# Algorithmic pragmatism: First steps

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***Abstract*—Algorithmic interventions (the intricate, dynamic arrangements of people and code deployed to address everyday life problems) benefit society. However, they are also responsible for many complex social, economic, and political harms. Unfortunately, there is an epistemological gap in computer science. Computer science lacks the language, the knowledge, and the methods for dealing with how to make algorithms' stakeholders responsible, accountable, and liable for their outcomes' effects, impacts, and consequences. Our research focuses on seizing pragmatism philosophy and linguistic pragmatics to reform computer science epistemology, expanding SDLC (system development life cycle framework) based on clinical pragmatics. We support reform to SDLC to help diminish algorithmic interventions' adverse effects by design or, at least, to assign stakeholders' duties for every algorithmic intervention in society. The algorithmic pragmatism conceptual framework presented could be taught in schools and universities and be used to public regulate and judge algorithmic interventions. Overall, we aim to design means of thinking about computer systems and algorithms to fill the computer science epistemology gap related to the impacts and consequences of algorithmic interventions.**

***Keywords— algorithms, science, technology and society, STS, innovation, software, epistemology, pragmatism, pragmatics, accountability, ethics, liability, regulation, law, theory.***

## I. Introduction: Computer Systems, Algorithmic Interventions, and Responsible Innovation

The rapid adoption of computer systems, algorithms, and the digitalization of many dimensions of society suggests that algorithms interventions are integrated into everyday life, in many forms of decision-making, with significant social, political, and economic impacts (some of which are not always positive) [1] [2]. An essential challenge in assessing the implications of everyday life algorithmic interventions is their inherent Opacity [3] and Black box [4] characteristics, for instance, meaning it is difficult to look 'inside' those systems and understand how they truly work [5]. Attempts to make algorithms open to question have led to the development of ideas that resonate with ethical and human values [6], such as Fairness [7], accountability [8], transparency [9], openness [10], ethics [11].

Unfortunately, the current education of computer scientists or engineering methods used to develop systems offer little foundation, or even a language, to answer the following central question: How should computer science acknowledge, reason about, and evaluate algorithmic interventions' aspects, context, and impacts in contemporary society? It denotes a particular epistemology gap in the underpinnings of computer science – as noted by Green and Viljoen (2020), stating, "computer science epistemology lacks language and methods to deal with algorithmic interventions and their negative impacts, whenever they do happen" [12].

There are few efforts for bridging this epistemological gap in computer science. One notable comes from Green and Viljoen (2020), which propose "algorithmic realism" as a conceptual framework. Their work starts from suitable premises and discusses important epistemological issues, but we have identified some misunderstandings in their proposition related to scope, foundation, and terminology.

In this essay, our work aims to bring in both computer science and humanity voices to fulfill society's expectations for responsible innovations related to algorithmic interventions. Our approach offers a conceptual framework inspired by pragmatism philosophy [13], linguistic pragmatics [14], and based on clinical pragmatics [15]. Such an approach generates the following four preliminary foundational principles: 'Algorithm's oneness, in action, working in a specific context, and under a justified act.' We seek to raise reflections to help implement reform on how computer science SDLC should be taught in schools and universities [16] and how algorithmic interventions should be publicly regulated [17] and judged by the courts.

This essay presents our research with a preliminary methodology to reform the computer science epistemology gap between its technical performance and societal impacts. The challenge is how computer science accounts for negative social, political, and economic consequences to achieve its aims more responsibly [18]. Knowing all we know about algorithms negative impacts to people, groups, and communities, it is clear from our work that computer science should stop excuse itself by saying, "I know not what I have done."

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## II. Context: An Epistemology Gap in Computer Science

Epistemology is the branch of philosophy concerned with knowledge. Epistemologists study the nature of knowledge, epistemic justification, the rationality of belief, and various related issues [19]. Computer science has an epistemological gap because it lacks the language and methods to acknowledge, reason about, and evaluate algorithmic interventions—their aspects, context, and impacts in society [12].

Computer science leads the development of algorithms [20] and computer systems [21] used in business [22], courts [23], city governments [24], hospitals [25], schools [26], and other essential societal institutions [27] [28]. However, many of those well-intentioned applications of algorithms and computers have led to negativity. Starting now, we discuss computer science epistemology problems to enlighten the debate and find a new basis for facing the field's social, political, moral, and ethical challenges.

Historically, computer science epistemology studies [29] have focused on technical problems associated with computer systems design, specification, programming, implementation, verification, deployment, testing, and maintenance (altogether, referred to as SDLC, meaning 'system development life cycle framework' [30]). Traditionally, computer science languages and methods focus on making computational systems more accurate, efficient, and protected, amongst other technical characteristics, all restricted to the technical realm [12]—such a technical perspective is needed, but it is not enough. It falls short in understanding and discussing algorithmic interventions, their negative impacts, and harmful consequences to contemporary society. A non-technical approach is missing, and that is precisely the epistemological gap in computer science we are pointing at and addressing in this essay.

Computer science needs new language and methods to open algorithms and computer systems to question by raising human, social, and ethical issues [11] (alongside technical responsibilities [31], indeed). Many choices in SDLC are essentially non-technical and, under closer scrutiny, reveal systematic social and racial biases that run through the programming that often runs through how programming is done. An example of ethical, social, political, and moral dilemmas is Nexa Technologies' involvement with the authoritarian regimes in Libya and Egypt. The company has had four former executives indicted over accusations of supplying these countries with software and tools eventually used for the invasive surveillance, and sometimes kidnap, murder, and torture, of activists and dissidents [32]. Could Nexa argue: "I know not what I have done?"

## III. State-of-the-art Literature: A Critique on Algorithmic Realism

A recent effort to bridge this epistemological gap in computer science proposes "algorithmic realism" as a conceptual framework instead of the current "algorithmic formalism." Although agreeing that such work starts from reasonable grounds, discusses important epistemological issues, and raises a suitable approach to deal with the problem at hand, we have identified some misunderstandings in its proposition related to scope, foundation, and terminology. The article we are referring to is named "Algorithmic Realism: Expanding the Boundaries of Algorithmic Thought," Green and Viljoen (2020) [12], from here onwards simply mentioned as "AR."

AR states that computer science lacks the language and methods to fully recognize, reason about, and evaluate algorithmic interventions' social aspects and impacts. Based on this premise (of an epistemology gap in computer science), AR proposes what we understood as a conceptual framework to cope with the current computer science ethical challenges. We do consider AR an advance in the underpinnings of computer science epistemology. However, we have identified the following misunderstandings:

AR supposes that all computer scientists create their algorithms following a so-called "algorithm formalism" approach, with three undesirable characteristics: Objective/neutral, internal, and universal. According to AR, it would be better to adopt a realism approach, with the following three characteristics opposed to "algorithmic formalism," known as political, porous, and contextual. In short, AR suggests algorithms to be: Instead of objective/neutral, to be political; instead of internal, to be porous; and instead of universal, to be contextual. Based on American Legal History, AR is presented as a new model of computer science thinking that may provide the epistemic and methodological tools to develop algorithmic interventions that question unjust social conditions [12].

Despite AR having 156 bibliography references listed and being well-rounded in form, AR uses American Legal History to present a subset framework (the evolution from 'legal formalism' to 'legal realism') and bring misconceptions between 'legal formalism' and 'computer science formal methods.' AR intertwines the concepts of 'formalism' and 'formal methods' to forcefully make computer science fit into an American Legal History metaphor.

Besides, AR deals with computer science's epistemological gap from the point of view of 'algorithmic thinking' activities only. 'Algorithmic thinking' are specific techniques to develop algorithms and computational systems and refers to a subset of activities within 'computational thinking,' understood as a necessary first step requirement towards solving a problem by computing [33]. It involves recognizing patterns and adopting abstraction—as a technique—to focus on the important and ignore details [34]. In AR, the consequences created by algorithmic interventions are directly related to such an initial phase of the SDLC named 'algorithmic thinking'.

We, intern, believe that every stakeholder involved in SDLC must be responsible and accountable for the consequences that their actions, respectively, may cause through algorithmic interventions. Algorithmic thinking, as a specialized field of computer science, is just one piece of the puzzle. One of the many phases in SDLC that must expand its epistemology to account for their respective share in algorithmic interventions social, political, moral, and ethical responsibilities. We see the epistemological gap persisting throughout SDLC's stages and procedures – not restricted to one phase of the process. Our research has increasing evidence that such epistemological gap goes beyond 'algorithmic thinking' activities to influence 'system requirements,' 'data basis,' 'data training,' 'testing,' etc. It happened with the algorithm used for dosimetry by state courts in the United States [35] and with the algorithm in health that calculates the amount of treatment a particular subject should receive [36], as well as with the algorithm giving credit scores to different social groups [37].

Almost as a corollary of the focus on algorithmic thinking only, AR frames all computer science professionals as the same, suggesting no distinction in roles, contributions, and career paths in computer science. AR seems to consider computer scientists one-professional-persona, with mindsets, experiences, and responsibilities alike, all going down the same career path. AR does not distinguish the different functions computer scientists have throughout different phases and stages of algorithms and computer systems construction—which, to some extent, demonstrates poor acquaintance with SDLC's governance and compliance. When working to create algorithms and computer systems, different scientists exercise different roles and activities related to different stages and responsibilities.

Overall, having criticized and learned from AR, we now share highlights of our research on pragmatism philosophy and linguistics pragmatics as a better way forward in bridging the epistemological gap in computer science.

## IV. Our Philosophical Stance: Pragmatism & Pragmatics to Fulfill the Gap

We explore elements and possible reform in computer science epistemology. The purpose is to help diminish algorithmic interventions' adverse effects by design or, at least, to assign stakeholders' responsibilities and liabilities for each algorithmic intervention in society. We believe pragmatism and pragmatics can help computer science design new language and methods for algorithmic interventions. The word *pragma* comes from the Greek and means 'fit for action'; 'an object, a thing that the senses can perceive; 'to do, act, pass over, practice, and achieve' [38]. We are choosing pragmatism and pragmatics as superior to other philosophies and methodologies in dealing with algorithmic interventions and, from now on, we present our reasons:

### *Pragmatics*

By the early twentieth century, pragmatism saw people's need for a philosophy that is both empiricists in its adherence to facts yet finds room for faith – in one way or many [13]. As philosophical studies, pragmatism's key ideas originated in discussions at a so-called 'Metaphysical Club' that met at Harvard University. Charles Peirce (1839 – 1914) and William James (1842 – 1910) are considered 'classical pragmatism.' Those two intellectuals argued that knowledge is only meaningful when coupled with action. Nothing is true or false. It either works, or it does not. Pragmatism is a philosophy deeply embedded in the reality of life, concerned firstly with the individuals' direct experience of the world they inhabit. It is action, experiment, and experience [39]—just as algorithmic interventions should be perceived.

Pragmatism philosophy considers that the value and meaning of any concept is the set of its possible effects. If a concept has no possible outcomes, then it has no value and no meaning. If two concepts have the same set of potential impacts, then the two concepts are the same [40]. Philosophically, when pragmatic clarification disambiguates the question, all disputes come to an end. From a pragmatism perspective, everything we do and think engages with matters of actual daily importance. The same can be said about computer science epistemology: It should engage with matters of actual daily importance (both technical and non-technical matters).

Pragmatism is a method of philosophy in which the sum of the 'practical consequences' which result by necessity from the truth of an intellectual conception constitutes the entire meaning of that conception [41]. Pragmatism is a practical approach that sees everything in our minds based on something generated by our senses. The world around us interacts with us and makes us learn, adapt, and evolve [42]. One may say, for instance, that algorithms interact with users to learn, adapt, and evolve. Experience, through interactions, increases one's knowledge and expertise about something related to the world.

To cite a contemporary example that nicely illustrates our thoughts on how pragmatism may influence algorithms, we mention SaaS (software as a service [43]). In the realm of SaaS, algorithms, and computer systems are designed, developed, and work through iterative interactions with consumers, which generates experiences with consumers that are translated into data that serve as feedbacks. SaaS first launches MVPs (minimum value products [44]), and, from there, they learn with fruitful feedbacks coming from people using the system. Those feedbacks are advantageous to SaaS-SDLC (Software as a Service – System Development Life Cycle). Today, this approach is vital to e-commerce companies and the game industry, for instance.

Pragmatism is an account of the way people think and act. Within an algorithmic intervention, pragmatism helps us account for the way algorithms' think' and 'act' in society. Pragmatism copes with the environment, is created through examples rather than a detailed analysis of its meaning, and is utilitarianism with long-range goals [45]. As we present in Table I, a new epistemology approach to computer science should consider those characteristics when dealing with algorithmic interventions.

### *Linguistic Pragmatics*

Learning linguistics is to understand how language itself works. Precisely what we are seeking to do with algorithms: to know how algorithms work and affect society. Linguistics looks at language structure from the smallest building blocks of sounds and handshapes to the structure of words and meanings, to how words go together to make sentences and conversations [46][47]. Linguistics scholars learn about writing, language acquisition, and the diversity of human languages—just as computer scientists learn about programming languages, coding, and the possibilities of the digital.

Pragmatism philosophy, mentioned in the previous topic, influenced linguistics to create linguistic pragmatics—the area of linguistics that puts meaning into context. It is a subfield of linguistics that studies how people use language within a context and why they use language in particular ways [48]. Context is the discourse surrounding a language unit and helps determine its interpretation [49]. Through pragmatics lenses, context fills in the details and allows complete understanding. We do not have one hundred percent complete information about everything going on when talking to people, and we often need to make assumptions based on the context—that helps us understand each other.

In linguistics, the act of expressing something in words is an 'utterance'—the smallest unit of speech, the object of study in linguistics pragmatics analysis. To utter means 'to say,' so when one says something, one makes utterances [50]. Individual conversation styles and cultural norms mean each conversation or interaction can turn out a bit differently based on expressed utterances. Linguistics pragmatics investigates how context affects the meaning of utterances [51]. Algorithmics pragmatism, as we propose, investigates how context affects the purpose of algorithmic interventions and helps interpretations of reality and social justice [52].

In linguistics, utterances are the units of sound one makes when one talks, but the signs accompanying those utterances give syntax and semantics their true meaning [53]. Learning from that, we consider algorithmic interventions as utterances of computational systems. Table I frames a possible conceptual analogy between 'linguistics utterances' and 'algorithmic interventions' – evaluating algorithmic interventions as units of computer systems. The impacts and consequences accompanying them give computer systems their true meaning.

Another central linguistic pragmatics assumption believes that people are generally trying to cooperate with one another ('cooperative principle') [54]. Under the cooperative principle, whenever someone says something that does not make sense at a literal level, others can figure out, or infer, what else they could have meant. Assuming they are trying to contribute cooperatively to the conversation, we take cooperation in a way we do not notice we did it. Because we understand context and cooperation, we interpret conversations – building from that, how could context and cooperation pragmatically help us deal with algorithmic interventions [55]?

The definition of linguistics pragmatics is strongly influenced by the results from the field of 'clinical pragmatics.' Clinical pragmatics means studying a person's linguistics deficit. It is the study of the various ways in which an individual's use of language to achieve communicative purposes can be disrupted [56]. The study of clinical cases has offered valuable new data sources concerning traditional philosophical and linguistic pragmatics issues [57]—our research has been immensely influenced by 'clinical pragmatics.'

*Clinical Pragmatics*

Language deficits pose a significant barrier to effective communication and compromise social, academic, and occupational functioning. In clinical linguistic, pragmatics can be informed and extended by studying 'pragmatic impairments' (also known as social communication disorder). Language impairments are any breakdown in language use across a range of communicative contexts [58]. Patients may display many types of pragmatic language impairments that disrupt social communication, such as literal interpretation and expression, impulsive remarks, talking incessantly, socially inappropriate comments, tangential talk, lack of attention, and inability to understand when someone is joking or teasing [59]. To mitigate adverse consequences, speech-language pathologists must assess and treat individuals with pragmatic impairment [58]. How could we effectively apply such a concept of 'pragmatic impairment' to algorithmic interventions? For example, could we diagnose that algorithmic interventions may hold pragmatic impairments? Could we interpret an algorithm as being socially inappropriate decision-making or a spy and tangential talker?

Clinical pragmatics, for instance, has proved helpful in working with children with autism. Many children with autism find it difficult to pick up on what some autism theorists describe as "social pragmatics," which refers to the ability to effectively use and adjust communication messages for various purposes with an array of communication partners within diverse circumstances [49]. When educators, speech pathologists, and other interventionists teach these explicit communication skills (known as "social pragmatics"), the results are often profound to children with an autism spectrum disorder. They can have a significant impact on improving their conversational interaction skills [60].

## V. Preliminary Insights: Algorithmic Pragmatism Foundational Principles

Pragmatism philosophy, linguistics and clinical pragmatics are helping design principles and means of thinking about algorithmic interventions. However, we are not the first initiative to consider ethical, political, and moral implications of algorithmic interventions—many scholars and organizations have already stated values and principles to analyze algorithmic interventions. It is worth mentioning recommendations being developed in artificial intelligence [18] [61] based on principles of Beneficence, Non-maleficence, Justice, Autonomy, and Explainability [62]. Rather than conduct a similar, potentially redundant exercise here, we strive to constructively move the dialogue from principles to proposed concrete orientations for new strategies [18]. Our research has engaged with a multi/inter/trans-disciplinary group of engineers, policymakers, entrepreneurs, social scientists, and technologists to collaborate, exchange experiences, and discuss the social implications of algorithmic interventions [63][64].

We present an introduction of four foundational principles to a conceptual framework related to algorithmic interventions analysis:

### Principle #1—Oneness: Algorithms as a oneness system representing a collective of other systems

The oneness system indicates one multiplicity system in itself, always perceived as a collective experience. To understand algorithmic interventions, we must understand where the algorithm starts and where it finishes itself. The way to get forward with this notion is to treat it pragmatically, i.e., mapping its implementation trace. The world is one or many: If its 'manyness' were so irremediable as to permit no union of its parts, not even our minds could 'mean' the whole of it at once. Granting the oneness to exist, what facts to algorithmic interventions will be different in consequence? What will the unity of an algorithmic intervention be known as? The world is one – yes, but how one? What is the practical value of oneness that helps us create boundaries and understand algorithmic interventions? Asking such questions, we pass from the vague to the definite, abstract to the concrete [65].

### Principle #2—Intention: Algorithms and people act upon society

Pragmatism suggests a practical approach to algorithmic interventions: Nothing is true or false. It either works, or it does not. Pragmatism is a philosophy deeply embedded in the reality of life [39]. Scientists and programmers should consider, test, monitor, maintain, evaluate, and evolve practical situations and their impacts worldwide. Algorithmic interventions either works accordingly planned, or it does not. Trials, tests, and experiments are the way to analyze algorithmic intervention: How are algorithmic interventions made? How are they thought, brought into being, and put to work? Imagine the SDLC of an algorithm designed to optimize the number of boxes that fit in a truck. The algorithm's purpose is to optimize the space inside the truck: The more boxes in the truck, the better. But it should matter to computer science what the boxes will carry? Those boxes can be moving food from one place to another or carrying bombs. Should computer science account for that choice? Who should account for such a decision? Should SDLC expand its guidelines to inquiry and account for algorithmic interventions' negative impacts if the truck carries bombs instead of food? Pragmatists should acknowledge algorithms' relations with the world, focusing on the stakeholders' agency [66] and how algorithms act upon society.

### Principle #3—Context: Algorithms working in a specific context

Context recognizes the complexity and fluidity of the world. Many different interpretations of the algorithm's usage are possible for any given context. Considerations that fall within context boundaries are the subject of sharp focus. Still, when aspects of the world fall outside these boundaries, a method has no hope of discovering these truths since it has no means of representing them [12]. As computer science increasingly engages with social, economic, and political contexts, we raise our voices against the current realm of SDLC. We propose redesigning and expanding to include algorithmic interventions. Computer scientists and programmers should be responsible for an extended framework of SDLC that takes ethical, political, and moral context iteratively when designing, developing, implementing, and maintaining their algorithmic interventions.

### Principle #4: Algorithms under a Justified Act

Periodically, SDLC should explain and justify their actions, effects, impacts, and consequences generated by an algorithmic intervention? Who should be responsible for the impacts that algorithms' interventions have on society? Through pragmatism's lens, experience is the only way we learn. In order to understand how the system truly works and impacts society, algorithms must experience recurrent interactive and iterative ethical, political, and moral processes capable of justifying their usage under the idea that it benefits society (i.e., social justice and welfare [52]). Algorithms trials, tests, and actual experiences may be subjected to an ethical committee [67] to justify and account for its algorithmic interventions (either excellent or bad interventions).

* * *

The pragmatic approach presented as preliminary foundational principles consider: Algorithm's oneness, with intention, working in a specific context, and under a justified act. Such foundational principles represent a mental action of consciousness and skills that may prevent algorithmic interventions from causing social, political, and economic harm to society. A fuller explanation of the scope, selection, and understanding of this set of principles will be available in the first author's doctoral thesis (Forthcoming). Here, we focus on the commonalities and noteworthy characteristics across a set of pragmatism philosophy and linguistic and clinical pragmatics principles given the algorithmic interventions' rationale offered in this essay.

## VI. A Possible Conceptual Framework

Conceptual framework meaning a supporting structure around which something can be created [68]. A system of rules, ideas, or beliefs used to plan or decide something [69]. A basic structure underlying a design, concept, text, or code [70]. Table I presents a preliminary conceptual framework that might help stakeholders account for their respective algorithmic interventions in the world – we aim to prevent algorithmic intervention harm by design.

TABLE I. ALGORITHMIC PRAGMATISM CONCEPTUAL FRAMEWORK

| | Field of Study | |
|---|---|---|
| | ***Linguistics*** *How to use language in a context in particular ways* | ***Algorithms*** *How to use algorithms in a context under justified ways* |
| **Object of Study** | **Utterance**: Linguistic information produced by the sender | **Effects**: The computer system output produced by the algorithm |
| **Source Sender** | Humans who encode messages, data and transmit information (Written / Orally) | Of what intention does the algorithm consist? Where it starts, and where it ends? To what extent does it change? |
| **Receiver Observer** | The one who receives decoded information from the sender. | The one who receives the algorithmic effects from the sender. |
| **Context Space-time** | Physical background in which the utterance is going on; where the conversation takes place. | Physical and digital background in which the computer system is going on, where the algorithmic intervention occurs. |
| **Purpose** | The relationship between the source and the information. | If algorithms make decisions, who takes care of the algorithms? |
| **Social background** | The relationship between interlocutors. | The relationship between humans, computer machines, and algorithms. |
| **Background** | A set of extra-linguistic factors that conditionate both the production and the meaning of the utterance. | A set of extra-algorithmic-intervention factors that conditionate both the production and the meaning of its effects. |
| **Bias** | Belong to a specific social group is understood by that group (set of speakers and hearers). | Belong to a specific set of data training and is understood by that data training. |
| **Situational** | It can be understood only by the source and the observer – here and now. | It should be understood by whoever is affected – here and now. |
| **Metaverse** | It is the linguistic environment where a word can be found (utterances previous to the utterance). | It is the digital system environment where algorithms are found (intervention previous to the intervention). |
| **Epistemic** | Knowledge shared by speakers and hearers | Knowledge shared by algorithms' stakeholders and scientists. |
| **Pragmatic information** | A set of knowledge, beliefs, opinions, and feelings of a person. | Algorithmic interventions' intentions when designing the world's composition. |

## VII. CONCLUSION: TOWARDS ALGORITHMIC PRAGMATISM

The fundamental concept we have presented in this essay is that thinking about and experimenting with algorithmic interventions may prevent the harmful effects they sometimes cause to people, groups, and individuals. We see Algorithmic Pragmatism as a strategy that, in some cases, may be undertaken by national or supranational policymakers to legislate [18] about algorithmic interventions or by corporate executives to self-regulate them in the private sector. If adopted, Algorithmic Pragmatism might serve as an extended pilar foundation to SDLC and computer science epistemology.

Before launching an algorithmic intervention, one should always consider that an algorithmic intervention can be biased [71], discriminatory [71], dehumanizing [73], and violent [74]. It can exclude citizens from receiving social services [75][33], spread hateful ideas, and facilitate government oppression of minorities [76] [77]. Our research has elaborated some thoughts to introduce pragmatism philosophy and linguistic pragmatics elements to fulfill the epistemological gap in computer science.

If one supposes to make sense of algorithms and ethical and human values, our first and foremost recommendation is to pragmatically engage with algorithms and computer systems through its SDLC, asking the following questions: How are algorithms and computer systems created? How are they thought, brought into being, and put to work? What are the consequences produced by it? Who should be responsible, respectively, for the impacts that algorithmic interventions have on society? Computer science needs new vocabulary and practices to assume responsibility for human rights, social justice, and ethical values – because that's how algorithms interventions will make sense to people.


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