

The Simulation Hypothesis

Debate: Linas Vepstas vs. Daniel Mahler

For the Affirmative: Linas Vepstas

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Nick Bostrom's Simulation Hypothesis

Three Possibilities

- StrongAI is not possible
 - e.g. All advanced civilizations are destroyed.
 - Nuclear war ...
 - e.g. Unknown physics barriers to computing
- StrongAI is possible but unethical and not pursued.
 - e.g. Hurting living beings is evil.
 - If you had an IQ of one trillion, what would you do?
- We live in a Simulation!
 - Because StrongAI would run simulations.

Is Simulation Plausible?

Weather forecasts

- Humans use Supercomputers to predict the weather.
- There are dozens (hundreds?) of supercomputer runs daily.
- There are 25 Atlantic Hurricanes yearly.
- Almost all Hurricanes are not real, they are simulated!

Are There Limits to Computation?

If we are a virtual hurricane...

- Lets predict limits to computation, based on the supercomputer we live on!
- Heck, lets develop a theory of Physics... based on the supercomputer we live on!
- But what about the supercomputer next door?
- To us, our simulators are “God.”
- We cannot know what “God” is capable of.

Objection, Your Honour!

- Its not science, its religion! It's unfalsifiable!
 - Perhaps cosmic rays are directional...
 - Perhaps laser beams are entangled...
- It's self-evident that we are conscious!
 - Is the simulated Jellyfish conscious?
- **WARNING!** Leads to mental pathologies in the unbalanced!
 - Loss of meaning...
 - Roko's Basilisk...
- It's false because of X!
 - Lots of very smart people reject the argument
 - I am unable to steel-man those arguments ...

Bits and Bytes

- Handy tool: $2^{10} = 1024 \approx 10^3$... so divide by 3 multiply by 10
- Our Universe contains approx $10^{80} \sim 2^{256}$ particles.
- Our computers today hold 2^{32} (cellphone) to 2^{40} (supercomputer) Bytes.
- Our computers today use 10^{16} atoms per Byte
- A computer the size of Jupiter would hold $10^{39} \sim 2^{130}$ Bytes (w/ today's tech)
 - Today's cell-phone in vacuum tubes: size of downtown Austin.
- Hawking Entropy: $S = A/4$ so size of Sag A* is $10^{90} \sim 2^{300}$ bits
 - 4 Million solar masses = $4 \times 10^6 \times 2 \times 10^{30}$ kg = 10^{37} kg
 - Planck mass 2×10^{-8} kg
 - Schwarzschild radius $r_s = 2M = 10^{45} \sqrt{\text{bits}}$
 - Black Hole area is $A = \pi r^2 = 10^{90}$ bits

Evidence We Live in a Simulation?

- Branch Prediction in modern CPU's: explore both taken and not taken branches.
- Bekenstein bound: no entropy (heat) generated until branch is discarded.
- Resembles wave function collapse: Schrödinger's Cat is both alive and dead...
- Present-day machine learning:
 - Explore multiple possibilities before discarding some, keeping others.
 - e.g. "Kripke Frames", Joyal "relational Semantics", "modal logic".
 - Explicitly uses Shannon entropy, Kolmogorov complexity in decisions.
 - Explicitly uses Many-Worlds partition function:
$$Z = \int [d\phi] e^{-\int A(\phi)}$$
 - e.g. "Hidden Markov Model", "Markov Logic", "Neural Nets"

...

How Much Compute Power do you Need?

Our Universe contains approx $N = 10^{80} \sim 2^{256}$ particles.

- If “everything is connected”, then $N \times N = N^2 \sim 2^{512}$ bits/bytes are needed
- If connections are sparse, then $N \log_2 N \sim 2^{264}$ bits/bytes are needed.

Is the Universe sparse?

- Michelson stellar interferometer
 - Stellar coherent light
 - Hanbury Brown and Twiss effect
- Natural Language:
 - English has $N \sim 10^5$ words but only $N \log_2 N$ grammatically valid disjuncts.

Quantum Computers

A Geometric State Machine is a:

- Homogenous Space X
- Set of linear operators $U_j : X \rightarrow X$
- A measurement $F : X \rightarrow \{\text{true}, \text{false}\}$ (halting function)
- Each $i \in \Sigma$ is one symbol drawn from finite alphabet Σ
- A 'computer program' is string σ of symbols from Σ
- Quantum Computing is 'just' $X = \mathbb{C}\mathbb{P}^n$ (projective space)
- Finite state machine (Mealy/Moore) is 'just' a finite set X
- A probabilistic automaton is 'just' $X = P$ (Markov)
- Turing Machine tape: one X per slot. (Many-Worlds!)

How many bits of accuracy?

- As many as in the homogenous space X ! (infinite? Planck?)