Overview of Artificial Intelligence (AI)

• What is AI? -- Four views
• AI Ancient History
• AI and Modern Philosophy
• AI Dimensions
• AI Collaborators
• AI Recent History
• State of the Art
What is AI?

Views of AI fall into four categories:

AI is a science concerned with making computers that:

<table>
<thead>
<tr>
<th>Think humanly</th>
<th>Think rationally</th>
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<tbody>
<tr>
<td>Act humanly</td>
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AI Ancient History

• 800 B.C. -- Moving statue of the god Amon in ancient Egypt operated with levers by a concealed priest.
• 300-100 B.C. -- Automated figures (like singing ravens) through the force of steam and water in Greek city of Alexandria.
Aristotle's Logic of Syllogisms (350 B.C.)

All men are mortal.
Socrates is a man.
Therefore, Socrates is mortal.

All S are P.
a is an S.
Therefore, a is a P

Modern notation:
\[ \forall x \ S(x) \rightarrow P(x) \]
\[ S(a) \]
\[ \therefore P(a) \]

All S are P.
a is not a P.
Therefore, a is not an S
17th Century Continental Rationalism:  

**Rene Descartes**

- Built an automaton called "my daughter Francine" which was so lifelike in movement a superstitious ship captain threw it overboard.
- Developed theory of mind/body dualism:
  - *res extensa*: physical stuff
  - *res cogitans*: mental stuff
- Mind/body duality is often made analogous to the software/hardware distinction in computers.
- However, Descartes believed machines would never be able to think
17th Century Continental Rationalism: Gottfried Leibnitz

• Was a mind/body dualist, but believed in “pre-established harmony” between mind and body, not causal interaction between them
• Suggested a "reasoning calculus" to mechanize thought: assign every concept a number and solve problems through numeric manipulation
• Proposed the collection of expertise and knowledge of individuals into encyclopedic knowledge bases
17th Century Continental Rationalism: Benedict Spinoza

- Believed in monism: Double-aspect theory
- Came up with a complete philosophy, including treatment of human actions and desires, using the model of deductive proofs.
17th Century British Philosophy: Thomas Hobbes

- Believed if God can make natural life, man can make artificial life (the commonwealth)
- Believed that *ratiocination*, or the use of one's cognition to reason from sense and memory, is the same as *computation*
- The basis of modern AI and cognitive science's computational model of the mind
The 1956 Dartmouth Conference

• Theme:
  – "Every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it."

• Participants
  – Marvin Minsky: converted from neural networks to symbol processing point of view
  – John McCarthy: coined term “AI”
  – Claude Shannon: invented switching circuits
  – Nathaniel Rochester: designed first popular IBM
  – Newell & Simon: wrote first AI program
Thinking humanly: cognitive modeling

- 1960s "cognitive revolution": information-processing psychology
- Requires scientific theories of internal activities of the brain
- -- 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
Early Work in Cybernetics and Artificial Neural Networks

• Norbert Wiener:
  – Created cybernetics, the science of control
  – Feedback control of anti-aircraft guns
  – Couched feedback theory in terms of information, not energy

• McCulloch and Pitts: Computing with artificial neural networks

• D. O. Hebb: Learning with artificial neural networks
Random Sampling of Neural Net Applications

- Vehicle control
- Game playing
- Radar pattern recognition
- Face identification
- Data mining
- Spam filtering
- Cancer diagnosis
Thinking rationally: "laws of thought"

- 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
- Problem: Not all intelligent behavior is mediated by logical deliberation
Early AI Program Successes

• **Logic Theorist** proved 38 of the first 52 theorems in Chapter 2 of *Principia Mathematica*
• **SAINT** (Slagle) performed calculus integration
• **STUDENT** (Bobrow) solved algebra story problems
• **ANALOGY** (Evans) solved analogy problems
• **SHRDLU** (Winograd) natural language understanding and planning in the blocks world
Random Sampling of Expert System Applications

- Software fault prediction
- Evaluating tomato ripeness
- Source identification of mobile device images
- Stock portfolio management
- Fuzzy pattern mining for classification
- Evaluation of fabric pilling resistance
- Image segmentation
- Health care data classification
Acting humanly: Turing Test

- Turing (1950) "Computing machinery and intelligence":
  - "Can machines think?" → "Can machines behave intelligently?"
- Operational test for intelligent behavior: the Imitation Game

- Predicted that by 2000, a machine might have a 30% chance of fooling a lay person for 5 minutes
- Anticipated all major arguments against AI in following 50 years
- Suggested major components of AI: knowledge, reasoning, language understanding, learning
- **ELIZA** (Weizenbaum) simulated a psychotherapist
An Impressive Script from Eliza

Men are all alike. (human)

IN WHAT WAY (machine)

They're always bugging us about something or other.

CAN YOU THINK OF A SPECIFIC EXAMPLE

Well, my boyfriend made me come here.

YOUR BOYFRIEND MADE YOU COME HERE

He says I'm depressed most of the time.

I AM SORRY TO HEAR YOU ARE DEPRESSED

It's true. I am unhappy.

DO YOU THINK COMING HERE WILL HELP YOU NOT TO BE UNHAPPY
I need some help, that much seems certain.

WHAT WOULD IT MEAN TO YOU IF YOU GOT SOME HELP

Perhaps I could learn to get along with my mother.

TELL ME MORE ABOUT YOUR FAMILY

My mother takes care of me.

WHO ELSE IN YOUR FAMILY TAKES CARE OF YOU

My father.

YOUR FATHER

You are like my father in some ways.

WHAT RESEMBLANCE DO YOU SEE
You are not very aggressive but I think you don't want me to notice that.

**WHAT MAKES YOU THINK I AM NOT VERY AGGRESSIVE**

You don't argue with me.

**WHY DO YOU THINK I DON'T ARGUE WITH YOU**

You are afraid of me.

**DOES IT PLEASE YOU TO BELIEVE I AM AFRAID OF YOU**

My father is afraid of everybody.

**WHAT ELSE COMES TO MIND WHEN YOU THINK OF YOUR FATHER**

Bullies.

**DOES THAT HAVE ANYTHING TO DO WITH THE FACT THAT YOUR BOYFRIEND MADE YOU COME HERE**
I don't understand your motives.

WHY DON'T YOU UNDERSTAND MY MOTIVES?

Shouldn't I be?

WHY DO YOU SAY THAT JUST NOW?

That's just the way it is.

SUPPOSE THAT'S JUST THE WAY IT WERE NOT.

So?

I AM NOT SURE I UNDERSTAND YOU FULLY.

You harp on the same questions too much.

WHAT DOES THAT SIMILARITY SUGGEST TO YOU?

I don't get you.

DO YOU WISH THAT YOU DID GET I?
Do you think that I can use the computer this morning?

WHY DO YOU ASK?

I might be able to make some additional telecomp sales.

WHY AREN'T YOU SURE?

My prospective customers have never seen a demonstration of this system.

DOES THAT MEAN VERY MUCH TO YOU?

Of course it does.

YOU SEEM VERY POSITIVE ABOUT THAT.

This is ridiculous.

WHAT DO YOU MEAN THIS IS RIDICULOUS?

Is there any reason I can't use the computer now?

TELL ME MORE ABOUT YOUR PROSPECTIVE CUSTOMERS.
Alan Turing

- Turing machines – theory of computer science
- Turing test for intelligence
- Colossus:
  - first electronic computer
  - cracked German codes enabling the Normandy landing
Acting rationally: rational agent

- **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
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• 1995--  The emergence of intelligent agents -- “-bots”
AI Collaborators

- Philosophy
  Logic, methods of reasoning, mind as physical system, foundations of learning, language, rationality
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- **Linguistics**: knowledge representation, grammar
Examples

- *Deep Blue* defeated the reigning world chess champion Garry Kasparov in 1997
- Proved a mathematical conjecture (Robbins conjecture) unsolved for decades
- *No hands across America* (driving autonomously 98% of the time from Pittsburgh to San Diego)
- During the 1991 Gulf War, US forces deployed an AI logistics planning and scheduling program that involved up to 50,000 vehicles, cargo, and people
- NASA's on-board autonomous planning program controlled the scheduling of operations for a spacecraft
- *Proverb* solves crossword puzzles better than most humans
- IBM's *Watson* beats best humans at Jeopardy!
Super- Or Par-human Level

- Backgammon, Bridge
- Chess, Crosswords
- Jigsaw puzzles
- Car driving
- Scrabble
- Quiz show question answering
- Go
- OCR for printed text
Sub-human Level

- Handwriting recognition
- Object recognition
- Translation
- Speech recognition
- Word-sense disambiguation
- Natural language processing
State of the art

“A lot of cutting edge AI has filtered into general applications, often without being called AI because once something becomes useful enough and common enough it's not labeled AI anymore”

(N. Bostrum)
National Strategic Computing Initiative

White House Grand Challenge:

“Create a new type of computer that can proactively interpret and learn from data, solve unfamiliar problems using what it has learned, and operate with the energy efficiency of the human brain.”