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**Learning to Learn: The Art of Doing Science
and Engineering, Session 8:**

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Richard W. Hamming



Learning to Learn

The Art of Doing Science and Engineering

**Session 8: Artificial
Intelligence III**



Topic Outline

Question: Can Machines Think?

Some Perspectives

Open Discussion

Question: Can Machines Think?



Goal is to think about this question, not to give answers.

Common observations:

- "I would never have my life depend on a machine!"
- "I do not want machines to control my life!"
- "Machines can never do things humans can do!"
- **It is the combination of human and computer that is important.**

Question: Can Machines Think?



Advantages of computers over humans:

- Economics, speed, accuracy, reliability, rapidity of control, freedom from boredom, bandwidth in and out, ease of retraining, hostile environments, personnel problems
- **It is the combination of human and computer that is important.**
- **The surer you are of one side of the argument, the more you should probably argue the other side!**



Perspectives

Maybe computers have not yet been programmed to think because programmers are stupid!

Just because you want to believe machines can think doesn't mean they can.

Just because you want to think machines cannot think doesn't mean they can't.

Computer programs can learn from experience (e.g., Samuels' checker program).

Isosceles triangle theorem proving showed "originality."



Perspectives

Imagine the shortest program that could think - no component of it could think.

Consider “logical” and “psychological” novelty.

Whatever your opinion, what evidence would you accept to indicate you are wrong?

Thinking may be a matter of degree and not a yes/no answer.

Thinking may be the *way* something is done rather than *what* is done.



Discussion Point 1

Student

- Computers cannot think – it takes a thinking individual to write a program to simulate thinking. A computer is not capable of creative thought.
- Cannot identify every situation and come up with a move.

Hamming

- What about Samuels' checker-playing program – did it learn?



Discussion Point 2

Student

- A computers cannot think – it is limited by its programming, but as programs become more and more complex, it gives the illusion of thinking.
- Chess/checkers programs analyze the board and make a move based on best probability of success.
- Do we have a creative spark that computers do not have?



Discussion Point 3

Student

- We learn through repetition.
- Computers will only think as well as its program performs.
- A computer doesn't think, it just executes.



Discussion Point 4

Student

- Checkers world is a 2-dimensional board with limited number of decisions and limited sensory input. Can write a program to deal with this and to “think.”
- If you could provide a computer with enough input to emulate human perceptions, then you could potentially write a computer program that could think.
- Not likely in near future, but possible.



Discussion Point 5

Student

- Start with question, “What is thinking?” It is the ability to ask questions! Questions are based on a need – what does a computer need?
- On this premise, a computer cannot think because it cannot pose questions to search for answers.
- Regarding limits, I realize I have limits but can a computer realize it has limits? A computer does not have self-awareness.



Discussion Point 6

Student

- Computer operates within whatever paradigms the programmer has given it. Computer cannot operate outside these paradigms, but humans have that creative ability.

Hamming

- What about child development through learning? Are we different than computers?



Discussion Point 7

Student

- New question: Do we want machines to think? I say no, because then they will become just as unreliable as people!
- What we want is to be able to control machines and not allow them to think.

Hamming

- Very good point, yet AI wants to get machines to do what we cannot. Can they in the long run?



Discussion Point 8

Student

- “Thought” evolved as a survival tool. It is a procedure:
 - *Perception of the environment (ability to sense)*
 - *Anticipate a change in the environment (recognize pattern, imagine/create internal environment)*
 - *Derive an appropriate behavior to account for that change (develop appropriate response; projecting likelihood of success of action)*
- Thinking is a continuum of abilities.
- From this perspective, a machine can think.



Hamming on Creativity

Regarding creativity to construct something like the theory of relativity - when you look closely, the person was led little by little to the result.

Einstein - as a child had asked himself questions about traveling at the speed of light.

Creativity is not the “light bulb going on” but much more of a deliberate process, much of it subconscious.



Discussion Point 9

Student (revisits earlier comments)

- Chess program thinks within the limited environment of the chess game.
- Consider a fish in a fish bowl - it thinks and makes choices in its environment, but its brain is limited just as the chess program is limited.



Discussion Point 10

Student

- Humans can daydream and imagine, computers cannot.



Discussion Point 11

Student

- Define thinking as the ability to deviate from the standard program or paradigm.
- So, could a computer be classified as thinking if it has deviated from its original programming?
 - *Wouldn't the deviation also have been programmed into the computer?*
 - *Humans also – could the deviation even be something programmed into us at a deeper level?*



Discussion Point 12

Student

- From the dictionary, to “think” is to “exercise of powers of judgment, conception, or inference.”
- Computers and humans operate by a set of rules, but humans have difficulty expressing what the rules are that they operate by.
- Humans also operate on the basis of concepts – just having the general idea instead of a set of rules.



Discussion Point 13

Student

- Regarding rules, can use neural networks and genetic algorithms to enable machines to learn (e.g, flight controller).
- The program can even adapt to new circumstances very rapidly.



Discussion Point 14

Student

- Machines, even Marines, can think.
- What machines cannot do is *feel*. If a chess program wins a game, is it glad that it won?
- Generally, what we consider thinking is applying what we know to solve a problem. Machines are no different.



Discussion Point 15

Student

- Prefer the word “intelligence” to “thinking.”
- Intelligence at its most basic level is being aware of ones surroundings. Computers can do this.
- Thinking is the ability to take the perceptions and put them together into a logical result or to compute something. Computers can do this.
- Distinguish “being smart” from “common sense.”
- Overall intelligence is the sum of all of these. Computers currently lack this ability because we are limited in our ability to program them.
- The question is driven by human arrogance!



Discussion Point 16

Student

- Thinking is related to the broader issue of good and evil. We can't program feelings into machines.
- Humans are unique in their capacity to love and to hate.

Hamming

- There was a story of a robot that killed a person...
- What if a computer had the same sensory experience as humans? Could it then do better than humans?
- Machines can make other machines.



Discussion Point 17

Student

- Machines making other machines – is that tasking or reproducibility?
 - *When machines make other machines, we know the outcome.*
 - *When humans reproduce, we do not know the full characteristics of the baby.*

Hamming

- We can program machines to be random. We've just typically programmed them to do exactly what we want them to do.



Discussion Point 18

Student

- How do you program a machine with morality?
- There are as many opinions about what is moral as there are students in the room.



Discussion Point 19

Student

- Human is a biological engine – DNA executes its code that makes processes inside the mind happen.
- Similar for computers – processor, memory, instructions.
- We now have software objects reacting to other software objects. We will see programs processing software at one level, but at a higher level there will be objects interacting with other objects within and across machines.
 - *And agents talking to agents in the Semantic Web!*
- Morality, creative thought, and intuition are being applied in a human sense – computers will have their own definitions for these concepts.



Discussion Point 20

Student

- Regarding morality, machines operate in a black and white world. Humans make judgments.
- Perhaps computers have an advantage over us in this regard.
- Would be interesting exercise for each individual to try to write rules for behavior in different situations.



Discussion Point 21

Student

- The real test is what a computer can learn and do on its own.
- Computer can be very good at acquiring information but it cannot acquire understanding of what it perceives. Does not ask “why?”
- We are motivated to ask “why?” so we have evolved to discover things we do not observe.



Discussion Point 22

Student

- Are computers really thinking or just simulating thinking?
- Perhaps a chess master thinks on some different level than the computer chess-playing program.
- Can possibly write a program to have the computer ask "Can a computer think?" but it wouldn't be the computer asking the question; it would be the program.

Hamming

- There are times when a teacher feels a class is only simulating intelligence!



Discussion Point 23

Student

- What's to stop a computer from learning to write its own programs?
- Today, we write the programs. If a computer can write code and learn, might it evolve much faster than we did?



Related topics

Semantic Web

- <http://www.w3.org/2001/sw/>

Blending and Conceptual Integration - beginnings of a computational model for the way we think?

- <http://blending.stanford.edu>
- See [The Way We Think: Conceptual Blending and the Mind's Hidden Complexities](#) by Gilles Fauconnier and Mark Turner