



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)



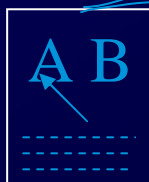
Turing's Test

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 a 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

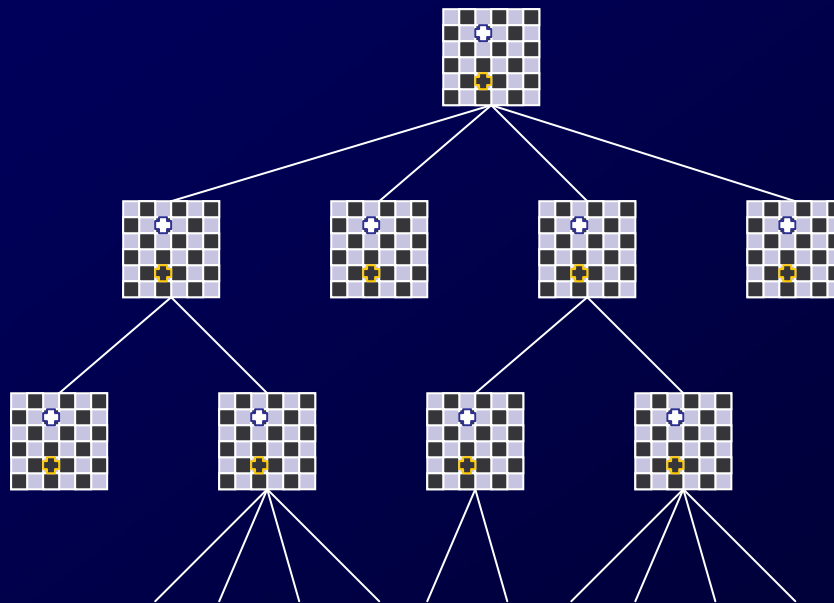
- They already act intelligent ... e.g. they can correct your spelling mistakes
- Is this intelligent behavior? Most AI researchers would say "no" ... algorithmic
- Playing grandmaster level chess in a tournament became an AI goal (1952)
 - Minimizes real world knowledge
 - Clear goal, formal system



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 repeats 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?

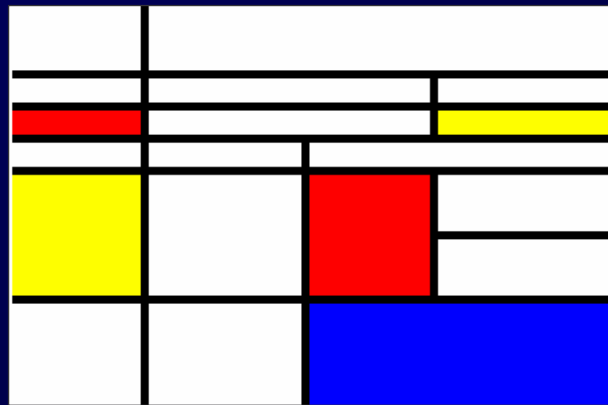
What do you think?



Being Creative

Computers can do things deemed creative in the past

- Create designs in the style of Piet Mondrian



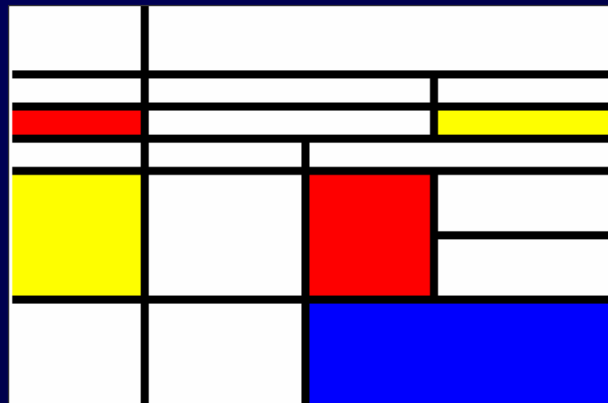
- Composing Bach: EPI, Bach, Professor



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- Composing Bach: EPI, Bach, Professor
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, given 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 program 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)

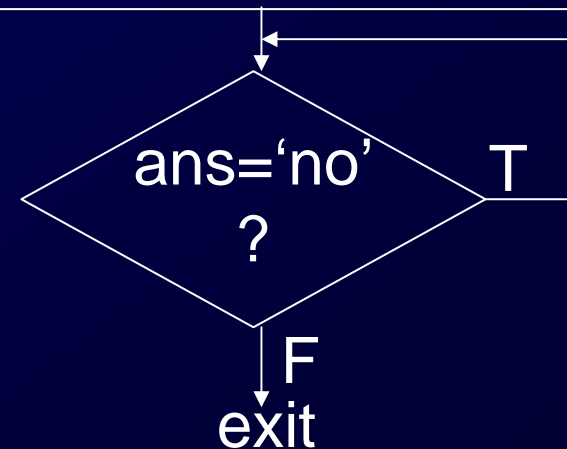
What happens when we run

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



Robotics

What tasks would you want a robot to do?