Computation, cognition and artificial intelligence

BCS153 Week 8.2
3/7/2019
Roadmap

• Functional description and functional architecture
  ➢ Cognitive penetrability
• Turing machine
• Model algorithm
• Artificial intelligence
  ➢ Strong vs. Weak AI
  ➢ Turing test
  ➢ Chinese room experiment
Recap

• Why computational models: materialize cognitive processes as analyzable discrete units

• One central component underlying (traditional) computational models: representation

• Computation: symbolic operations to explain behavior (representation-based)
Is detailed functional description needed for computation (in the traditional view)?

- Not really...Just the typical functional architecture
  - Fixed features of the system
- Detailed specification of the physical properties not needed
  - How many neurons do we have in our hippocampus?
  - Size of brain and perceptual ability
  - Keyboard model specification and the function of sending input into the machine
  - Another similarity between a machine and human mind
Any computational model should be able to:

• Emulate the functional architecture of mind
  ➢ Specify and justify the functional mechanisms in which a cognitive process is taking place

• Execute the hypothetical algorithm
  ➢ Model characteristics
  ➢ What the model tries to account for
  ➢ What the model can (and cannot) do
Basic assumption of functional architecture

• Fixed functions (cognitive impenetrable)
  ➢ Applicable to machines
e.g., CPU, GPU, harddrive, RAM

➢ Applicable to humans?

• Execute the mental algorithms

• Are functions always fixed or flexible (penetrable)?
Turing machine: a primitive architecture (Alan Turing 1936)

• Simply put: a primitive computing device for input processing and output generation

• Basic components
  • A tape with squares (states)
  • Only 3 codes: 1, 0, blank
  • A read-write head that can move left and right
  • Transition rules
  • Execution

(For more details, read “What is Turing machine” under “Reserves > Supplemental materials” on Blackboard)
Turing machine: a primitive architecture

• How does Turing machine actually work?

https://turingmachinesimulator.com/
To build a cognitive virtual machine

• Mind as a virtual machine

• Functional architecture

• Mental algorithm

→ Cognitive process
  → Result of computation from the algorithm
A typical computational model of behavior

- Representation of an initial state (e.g., goal)
- Series of operations on various types of representations
- Output generator
- Output
A simple algorithm: Test-Operate-Test-Exit (TOTE; Miller et al. 1960)

Mental activity: execution of an algorithm
Beyond the original (traditional) computational models...

- Connectionism
- Neural science
- Dynamical systems
Can computers think?
Strong vs. Weak AI

• Strong version: machines can have a “mind”; cognitive processes are simply symbolic operations

• Weak version: Computer models as a tool to study human mind

One requirement of an AI system to be considered as having a mind – Ability to “duplicate the causal powers of brains” (Searle 1990)
Turing test (Alan Turing 1950)

• Simply put: can you tell if the response is generated by human or a machine?

• Goal of the test: Can machine think?

• Criterion: ~30% time judged as human’s response

Graph adopted from Bashir et al. (2013)
Can computer really pass the Turing test?

A fake 13-yo Ukrainian boy “Eugene Goostman” reportedly passed the test. Here is an excerpt of the conversation conducted by a journalist from *Time magazine* in 2014:

**How are you adjusting to all your new-found fame?**

I would rather not talk about it if you don’t mind. By the way, what’s your occupation? I mean – could you tell me about your work?

I’m a technology blogger.

It’s quite surprising that you are a technology blogger. Where do you came from, by the way? Could you tell me about the place where you live?

I live in Boston but I grew up in Minnesota. I also lived in Seattle for a while.

Could you invite me to Seattle? I would be so grateful:-)

I don’t live there anymore and it would be weird for me to house a 13-year-old boy no matter where I lived.

Possibly, it will be a big surprise for you, but “no” isn’t the only answer. The word “yes” also exists! :-) Wanna ask me something more?

**That last answer of yours was a little shaky, Bro-Bro.**

Damn! I’ve just recalled that I didn’t feed my guinea pig this morning. Poor animal!

**Ah, okay. We’re changing the subject. What’s your guinea pig’s name?**

Name of my guinea pig’s name is Bill. But I suspect he doesn’t go by it. Perhaps, he is deaf and I should call him “Beethoven”.

Can computer really pass the Turing test?

• What patterns of responses did you observe?

• If you were the judge, would you say it passed the test?

• What are some limitations of the test?
A modified version of the Turing test (Lake et al. 2015, in Science)

• Task: Reproduce the given symbol with subtle variations
• Results: ~50% of time judged as human
• Which symbols in each panel are produced by a machine?
Chinese room experiment
Implications of the Chinese room experiment?

• What does this experiment tell us about the Turing test?

• What does the machine (or the person in the Chinese room) actually do?

• Does the Chinese room experiment support strong AI?
Some defenders’ arguments against the Chinese room argument

• Although the man in the room doesn’t know Chinese, the system (including the room itself) does. (!)

• We can simulate the system at the neuronal level so that it can understand Chinese like a Chinese person.

• The person in the room actually understands Chinese subconsciously.

• Semantics (content) is not needed – just the rules and structures (syntax)
Do connectionist models support strong AI?

• Can we make machine “think” by using connectionist models?
  ➢ How and what does it think?

• Can we make machine “learn” by using connectionist models?
  ➢ How and what does it learn?
Syntax vs. Semantics in AI?

Is the Brain’s Mind a Computer Program?

No. A program merely manipulates symbols, whereas a brain attaches meaning to them

by John R. Searle
Take-home messages

• Many of our functions are cognitively penetrable because of our belief system

• Strong vs. Weak AI

• Turing machine and Turing test: can computers think?

• Implications of Chinese room experiment: AI has syntax but lacks semantics

• Machine learning ≠ Machine thinking