Universal Intelligence: A Definition of Machine Intelligence (Addendum)

Spring 2021 CSE 6369 HLAI UTA

Ogenna Esimai

February 12, 2021

Outline

- Take-home points (5)
- Expansion of Take-home points (5)
- Take-home points (6)
- Summary

Outline

- **Take-home points (5)**
- Expansion of Take-home points (5)
- Take-home points (6)
- Summary

Take-home points (5)

- Survey/tests and definitions of machine intelligence
  - Turing Test and Derivatives
  - Compression Tests
  - Linguistic Complexity
  - Multiple Cognitive Abilities
  - Competitive Games
  - Collection of Psychometric Tests
  - C-Test
  - Smith's Test

Outline

- Take-home points (5)

- **Expansion of Take-home points (5)**

- Take-home points (6)

- Summary

Expansion of Take-home points (5) - 1

- Survey/tests and definitions of machine intelligence
  - Turing Test and Derivatives
    - Turing Test – paper is of view that Turing realised how difficult it would be to directly define intelligence, thus attempted to side step the issue by using his imitation game
    - criticisms of Turing Test are listed
      - 1) passing test is insufficient to establish intelligence. Machine could appear intelligent potentially by using a very large table of answers to questions
      - 2) passing test is unnecessary to establish intelligence. The test requires the machine to have a highly detailed model of human knowledge and patterns of thought, thus, a test of humanness rather than intelligence
        - also machine can pretend to have human faults, in order to do better on the test, going against purpose of test
      - 3) current AI systems are far from passing unrestricted test. Practically, full test is unable to guide this paper's work
      - 4) test is unreliable. It returns different results depending on who the human judges are.

Expansion of Take-home points (5) - 2

- Survey/tests and definitions of machine intelligence
  - Compression Tests
    - text compression tests solve binary P/F problem with Turing test
    - similar to ''Cloze test'' where guessing missing words from a passage of text is a proxy of comprehension and knowledge in a domain
    - simple text compression using symbol frequencies provides poor compression
    - more complex models using higher level features, ex. aspects of grammar provide best compression (~ 1.5 bits per character for English)
    - humans compress even further to ~ 1 bit per character
    - compressor performing well on such a test is mathematically equivalent to being able to determine which sentences are probable at a given point in a dialogue
    - as failing a Turing test occurs when a machine (or person) generates a sentence which would be improbable for a human, extremely good performance on dialogue compression implies the ability to pass a Turing test.

Expansion of Take-home points (5) - 3

- Survey/tests and definitions of machine intelligence
  - Linguistic Complexity
    - used by HAL project at Artificial Intelligence NV company
    - measures a system's level of conversational ability by using techniques developed to measure the linguistic ability of children
    - considers vocabulary size, length of utterances, response types, syntactic complexity, etc.
    - systems can be ''... assigned an age or a maturity level beside their binary Turing test assessment of 'intelligent' or 'not intelligent' ''(Treister-Goren et al. 2000)

Expansion of Take-home points (5) - 4

- Survey/tests and definitions of machine intelligence
  - Multiple Cognitive Abilities
    - used by IBM's Joshua Blue project
      - goal is to first pass a ''toddler Turing test'', to develop an AI system that can pass as a young child in a set up similar to Turing test
      - consider a broad range of linguistic, social, association and learning tests
    - also used by a2i2 project at Adaptive AI
      - work toward a level of cognitive performance of a small mammal

Expansion of Take-home points (5) - 5

- Survey/tests and definitions of machine intelligence
  - Competitive Games
    - propose that ''… doing well at a broad range of tasks is an empirical definition of 'intelligence''' (Masum et al. 2002)
    - seek to identify tasks that measure important abilities, admit a series of strategies that are qualitatively different, and are reproducible and relevant over an extended time
    - Masum et al acknowledge open challenge is to
      - work out what these tasks should be
      - quantify how broad, important and relevant each is

Expansion of Take-home points (5) - 6

- Survey/tests and definitions of machine intelligence
  - Collection of Psychometric Tests
    - Psychometric AI tries to address problem of what to test for in pragmatic way
    - ''Some agent is intelligent if and only if it excels at all established, validated tests of [human] intelligence.''(Bringsjord and Schimanski 2003)
      - later added ''tests of artistic and literary creativity, mechanical ability, and so on''
    - criticisms. This paper believes unlikely to be adequate for measuring machine intelligence
      - 1) these tests are highly anthropocentric
      - 2) they embody basic assumptions about the test subject that are likely to be violated by computers
        - For ex., fundamental assumption - test subject is not simply a collection of specialised algorithms designed only for answering common IQ test questions which a computer could very well be

Expansion of Take-home points (5) - 7

- Survey/tests and definitions of machine intelligence
  - C-Test
    - intelligence is ''the ability to deal with complexity''(Gottfredson 1997)
    - C-test of Hernández-Orallo inspired by Solomonoff induction and Kolmogorov complexity (Hernández-Orallo 2000b; Hernández-Orallo and Minaya-Collado 1998)
    - **also this paper's approach (major differences underlined below)**
    - C-test uses a <u>passive</u> environment
    - C-test solves problem of Kolmogorov complexity not being computable by using <u>Levin's Kt complexity</u> (Levin 1973) instead
    - universal intelligence is based on universally optimal AIXI agent for <u>active</u> environments, which is also based on <u>Kolmogorov complexity</u> and Solomonoff's universal model of sequence prediction

Expansion of Take-home points (5) - 8

- Survey/tests and definitions of machine intelligence
  - Smith's Test
    - agent tries to produce the correct response to series of problems generated by algorithm
    - agent determines when it is shown next problem
    - scoring system produces a cumulative score
    - agent's intelligence is cumulative score as a function of time
    - problems must be in P
    - criticisms offered by this paper
      - 1) unnecessary to restrict problems to be in P
      - 2) use of passive environments
      - 3) does not address what exactly the tests should be

Outline

- Take-home points (5)
- Expansion of Take-home points (5)
- **Take-home points (6)**
- Summary

Take-home points (6)

- ## Comparison of Machine Intelligence Tests and Definitions

Table 1 In the table ● means "yes", • means "debatable", · means "no", and ? means unknown. When something is rated as unknown that is usually because the test in question is not sufficiently specified

Intelligence test	Valid	Informative	Wide range	General	Dynamic	Unbiased	Fundamental	Formal	Objective	Fully defined	Universal	Practical	Test vs. def.
Turing test	•	·	·	·	•	·	·	·	·	●	·	•	T
Total Turing test	•	·	·	·	•	·	·	·	·	●	·	·	T
Inverted Turing test	•	•	·	·	•	·	·	·	·	●	·	•	T
Toddler Turing test	•	·	·	·	•	·	·	·	·	·	·	•	T
Linguistic complexity	•	●	•	·	·	·	·	•	•	·	•	•	T
Text compression test	•	●	●	•	·	•	•	●	●	●	•	●	T
Turing ratio	•	●	●	●	?	?	?	?	?	·	?	?	T/D
Psychometric AI	●	●	•	●	?	•	·	•	•	•	·	•	T/D
Smith's test	•	●	●	•	·	?	●	●	●	·	?	•	T/D
C-test	•	●	●	•	·	●	●	●	●	●	●	●	T/D
Universal intelligence	●	●	●	●	●	●	●	●	●	●	●	·	D

Source - Universal Intelligence: A Definition of Machine Intelligence. Legg et al. Minds & Machines (2007) 17:391–444

Outline

- Take-home points (5)

- Expansion of Take-home points (5)

- Take-home points (6)

- **Summary**

Summary

- Definition
  - Formula
    - measure machine intelligence
  - Collection of definitions
    - human intelligence
  - Features
    - mathematical
- Definition vs. theory
  - theory of universal optimal learning agents
- Survey
  - tests and definitions of machine intelligence