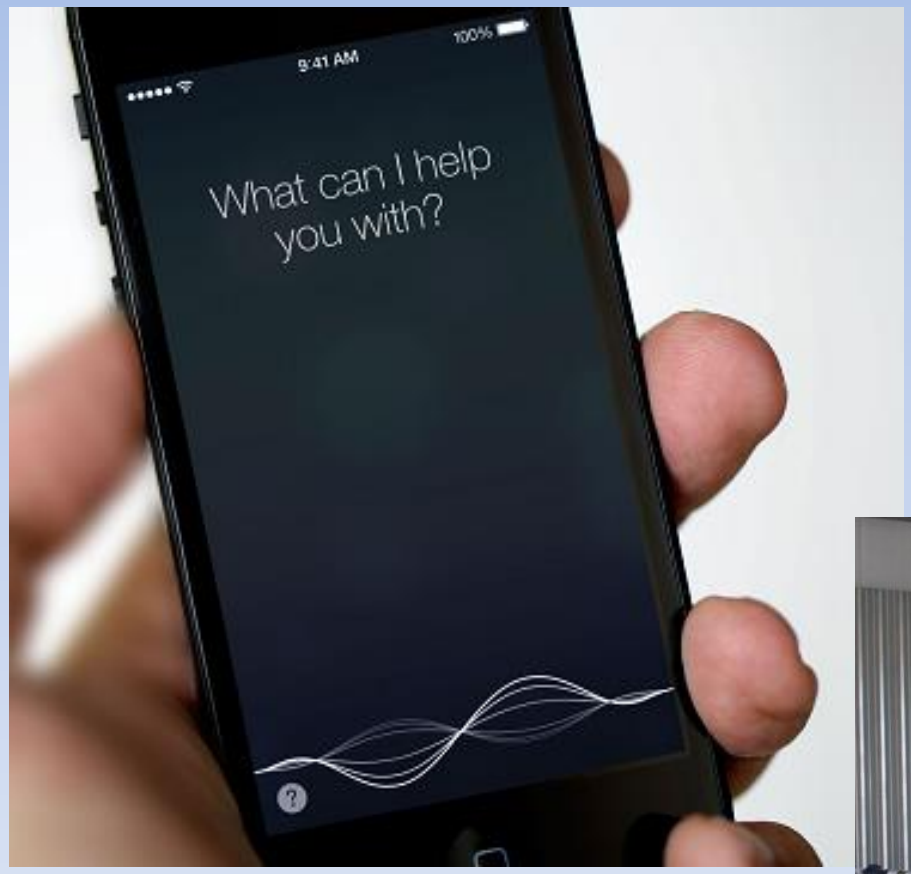
Locked Door Problem!

- Check for Keys:
  - REMEMBER: I was told I do not have key for this door!
- Other Entrances?
  - Hangar Only: LOCKED from OUTSIDE!
- Start to Worry!
  - Long nite in cold hangar!
  - No Lights!
  - Pre-Cell Phone Days!

Locked Door Problem:

- Scream ??
  - Pilots might hear
    - It was late, and in a quiet corner of runway!
  - Might be embarrassing!
  - Probably won't die overnight!

Siri.. What should I do?



Locked Door Problem:

- Alternate Access
  - Perhaps modify object not designed as entrance.
  - Can anything be modified to act as entrance.
- Search Alternate Access Ideas
  - Break Door? : Defeat Lock?
    - COSTS
    - Possible Injury!
- Search Ideas……..
- Search Memories……..

Memories..

- Dad frequently forgot his keys!
- Would Remove Back Door Hinges….
- Maybe this will work here…..

Locked Door Problem:

- Alternate Access
  - Perhaps modify object not designed as entrance.
  - Can anything be modified to act as entrance.
- Search Alternate Access Ideas
  - Break Door? : Defeat Lock?
    - COSTS
    - Possible Injury!
  - **Remove Door Hinges??**
    - **Seen this a few times at home!!**

Locked Door Problem!
Solution: Door Hinge Removal

- Fortunately (for me) door hinges were on my side!
- I was able to remove all hinges --- In The Dark!!!
  - They seemed loose.
  - Maybe I wasn't the first in this situation!
- Door came off!!!
- Finished my night work ---

TOLD NO ONE!!!

Till Spring '16 164!!!

Locked Door
Thinking / Acting

- Locked Door Problem requires Intelligence (some) to solve.
- Perceiving the world:
  - Door is LOCKED
  - I don’t have KEY.
- (Knowledge + Evidence) -> Answer Query
  - Is there a Window?
  - Is there an alternate access?
  - Is there a key alternative?

Locked Door
Thinking / Acting : Intelligence

- Modeling the World:
  - Backdoor Access
  - Detailed Door mechanism
- World Knowledge can be Deterministic
  - The door is OPEN or LOCKED
  - The window exists YES or NO
  - DO HAVE KEY or DO NOT HAVE KEY.
- World Knowledge can be Probabilistic:
  - Anyone likely to hear me scream?
- Constraints:
  - No Access unless Open Door.
- Predictions: Likely to be long cold nite in hangar!

Locked Door
Thinking / Acting : Intelligence

- Intelligent Action:
  - Remove Door Hinges!: YES!
  - **Remove Door!!!** YES!
- Adaptation:
  - Door opened WITHOUT key!
- Learning:
  - Check Door Before Exit! Twice!! ……..Thrice!!!!!?

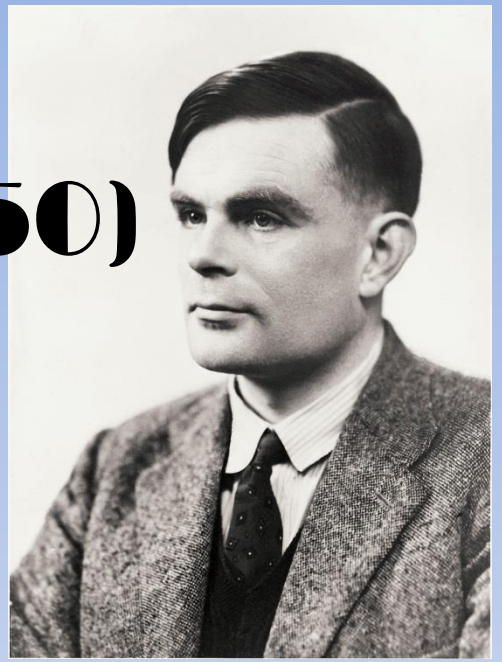
Back to … What is AI ??

Back to … What is AI

Acting Humanly

- Meet Data….

Acting Humanly: The Turing Test (1950)



- Requires:
  - Natural Language
  - Knowledge Representation
  - Automated Reasoning
  - Machine Learning
  - Total Turing Test – Vision & Robotics

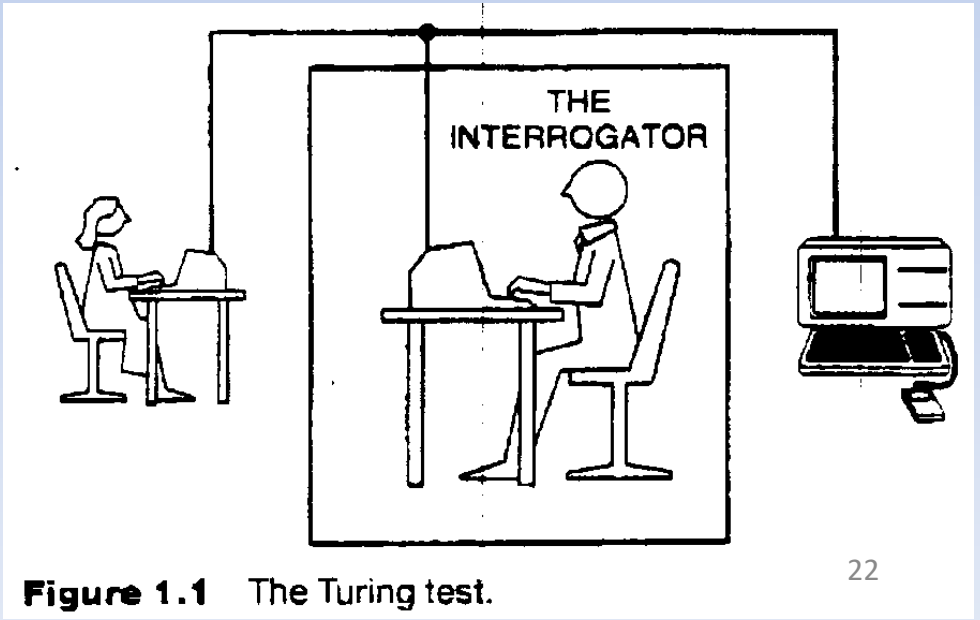
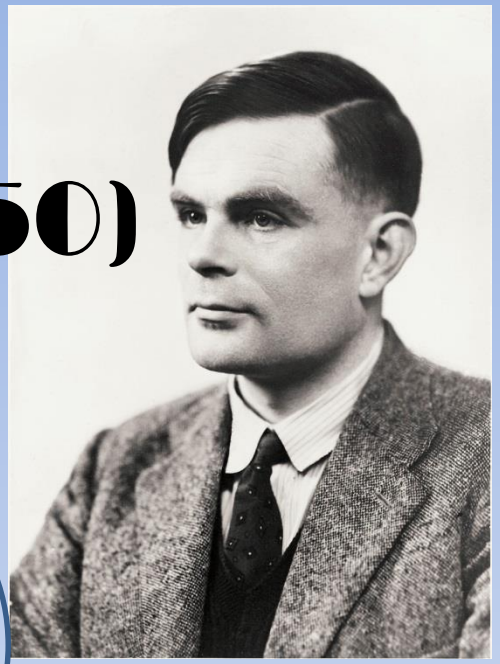


Figure 1.1 The Turing test.



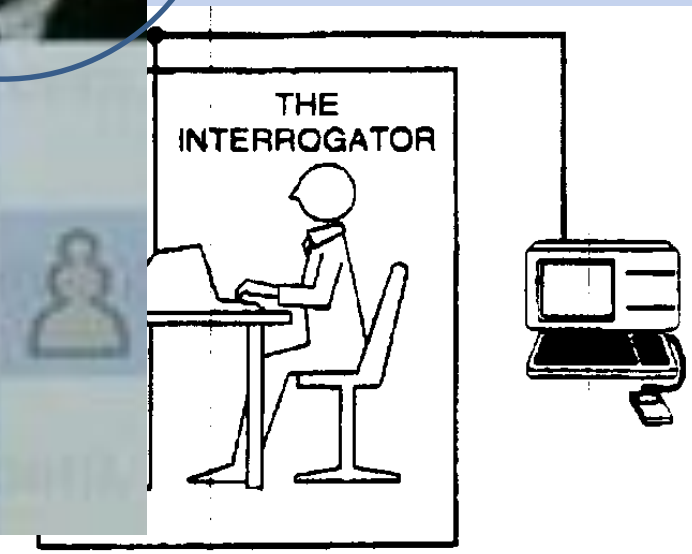


Figure 1.1 The Turing test.

Back to … What is AI

Acting Humanly

"The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990)

"The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)

Thinking Humanly: Cognitive Modeling

- Cognitive Science:
  > AI Computational Models + Psychological Experimentation

Back to … What is AI

Thinking Humanly

"The exciting new effort to make computers think . . . machines with minds, in the full and literal sense." (Haugeland, 1985)

"[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . ." (Bellman, 1978)

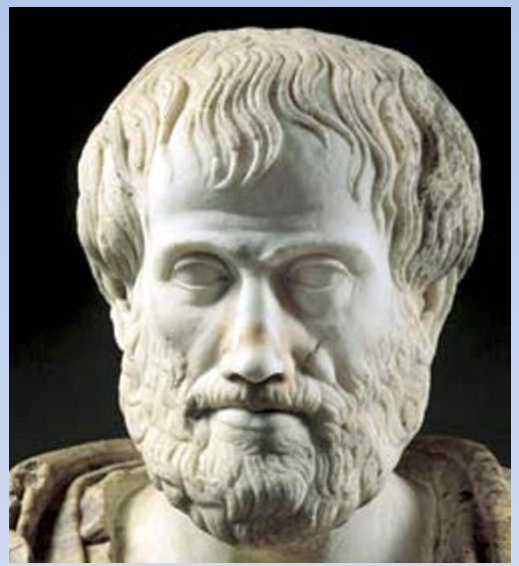
Acting Humanly

"The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990)

"The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)

Thinking Rationally: Logic – Laws of Thought

- Perhaps a set of perfect thought rules exist
- Logicist Tradition (Planning/KR)
- Aristotle (384–322 B.C.)

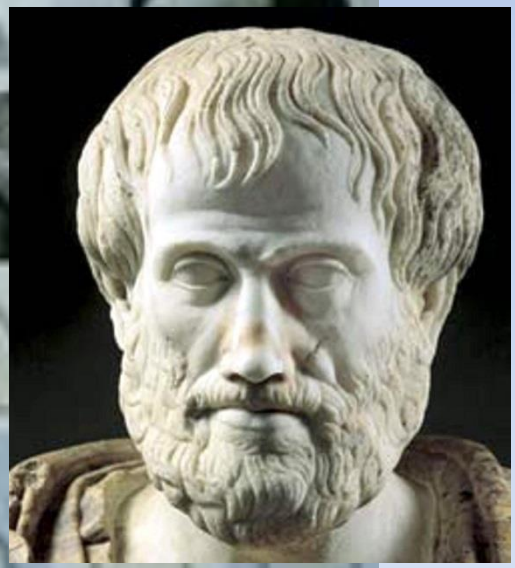


Socrates is a man,
all men are mortal,
therefore……

Socrates is mortal !

ally:
ought

ules exist



Aristotle

. . .

Thinking Rationally: Probabilistic Reasoning

- Perhaps mathematical rules

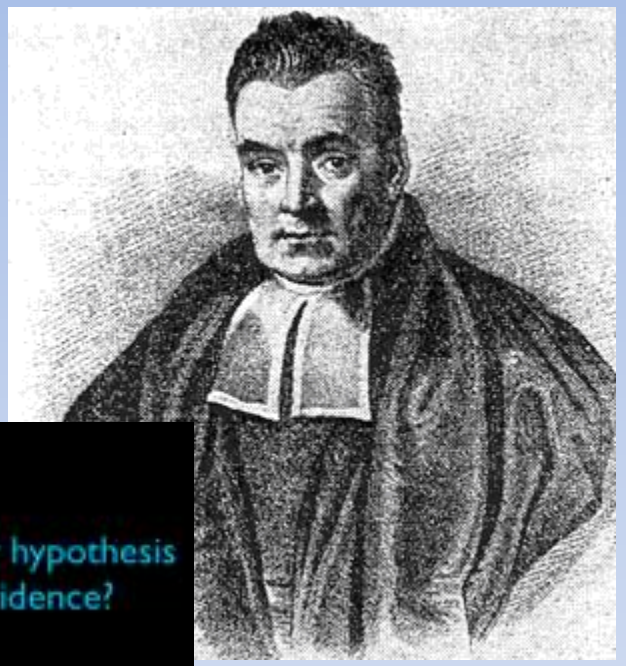
VS

- EXPECTED Return:

Prob(Return) * Return

Thinking Rationally: Probabilistic Reasoning

- Bayesian Methods
- $Prob(Flu|Sneeze) = \frac{Prob(Sneeze|Flu) * Prob(Flu)}{Prob(Sneeze)}$



Likelihood
How probable is the evidence given that our hypothesis is true?

Prior
How probable was our hypothesis *before* observing the evidence?

$$P(H \mid e) = \frac{P(e \mid H)\, P(H)}{P(e)}$$

Posterior
How probable is our hypothesis given the observed evidence? (Not directly computable)

Marginal
How probable is the new evidence under all possible hypotheses?
$P(e) = \sum P(e \mid H_i)\, P(H_i)$

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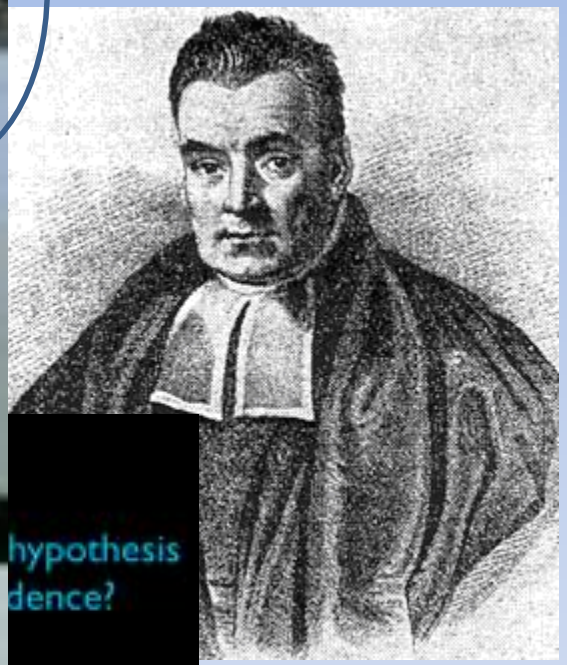


Rev. Thomas Bayes

hypothesis
dence?

nce

(Not directly computable)

$$P(e) = \sum P(e \mid H_i)\, P(H_i)$$

Back to … What is AI

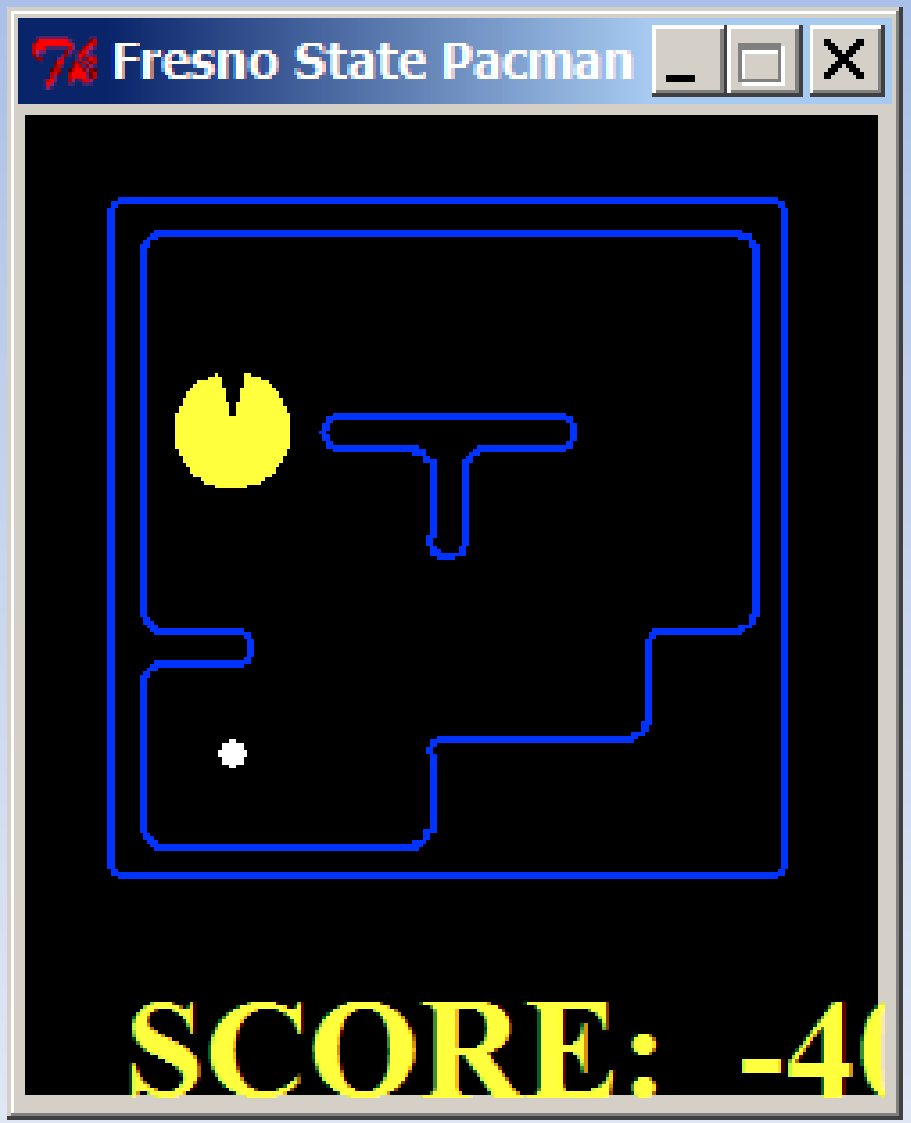
Thinking Humanly	Thinking Rationally
"The exciting new effort to make computers think . . . machines with minds, in the full and literal sense." (Haugeland, 1985) "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . ." (Bellman, 1978)	"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985) "The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992)
Acting Humanly "The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990) "The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)	

Acting Rationally!

- Maybe we can't prove algorithm is "intelligent"
- But, behavior evaluated as "intelligent"
- Solar Powered Robotic Pool Skimmer

Acting Rationally!

* Robotic Pacman



Acting Rationally! Rational Agents

- Agent: Something that acts
- Rational Agent: Acts out to best achieve aim.
  -> Books Approach

Chapter 2: Intelligent Agents

Back to … What is AI

Thinking Humanly	Thinking Rationally
"The exciting new effort to make computers think . . . machines with minds, in the full and literal sense." (Haugeland, 1985) "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . ." (Bellman, 1978)	"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985) "The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992)
Acting Humanly	**Acting Rationally**
"The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990) "The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)	"Computational Intelligence is the study of the design of intelligent agents." (Poole et al., 1998) "AI ...is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

Artificial Intelligence is Multidisciplinary

- Chapter 1 explores disciplines influencing the foundations/study of Artificial Intelligence.

AI Foundations

- Philosophy
- Mathematics
- Economics
- Neuroscience
- Psychology
- Computer Engineering
- Control Theory & Cybernetics
- Linguistics

Philosophy

- Aristotle (384-322B.C.) was first to formulate a precise set of laws governing the rational part of the mind?
- Rene Descartes (1596–1650) gave the first clear discussion of the distinction between mind and matter and of the problems that arise.
- The empiricism movement starts with Francis Bacon (1561-1626) works to understand the world through observations.
- Thinking to action also proposed by Aristotle as taking goals and looking for actions to achieve them.
  - Later implemented by Newell & Simon in 1959 w/ GPS

Mathematics

- The field of Mathematics was needed to contribute formalism to AI in three critical areas:
  - Logic
  - Computation
  - Probability

Mathematics – Logic/Computability/Probability

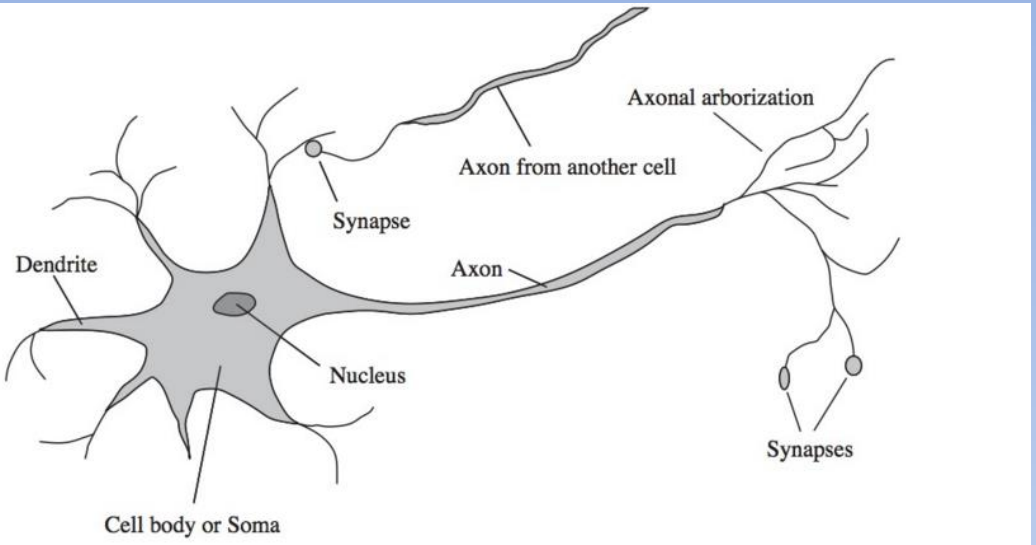
- George Boole (1815-1864) fully formalized Boolean Logic.
- The first non-trivial algorithm is considered Euclid's (300B.C.) for finding greatest common divisor.
- Alan Turing (1912 – 1954) developed a theory for what was computable.
- Steven Cook (1971) and Richard Karp (1972) introduced idea of determining intractable problems with NP-Completeness
- Gerolamo Cardano (1501-1576) first proposed probabilities to understand games of chance.
- Thomas Bayes (1702-1761) developed a formalism for updating probabilities in light of new evidence.

Computer Engineering

- First operational computer
  - Heath Robinson built by Alan Turing's team in 1940
  - Electro-Mechanical to decipher Enigma Code
  - 1943 team built general purpose machine w/ vacuum tubes
- First operational programmable computer
  - Z3 by Conrad Zuse 1943 in Germany
- First Electronic Computers
  - ABC Iowa State 1940-1942
  - ENIAC 1946 U of Penn

Economics

- Adam Smith (1723 – 1790) Wealth of Nations
  - Economies as individual agents acting to maximize their own economic well-being.
- Preferred Outcomes w/ Utility Theory & Game Theory
  - John von Neumann & Oskar Morganstern (1944)
- Operations Research looked at multiple decisions before feedback
  - Markov Decision Process w/ Richard Bellman
  - Bellman Equation
- Herb Simon Nobel Prize in Economics in 1978 for Satisficing Decisions rather than optimal decisions



Neuroscience

- Neurons
- Inspiration for Neural Nets

	Supercomputer	Personal Computer	Human Brain
Computational units	10^4 CPUs, 10^{12} transistors	4 CPUs, 10^9 transistors	10^{11} neurons
Storage units	10^{14} bits RAM	10^{11} bits RAM	10^{11} neurons
	10^{15} bits disk	10^{13} bits disk	10^{14} synapses
Cycle time	10^{-9} sec	10^{-9} sec	10^{-3} sec
Operations/sec	10^{15}	10^{10}	10^{17}
Memory updates/sec	10^{14}	10^{10}	10^{14}

Figure 1.3 A crude comparison of the raw computational resources available to the IBM BLUE GENE supercomputer, a typical personal computer of 2008, and the human brain. The brain's numbers are essentially fixed, whereas the supercomputer's numbers have been increasing by a factor of 10 every 5 years or so, allowing it to achieve rough parity with the brain. The personal computer lags behind on all metrics except cycle time.

Psychology
Cognitive Science

- Cognitive Science born in 1956 at MIT workshop
  - Noam Chomsky
  - Allen Newell and Herb Simon
- A Cognitive Theory should be like a computer program (Anderson, 1980)
  - Well accepted in Psychology but not Universal

Control Theory

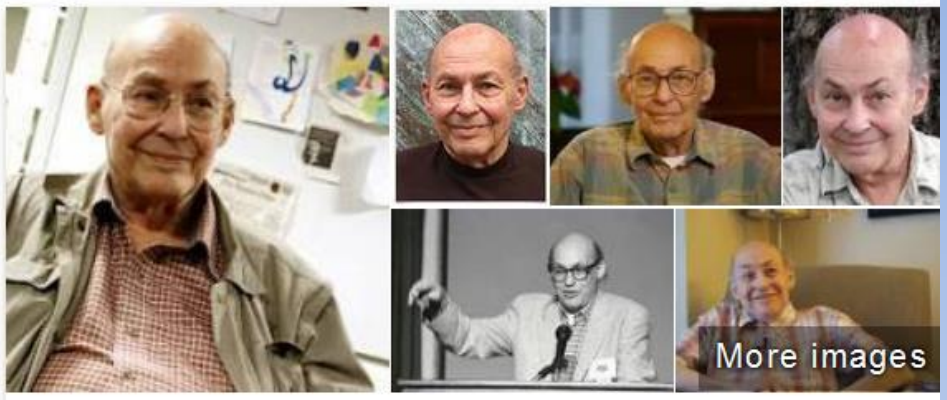
- How can artifact operate under their own control.
- Modern Control Theory: Design of systems that maximize an objective function over time.
- Modern Control Theory differs from AI in its close coupling with its set of mathematical tools.
- Markov Decision Process (MDP) used in Reinforcement Learning.

Linguistics

- How does language relate to thought.
- Psychotherapy based on self understanding based on language.
  - Work on Writing/Re-Writing ones own story to improve quality of life.
- Computational Linguistics
- Natural Language Processing

Gestation of AI

- 1943 Warren McCulloch and Walter Pitts: Earliest Work Combined:
  - Early understanding of the Neuron
  - Propositional Logic ($A \wedge B \vee \neg C$)
    - Russell & Whitehead
  - Alan Turing's Computability Theory
- Marvin Minsky and Dean Edmonds, two Harvard Undergrads, built the first neural network computer in 1950.
  - Marvin Minsky went on to Princeton PhD, then MIT Faculty.
- Alan Turing lectured on AI as early as 1947.



Marvin Minsky

Scientist

Marvin Lee Minsky is an American cognitive scientist in the field of artificial intelligence, co-founder of the Massachusetts Institute of Technology's AI laboratory, and author of several texts on AI and philosophy. Wikipedia

Born: August 9, 1927 (age 88), New York City, NY

Education: Princeton University (1954), More

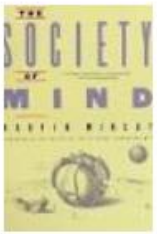
Movies: Machine Dreams

Children: Margaret Minsky, Julie Minsky, Henry Minsky

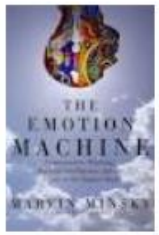
Parents: Henry Minsky, Fannie Resier

Books

View 4+ more



The Society of Mind
1988



The Emotion Machine
2006

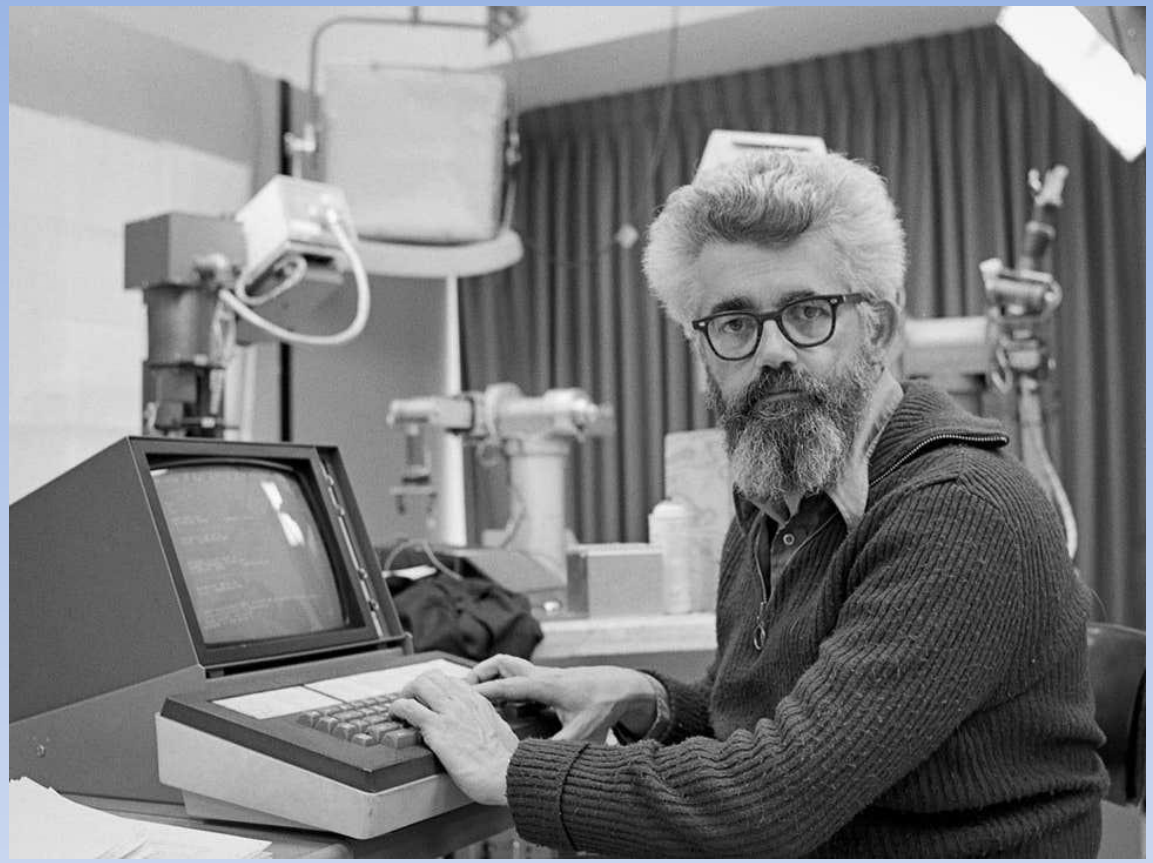
Perceptrons
1969

Semantic Information Processing
1968

The Turing Option
1992

Birth of AI - 1956

- John McCarthy convinced:
  - Marvin Minsky
  - Claude Shannon
  - Nathaniel Rochester
- Organized 2-month Dartmouth Workshop
- Allen Newell and Herbert Simon from CMU big hit!
- For the next 20 years (late 70's) the field dominated by these researchers and their students!



- John McCarthy, professor of computer science in the artificial intelligence lab at Stanford in 1974. | Photo by Chuck Painter

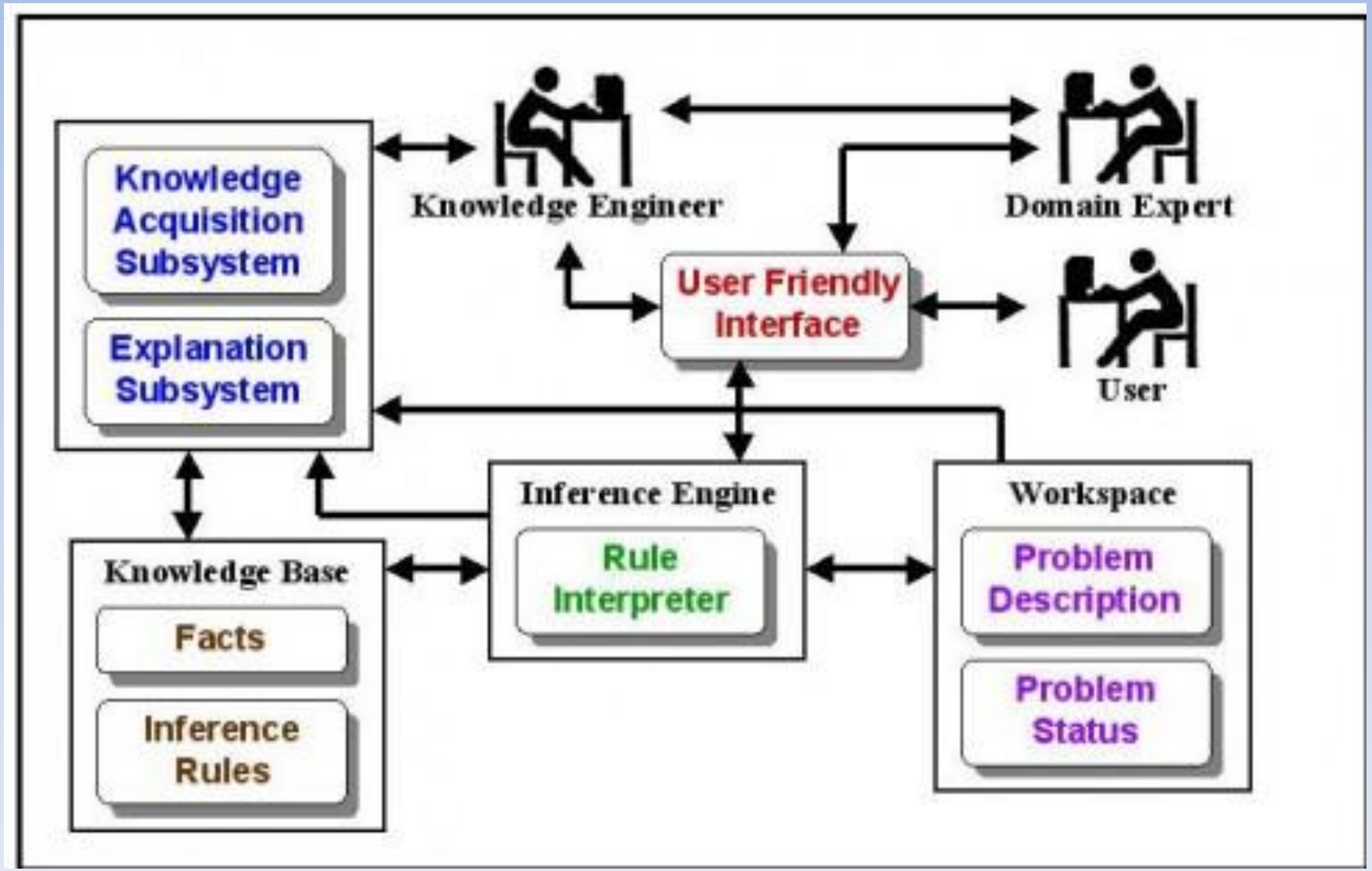
Early Enthusiasm (1952-1969)

- Lots of interesting problems can be solved by computers …
  - WHEN size is SMALL!
- Newell & Simon General Problem Solver
  - Subgoal Ordering
- Herbert Gelernter (1959) Geometry Theorem Prover
- Arthur Samuel (1952) Checkers

A dose of reality (1966-1973)

- These early systems failed to scale!
- Limitations with initial representations.
- Limitations with initial computing power.

Knowledge-Based Systems (1969-1979): Expert Systems / AI Industry (1980->)



More Neural Nets
1986 ->

- Back-propagation Algorithm
- Connectionist Models

AI & Rigor
Scientific Method: 1987 ->

- Early Work : “Look, Ma! No Hands!”
- Later Work:
  - Rigorous Empirical Experiments
  - Statistical Analysis of Results
  - Shared repositories of test data and code.
- Judea Pearl’s work with Bayesian Networks led to an acceptance of Probabilistic Reasoning in AI.

(1989) Q-Learning, Watkins

- In 1989, Watkins presented Q-Learning in a thesis on model-free reinforcement learning (RL).
- Q-Learning involves an agent learning a policy to maximize total future reward.
- The policy is meant to maximize the expected value of the reward from the present state.

(1990s) Various Advances in NLP

- Much like the rest of the AI world, NLP was getting a boost from the increasingly available amount of data and compute.
- With the internet starting to make large amounts of text available, much of NLP was able to benefit.
- Statistical Machine Translation (MT) really started to take off with stochastic parsers and developments like Data-oriented parsing or DOP

(1995) Support Vector Machines, Corinna Cortes and Vladimir Vapnik

- Cortes and Vapnik published their work on SVMs in 1995 and would continue the surge of profound developments in models.
- Their paper was the foundation of a widely regarded and highly used modern machine learning technique that they described in their 1995 paper.

Intelligent Agents: 1995->

- Web –Bots a common example
- Conflict over ever improving systems for specialized tasks
  - Self-driving cars
  - Facial Recognition
- Artificial General Intelligence one subfield.

(1998) MNIST, Yann LeCun

- Infamous MNIST dataset was released.
- MNIST is widely used as a modern benchmark of many systems.

Very Large Data Sets : 2001 ->

- Big Data
- Data Mining
- Machine Learning
- Human Genome Project
- Internet Click Streams
- Sensor Data
- Internet of Things
- Deep Learning

(2009) ImageNet, Fei-Fei Li

- ImageNet is a massive Stanford database of images.
- Efforts like this are key contributors to a move towards the democratization of data.
- ImageNet contains over 20,000 categories of images with standard categories having hundreds of images.
- Some categories like “cats” having many more.

(2011) Watson Beats Jeopardy, IBM

- Watson is a very popularized system that famously beat two Jeopardy champions in 2011.
- Watson used modern NLP to gain an understanding of a question and then search its database (not web-enabled) to find the answer.

(2014) Generative Adversarial Networks (GANs), Ian Goodfellow

- A hugely popular development in modern AI, GANs are responsible for the current applications in realistic photo generation, videos, deep fakes, and other profound developments.
- Two neural networks compete in a game with rules set by the developer, not always zero sum.

(2014-Present) Autopilot, Tesla

- Tesla has the largest fleet of active autopilot equipped vehicles on the market.
- As such, they are the mention here and not Waymo, Cruise, or any of the other competitors.
- Who knows what will happen in this future race towards Level 5 autonomous vehicles.

(2015) TensorFlow Release, Google

- In 2015, TensorFlow was open sourced and grew to become the most used open source machine learning library.
- 2017: Keras interface support.

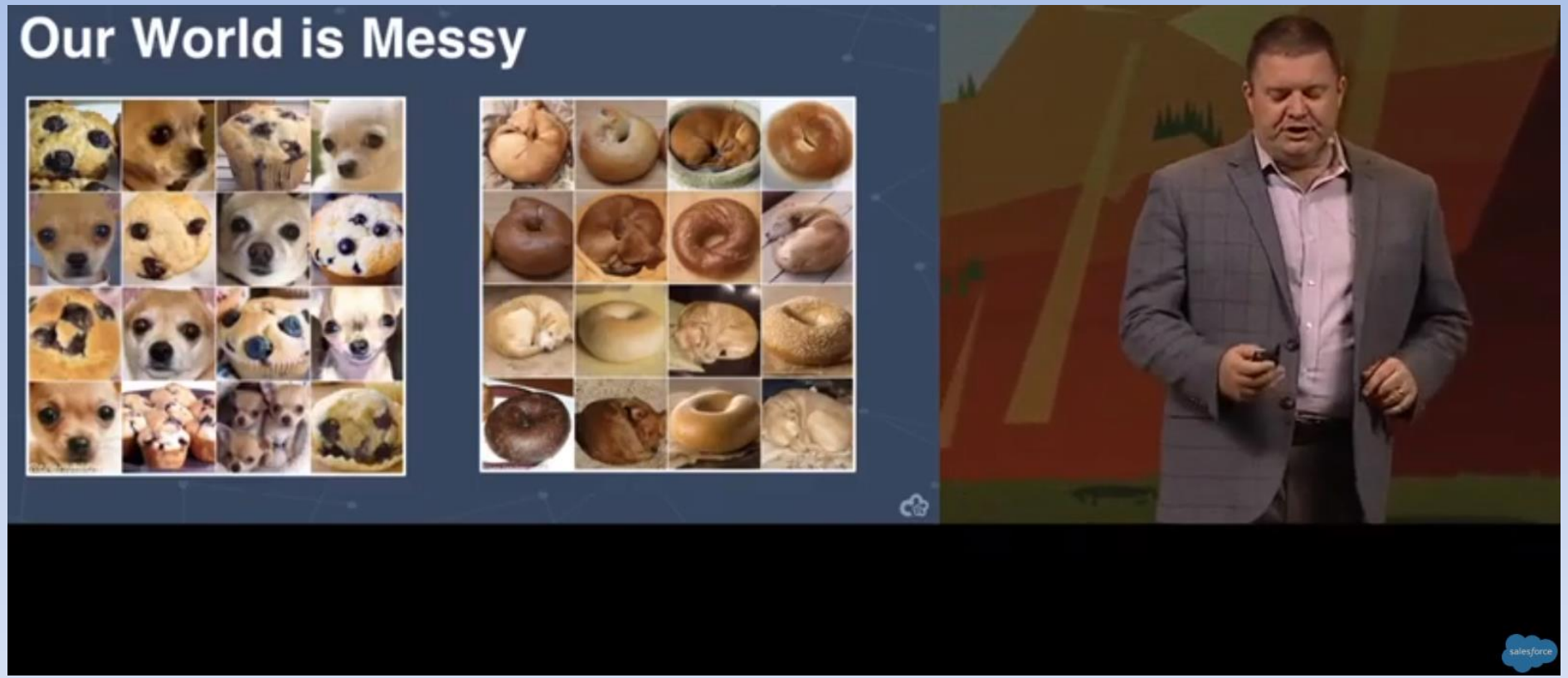
(2016) AlphaGo, AlphaGo Zero, etc., DeepMind

- DeepMind developed and continues to develop game beating AI systems.
- DeepMind first conquered Go and then moved onto Chess, Dota, Starcraft, and other games.
- DeepMind's AI routinely beats professionally ranked humans in their game of choice.
- DeepMind's AI are Reinforcement Learning based.

History of AI
Are we there yet?

- Birth: 1943 – 1956
- Early Enthusiasm: 1952 – 1969
- Dose of Reality: 1966 – 1973
- Knowledge Based Systems: 1969 – 1979
- AI Industry: 1980
- Neural Nets: 1986
- Scientific Method: 1987
- 11/9/1989 : Fall of the Berlin Wall (End of Cold War)
- Intelligent Agents (-Bots): 1995
- 2001: Very Large Datasets

Salesforce Expression



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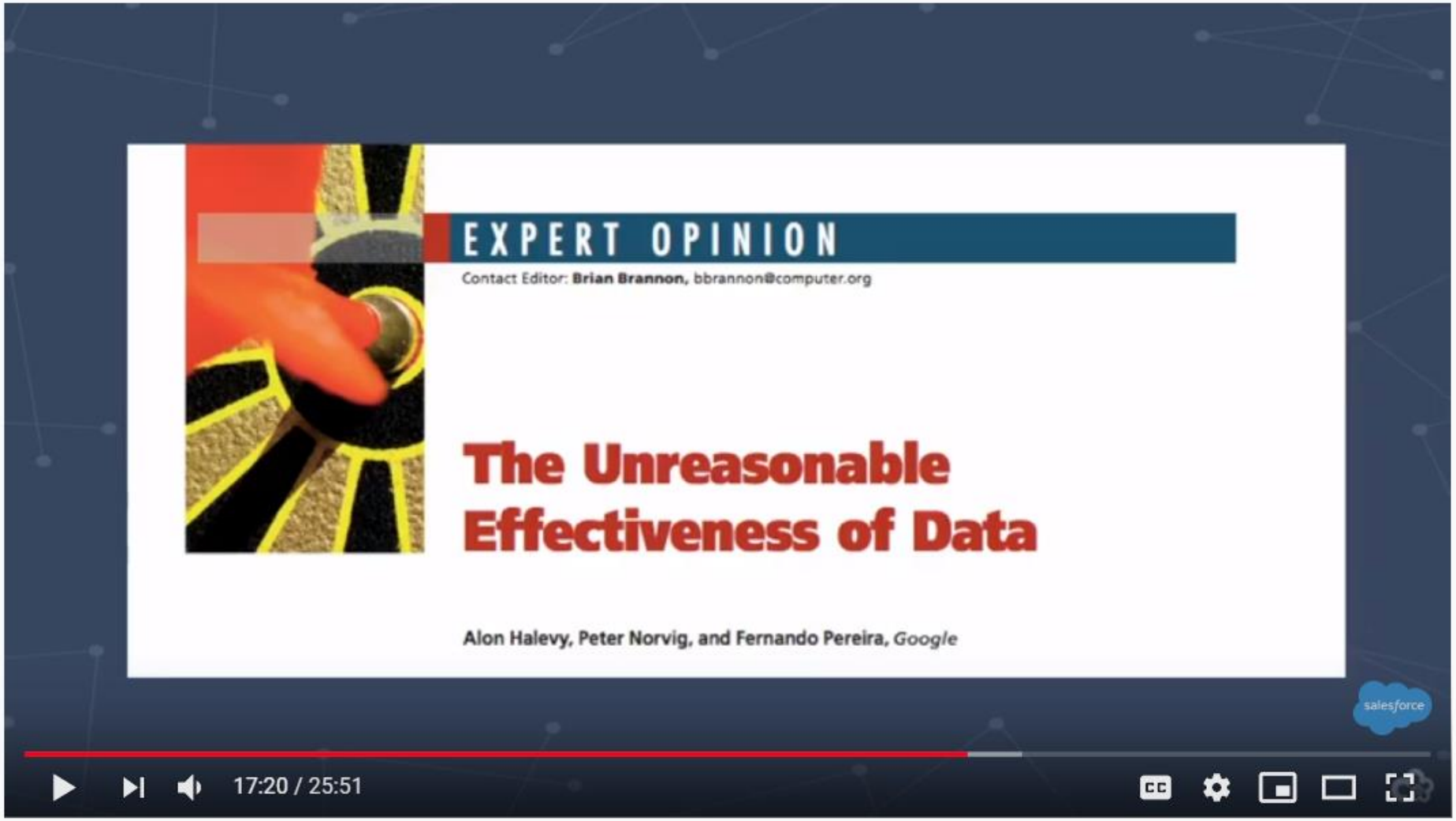

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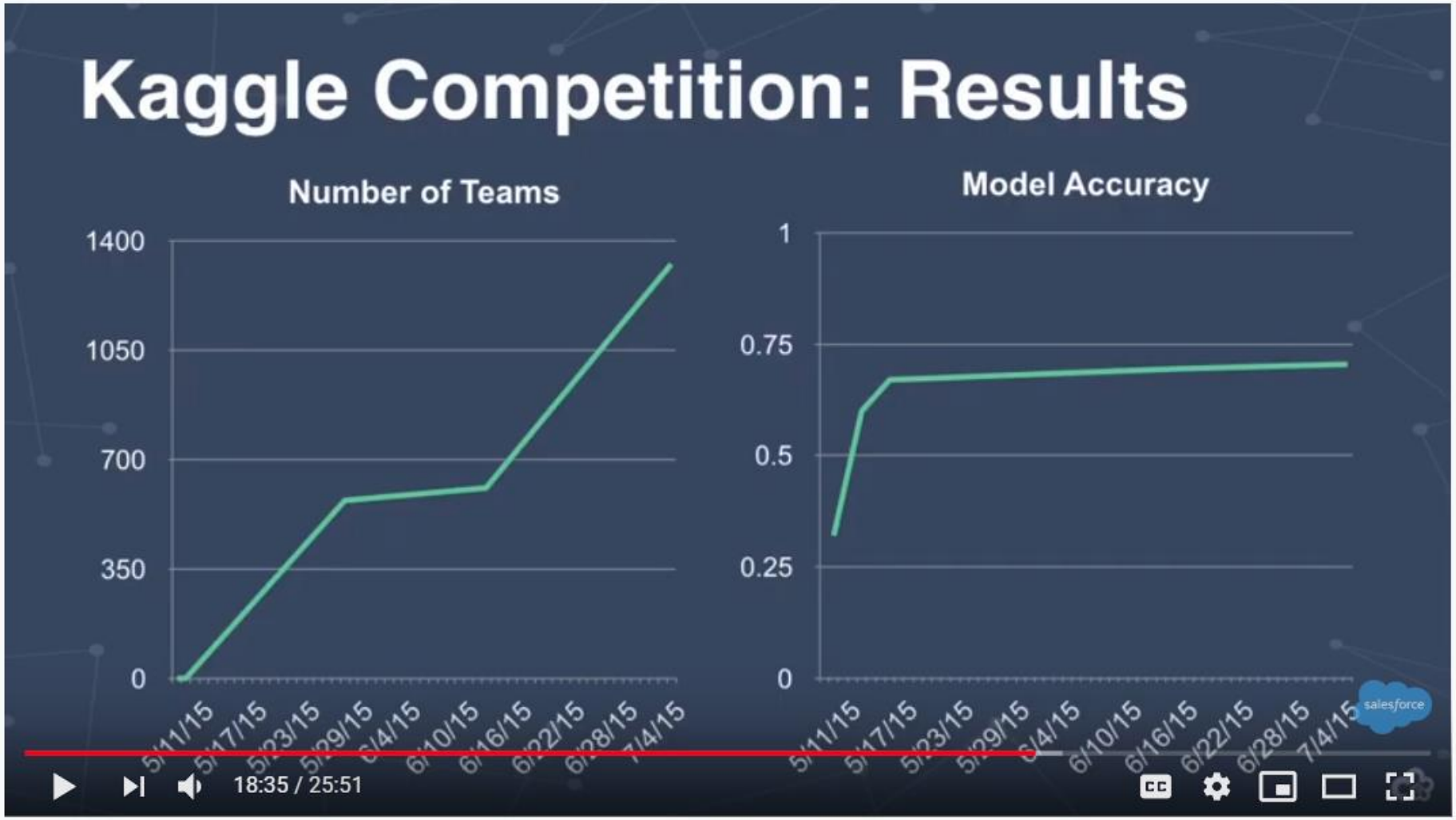

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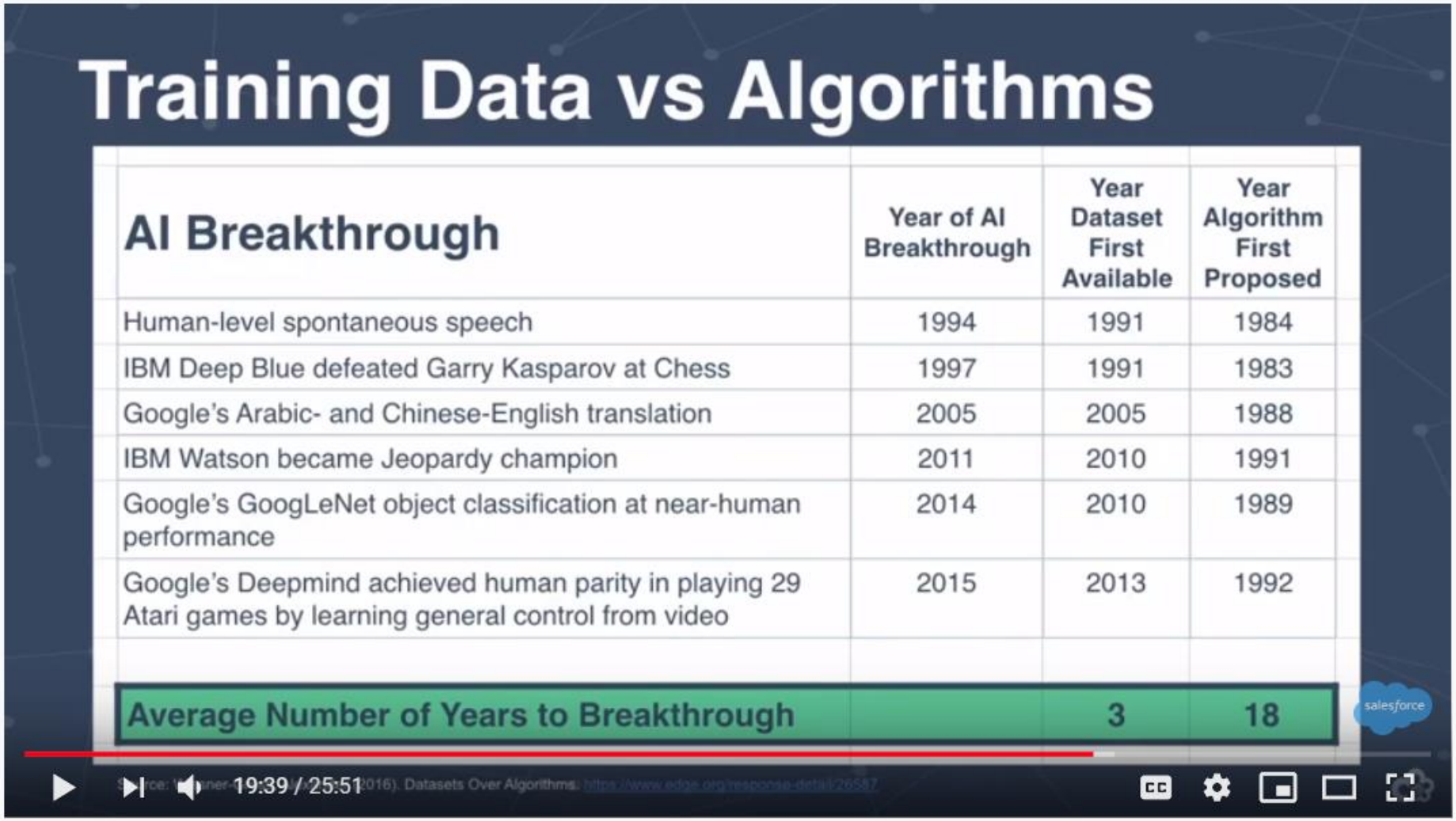

A Brief History of AI

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Chapter 1: Questions 1.7

- 1.7: To what extent are the following computer systems instances of artificial intelligence:
  - a) Supermarket bar code scanners.
  - b) Web search engines.
  - c) Voice-activated telephone menus.
  - d) Internet routing algorithms that respond dynamically to the state of the network.

Supermarket bar code scanners.

- Vision System?
- Not AI Vision!
  - The problem of reading a bar code is an extremely limited and artificial form of visual interpretation,
  - Scanner has been carefully designed to be as simple as possible, given the hardware.

Web search engines

- Natural Language Understanding?
  - In some sense
  - Determining the relevance of a web page to a query is related to the techniques are of Chapters 22 and 23.
- Clustering
  - Search engines which group the retrieved pages into categories, use clustering techniques analogous to those from Chapter 20.
- Other functionalities provided by a search engines also use intelligent techniques;
  - the spelling corrector uses a form of data mining based on observing users' corrections of their own spelling errors.
- On the other hand, the problem of indexing billions of web pages in a way that allows retrieval in seconds is a problem in database design, not in artificial intelligence.

Voice-activated telephone menus

- To a limited extent. Such menus tends to use vocabularies which are very limited – e.g. the digits, “Yes”, and “No” — and within the designers’ control, which greatly simplifies the problem.
- On the other hand, the programs must deal with an uncontrolled space of all kinds of voices and accents.
- The voice activated directory assistance programs used by telephone companies, which must deal with a large and changing vocabulary are certainly AI programs.

Internet routing algorithms that respond dynamically to the state of the network

- This is borderline.
- There is something to be said for viewing these as intelligent agents working in cyberspace.
- The task is sophisticated, the information available is partial, the techniques are heuristic (not guaranteed optimal), and the state of the world is dynamic. All of these are characteristic of intelligent activities.
- On the other hand, the task is very far from those normally carried out in human cognition.

Discussion

- Consider your own examples of activities or events that require intelligence.