Artificial Intelligence (AI)

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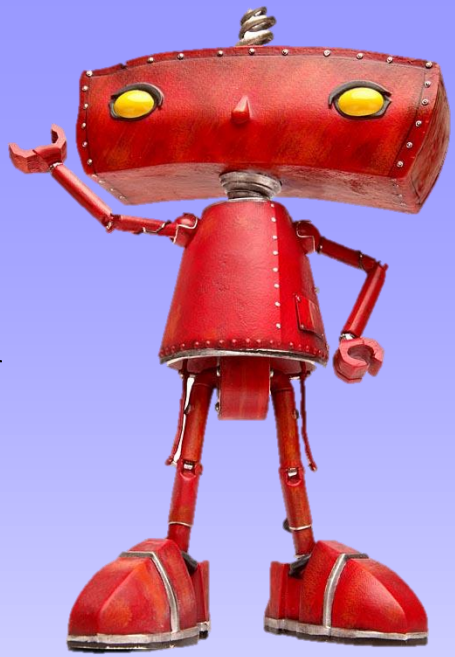
CS361

You Remember
(Metcalf, 1997 and others)

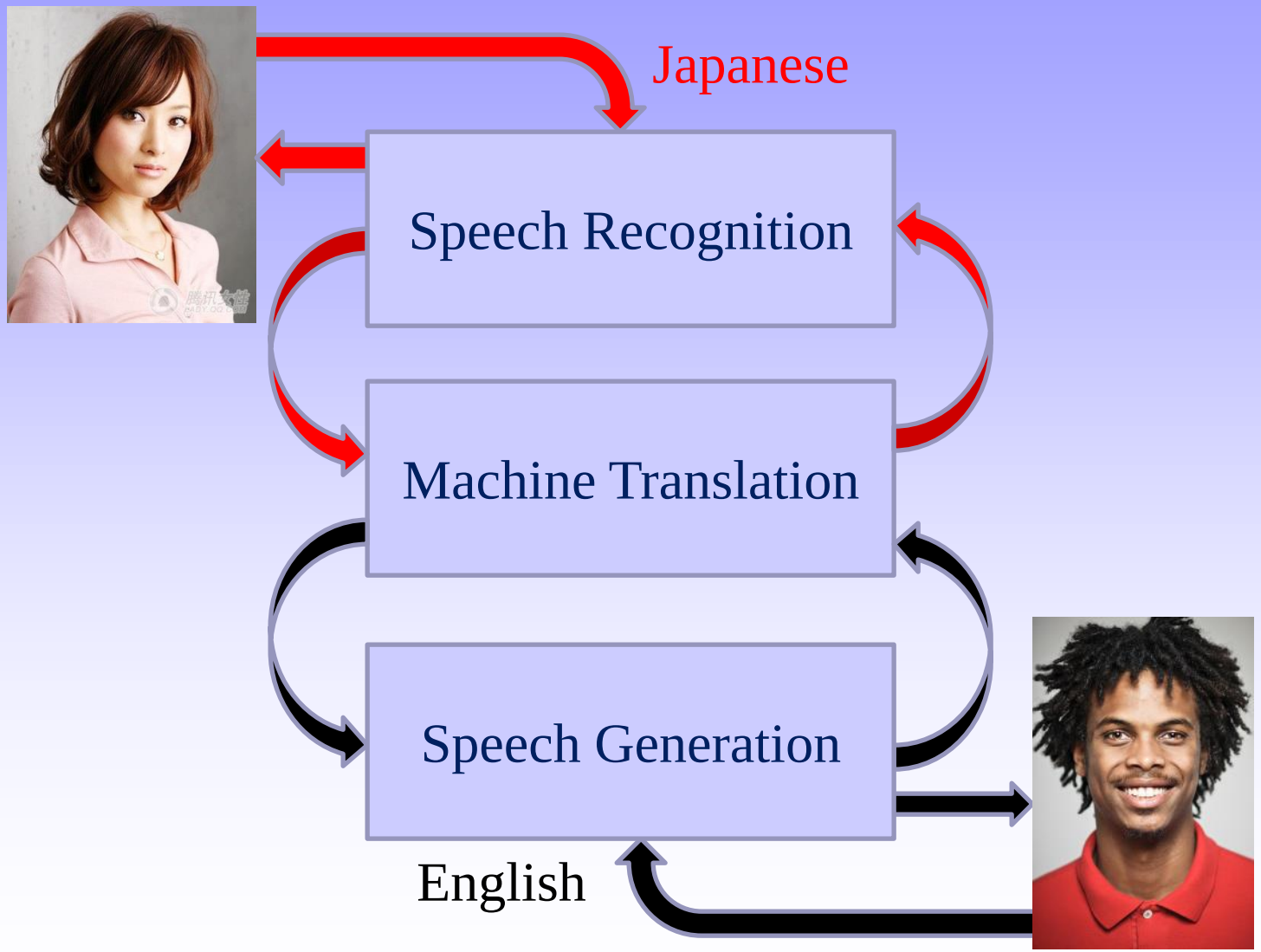
- 10% of what you read
- 20% of what you hear
- 30% of what you see
- 50% of what you hear and see together
- 70% of what you think and say out loud
- 90% of what you do
- **??% of what you hear, see, and write down**

Some AI Milestones



- Computer beats leading chess grand master (1997)
- Computer wins Jeopardy (2011)
- Speech recognition in smartphone (2011)
- Self-driving cars (2014)
- “Star Trek telephone” (2015)

The “Star Trek” Telephone



AI Movies
(suggest better/other videos)

- AI Algo Beats Kasparov at Chess
  https://www.youtube.com/watch?v=NJarxpYyoFI
- IBM Watson Wins Jeopardy
  https://www.youtube.com/watch?v=WFR3lOm_xhE
- Stanford+Google Car
  http://www.ted.com/talks/sebastian_thrun_google_s_driverless_car
- Microsoft SKYPE Translator
  https://www.youtube.com/watch?v=mWTySUGXR2k&list=PLD7HFcN7LXRd4kd2XgZjIbQ8TwTC32Zc9&index=3
- CS540 Nannon © Competition
  https://www.youtube.com/watch?v=b1SqrjuPrmE

Some More Videos/Images

- Robots Falling Down at the 2015 DARPA Robotics Challenge
  https://www.youtube.com/watch?v=g0TaYhjpOfo

- Google Translate (2015 cellphone app)

In which Year will Children Born that Year not Need to Learn How to Drive?

Recently a leading robotics researcher said his answer is ‘2014’

- Robots too polite?
  Eg, never speed, always yield
- Will existing cars be retrofitted?
- Will airplanes (especially freight) and trucks be first?

Machine Learning is Becoming Ubiquitous

- Search (in the Google/Bing/etc sense)
- Credit-card scoring, finance in general
  - Why might "hadBankruptcy" be the *best* feature for deciding who gets a credit card?
- Personalization/recommendation in various forms
- Extracting 'knowledge' from 'natural' languages (Machine Reading)
- Understanding pictures and videos, face recognition

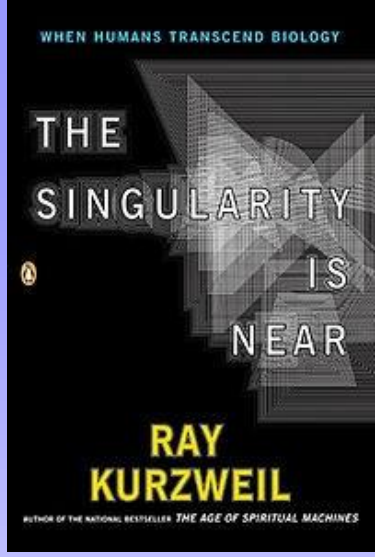
An AI Axiom

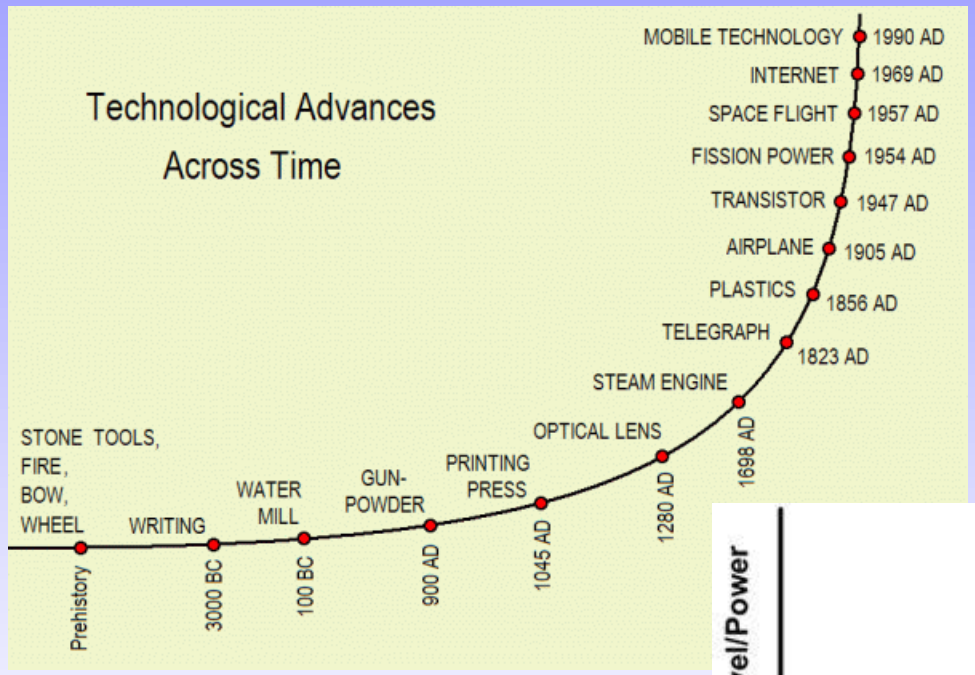
The easier something is for humans the harder it is for computers

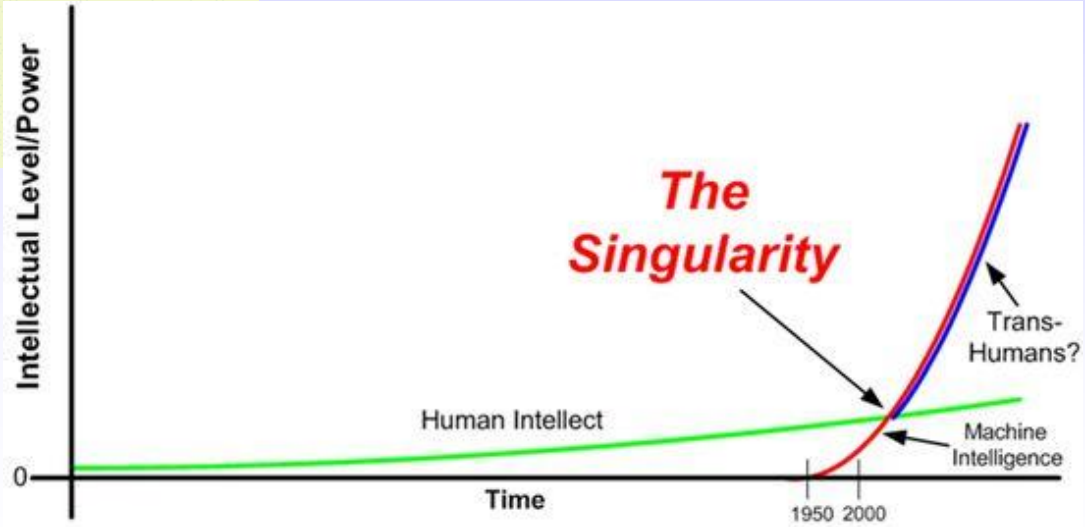
and vice versa

- A point I've been making for ≈ 25 years, but maybe no longer true?
- Human-machine cooperation appealing
- AI (rapidly) replacing 'white collar' jobs?
  (Robots have been replacing 'blue collar' jobs for awhile)

The Coming Singularity?







AI Founding Fathers

John McCarthy

Marvin Minsky

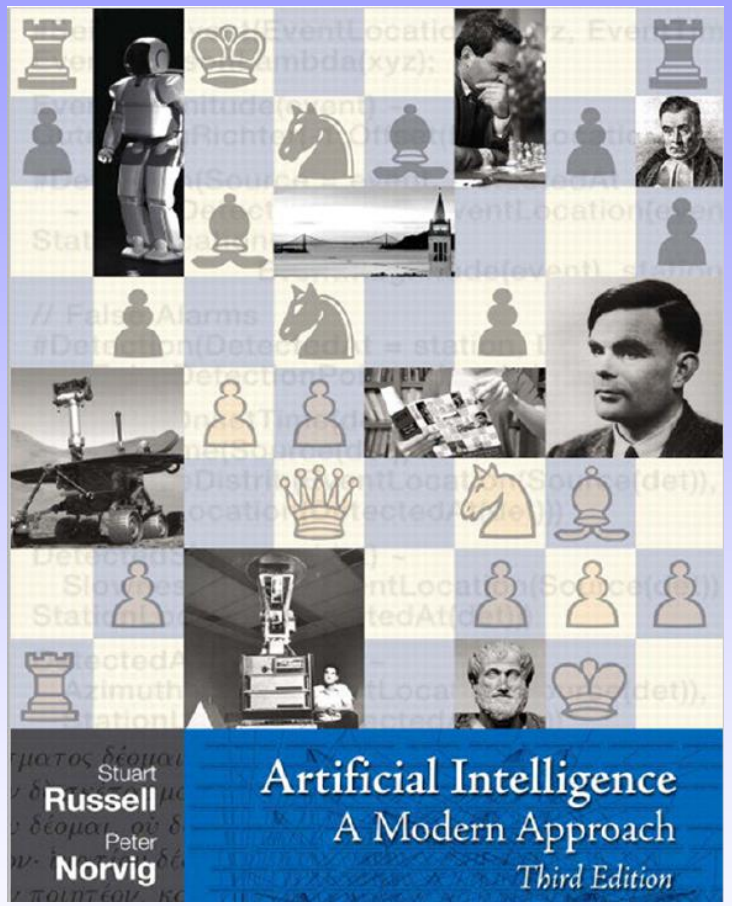
Alan Newell

Herbert Simon

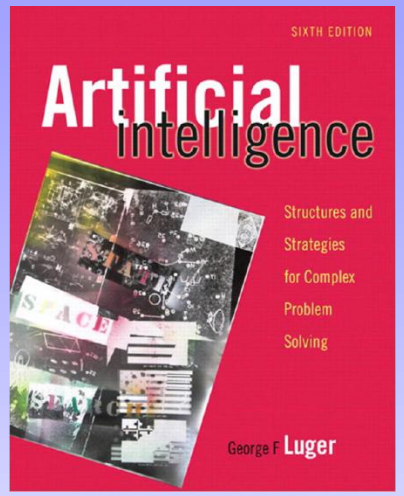
The Dartmouth Conference

- Officially, AI was born in Dartmouth , in the summer of 1956.
- McCarthy (together with Minsky, Shannon, and Rochester) organized a two-month workshop in Dartmouth.
- They invited researchers interested in automata theory, neural networks, and intelligence.
- Ten people attended the workshop, among them Newell and Simon.
- They laid the foundations of AI, and dominated the field thereafter.
- McCarthy coined the term ‘Artificial Intelligence’.

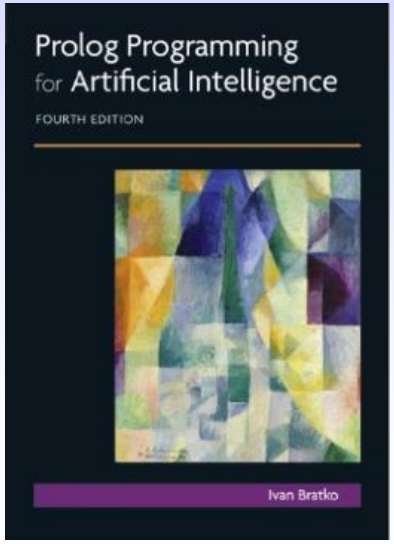
Textbooks



Artificial Intelligence: A Modern Approach, S. J. Russell and P. Norvig, 3rd Edition, 2010.



Artificial Intelligence: Structures & Strategies for Complex Problem Solving, G. F. Luger, 6th Edition, 2009.



Prolog Programming for Artificial Intelligence, Ivan Bratko, 4th Edition, 2011.

Chapter 1

Introduction

CS361 Artificial Intelligence

Dr. Khaled Wassif

Spring 2019

(This is the instructor's notes and student has to read the textbook for complete material.)

Chapter Outline

- What is AI ?
- The Foundations of AI
- The History of AI
- Fundamental Techniques of AI
- AI in Everyday Life
- Some Sub-fields of AI

What is Intelligence ?

- Intelligence may be defined as:

  1. The capacity to acquire and apply knowledge.

  2. The ability of thought and reason.

What is AI?

- **Charniak and McDermott**

  "Artificial intelligence is the study of mental faculties through the use of computational models."

- **Shapiro**

  "Artificial intelligence is a field of science and engineering concerned with the computational understanding of what is commonly called intelligent behavior, and with the creation of artifacts that exhibit such behavior."

- **Rich and Knight**

  "The study of how to make computers do things at which, at the moment, people are better."

What is AI?

- **Goals of AI:**
  - AI began as an attempt to understand the nature of intelligence, but it has grown into a scientific and technological field affecting many aspects of commerce and society.
  - The main goals of AI are:
    - » **Engineering**: solve real-world problems using knowledge and reasoning.
      - AI can help us solve difficult, real-world problems, creating new opportunities in business, engineering, and many other application areas.
    - » **Scientific**: use computers as a platform for studying intelligence itself.
      - Scientists design theories hypothesizing aspects of intelligence then they can implement these theories on a computer.
  - Even as AI Technology becomes integrated into the fabric of everyday life.
  - AI researchers remain focused on the grand challenges of automating intelligence.

What is AI?

- **Russell and Norvig** view definitions of AI fall into four categories:
  - Systems that think like humans.
  - Systems that act like humans.
  - Systems that think rationally.
  - Systems that act rationally.

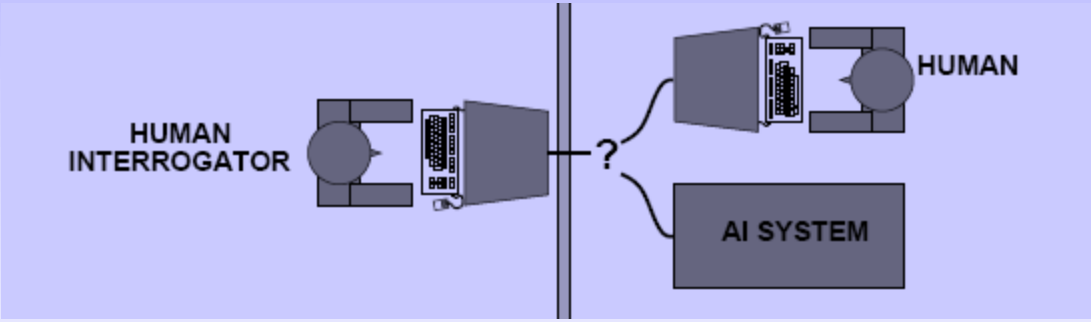
What is AI?

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)

Figure 1.1 Some definitions of artificial intelligence, organized into four categories.

Acting Humanly: Turing Test

- **Turing** (1955) defined intelligent behavior as the ability to achieve human-level performance in all cognitive tasks, sufficient to fool an interrogator.



- Roughly speaking, the test he proposed is that the computer should be interrogated by a human via a teletype, and passes the test if the interrogator cannot tell if there is a computer or a human at the other end.

Acting Humanly: Turing Test

- Suggested major components of AI:
  - **Natural Language Processing** to enable it to communicate successfully in English (or some other human language);
  - **Knowledge Representation** to store information provided before or during the interrogation;
  - **Automated Reasoning** to use the stored information to answer questions and to draw new conclusions;
  - **Machine Learning** to adapt to new circumstances and to detect and extrapolate patterns;
  - **Computer Vision** to perceive objects, and
  - **Robotics** to move them about

Thinking Humanly: Cognitive Modeling

- 1960s "cognitive revolution": information-processing psychology replaced prevailing orthodoxy of behaviorism.
- Requires scientific theories of internal activities of the brain
  - What level of abstraction? "Knowledge" or "circuits"?
  - How to validate? Requires
    - » 1) Predicting and testing behavior of human subjects (top-down), or
    - » 2) Direct identification from neurological data (bottom-up)
- Both approaches (roughly, Cognitive Science and Cognitive Neuroscience) are now distinct from AI

Thinking Rationally: Laws of Thought

- Normative (or prescriptive) rather than descriptive
- **Aristotle**: what are correct arguments/thought processes?
- Several Greek schools developed various forms of **logic**:
  - Notation and rules of derivation for thoughts;
  - May or may not have proceeded to the idea of mechanization
- Direct line through mathematics and philosophy to modern AI.

Acting Rationally

- Rational behavior: doing the right thing
- The right thing: that which is expected to maximize goal achievement, given the available information
- Doesn't necessarily involve thinking - e.g., blinking reflex - but thinking should be in the service of rational action.
- An agent is an entity that perceives and acts.
- This course is about designing rational agents.
- Abstractly, an agent is a function from percept histories to actions.

The Foundations of AI

- **Philosophy**
  - logic, methods of reasoning
  - mind as physical system
  - foundations of learning, language, rationality
- **Mathematics**
  - formal representation and proof
  - algorithms, computation, (un)decidability, (in)tractability probability
- **Psychology**
  - adaptation
  - phenomena of perception and motor control
  - experimental techniques (psychophysics, etc.)

The Foundations of AI

- **Economics**
  - formal theory of rational decisions
- **Linguistics**
  - knowledge representation
  - grammar
- **Neuroscience**
  - plastic physical substrate for mental activity
- **Control theory**
  - homeostatic systems, stability
  - simple optimal agent designs

The History of AI

- 1943
  - McCulloch & Pitts: Boolean circuit model of brain
- 1950
  - Turing's “Computing Machinery and Intelligence”
- 1950s
  - Early AI programs, including Samuel's checkers program,
  - Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
- 1956
  - Dartmouth meeting: “Artificial Intelligence” adopted
- 1965
  - Robinson's complete algorithm for logical reasoning

The History of AI

- 1966-74
  - AI discovers computational complexity
  - Neural network research almost disappears
- 1969-79
  - Early development of knowledge-based systems
- 1980-88
  - Expert systems industry booms
- 1988-93
  - Expert systems industry busts: “AI Winter”
- 1985-95
  - Neural networks return to popularity

The History of AI

- 1988-
  - Resurgence of probability; general increase in technical depth
  - “ Nouvelle AI ” : ALife, GAs, soft computing
- 1995-
  - Agents, agents, everywhere : : :
- 2003-
  - Human-level AI back on the agenda

Fundamental Techniques of AI

- Knowledge Representation
  - Intelligence/intelligent behavior requires knowledge, which is:
    - » Voluminous
    - » Hard to characterize
    - » Constantly changing
  - How can one capture formally (i.e., computerize) everything needed for intelligent behavior? Some questions...
    - » How do you store all of that data in a useful way?
    - » Can you get rid of some?
    - » How can you store decision making steps?
  - Characteristics of good data representation techniques:
    - » Captures general situation rather than being overly specific
    - » Understandable by the people who provide it
    - » Easily modified to handle errors, changes in data, and changes in perception
    - » Of general use

Fundamental Techniques of AI

- Search
  - How can we model the problem search space
  - How can we move between steps in a decision making process?
    - » How can you find the info you need in a large data set?
    - » Given a choice of possible decision sequences, how do you pick a good one?
    - » Heuristic functions
  - Given a goal, how do you figure out what to do (planning)?
  - Base-level versus meta-level reasoning
    - » How can we reason about what step to take next (in reaching the goal)?
    - » How much do we reason before acting?

AI in Everyday Life

- AI techniques are used in many common applications:
  - Intelligent user interfaces
  - Search Engines
  - Spell/grammar checkers
  - Context sensitive help systems
  - Medical diagnosis systems
  - Regulating/Controlling hardware devices and processes (e.g, in automobiles)
  - Voice/image recognition (more generally, pattern recognition)
  - Scheduling systems (airlines, hotels, manufacturing)
  - Error detection/correction in electronic communication

AI in Everyday Life

- AI techniques are used in many common applications:
  - Program verification / compiler and programming language design
  - Web search engines / Web spiders
  - Web personalization and Recommender systems (collaborative/content filtering)
  - Personal agents
  - Customer relationship management
  - Credit card verification in e-commerce / fraud detection
  - Data mining and knowledge discovery in databases
  - Computer games

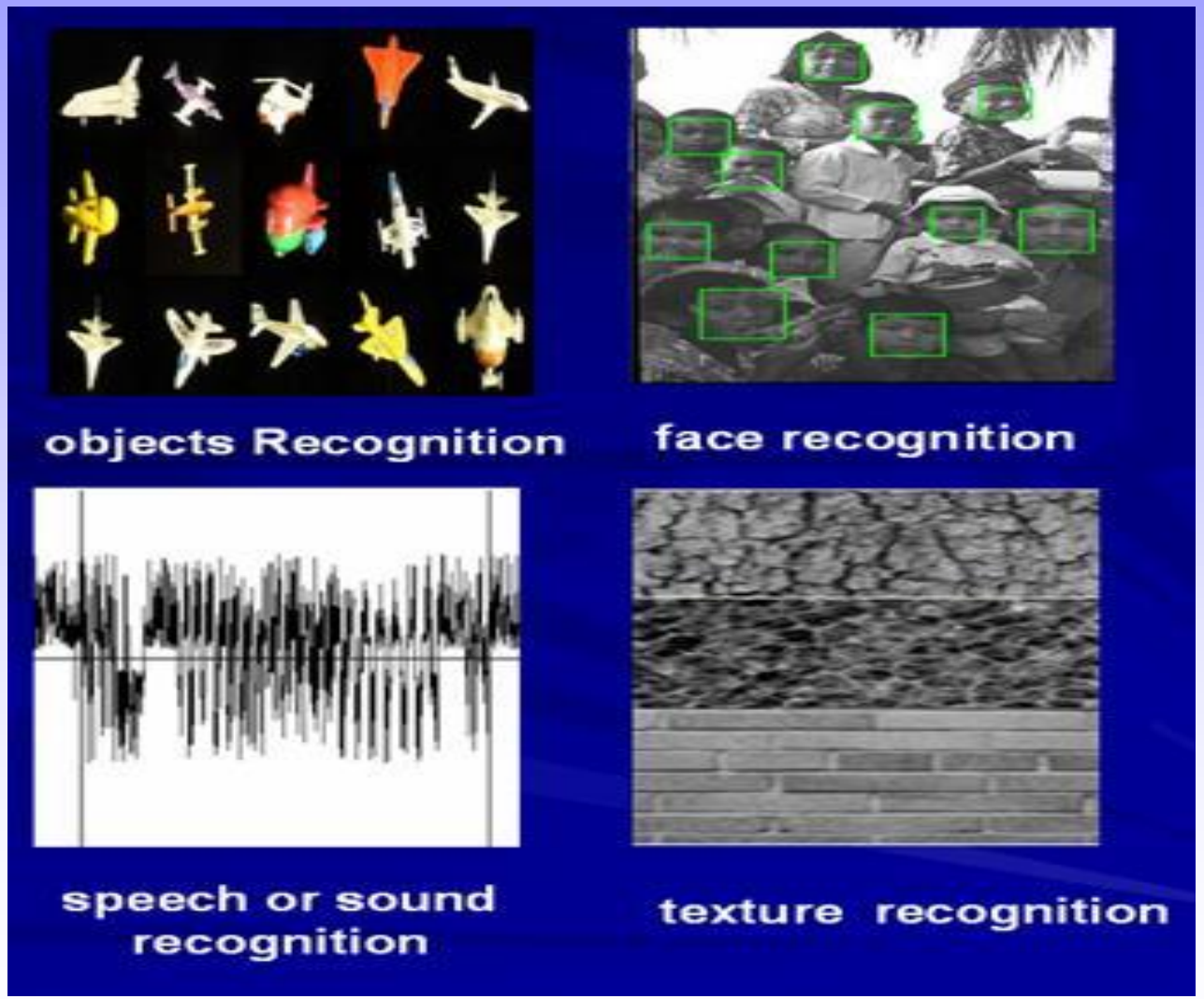
Locomotion

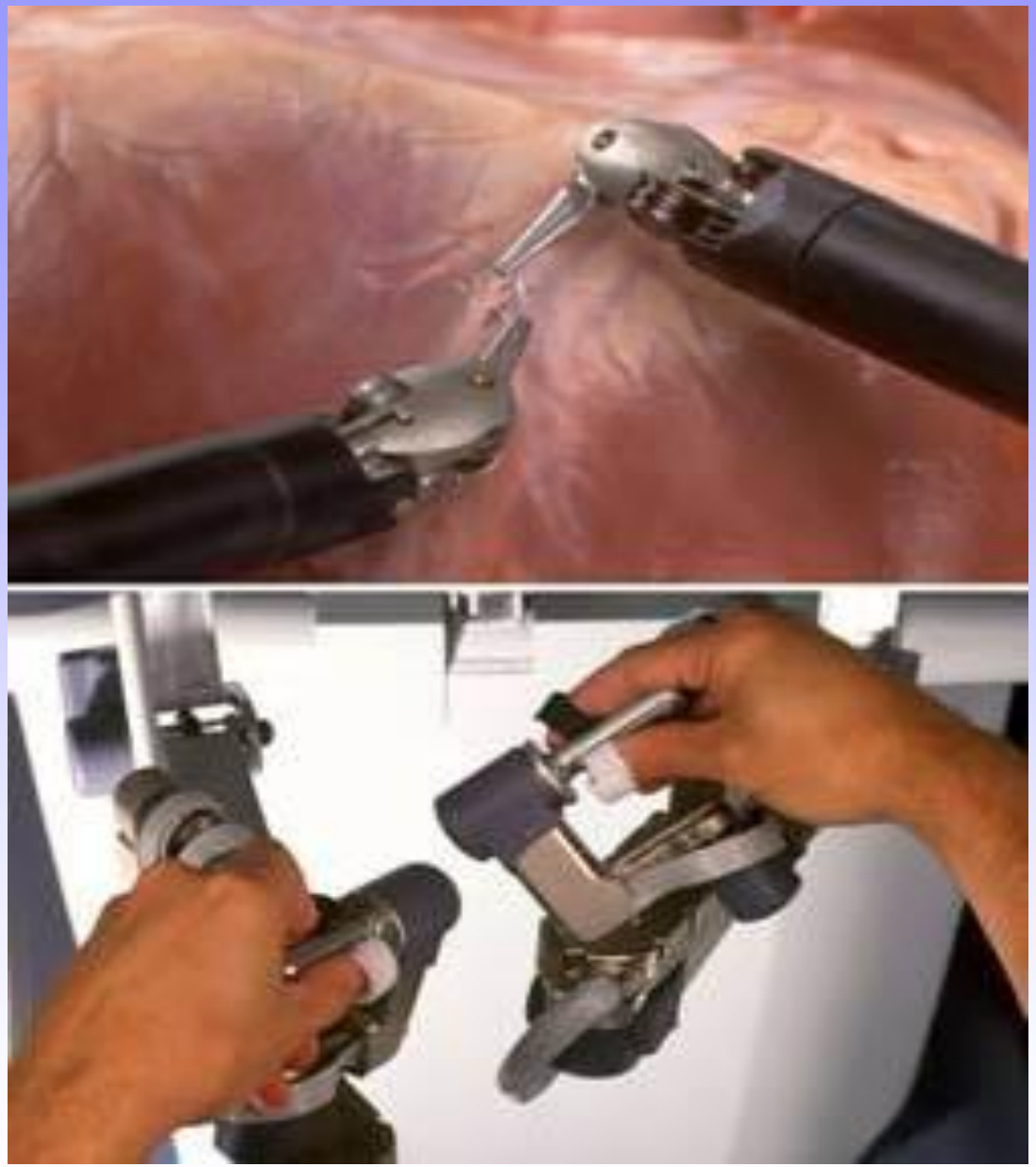
Locomotion

Locomotion

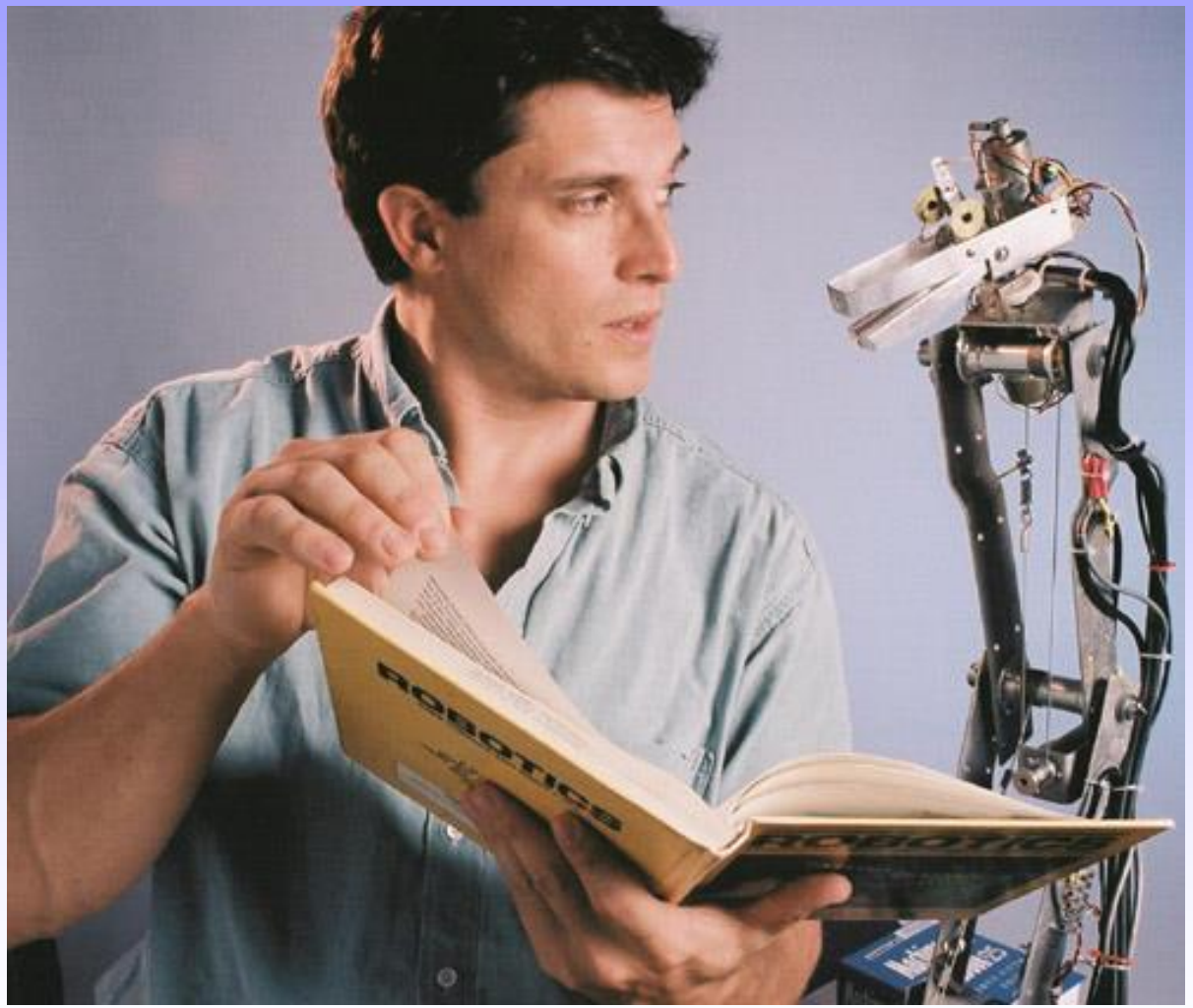
Locomotion

Robot Vision





In The Future



Blind person
Robot will read the book

Some Sub-fields of AI

- Problem solving
  - Lots of early success here
  - Solving puzzles
  - Playing chess
  - Mathematics (integration)
  - Uses techniques like search and problem reduction
- Logical reasoning
  - Prove things by manipulating database of facts
  - Theorem proving
- Automatic Programming
  - Writing computer programs given some sort of description
  - Some success with semi-automated methods
  - Some error detection systems
  - Automatic program verification

Some Sub-fields of AI

- Language understanding and semantic modeling
  - One of the earliest problems
  - Some success within limited domains
  - How can we “understand” written/spoken language?
  - Includes answering questions, translating between languages, learning from written text, and speech recognition
  - Some aspects of language understanding:
    - » Associating spoken words with “actual” word
    - » Understanding language forms, such as prefixes/suffixes/roots
    - » Syntax; how to form grammatically correct sentences
    - » Semantics; understanding meaning of words, phrases, sentences
    - » Context
    - » Conversation

Some Sub-fields of AI

- Pattern Recognition
  - Computer-aided identification of objects/shapes/sounds
  - Needed for speech and picture understanding
  - Requires signal acquisition, feature extraction, ...
  - Data mining and Information Retrieval
- Expert Systems and Knowledge-based Systems
  - Designers often called knowledge engineers
  - Translate things that an expert knows and rules that an expert uses to make decisions into a computer program
  - Problems include
    - » Knowledge acquisition (or how do we get the information)
    - » Explanation (of the answers)
    - » Knowledge models (what do we do with info)
    - » Handling uncertainty

Some Sub-fields of AI

- Planning, Robotics and Vision
  - Planning how to perform actions
  - Manipulating devices
  - Recognizing objects in pictures
- Machine Learning and Neural Networks
  - Can we “remember” solutions, rather than recalculating them?
  - Can we learn additional facts from present data?
  - Can we model the physical aspects of the brain?
  - Classification and clustering
- Non-monotonic Reasoning
  - Truth maintenance systems