Can Computers Think?

Dijkstra: Whether a computer can think is about as interesting as whether a submarine can swim.

Thinking with Electricity

The inventors of ENIAC, 1st computer, said it "thinks with electricity"

- Do calculators "think"?
- Does performing arithmetic, which is entirely algorithmic, require thinking?
- Once, performing arithmetic, was thought to be divinely or magically conferred

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The Problem: Many human activities look like thinking until they are understood (to be algorithmic)

Turing's Test

A.M. Turing, computer pioneer, worried about intelligence in humans & machines and proposed a test (1950)

- Aware that it's intelligence til it's understood Turing devised this experimental setup:

Room A: containing a person or machine

Room B: containing a person or machine

Judge: Asks questions via keyboard to decide which is which

What To Ask

Formulate questions a person can answer but a computer can't

Seeming To Be Intelligent

Joel Weizenbaum's "Doctor" was an program that *appeared* intelligent

User: I'm depressed.
Doctor: Why are you depressed?
User: My mother is not speaking to me.
Doctor: Tell me about your mother.
User: She doesn't want me to major in CS.
Doctor: No?
User: No, she wants me to go into medicine.

Find the cues Doctor uses

Artificial Intelligence

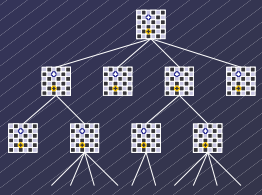
The study of making computers act intelligently

- They already act intelligent … e.g. they can correct your spelling mistakes
- Is this intelligent behavior? Most AI researchers would say "no" … algorithmic
- Playing grandmaster level chess in a tournament became an AI goal (1952)
  - Minimizes real world knowledge
  - Clear goal, formal system

Playing Chess

Chess is a game, so it uses a game tree

- At each node is a 'board'-- easily digitized
- Below it are all boards created in 1 move



An objective function evaluates "goodness" of the position: go for highest … opponent goes for lowest

Deep Blue vs Kasparov

An IBM system, Deep Blue, played world champion Gary Kasparov

- In 1996 Kasparov won, but Deep Blue played 1 game well!!!
- In May 11, 1997 Deep Blue won 3.5-2.5

Deep Blue is a 32 processor parallel computer with 256 "chess processors" that can consider 200,000,000 chess positions per second + opens + ends

Intelligent?

Does Deep Blue's performance show that a computer can be intelligent?

- No -- it repeat's its designers intelligence
- Yes -- it's better than anyone in the world at something people find interesting and fun
- Maybe -- it shows intelligence in chess, but can it apply its intelligence elsewhere?

What do you think?

Being Creative

Computers can do things deemed creative in the past

- Create designs in the style of Piet Mondrian

- Composing Bach: EPI, Bach, Professor

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Audience Thought: Bach Prof EPI

Definition of Creativity

Creativity has two forms: "flash out of the blue" and "incremental revision"

- "Flash," i.e. inspiration, is rare; is it just luck?
- "Revision", i.e. hard work, is common and to a large degree algorithmic

Advertising agencies are famous for creativity, but in a recent study, 89% of all *award-winning* ads were an application of one of six templates -- design algorithm

Computers Can't Debug

There are some things computers cannot do … and we can prove it!

- No computer program can tell, give another program P, if P loops forever … *halting prob*
- If possible, it would be handy for debugging
- In fact, it seems possible … look closely at the program, check the **for**-statements (and other looping structures we didn't learn)
- Suppose Loop_Check (P, Q) tests pgm P on input Q, answering "yes/no" to loops forever

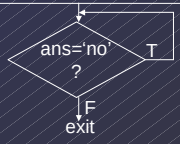
Loop_Check Cannot Be

Loop_Check could not work, because if it did we'd make a new program

Contradict (P): ans = Loop_Check(P,P)

What happens when we run Contradict(Contradict)?
If L_C says C loops forever, it stops
If L_C says C stops, it loops forever

C is nonsense, so L_C can't exist



Intelligence & Creativity

The bottom line on the "intellectual skills" of computers …

- It has long been an interesting question
- Computers are amazing, but probably not intelligent
- When a task becomes algorithmic computers (and humans) can do it well

Maybe thinking is what people do