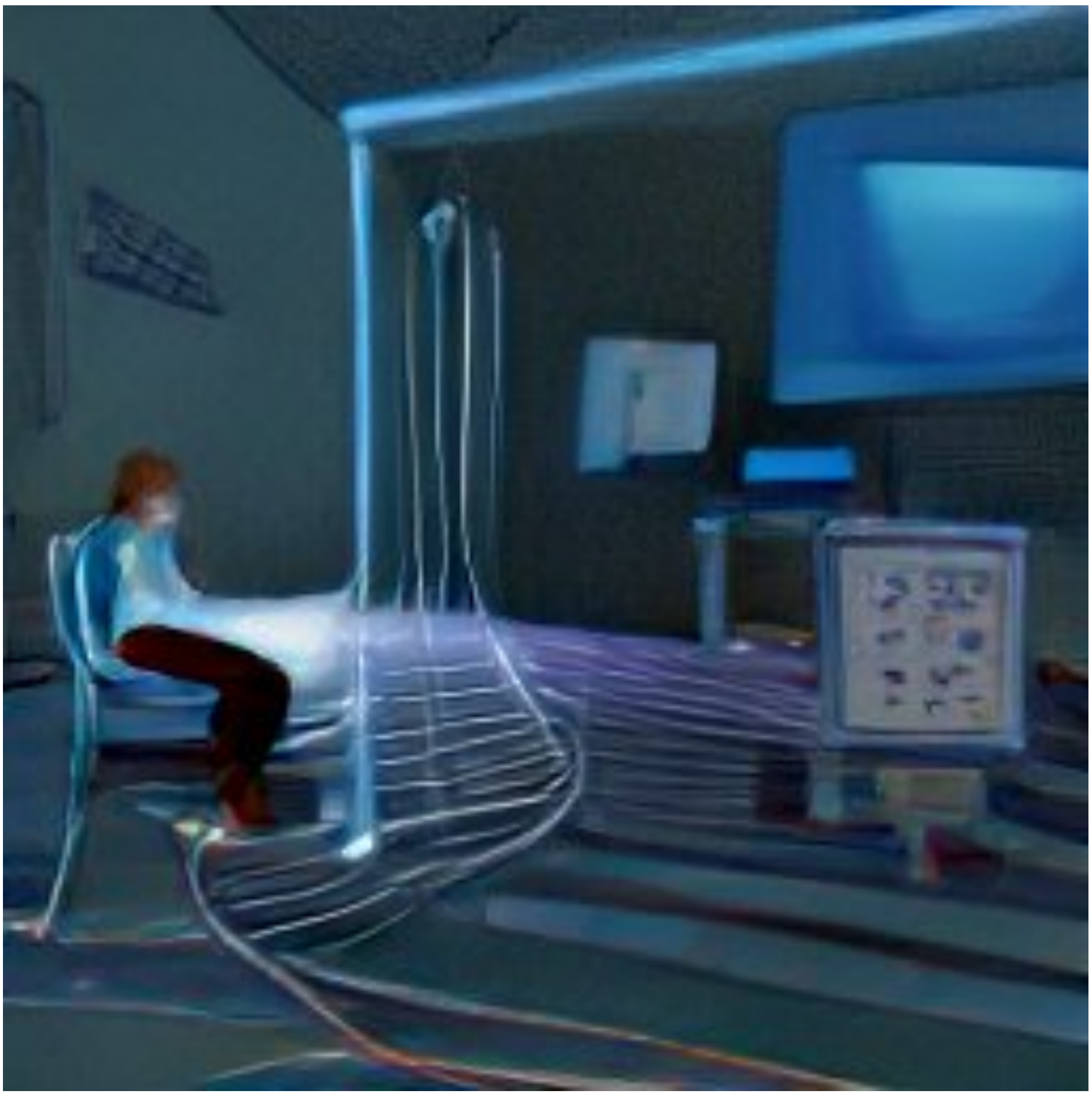
Biology or Information: Refuting the Simulation Argument



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Abstract

In his seminal 2003 paper (*Are You Living in a Computer Simulation?*), Nick Bostrom argues that provided one accepts a few basic assumptions, one must also accept that our Universe is almost certainly a *simulation*. I will show that *if* his argument is used to draw an epistemic claim, then it is reducible to absurdity; and *if* it is used to draw an ontological claim, then it relies on an unjustified – and implausible – presupposition. Lastly, a conceptual error within the arguments mathematical model will be uncovered. These considerations will show, and this paper will thus conclude, that the widely-supported *simulation argument* is false.

> *All of this [pointing to the stars] might just be an elaborate simulation running inside a little device sitting on someone's table.*
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> – Capt. Jean-Luc Picard (Patrick Stewart).

I. Introduction

Many believe that me, you, and our entire Universe – including every thought and experience – supervenes over some complex computer simulation. This hypothesis has been pondered by physicists for several decades, but has seen unprecedented interest following a recent development: the publication of Nick Bostrom's *simulation argument* (*SA*). A probabilistic analysis ratiocinated across many disciplines, and, in its reductionist form, amongst the general public as well. While its widespread recognition is partially due to pundits frequently voicing their support (e.g., Neil deGrasse Tyson, etc.), there is another reason behind *SA* garnering so much attention. That is, if sound, it derives a remarkable conclusion about the implementation of our Universe; and does so from rather simple empirical assumptions. It is rare to gain so much leverage out of a short philosophical argument.[120] Before explicating its reasoning, however, I must first explain what this project is *about*. I will show that – depending on how it is employed (epistemically or ontologically) – the simulation argument can be either reduced to *absurdity*, or shown to rely on an implausible presupposition. Moreover, I will also uncover a conceptual error within the argument's mathematical model.

To be clear, I will *not* show that the Universe is biological. Nor will I show that it has a significant probability of being so. I *will*, however, provide an explication of Bostrom's argument (and its implications) while calling attention to several flaws, each of which invalidate its conclusion. This, in turn, will undermine the leading justification for a non-biological Universe. So let us now consider the argument.

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[120] Nick Bostrom, *FAQ Section*, https://www.simulation-argument.com/faq.html.

II. The Simulation Argument (SA)

Most technologists believe that there will be enormous amounts of computational power available in the future. Enough to simulate the entire history of our Universe *many* times over. If this is correct, these future civilizations may run highly detailed simulations of their forbears (or people like their forebears), and because their computers would be so powerful, they could run a great number of simulations.[121]

Now consider that the forebears in these simulations are conscious like us. It would then follow that the vast majority of observers that will exist (with experiences like ours) will be simulated rather than biological. If this were the case, Bostrom (2003) argues that we would be rational to think that we are likely among the simulated minds rather than among the biological ones.

> If we don't think that we are currently living in a computer simulation, we are not entitled to believe that we will have descendants who will run lots of such simulations of their forebears.[122]

This is the gist of his argument; however, he offers a *formal version*, claiming that at least one of the following propositions is true:

1. The human species is very likely to go extinct before reaching a posthuman stage.[123]
2. Any posthuman civilization is extremely unlikely to run a significant number of simulations of their evolutionary history (or variations thereof).

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[121] Nick Bostrom, *Are we Living in a Computer Simulation?* (2003), p. 2.

[122] Bostrom, p. 2.

[123] A *posthuman stage* refers to a period of human evolution in which technological capabilities are vastly superior to what we (today) would consider 'human'. In this context, it denotes a period in which civilizations are capable of simulating vast numbers of conscious beings whose experiences are indiscernible from our own.

3. We are almost certainly living in a computer simulation.[124]

If this tripartite disjunction is true, one of its propositions *must* be true. To deny the first two propositions (*1* and *2*) is therefore to commit to the truth of the third (*3*). In other words, unless we are currently living in a simulation, the belief that there is a significant chance that our species will one day become posthumans who run ancestor-simulations is false.[125]

There are two assumptions needed to get this argument off the ground:

Assumption-A is common in the philosophy of mind; that is, the *substrate-independence thesis*. This asserts that "mental states can supervene on any of a broad class of physical substrates."[126] In other words, if a system implements the right sort of computational structures and processes, it can be associated with conscious experience. It is not an essential property of consciousness that it is implemented on carbon-based biological neural networks. This assumption is necessary for if consciousness relies on biological substrates, then it cannot be *simulated* (*1* would thus be true and *3* would be false). According to Bostrom, however, the substrate-independence thesis is widely accepted among cognitive scientists and philosophers of mind.

Assumption-B regards the technological limits of computation. Specifically, it is required that posthuman civilizations have enough available computing power to perform a sufficiently large number of simulations. Citing the work of several technologists and computer scientists, Bostrom considers $\sim 10^{33}$ - 10^{36} operations per second to be a fair estimate of the computational power necessary to perform a realistic simulation of the entire mental history of humankind. Then, citing the work of R.J. Bradbury, he notes that a computer

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[124] Bostrom, p. 1.

[125] Bostrom, p. 1.

[126] Bostrom, p. 3.

powered by a *Dyson sphere*[127] (with nanotechnological designs of the early 2000's) could perform an estimated 10^{42} operations per second. Given this, Bostrom thinks it is safe to assume that posthuman civilizations would have enough computing power to run an astronomical number of ancestor-simulations, even while using only a tiny fraction of their resources for that purpose.[128]

With these assumptions in mind, we can now get to the crux of Bostrom's argument. He makes use of some formal probability here, which I will reproduce verbatim before offering an alphabetic translation. Let us start by considering the following notation (Quoted directly from Bostrom, 2003):

f_P: Fraction of all human-level technological civilizations that survive to reach a posthuman stage.

$\overline{N}$: Average number of ancestor-simulations run by a posthuman civilization.

$\overline{H}$: Average number of individuals that have lived in a civilization before it reaches a posthuman stage.

The actual fraction of all observers with human-type experiences that live in simulations is then:

$$f_{sim} = \frac{f_P \overline{N} \overline{H}}{(f_P \overline{N} \overline{H}) + \overline{H}}$$

Writing f_I for the fraction of posthuman civilizations that are interested in running ancestor-simulations (or that contain at least some individuals who are interested in that and have sufficient resources to run a significant number of

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[127] A *Dyson sphere* is a hypothetical artificial structure capable of capturing large percentages of a star's power output.

[128] Bostrom, p. 7.

such simulations), and $\overline{N_I}$ for the average number of ancestor-simulations run by such interested civilizations, we have:

$$\overline{N} = f_I \overline{N_I}$$

And thus:

$$f_{sim} = \frac{f_P f_I \overline{N_I}}{(f_P f_I \overline{N_I}) + 1} \qquad (*)$$

Because of the immense computing power of posthuman civilizations, $\overline{N_I}$ is extremely large. By inspecting (*) we can then see that *at least one* of the following three propositions must be true:

(*1*) $f_P \approx 0$

(*2*) $f_I \approx 0$

(*3*) $f_{sim} \approx 1$

More generally, if we knew that a fraction *x* of all observers with human-type experiences live in simulations, and we don't have any information to indicate that our own particular experiences are any more or less likely than other human-type experiences to have been implemented *in vivo* rather than *in machina*, then our credence that we are in a simulation should equal *x*:

$$Cr(SIM \mid f_{sim} = x) = x \qquad (\#)^{129}$$

I will now offer an alphabetic translation of the probability theory just presented. Bostrom first estimates the fraction of all people in existence that are simulated (*fsim*). This is the expectation of the number of simulated people divided by the expectation of the number of simulated people plus the number of non-simulated people. Note, the expectation of the number of simulated people is equal to the probability of simulations being done times the average number of simulations that would be done (if simulations were done) times the average number of people in each simulation.[130]

Translating this fraction into slightly different notation, it follows that – because the number of simulations run by a civilization capable of running them would be very great (*Assumption-B*) – unless there is a very low fraction of simulations being done (practically null), then there is an extremely high fraction of simulated people in existence (practically unity).

From here, Bostrom makes an appeal to the *principle of bland indifference* – a non-informative prior adopted from Bayesian statistics.[131] Essentially, the principle (hereinafter referred to as PBI) states that if there are x possible outcomes and there is no reason to view one as being any more likely than another, then each should be assigned a probability of 1/x. For example, if we are flipping a fair coin, then the odds assigned to landing either side (heads vs. tails) should be 1/2. The principle of bland indifference holds. However, if we learn that the coin is weighted to land on heads, then the odds assigned should no longer be 1/2. The principle of bland indifference no longer holds.

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[129] Bostrom, p. 7-9.

[130] This paragraph has been (loosely) extracted from Brian Eggleston's *Review of Bostrom's Simulation Argument* (undated).

[131] A Bayesian *prior* is a probability distribution that would express one's beliefs about some quantity before some evidence is taken into account.

Applied to Bostrom's argument, PBI tells us that the probability of living in a simulated Universe instead of a biological one should be considered equal to the fraction already established (*fsim*). That is because, as it stands, we have no evidence to suggest that our own experiences are more or less likely than other human-type experiences to be biological rather than simulated.

Notice then, if future civilizations are expected to run a significant number of simulations (which would value the fraction of simulated people in existence [*fsim*] at almost unity), and PBI is applied, then the fraction that we ourselves live in a simulation is the same (almost unity). This demonstrates that one of two things must be true: *either we are living in a simulation, or our descendants will almost certainly never run a significant number of ancestor-simulations*.

II - i. Important Clarification

Explained just now is *the simulation argument* (*SA*), which suggests a direct relation between how likely it is that we (humans) will one day create ancestor-simulations, and how likely it is that we ourselves are in one. It also suggests an epistemic dependency between these propositions. That is, if it is *believed* that we will likely create ancestor-simulations, then it should also be *believed* that we are in one. Remember: *SA* suggests the existence of a relation between propositions, *not* that our Universe is simulated.

III. Objections

Almost all objections to the argument have attempted to refute its operative assumptions (e.g., the limitations of computational power, the substrate independence thesis, etc.).[132] Notice, however, these are not actually tackling the arguments logic. Which says *if* all stated assumptions are true *then* some fact

[132] A popular example of one such objection can be found in Jonathan Birch's *On the "Simulation Argument" and Selective Skepticism* (2013). Birch accuses Bostrom of being selectively skeptical by presupposing that we possess good evidence for claims about the physical limits of computation and yet lack good evidence for claims about our own physical constitution.

about the world is true.[133] It is a *conditional claim* which does not depend upon the assumptions actually being true, but what logically follows from their truth. It is an extremely persuasive argument (as it is yet to be refuted[134]); although in this section, I will refute it.

III – i. Conceptual Error

My first objection will display a conceptual error within Bostrom's probability theory. Let us start by reconsidering the following notation (quoted directly from Bostrom, 2003):

f_p: Fraction of all human-level technological civilizations that survive to reach a posthuman stage.

f_i: Fraction of posthuman civilizations that are interested in running ancestor-simulations (or that contain at least some individuals who are interested in that and have sufficient resources to run a significant number of such simulations).

$\overline{N_i}$: Average number of ancestor-simulations run by such interested civilizations.[135]

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[133] According to SA, we need *five* assumptions to derive this "fact about the world" (i.e., that we are almost certainly living in a simulation). They are (1) the substrate independence thesis, (2) adequately high levels of computational power available for posthuman civilizations, (3) ¬ ($f_p \approx 0$), and (4) ¬ ($f_i \approx 0$). Then there is also the weak assumption just discussed in *section 5.3.* (i.e., that the average number of people living in the pre-posthuman phase is not astronomically greater for non-simulating civilizations than for civilizations that end up running significant numbers of ancestor-simulations).

[134] Nick Bostrom. *Why Make a Matrix? And Why You Might be in One* (2005); Bostrom has also reaffirmed this claim in a recent interview.

[135] Bostrom (2003), p. 6.

Bostrom argues that the fraction of all observers with human-type experiences that live in simulations is:

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$$f_{sim} = \frac{f_P f_I \overline{N_I}}{(f_P f_I \overline{N_I}) + 1}$$

Notice, the product of f_P and f_I alone gives us the fraction of human-level technological civilizations that perform ancestor-simulations. Thus, if the value applied to $f_P f_I$ is say 1/50, it would follow that – in order for it to be most probable that a *single* ancestor-simulation is performed – there must be at least twenty-five other human-level technological civilizations in the Universe (including past, present, and future) aside from humans. But what if someone does not believe that there are? Well, because $\overline{N_I}$ would be very high, Bostrom's model above tells them that they must still believe – indeed, on the basis of epistemic consistency – that some civilization(s) will in fact perform ancestor-simulations. Clearly, this is a problem; there must be an error in the model.

To demonstrate, consider the following scenario. Some agent X believes that *humans are the only human-level technological civilization in the Universe (including past, present, and future)*. Such a belief may be motivated by theology, a desire for significance, or abstract reasoning (e.g., the Fermi paradox). Nevertheless, the cause of the belief is irrelevant.

It would then follow that, to calculate the odds that X must accept regarding *fsim*, such that he can avoid epistemic inconsistency, $f_P f_I$ cannot be *in* the fraction, as it is in Bostrom's model, but rather extracted (both from the numerator and the denominator) and used as an *upper bound* on the value of the remaining fraction.[137]

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[136] Bostrom (2003), p. 7.

[137] The remaining fraction would represent *fsim* assuming human-level technological civilizations become posthuman and are interested in running ancestor-simulations.

$f_P\ f_I$ must be multiplied by: $\overline{N_I}$ / ($\overline{N_I}$ + 1).

So in X's case, $Fsim = (f_P\ f_I) \times [\overline{N_I} / (\overline{N_I} + 1)]$

That is because, if X applies a probability of say 1/4 to $f_P\ f_I$, he is suggesting that the probability of any and all simulations existing can be no higher than twenty-five percent, given that $f_P\ f_I$ in his case, must apply to a *single* civilization. Within Bostrom's model, however, this is not respected. His model suggests that if X applies a value of 1/4 to $f_P\ f_I$, then (because $\overline{N_I}$ would be very high) X must believe that some number of simulated observers do in fact exist. Remember, however, an $f_P\ f_I$ value of 1/4 would not permit this belief for X, as it would suggest a majority probability (3/4) that *no* simulated observers exist, due to his anthropocentrism.

The core of the problem is that Bostrom's model *necessarily* considers all three variables (f_P, f_I, and $\overline{N_I}$) to carry equal weight in determining how many simulated observers exist. However, in X's case, they quite clearly do not, for $f_P\ f_I$ indicates the likelihood – supposed by X – of any and all simulations existing. So X's credence in *SIM* should be no higher than the value he applies to $f_P\ f_I$.

The modification I have put forth for X (i.e., extracting $f_P\ f_I$ and multiplying its value by the value of the *remaining fraction* $\{\overline{N_I} / [\overline{N_I} + 1]\}$) reflects this; for $\overline{N_I}$ then affects his credence in *SIM* only within the upper bound set by $f_P\ f_I$. Notice further, on this revised model, contrary to *SA*'s conclusion, X may apply a value of say 4/5 to $f_P\ f_I$, and thus *believe* (up to ~ 80% credence) that his descendants will perform a significant number of ancestor simulations ($\neg$ [*1* $\vee$ *2*]), without implying (*3*) that he himself almost certainly lives in a simulation. In other words, *while avoiding epistemic inconsistency, X*

may consider all three disjuncts to be false. Thus, so can we the simulation argument.

With that said, you may have noticed that X's belief is not *typical*. There is no appropriate definitive standard to believe that humans are technologically unique. Rather, varying beliefs will apply. So let us consider another variable, call it ₳, which respects this fact: ₳ symbolizes the *number* of human-level technological civilizations in the Universe (including past, present, and future).

Notice then, ₳($f_P\ f_I$) denotes the number of human-level technological civilizations in the Universe (including past, present, and future) that perform ancestor-simulations. Moreover, *iff* the value one applies to ₳($f_P\ f_I$) is less than 1, then this puts them in the same predicament that X was in (*see footnote*).[138] ₳($f_P\ f_I$) must then act as an upper bound on *fsim*.

₳($f_P\ f_I$) must likewise be multiplied by: $\overline{N_I}\ /\ (\overline{N_I} + 1)$.

$$Fsim\ =\ [\ ₳(f_P\ f_I)\ ]\ \times\ [\overline{N_I}\ /\ (\overline{N_I} + 1)\ ]$$ [139]

For if the value applied to ₳($f_P\ f_I$) is sufficiently low (e.g., 0.8), there can be no epistemic constraint to believe that the Universe is almost certainly a simulation – at least not on the basis of consistency – for one would have supposed a significant probability (1/5) that no such simulations exist. Notice, as well, that to establish a value of 0.8 for ₳($f_P\ f_I$), neither f_P nor f_I need to be ≈0 (practically null). For example, each could have a value of 1/20, with ₳ having a value of 320. Yet, nevertheless, it would still follow that *fsim* should not be ≈1.

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[138] For in X's case, ₳ = 1. So for him, $f_P\ f_I$ is equivalent to ₳($f_P\ f_I$).

[139] Of course, *fsim* should be calculated this way *iff* ₳($f_P\ f_I$) < 1. If not, Bostrom's model may suffice.

And so, *SA* is false. It is *not* true that one of the following propositions *must* be true:

(*1*) $f_p \approx 0$

(*2*) $f_i \approx 0$

(*3*) $f_{sim} \approx 1$

Once again, the problem is that Bostrom's model *necessarily* considers all three variables (f_p, f_i, and $\overline{N_i}$) to carry equal weight in determining how many simulated observers actually exist (without accounting for the *number* of human-level technological civilizations). However, when we account for the number of human-level technological civilizations (₳), we discover certain instances – where ₳(f_p f_i) < 1 – in which the three variables must *not* carry equal weight; f_p and f_i must instead carry more, working with ₳ to generate an upper bound on *fsim*.

With that said, one may respond by claiming that individuals should not trust their beliefs regarding ₳. For they would first need to estimate the probability of life emerging from non-life, which is *impossible* without a second example—aside from Earth.[140] By this logic, however, we should not trust *any* of our beliefs regarding the variables in *SA*, which indicates an even weightier problem. For if we shouldn't trust our beliefs regarding the variables in *SA* then, even if we believe that *1* and *2* are false, it's no longer clear why we actually *should* believe that *3* is true. Indeed, this becomes an intractable matter.

Before advancing, I must stress that the objection presented in this section (*6.1.*) can be offered as an aside. For *SA* may be refuted while *accepting* its mathematical model. This shall be revealed by the following two objections (*6.2.*, and *6.3.*).

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[140] See Paul Davies', *The Eerie Silence: Renewing Our Search for Alien Intelligence* (2010).

III – ii. Reductio ad Absurdum

The first of which is intended to refute Bostrom's epistemic claim (quoted directly from Bostrom, 2003):

> If we don't think that we are currently living in a computer simulation, we are not entitled to believe that we will have descendants who will run lots of such simulations of their forebears.[141]

The problem is that, when one believes that their descendants will create a *sufficient* (significantly large) number of simulations, Bostrom's claim above can be reduced to absurdity. For example, let us consider some agent, call her Z, who estimates – using Bostrom's probability theory – that the fraction of simulated people in existence ($fsim$) is a billion to one. Citing the principle of bland indifference (PBI), it is argued that Z should then take this fraction to represent the probability that she herself lives in a simulation.

Notice, however, that while Z cannot infer much information about her simulators, she can – per Bostrom's reasoning – infer that they are characteristic of her descendants, and that they have an ability, and will, to create many ancestor-simulations. It then follows that in *their* supposed reality (Z's simulators), the first two possibilities (*1* and *2*) of the tripartite disjunction are *necessarily* false. Therefore, if *SA* is valid, the third possibility (*3*) must be true. Another way of spelling this out is that, if faced with the logic of *SA*, assuming it is valid, Z's supposed simulators must accept that they are almost certainly living in a simulation. This, then, raises the question of whether Z should accept it too. I argue that she should, for she accepts Bostrom's reasoning, and that reasoning implies that her simulators – should they exist – are almost certainly living in a simulation.

From here, one may ask: what is the problem? We only seem to be bolstering the probability of *SIM* through postulating the existence of even more

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[141] Bostrom (2003), p. 1.

simulations (or a likelihood thereof). The problem, albeit subtle, is that the logic of *SA* can be applied not just to Z and her simulators, but to her simulators' simulators as well, and so on and so forth. This is *not* an infinite regress[142] for each parent simulation should be considered progressively less likely to exist. But each by no more than the diminution from Z to her simulators given that the evidence for their existence – 1 and 2 being *necessarily* false – is stronger. Notice then, the number of simulated Universes which Z should believe to exist is *excessively* high (i.e., billions progressively stacked over a similarly large number of generations). And indeed, this is where the contradiction lies. For Z must accept that all of these simulated Universes are being carried out on a *single* computer. However, any single computer – operated by the descendants of a human-level technological civilization – will likely be incapable of performing that many highly detailed simulations, even on the most generous of expectations.

For example, Seth Lloyd of MIT has argued that if every single elementary particle in the Universe were devoted to quantum computation, it would be able to perform 10^122 operations per second on 10^92 bits of information.[143] In a stacked simulation scenario, where only 10^6 simulations are progressively stacked, after only 16 generations, the number of simulations would exceed by a factor of 10^4 the total number of bits of information available for computation in the Universe.

Even intuitively, it's a strange leap: believing that the *sum* of posthuman civilizations will perform an aggregate one-billion simulations, should not support, much less mandate, on epistemic grounds, the belief that some *single* posthuman civilization will perform immensely more – far more than *possible* by all appearances – all on a *single* device.

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[142] See Aristotle's *Physics* (350 B.C.E).

[143] Seth Lloyd, *Programming the Universe* (2006).

The simulation argument is therefore incoherent. It can establish that one must believe they *might* be simulated – provided they reject disjuncts *1* and *2* – to avoid epistemic inconsistency. However, it is *absurd* to suggest that unless they are simulated, they are not entitled to believe that their descendants will run lots of such simulations themselves.

III – iii. Implausible Assumption

I will now shift focus. For *SA* seems to argue more than the *epistemic* claim just refuted; it also seems to put forth an *ontological* claim, entirely separate from belief.

> *If future civilizations are likely to perform a significant number of ancestor-simulations, then we ourselves are almost certainly living in a simulation*.

As I will show, however, this claim is highly problematic. To understand why, consider the following passage (quoted directly from Bostrom, 2003):

> If the computational cost of running even a single simulation is very great [and we are in a simulation] then we should expect our simulation to be terminated when we are about to become posthuman.[144]

This passage indicates a serious problem: *SA must assume that the type of simulations which are most likely to occur are those capable of performing nested simulations*.[145] Those with this capability will hereinafter be referred to as simulations*.

Allow me to explain. On any formulation of *SA*'s reasoning, to conclude that we almost certainly live in a simulation, there must be a prior premise stating that ancestor-simulations are likely to be performed in the future

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[144] Bostrom (2003), p. 7.

[145] A *nested simulation* is a simulation within a simulation.

(by at least some civilization[s] in the Universe). However, if the conclusion (i.e., that we almost certainly live in a simulation) is true, but it was not true that simulations* are the most likely form of simulation, then the prior premise (i.e., that ancestor-simulations are likely to be performed in the future) should be considered false. Notice then, in order for both the premise and the conclusion to be true, it must be *assumed* that the most likely form of simulations are simulations*. Otherwise, we could move from the premise to the conclusion only by contradicting the very premise – *the conclusion would contradict its own premise*.

I suspect that this assumption, now marked, will weaken the simulation arguments appeal. In fact, the assumption may be untenable; however, let us take a closer look at what might support it. The only means of justification, I presume, would adhere to Bostrom's method of extrapolating probabilities regarding our own reality. In other words, his argument must make the further assumption that if ancestor-simulations are performed by some civilization(s) in our reality, a significant number of them will be simulations*. A *significant number* being at least however many it takes to make simulations* the most common form of simulation.

With that said, I am not confident that drawing this further assumption would work, for we may become overly presumptuous in our extrapolations. Nevertheless, let us entertain the thought for a moment as it would weaken Bostrom's argument significantly. For instance, philosopher Alexander Pruss has noted that lower quality simulations would be easier to create than higher quality simulations. Another thinker, physicist Lorenzo Pieri, has called this the *simplicity assumption* (quoted directly from Pieri, 2021):

> If we randomly select the simulation of a civilization… the likelihood of picking a given simulation is inversely correlated to the computational complexity of the simulation.[146]

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[146] Lorenzo Pieri, *The Simplicity Assumption and Some Implications of the Simulation Argument for our Civilization* (2021), p. 3.

In proper fashion then, we should expect "most computer simulations to be… limited in scope."[147] As I have shown, however, *SA* relies on the *majority* of simulations having great scope (i.e., having the capability to sustain multiple levels). Indeed, this is a problem.

Even Bostrom himself acknowledges that "a consideration counting against the *multi-level hypothesis* [the existence of simulations*] is that the computational cost for the basement-level simulators would be very great."[148] Thus, by assuming not only that the multi-level hypothesis is true, but that it represents the *majority* of simulations that will be created, *SA* paints an implausible picture of the future.

IV. Conclusion

I must reiterate that nowhere in this work have I shown that *SIM* is false.[149] Nor have I shown a significant probability of it being so. I have shown, however, that *SA* is flawed; that it suffers from several inherent contradictions, as well as a conceptual error in its mathematical model. With that said, I am *not* disparaging the argument. It *is* incredibly powerful. Even though its conclusion (*1* ∨ *2* ∨ *3*) does not hold, it has influenced a vast range of academics – spanning many disciplines – to believe that our tangible Universe is in fact numerically structured, and composed entirely of information. A remarkable outcome for a short philosophical argument.

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[147] This quote can be found in a 2017 submission on Pruss's personal blog, titled: *Are we Living in a Computer Simulation?*

[148] Bostrom (2003), p. 7.

[149] Such an undertaking is likely *impossible* given that any evidence we receive in support of our universe being non-simulated could – in theory – be simulated.

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