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The Anthropocentrism of Intelligence: Rooted Assumptions that Hinder the Study of General Intelligence

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Abstract: We postulate that Artificial General Intelligence remains elusive because of numerous undisputed assumptions that are deeply rooted into the traditional understanding of intelligence. We claim that these assumptions shape an anthropocentric bias that prevents the development of a general theory of intelligence capable of explaining the behavior of not only human and machine intelligence, but also any other entity that exhibits intelligent behavior. The most important of these assumptions is the failure to recognize darwinian evolution as an intelligent entity despite the growing consensus about its superior capabilities to develop biological contrivances. In order to avoid underrating and neglecting evolution as intelligent, other assumptions must be dropped. Such is the case for the requirement of language, which is only relevant in social contexts. Moreover, the boundary of evolution as an agent distinguished from the environment is not well-defined, which suggests that agent boundaries are redundant in General Intelligence and results in an equal treatment of polymorphic robots and multi-agents, to name a few. By revealing these and other assumptions, we propose that human intelligence should be relieved from standing at the center of studies about General Intelligence.

1 Introduction

Artificial General Intelligence is a much pursued achievement since the birth of Artificial Intelligence in the mid 20th century. General Intelligence goes a step further by dealing with neuroscience and cognitive science as well. Despite all the efforts, there is no successful theory of intelligence that explains human intelligence nor any field that attains human-level intelligence. The reasons are many, and here we propose that the assumptions about what intelligence should be is hindering the research on what intelligence really is. We believe that this bias is an important factor in neglecting evidence that might hold the key to understand General Intelligence. A related bias might appear if we are confronted with an intelligent system and reject it if the intelligent processes do not match our expectations of elaborateness and intricacy.

On the other hand, it is generally accepted that human intelligence is the reference to study General Intelligence, yet this approach has only led to narrow intelligence. Artificial Intelligence is a fragmented field with many different subareas that have been developed independently [1]. Some researches attempt to combine several technologies [2, 3], but mostly are directed towards making different technologies work together rather than developing the common grounds of different approaches to Artificial Intelligence. General Intelligence requires all these subfields to be unified, or generalized, into a single framework that displays the advantages and disadvantages of these technologies with respect to each other. Likely, a combined approach that replicates the advantages of each technology, but not the disadvantages, would become a huge step towards General Intelligence.

Pfeifer and Scheier [4] gave a detailed account on behavior-based intelligence to argue for embodied intelligence. Langley [5] claimed that developing cognitive architectures is an important path to the development of generally intelligent systems. Laird & Wray [6] proposed a list of eight features that human-level intelligences should have. Pfeifer and Gomez [7] suggested the neccessity of interaction between the intelligent agent and a physical and social environment. Arakawa et al. [8] gave a broad overview of the current state of the art in Artificial General Intelligence. The common denominator is that all these researchers fol-

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low the *orthodox* view of intelligence, which suggests that human intelligence is the target to replicate, but does not question that human intelligence has evolved to accommodate to its environment and may not be the best ambassador of General Intelligence.

Objective

The objective of this paper is to study the obstacles that may hinder the study of General Intelligence by challenging the core assumptions that drive Artificial Intelligence. With that in mind, we do not intend to propose a theory of General Intelligence, but rather pave the way to facilitate the development of such a theory.

We hope that our viewpoint of Intelligence will help understand the fundaments of Intelligence by stripping away circumstantial features of human intelligence. In that respect, we see it as a particular realization of a theory of General Intelligence. These circumstantial features are easier to identify if we compare human intelligence with other systems that exhibit intelligent behavior. Specifically, we claim that darwinian evolution exhibits intelligent behavior and thus it must be considered an intelligent system. We will analyse human intelligence, darwinian evolution and artificial intelligence to find assumptions incompatible with any of these three systems and justify the rejection of those assumptions as part of a general theory of Intelligence, where possible.

2 Assumptions

We will start by defining intelligence and exploring the problems related to any definition of intelligence. Afterwards, we will show that some assumptions in Artificial Intelligence have not been properly justified and how they lead to revealing the rest of the assumptions. Most of these assumptions come from an anthropocentric view on intelligence that places representations of the world and speed at solving problems in the main focus of General Intelligence.

2.1 Intelligence requires a definition

Before delving into the intricacies of intelligence, we need to explain what exactly we are referring to. This is generally attained by an ambiguous definition of intelligence or by developing intelligence tests that measure some of the many abilities of human intellect, e.g. the g factor [9]. Legg & Hutter [10] collected and analysed numerous definitions of intelligence. The problem with these approaches is that once the definition of intelligence is set, we lose the capability to evaluate intelligence in a general way. In order to understand the problem, consider the following analogy. In quantum physics, quantum entities are described with wave functions. However, the complete state of a wave function cannot be directly measured because the measurement collapses the wave function into a particle. Similarly, the study of intelligence collapses into a biased view of intelligence as soon as it is defined, but the definition is still required for objective research.

This paper is no exception. We define intelligence as *fulfillment of goals*, deliberately leaving out any specification of goals. This way the definition only assumes intentionality of intelligence while remaining as general as possible, and without implying that this is the correct definition of intelligence. For example, problem solving is included in this definition by defining the goal as such. The risk of biased assumptions is still present though, since goals might also introduce tacit assumptions. Let us take a look into an example of an assumption in goals.

2.2 Efficiency is important

For the next assumption, let us take a look to our limitations. We live in a competitive environment with a limited lifespan, which means that efficiency and reliability to attain our goals is of utmost importance. If we were to consider only human-related goals, then being able to predict the future to better accomodate to it is important, but here we consider more general goals: goals that may or may not imply deadlines or resource scarcity.

Benchmarking

Consider two methods that we will call Faster and Slower. They are challenged with the same cognitive task and both solve the problem, yet Faster does it quicker. Does it mean Faster is more intelligent than Slower? Well, not necessarily. If we assign the goal to be to solve the cognitive task, then both methods are equally successful. Moreover, if the goal is to solve the cognitive task as fast as possible, then again both methods are successful because each methods arrives at the solution as fast as they can possibly be. It is only when the goal is specified such as solve the problem faster than Slower that Faster fulfils the goal but Slower fails because it cannot be faster than itself. Thus, claming that Faster is more intelligent than Slower implies a goal that compares both Faster and Slower.

Substrate

Human intelligence and artificial intelligence are supported by different physical substrates with very different characteristics. This is directly related to, for example, the speed of cognitive processing. Whereas the frequency of neuronal interspike intervals (ISI) go up to 10KHz [11], modern processors achieve easily 4GHz. This rises the question of whether even slower intelligent entitities, yet even more parallel in nature than the human brain, exist or are even possible. We believe this question to be positive: evolutionary processes rely on approximately $5 \cdot 10^{30}$ prokaryote cells [12].

Accepting this generalization of processing speeds in intelligence is crucial to understand the next assumption.

2.3 Evolution is not intelligent

Darwinian evolution is increasingly regarded as intelligent in the scientific community. Here we support this view, but first we justify that avoiding mistakes is not necessary for General Intelligence.

Aversion to mistakes

Mistake avoidance is another assumption commonly found implicitly in the definition of goals. Mistakes are associated to wasting resources, such that it is undesirable to have a system that makes mistakes. However, a more general view on intelligence is to allow for systems that make mistakes and waste resources, as long as the goal is fulfilled. If mistake avoidance is necessary, then it should be explicitly stated in the goal. For example, scientific research often implies a large number of experimentation, trial and error. Upon interesting results, previous mistakes no longer weigh with the importance of the discovery.

Darwinian evolution is a process that continually makes replication mistakes, yet the genetic code continues to evolve successfully. As opposed to human intelligence, which has a limited lifespan and a limited patience, evolution does not have deadlines nor needs to save resources by avoiding mistakes. As long as there are no constraints or conflicting goals related to repeatability or resource limits, making mistakes is not relevant for attaining goals. Consequently, mistakes should not factor into General Intelligence.

Free will

Our next step is to make similarities between darwinian evolution and human intelligence to strengthen our thesis on General Intelligence. We now show that human free will, as theorized with two-stage models, has strong similarities to natural selection, and by doing so we conclude that either human free will does not follow a two stage model or that evolution is endowed with free will similar to that of human intellect. Let us show evidence against the former and evidence in support of the latter.

James [13] proposed a two stage model of free will where choice is preceded by the production of alternatives to choose from. This model has become a reference position in free will, with many other authors revolving around the idea of conceiving alternatives and choosing among them. Many authors have proposed similar two stage models for free will [14] after James, and are all related to the process of *chance* and *choice*.

Interestingly, darwinian evolution also follows a two stage model. Mayr [15] claimed that evolution is a two-step process that involves the production of new individuals followed by the selection of the next generation. Genetic algorithms replicate natural evolution by assigning random mutations to a population of candidate solutions followed by the selection of the more successful ones. This similarity between free will and evolution suggests that evolution is endowed with free will, as would be expected from intelligent systems.

More recently, Simonton [16] suggested a relation between free will and creativity in his review of advances in two-stage theories of creative problem solving that consist of blind variation followed by selective retention. Creativity in biology is certainly present, whilst genetic algorithms, which imitate the processes of darwinian evolution, have been found to be more creative than original thought by providing unexpected and impredictable solutions to the problems they are confronted to, sometimes taking advantage of unknown bugs in simulation software [17].

In view of these arguments, human intelligence and darwinian evolution appear to be deeply related by two stage models.

Reinterpreting evolution

There are many more examples that defend that evolution is intelligent. The products of darwinian evolution have been explained throughout history by recurring to an intelligent entity as Hume [18] described in the *Argument from Design* on behalf of the philosopher Cleanthes. Additionally, Orgel [19] asserted that *evolution is cleverer* than you are in his two Rules of Orgel. Lately, Fogel [20] argued that evolution accomplishes learning by *some form of random search and the retention of these "ideas"* in the genetic code and wrote that *intelligence is not the end result of evolution; rather, it is woven into the process itself.*

There is enough evidence for regarding evolution as intelligence that it becomes difficult to reject it as a realization of General Intelligence. More importantly, if evolution is reinterpreted as intelligent, General Intelligence already has at its disposal the mechanisms that drive darwinian evolution in the form of biology. General Intelligence then becomes a matter of reconciling evolution and human intellect (and possibly Artificial Intelligence too) under a single framework, *e.g.* [21].

2.4 Intelligence runs on models

The requirement of models for intelligence is one of the most undisputed assumptions in artificial intelligence. Models are convenient to make representations of the world and speed up the process of finding the correct path to a goal by avoiding mistakes and reducing the resources required. Planning, reasoning, language, knowledge representation, etc. are all abilities that require the use of models. However, this requirement poses too many restrictions on which systems are allowed to be intelligent. As we have seen previously, it is possible to achieve goals without efficiency as long as efficiency is not part of the goal. Moreover, darwinian evolution is capable of intelligent design without the need of models. The conclusion is that intelligent systems capable of handling representations of the world are only a subset of all systems capable of showing purposeful behavior.

Human intelligence does have some limitations derived from the use of models. Complex systems, chaotic systems and basically any phenomenon that cannot be decomposed in smaller parts for cognitive processing are outside the limits of human understanding. We are referring to complex systems, chaotic systems, and all those systems whose internal entanglement is so strong that cannot be conceived as interrelated independent subsystems. Typically, these phenomena are treated like black boxes where features such as intelligence is said to emerge somehow, avoiding the need to justify the mechanisms further.

In contrast, darwinian evolution does not have these limitations. Life is indeed a complex system of biochemical processes where small variations can affect many biological processes simultaneously, but that does not stop evolution from improving life.

2.5 Intelligence emerges from agents

There is an important difference between human intelligence and evolution that reveals yet another rooted assumption. As opposed to human intelligence, the processes that drive evolution are not tied to physical substrates, i.e. neither mutations nor natural selection can be attributed to any embodied process. There are also some situations in cognitive robotics where the boundary of the agent is ambiguous and subjective: polymorphic robots, swarm intelligence, chaotic systems, damaged robots, etc. Our understanding of General Intelligence is that it should cope with all these situations under a single framework.

We propose to remove any agent boundaries and treat agent and environment as a single indivisible unit when it comes to evaluate intelligence. This way, a system is not intelligent by itself, but by all the interactions of the system with itself and with the environment. For example, emergent intelligence and synergetic systems are better understood by considering the whole, rather than the parts. Not only does this method remove the necessity of defining agent boundaries, thus removing ambiguities, but it also supports swarm intelligence, embodied cognition and evolutionary processes under a single framework.

2.6 Language is necessary

For the final assumption, we rely on the previous ones to suggests that natural language stands as a pillar of General Intelligence because of the over-importance that human intelligence receives. Again, once we accept that human intelligence does not have exclusivity over General Intelligence, the relevance of natural language lessens. Indeed, natural language is necessary in social contexts to understand the state and intentions of other people and it is based on assigning meaning to representations of the world. As was shown in previous sections, not only the use of models and representations is not required for General Intelligence, but human intelligence is not necessarily the best realization to imitate. Furthermore, if we consider agents and environment as a single undivisible unit, natural language falls back to a complex way of transmitting representations between internal components of that single unit, in the same way that other communication events not involving natural language function. From computer systems using bitstreams, to biology by means of hormones, neurotransmitters and other molecules, there is a pletora of systems transmitting information. These transmissions may also be regarded as transmitting representations and meaning.

This perspective unifies communication events whether they use natural language or not, such as non-verbal communication, which also conveys states of others, and data transfer between computers. The bottom line is that language in any form enables internal components of a system to collaborate and attain common goals that otherwise would be imposible to reach. These communication events ought to support intelligence in any form, including intelligent entities that do not make use of internal representations.

3 Discussion

This paper challenges some rooted assumptions in the study of Intelligence that are barely questioned in the scientific community:

1. Intelligence cannot be defined, but it requires a definition to discuss it.

2. Efficiency in speed and optimization of resource utilization are dispensable in General Intelligence. Rather, they are assumed in the definition of the goals.

3. Darwinian evolution is an intelligent entity. We ought to learn from evolutionary processes and generalize human intelligence and evolution into a single theory of Intelligence.

4. Models and representations of the world are an alternative approach to solve problems, but not a universal method to solve all goals.

5. The distinction between agent and environment is an adequate feature for human intelligence, but not necessarily a general feature.

The key to advance in General Intelligence is to understand that the scientific community assigns human intelligence a central role for General Intelligence and that the capabilities of evolution are underrated. We need to revise the requirements for General Intelligence to avoid relying too much on human intelligence, because it may be diverting research efforts from an underlying theory of General Intelligence.

In analogy with the scientific revolution that took place in astronomy when the geocentric model was replaced by the Copernican heliocentrism [22, spec. ch. 8], General Intelligence needs a change of paradigm from an anthropocentric model to a more integrative model that does not underrate darwinian evolution. A change of paradigm is justifiable because of the long history of failures at achieving General Intelligence in Artificial Intelligence. It is time we start rethinking our view on intelligence, even if that means that we walk away from the intuitive understanding of intelligence. As much as other sciences have proven that many advancements come from counterintuitive ideas, Artificial Intelligence still remains at its infancy with a deep anthropocentric bias. Our mental abilities seem to be modeled after the environment we live in and the phenomena we are exposed to. This makes convenient to think about separating the environment in different entities, including ourselves and other agents, but is not necessarily adapted to strictly follow the directions of a plausible theory of General Intelligence. Our stake is that human optimizations for dealing with the environment makes for a too complex realization of General Intelligence to study it as a canonical representative.

We have a great opportunity to boost General Intelligence if we credit evolution with intelligence because of the simplicity of the process, based on random mutations and natural selection. This simplicity is much explained by the lack of models, which does not impede evolution to reach complex goals.

An important criticism to this paper is that acceptance of the assumptions presented requires having an already biased view towards regarding evolution as intelligent. Also, there are many areas that we have not tackled. Consciousness and human intelligence are intertwined, but it is not known if consciousness is necessary for General Intelligence, which in that case evolution might be related to consciousness as well.

We hope that our perspective in General Intelligence will help broaden the view on Intelligence.

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