22. Artificial Intelligence
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- Life
- Games
- Cars
- Turing test
- Strong AI
Conway's game of life

A cellular automaton
- Cells live and die in an infinite square grid.
- Time proceeds in discrete steps.

Survival. Each cell lives or dies depending on its 8 neighbors:
- Too few neighbors alive? (0 or 1) Die of loneliness.
- Number of living neighbors just right (2 or 3) Survive to next generation.
- Too many neighbors alive? (more than 3) Die of overcrowding.

Birth. Cell born when it has exactly 3 living neighbors.
Conway's Game of Life

**Lesson.** Simple rules can lead to complicated behavior

Example 1. Glider

Example 2. Glider gun (generates gliders)

Example 3. Glider gun breeder (generates glider guns)

**Note.** YOU can write a program for the game of life (might have been an assignment).
A complex initial configuration for the game of life

Q. What happens with this starting configuration?

A. Anything we can compute! (It is a UTM).
**Questions**

Is REAL life described by discrete rules, or not?

Can a UTM be built from living components?

Can a machine do anything a human can do?

Can human intelligence be simulated by a machine?

*Artificial Intelligence.* The science and engineering of making intelligent machines.
Two conceptual approaches to artificial intelligence

**Strong AI.** Can a machine *be* intelligent?

“I propose to consider the question, 'Can machines think?'”

— Alan Turing, 1950

**Weak AI.** Can a machine *appear* to be intelligent?

“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.”

— John McCarthy, Marvin Minsky, Nathaniel Rochester, Claude Shannon, 1955
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The mechanical Turk (1770-1854)

A chess-playing automaton
- Developed in the court of Maria Theresa.
- Toured the world playing human opponents for decades.
- Defeated Benjamin Franklin and Napolean.
- Exposed as a hoax in 1820.

Q. Can a machine play a game (and defeat a human)?
A two-person game

- Number of possible games: 255,168.
- Machine can check all possibilities to make sure no move makes it possible for opponent to force a win.
- *Min-max algorithm* achieves the same goal without needing to check all possibilities.

Game is *solved*.

Q. Can a machine play a game *as well as* a human?

A. Yes. (Neither should lose.)
Checkers

A two-person game

- Number of possible games: about $10^{31}$.
- *Chinook* computer program by a team led by Jon Schaeffer awarded world championship in 1994 after 6 draws with Marion Tinsley (who withdrew).
- 2007: Schaeffer and team *solved* checkers (proved that neither player can force a win (!))

Q. Can a machine play a game (and defeat a human)?

A. Yes.
Chess

A two-person game

- Number of possible games: about $10^{123}$.
- *Deep Blue* computer program by IBM researchers beat Garry Kasprouv for the world championship in 1997.

Open question: can chess be solved?

---

Q. Can a machine play a game (and defeat *any* human)?

A. Yes.
Can a machine play a game?

Q. Can a machine play a game?
A. Sure.
Q. Does that constitute *intelligence*?
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Can a computer drive a car?

2004 DARPA Grand Challenge
- Navigate an autonomous vehicle.
- 142 mile course in Mojave Desert.
- Military speed.
- 15 entrants.
- $1 million prize.

Results. 0 finishers.

ENSCO
Flipped in the start area

Cliff (Virginia Tech)
Brakes locked in the start area

CIMAR (Florida State)
Wrapped up in wire (0.4 miles)

Sandstorm (CMU)
Stuck on an obstacle (7.4 miles)
Front wheels caught fire
Last surviving vehicle

Rascal (Auburn)
Stuck in an embankment (6.7 miles)

Caltech
Stuck in a fence (1.3 miles)
Can a computer drive a car?

2005 DARPA Grand Challenge

- Navigate an autonomous vehicle.
- 132 mile course in Mojave Desert.
- Military speed.
- 15 entrants.
- $2 million prize.

Stanley (Stanford)

Finished in under 7 hours

Results. FIVE teams finish. Stanford team collects the prize (!)

Sandstorm (CMU)

Second place, 10 minutes behind.
Can a computer drive a car?

2007 DARPA Urban Challenge
- Navigate an autonomous vehicle.
- 60 mile course in mock urban environment.
- Obey traffic laws.

Results. Six teams finish. (!!)
Progress report

Google driverless car (2012)
- 300,000 miles on public roads in CA.
- Typically a dozen cars on the road.
- No accidents.

Q. Does it take *intelligence* to drive a car?
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Turing test

Q. Can a machine be intelligent?
Q. Can a machine appear to be intelligent?
Q. If so, How could we tell?

“I propose to consider the question, 'Can machines think?' This should begin with definitions of the meaning of the terms "machine" and "think." Instead of attempting such a definition I shall replace the question by another, which is closely related to it and is expressed in relatively unambiguous words.”

— Alan Turing, 1950

Turing test

• Computer (program) and person communicate with a judge.
• Each claims to be a person.
• If judge cannot tell which is the program, the program passes the test.
A response to the Turing test

ELIZA [Weizenbaum 1966]
- Program imitates psychiatrist.
- Generates scripted responses to keywords.
- Just 200 lines of code!

Q. Does Eliza appear intelligent?
A. You be the judge.

Men are all alike.
IN WHAT WAY
They're always bugging us about something.
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 much 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
I need some help, that much seems certain.
WHAT WOULD IT MEAN TO YOU IF YOU GOT SOME HELP
Maybe 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.
...

Java translation of Weizenbaum's code available at
http://chayden.net/eliza/Eliza.html
TURING TEST EXTRA CREDIT:
CONVINCE THE EXAMINER THAT HE'S A COMPUTER.

YOU KNOW, YOU MAKE SOME REALLY GOOD POINTS.

I'M ... NOT EVEN SURE WHO I AM ANYMORE.

http://xkcd.com/329/
Annual Turing tests

Loebner Prize

• $100,000 to first program to pass restricted Turing Test.
• Annual competition held since 1995.
• Small awards given to best attempts.
• Prize still unclaimed.
Sample Loebner contest dialogs

"Hello, Judge. My name is Ella. Please tell me your first name, or whatever I should call you."
"Call me Lisa. Am I male or female?"
"Okay, I will call you 'Lisa. Am I Male Or Female?' I am here recently from Tainjin, China, so please be patient with me."
"I'm not a patient because I am not ill. Are you feeling well today?"
"What do you think it means that you are not ill?"
"Have you ever been ill?"
"'Have you ever been ill?' you say? That's it, Lisa Am I Male Or Female! I will schedule a whipping for you."

"What do you think of Reading?"
"I'm somewhat crazy about reading. I like to read mystery novels."
"I meant the town."
"Jones lives in the city and is a writer of children's books."
"Does Jones live in Reading, then?"
"Tomorrow is another day. We can only live today well."
"Do you live, then?"
"I live then a lot. Someday we will live on another planet."
"I think you are already there."
Digression: "Reverse" Turing test

**Reverse Turing test**
- Judge is a *program*.
- Application: Web commerce.

**Turing test**
- Judge is a person.
- Application: Validate AI.

**CAPTCHA**
- Completely **Automated** **Public** Turing test to tell **Computers** and **Humans** Apart.
- Approach: Display a word that is easily read by a human but not by a program.
- Invented in 1997 by a group at AltaVista, by reverse-engineering a scanner manual.
Progress report: Watson

Watson: a computer system specifically built to play *Jeopardy*

- Access to 200 million pages of content (4 terabytes).
- 2011: Watson beat two former *Jeopardy* champions.

Q. Is a machine that can answer questions intelligent?

Q. Does a machine that can answer questions *appear to be* intelligent?
Can a machine answer questions?

Q. Can a machine answer questions?
A. Sure.
Q. Does that constitute intelligence?

“Watson got the promotion to CIO over me. How am I supposed to compete with a supercomputer who won on Jeopardy?”
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"Weak" AI

**Weak AI**. Can a computer *appear* to be intelligent?

- Q. Can a computer play a game (and defeat a human)?
- A. Sure.
- Q. Does that constitute *intelligence*?

- Q. Can a computer drive a car?
- A. Sure.
- Q. Does that constitute *intelligence*

- Q. Can a machine answer questions?
- A. Sure.
- Q. Does that constitute *intelligence*?

**Strong AI**. Can a machine *be* intelligent?
Imagine that:

- You don't understand Chinese.
- You're alone in a room that has paper slots labeled "input" and "output".
- You have a big book of Chinese writing.
- You have English instructions (no translations) that tell you what to write on a piece of paper in response to any possible inputs.

And then:

- Chinese speakers outside the room pass in pieces of paper with Chinese writing. They know these are questions (but you don't).
- You consult your manual of instructions, figure out the proper Chinese response, copy it, and pass it out to them.
Q. The folks outside think you understand Chinese. Do you?

Q. If a computer did the same, would it understand Chinese?

http://www.mind.ilstu.edu/curriculum/searle_chinese_room/searle_chinese_room.php

Searle. Chinese Room thought experiment **absolutely refutes** the idea of strong AI.
"Systems" refutation of Searle's assertion that strong AI is impossible

Man/machine in the room is just one part of a system
- Huge memory (piece of paper for every possible symbol).
- Unlimited I/O.
Could implement a UTM!

Akin to the difference between a DFA and a Turing machine.

<table>
<thead>
<tr>
<th></th>
<th>DFA</th>
<th>Turing / UTM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Searle</td>
<td>human/machine</td>
<td>not acting intelligently</td>
</tr>
<tr>
<td></td>
<td>system</td>
<td>intelligent (?)</td>
</tr>
</tbody>
</table>

The *machine* may not understand Chinese, but the *system* does!
"Ship of Theseus" refutation

Ship of Theseus paradox

- Theseus sails the world in a wooden ship.
- During the trip, every single component of the ship is replaced, one by one.
- Is it the same ship when it returns?

Refutation of Searle's assertion that strong AI is impossible

- Suppose that we replace each neuron in a human brain, one by one.
- At what point does the brain become something that is not intelligent?

Note: ~100 billion neurons in the brain.
500+ billion bytes in your PC.
Longstanding debate: Is strong AI ultimately possible?

“Just as the Wright brothers at Kitty Hawk in 1903 were on the right track to the 747, so too is AI, with its attempts to formalize commonsense understanding, on its way to fully intelligent machines.”

– Patrick Winston

“Believing that writing these types of programs will bring us closer to real AI is like believing that someone climbing a tree is making progress toward reaching the moon.”

– Hubert Dreyfus

“The brain happens to be a meat machine.”

– Marvin Minsky

“Either AI is possible ... or we’re not.”

– Herb Simon

“The question of whether a computer can think is no more interesting than the question of whether a submarine can swim.”

– Edsger Dijkstra
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A challenge

Write a program that can pass this course.
- Exams
- Programming assignments
- Programming exams.

Q. Would such a program be intelligent?

Next challenge.
Write a program that can pass any college course.

Q. Would such a program be intelligent?
Modern AI: Machine learning

Machine learning is the branch of AI that concerns systems that can learn from data.

Applications
- Optical Character Recognition.
- Medical treatment.
- Robot navigation.
- Speech recognition.
- Genome analysis.
- Web commerce.
- ...

Approaches
- Sound statistical, computational and mathematical principles.
- Theories of learning processes.
- Methods of representing knowledge.

“How can we program systems to automatically learn and to improve with experience?”

Tom Mitchell, CMU

“Machine learning is the science of getting computers to act without being explicitly programmed.”

Andrew Ng, Stanford
Practical bottom line

The pursuit of AI has helped open limitless possibilities for applications of computer science.

And you are prepared to begin participating!
What is this course about? (revisited)

A broad introduction to computer science.

Goals

• Demystify computer systems.
• Empower you to exploit available technology.
• Build awareness of substantial intellectual underpinnings.

Topics

• Programming in Java.
• Design and architecture of computers.
• Theory of computation.
• Applications in science and engineering.

“Science is everything we understand well enough to explain to a computer.”

− Don Knuth

“Computers are incredibly fast, accurate, and stupid; humans are incredibly slow, inaccurate, and brilliant; together they are powerful beyond imagination.”

− Albert Einstein
Congratulations, and good luck!
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