

Applications for General Collective Intelligence

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Abstract

General Collective Intelligence or GCI has been described as a system that organizes groups into a single collective intelligence with the potential for vastly greater general problem-solving ability than any individual in the group. This paper explores examples of the classes of problems for which GCI might be required to solve them.

Introduction

Models for the cognitive computing approaches (Artificial General Intelligence and General Collective Intelligence) discussed in this paper have recently been developed from a functional point of view. To the author's knowledge, no work other than that of the author has defined functional models for cognitive computation that are complete in the sense of having the potential to represent all the functions required for human-like general problem-solving ability. Because this approach and its application are so new, there is no other work available to cite. So by necessity the examples discussed in this paper refer overwhelmingly to the author's own work.

Background

From the functional modeling perspective, all living organisms operate in some hierarchy of functional domains, each with its own functional state space (space defined by the states that can be accessed through the set of functions available to them). From this perspective, general problem-solving ability in any of the organism's functional domains is the ability to navigate the functional state space of that domain in response to any general problem posed by the environment. One of these functional domains is cognition, which is defined to have a "conceptual space" as its functional state space. What is commonly recognized as human intelligence is from this functional perspective described as a human-like level of general problem-solving ability in the domain of concepts (i.e. the potential ability to navigate the conceptual space from any general problem to its solution). The distinction of being "human-like" is critical because from the functional perspective human intelligence is a well-defined phase change from animal intelligence [1].

Defining General Problem-Solving Ability and Solvability of Problems

From this functional perspective, General Collective Intelligence or GCI is to collections of humans what human intelligence is to a human as a collection of cells. That is, GCI is a system that organizes individuals to have the potential for vastly greater general problem-solving ability (intelligence), than any individual. GCI is a well-defined phase change from human intelligence [1]. From this functional perspective, a problem is a gap between two points in the conceptual space. A solution is a set of reasoning or understanding processes that form a path connecting those two points, and intelligence is proportional to the volume of conceptual space the cognitive system can search per unit time for a solution to any general problem. The level of General Collective Intelligence is the volume of the collective conceptual space that the collective cognition (GCI) can search per unit time.

From the functional modeling perspective, systems are defined as having a set of functions through which they change their state. Through execution of these functions, the system moves through a "functional state space". Any problem of understanding the behavior of that system then becomes the

problem of how to navigate from one point in functional state space to another. And any solution is the set of functions that provide that path. This solution might involve not only those set of functions, but functions defined by interactions between those functions. That is, it might involve not only a function F_A followed by a function F_B , but also a first order interaction $F_1(F_A, F_B)$, a second order interaction $F_2(F_1, F_1')$ between first order interactions, or it might involve higher interactions. As mentioned, in the cognitive system, the functional state space is the “conceptual space”. When the order of interactions between cognitive functions that is required to define two points in conceptual space (i.e. required to define a problem), or that is required to define a path through conceptual space (i.e. required to define a solution) is sufficiently high that those interactions cannot be found (i.e. are no longer understandable within any individual human cognition), those interactions have been described as “higher order” (too complex) [1]. Since the number of relationships between concepts that must be navigated to define a concept is related to the size (resolution) of a concept in conceptual space, then visually, the limits to complexity are represented in conceptual space as the minimum resolvable volume for any concept, and the minimum resolvable distance between concepts. Problems that are higher order (too complex) for any system of cognition require a different system of cognition. In the case that problems cannot be solved by any individual human cognition that different system might be a system of individual cognition such as AGI, or a system of collective cognition such as GCI.

In addition to the problem of scaling ability to navigate cognitive complexity, there is the problem of scaling the size of the cognitive space itself. Because a problem cannot be solved if either the initial concept or the final concept falls outside the conceptual space of the cognitive system. Assuming that each reasoning or understanding process is a separate functional component, then scaling the conceptual space so that problems become solvable requires scaling the ability to orchestrate cooperation between these cognitive components. The problem of scaling the size of the cognitive space is then a problem of scaling capacity to orchestrate cooperation within the system of cognition.

In the face of these limits to cognition (complexity, and cooperation) the simple analogy between individual cognition being to cells what collective cognition is to individuals, then allows an intuitive understanding of the problems GCI might solve that any individual cannot solve. Considering only problems of cognition (problems addressed through reasoning or understanding processes consciously executed as a result of cognition):

Problems Not Solvable by Individual Cells (Without Human-Level Cognition)

The problem of complexity: individual cells cannot execute functions involving an interaction between one cell’s functions and another independent cell’s functions (higher order functions). For example, without cognition an organism cannot execute any conscious physical activity since it requires directing a complex interaction of cells within muscle groups. Any mental activity (act of cognition) requires a complex interaction between groups of neurons. In addition to cognition, human-level cognition is required to navigate any problems requiring the ability to potentially abstract any general solution to apply to any general problem.

Generalization to Problems Not Solvable by Individuals Without GCI

Without GCI the level of complexity that can be navigated by any individual or group is limited to those problems not requiring the ability to abstract any concepts defined by any individual, so that it is possible to abstract any general solution discovered by any individual to apply to the abstraction of any general problem. In other words, where an individual cognition deals with abstractions, a GCI must also deal with abstractions of abstractions. Individuals or groups of individuals without GCI cannot solve problems of higher-order complexity than individual human cognition can reliably navigate (e.g. reusing abstractions of all sustainability processes to achieve sustainable design and manufacturing, or reusing abstractions of all scientific concepts to achieve

The problem of scaling cooperation: cannot coordinate the massive cooperation between functional components that implement each element of reasoning or understanding without cognition. The scale of reasoning or understanding processes that can be involved in reasoning or understanding is limited by the size of the conceptual space, which limits the number of unique paths that can be navigated. This limit to the paths cognition can trace without repeating the same paths in turn limits the ability to sustain reasoning or understanding. Without human-level cognition, problems are limited to those not requiring the ability to sustain reasoning or understanding to the point at which it is possible to execute a sufficient number of such processes to abstract any general solution to apply to any general problem. Scaling cooperation scales sustainability. Where forty trillion individual single-celled organisms might compete for food until they died, the estimated forty trillion cells in an individual human might engage in cognition-drive cooperation to find or create sources of food, thereby using the value of cooperation to become more self-sustaining.

convergence in science).

Without collective cognition (GCI), problems are limited to those not requiring the ability to sustain reasoning or understanding to the point at which it is possible to execute a sufficient number of such processes to abstract all concepts defined by any individual, so that it is possible to abstract any general solution to apply to any general problem. Where the value of cooperation is positive, scaling cooperation to the point that cooperation reliably becomes self-sustaining is achievable (e.g. the collective intelligence based program to accelerate achievement of the sustainable development goals, which aims to make development sustainably self-funding at the scale required to be globally transformative).

Table 1: Understanding the problems that can't be solved by GCI through analogy.

A GCI defines functional models of problems and solutions so they can be decomposed into functional components and interfaces between those functional components that remove the need for an individual implementing one component within a specific domain of expertise to understand another component being implemented by another individual with a different set of expertise. The GCI functionality, including the ability to assess relative fitness of components in achieving a given function, and adaptive problem-solving, orchestrates the group's effort in self-assembling solutions.

Because no individual in the group can know all the options available to all participants, the collective understanding of the problem or the collective solution that might self-assemble is unknowable by any individual. Because the GCI provides the ability to predict fitness at achieving any outcome, this solution might involve not only functions of those functional components, but functions defined by interactions with those functions. That is, it might involve second order or higher interactions. When the order of these interactions is sufficiently high that those interactions are no longer understandable within any individual human cognition, those interactions have been described as "higher order"[1]. GCI is suggested to provide the ability to reliably navigate higher order processes, and therefore to have the ability to define higher order problems, and to discover higher order solutions. Without this ability, by definition groups cannot resolve higher order problems or solutions, and in those cases are likely to be solving the wrong problem with the wrong solution.

Problems Requiring GCI in Order to be Solvable

In this representation of "cognitive computing" data is modeled semantically so the "meaning" in the data can be understood by an Artificial General Intelligence based cognitive computing platform. This in turn can enable such a platform to intelligently execute any available applications in a way that optimizes outcomes for the user. GCI is a type of "collective cognitive computing" platform that orchestrates cooperation between individuals, or individuals represented by AGI based intelligent agents. This cooperation is used to adaptively learn which application processes are most fit in achieving targeted outcomes in each context, over all possible instances of individual use. And scaling this cooperation is used to gain the ability to significantly increase the speed and scale at which collective processes can be executed. Through doing so, GCI can significantly increase collective outcomes.

Computable problems are those that can be solved by deterministic algorithms. Any well-defined reasoning process can be automated, that is, can be represented by such an algorithm. Computable problems can be addressed by conventional computing methods as well as by cognitive computing. From the Human-Centric Functional Modeling point of view, intelligence involves a cognitive awareness process that provides the potential ability to navigate all possible reasoning processes. Where cognitive computing differs from conventional computing is that this cognitive awareness process also provides the ability to solve uncomputable problems through awareness of what the solutions can be observed to be. In the human mind, detecting solutions by observing past patterns is type 1 (fast) or intuitive reasoning, whereas computing solutions using methodical processes is type 2 (slow) or rational methodical reasoning. The cognitive awareness process combines both types of reasoning processes into a library that it can use to increase its general problem-solving ability [12].

General problem-solving ability is then needed for any problems in which some degree of unpredictability results in solutions being computable only part of the time. General problem-solving ability might also be the most sustainable way to solve problems given finite resources. Even if the solution to a problem is computable, a given computing system might not have the resources to execute any specific computational algorithm. In that case, the solution is effectively uncomputable. However, if the system has general problem-solving ability, it can simply choose another algorithm that can compute some answer within the computational resources available. That system might not be able to determine the exact answer, but can compute some answer that is more correct than the current state of not having provided any answer at all. It's important to note that from the HCFM point of view, general problem-solving ability is the potential ability to navigate the entire conceptual space from any general problem to any general solution. Every living animal is an adaptive problem-solving system within one or more adaptive domains. General problem-solving ability is adaptive problem-solving in the cognitive domain. Human-like general problem-solving ability has been suggested to have specific well-defined properties [1]. But the resources for human-like general problem-solving ability are not necessary for all problems. An ant, for example, might not have sufficient intelligence to play chess, but it solves some general problems like finding food quite efficiently. From the HCFM point of view, the types of problems that a given cognitive system can solve are well-defined [1].

Not all problems require the adaptive problem-solving ability of GCI. For many problems, simple computation is sufficient. As a specific example, where the term "cognitive radio" describes a system that automatically adapts to use the best available band for communication, cognitive computing based on GCI might address any problem of communication whatsoever. In a GCI orchestrated process to define communication mechanisms, intelligent agents based on some subset of AGI might work behalf of each user to negotiate the best available physical connection, electromagnetic spectrum, protocol at each protocol layer, network topology, and every other function of Internetworking and telecommunication. And GCI might orchestrate that cooperation to adaptively learn which

implementation of each function is most fit in each context from all possible occurrences of Internet and telecommunication use [13]. The usefulness of doing so would be expected to be the capacity to sustainably increased impact on all collective problems related to communication, like the problem of achieving increased sustainability across the entire telecommunications product life-cycle, the problem of achieving an increase in affordable access to communication, and the problem of achieving an increase in quality of communication at each level of affordability.

A recent paper attempts to define a methodology for systematically enumerating opportunities to deploy GCI based solutions [2]. Some key examples are briefly summarized here.

Design

In design, GCI based design processes are intended to replicate the capacity of nature's evolutionary design process to navigate a vast potential design configuration space, creating the potential to self-assemble structures with levels of complexity not achievable by humans today [3]. Designing any physical or virtual entity in terms of functional models permits design processes in which the GCI varies the functionality in each functional component, as well as varying the interfaces to that functionality, and then allowing individuals in the collective to implement those designs so that the collective can explore all possible design configurations and reliably adapt to utilize the best design components created by any individuals in the group. Currently human design processes can only solve problems their designers can understand, and can only do so with solutions their designers are able to discover. There a wide range of cases in which defining problems in particular ways is impossible for groups without GCI, and why for this reason, regions of the problem space are inaccessible. These reasons might be complexity, lack of alignment with the interests of key decision-makers [4], or other.

These problems all have proposed solutions, and these solutions are built into GCI. GCI based design processes can potentially define problems that can't otherwise be defined, or in other words access regions of the problem space that are otherwise inaccessible. And GCI based design processes can potentially discover solutions that otherwise can't be discovered, or in other words access otherwise inaccessible regions of design configuration space. Of course, using such a design process would be expected to require vastly greater general problem-solving ability to navigate the resulting complexity.

A specific GCI based smart sustainable housing program (“Design for Change Nairobi”) has been proposed as part of a larger collective intelligence based program to accelerate achievement of the sustainable development goals [5].

Manufacturing

In manufacturing, GCI based manufacturing processes are intended to replicate nature's ability to create sustainable manufacturing processes, and to create chains of cooperation that replicate nature's ability to create entire ecosystems within which the manufacture of a system (in nature's case a living organism) is self-sustaining [6], [7].

Healthcare

In healthcare, GCI has the potential to significantly increase access to affordable healthcare, and to significantly improve healthcare at any given level of affordability. A conceptual case suggests that one proposed GCI based healthcare program has the potential to lower healthcare costs sufficiently in countries with private healthcare, that the saving alone might be reliably pay for universal health coverage for those without [5].

Physics, Mathematics, and Other Sciences

In physics and mathematics, the functional modeling approach has been used in the attempt to define functional models of fundamental theories [8], to explore how GCI can be used to remove the barriers against testing all components of all physical theories against all available data, so that the most fit components can be determined in each context. In the current paradigm (without GCI), unconventional scientific theories without sufficient mind share might simply be ignored rather than reliably being assessed. While the common perception is that science follows a rigorous scientific method, what commonly escapes notice is that many constraints prevent this rigor from being evenly applied.

As theories become more complex, as they cross more disciplines, communication of those ideas becomes more difficult and unreliable. Without GCI groups might even collectively lack the capacity to recognize the opportunity to make truly revolutionary impact. A complex concept that has revolutionary implications in every field of science can often be simplified to the point that it can be reliably understood. But no reliable mechanism for sharing simplifying generalizations between the scientists or other thought leaders currently exists. Instead there are a growing number of scientific journals in each field that require a high degree of specialization. For a theory to be acknowledged as having profoundly transformative impact that crosses a wide range of different disciplines, experts in those disciplines will have to agree. But as the number of such experts that needs to be convinced rises, at some point it is outside the capacity of any individual human intelligence to communicate to all the people in all those different disciplines at a sufficient level of specificity and expertise to be published in those journals and so to convince those experts. In other words, when ideas are sufficiently revolutionary, groups currently lack the collective intelligence to reliably recognize them as such.

Implementing Artificial Intelligence

A model of Artificial General Intelligence or AGI has recently been defined [9] using this functional approach. Semantic modeling of concepts has been suggested to be required to achieve human-like general problem-solving ability. Because semantic modeling of concepts is required in order for an AGI to understand and reason with such concepts, because in the absence of AGI that modeling may have to be done manually, and because of the sheer magnitude of this modeling, GCI has been predicted to be required to actually implement the proposed model of AGI [10]. For this reason, and because GCI is expected to be required in order to make AGI safe, despite the ground-breaking importance of AGI, GCI has been suggested to be far more important [11]

Conclusions

GCI has been suggested to have the potential to drive an exponential increase in general problem-solving ability. According to the model of GCI discussed in this paper this exponential increase has never been possible before in the history of civilization. In every field of academic study, in every area of public policy, the effect of an exponential increase in ability to impact problems demands to be explored. The model of cognition described in this paper defines an objective approach to determining whether a problem is solvable within the power of individual human cognition and therefore where this exponential increase in general problem-solving ability is needed. In any problem domain, it's important to understand when a problem is solvable, but not reliably solvable with the tools available. In this case, it's important to understand when a problem is not reliably solvable within the power of any individual human cognition, and where GCI is therefore required. This understanding can potentially help conquer the cognitive bias of smart people with knowledge and cognitive abilities they are convinced can solve any problem. It might also help overcome ideologues with beliefs they are convinced can solve any problem. That is, those with the belief that "the problem of [insert problem] could be solved if everyone would just [insert belief]". Given that some of the collective challenges that are proposed to be of higher-order complexity and therefore not reliably solvable with current approaches are those like poverty that involve human suffering, there might be good cause to set aside

any ego that might drive such conviction of one's intelligence, or the emotion that might drive such conviction of one's ideology. Replacement with wisdom and humility might lead to consideration of whether some approach outside current capabilities (like GCI) might be required.

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