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MAIN PAPER

Abundant intelligences: placing AI within Indigenous knowledge frameworks

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Abstract
The current trajectory of artificial intelligence development suffers from fundamental epistemological shortcomings, resulting in the systematic operationalization of bias against non-white, non-male, and non-Western peoples. We argue that these failings are, in part, the result of certain Western rationalist epistemologies that exclude many ways of knowing about the world, and therefore they cannot provide a sufficient foundation on which to adequately, robustly, and humanely conceptualize intelligence. We present a new research agenda, Abundant Intelligences, an Indigenous-led, Indigenous-majority international, interdisciplinary research program that imagines anew how to conceptualize and design artificial intelligence (AI) based on Indigenous knowledge (IK) systems. Abundant Intelligences draws on the rich plurality of Indigenous knowledge systems, bringing together diverse sets of thought, culture, and protocol together. We show IK systems provide one way to rebuild AI's epistemological foundations and transform these tools' current role in reinforcing colonial practices of exclusion, extraction, manipulation, and eradication into engines of abundance that enable us to care better for ourselves, our communities, and our world. Our proposition is to fully engage with AI to explore how different conceptions of intelligence could be embodied in these technologies. In this paper, we present the tenets of the research program in detail, account for our methodological approach, describe the impact and limitations, and conclude on a discussion of the implications of the program.

Keywords Abundant intelligences · Indigenous AI · Relational AI · Interdisciplinary research · Research creation · Indigenous knowledge systems

> "We are what we imagine. Our best destiny is to imagine…who, and what, and that we are."
>
> N. Scott Momaday (1998)

1 Introduction

The artificial intelligence (AI) industry–academic complex does not have an ethics problem, it does, however, have an epistemology problem. The current trajectory of AI development suffers from fundamental epistemological shortcomings, resulting in the systematic operationalization of bias against non-white, non-male, and non-Western peoples. As such, researchers are continually discovering severe flaws in current approaches to creating AI systems (Caliskan et al. 2017; Eaglin 2017; Eubanks 2018; Gavaghan et al. 2019; Oswald et al. 2018). Namely, these systems incorporate deep structural blindnesses and biases that render them incompetent, even dangerous, when confronted with the complexity and variety of human social systems.

If left unaddressed, these blindnesses auger a future where the integration of AI into every nook and cranny of our societies will radically entrench economic inequality (Clark and Gevorkyan 2020; Goyal and Aneja 2020; Kim 2022), make it impossible to escape state control and surveillance capitalism (Yeung 2018; Zuboff 2020), systemize racial injustice (Benjamin 2019; Noble 2018), and cement white supremacy into the core operating system(s) of the world (Cave and Dihal 2020; Katz 2020; Phan 2019). We argue that these failings are, in part, the result of certain Western rationalist epistemologies that exclude many ways of knowing about the world, and therefore they cannot provide a sufficient foundation on which to adequately, robustly, and humanely conceptualize intelligence—much

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less attempt to replicate it. We argue that interdisciplinary research and research-creation reimagining the AI project is required now, while AI is still in early developmental stages, and urgently before deeply problematic assumptions about how people behave and interact with each other and their environment is encoded into the foundations of our socio-technical systems.

We would like to propose a research agenda for dealing with these urgent and foundational issues—Abundant Intelligences. Abundant Intelligences is an Indigenous-led, Indigenous-majority international, interdisciplinary research program that imagines anew how to conceptualize and design artificial intelligence (AI) based on Indigenous knowledge (IK) systems. Our approach is grounded in the Indigenous epistemologies containing robust conceptual frameworks for understanding how technology can be developed in ways that integrate it into existing lifeways, support the flourishing of future generations, and are optimized for abundance rather than scarcity. Our goal is to advance methods for improving AI to better serve everybody through exploring and developing culturally grounded AI systems that support Indigenous ways of knowing.

Our goal with Abundant Intelligences is to find a different way forward for developing these cutting-edge and seemingly ubiquitous technologies. IK systems provide one way to rebuild AI's epistemological foundations and transform these tools' current role in reinforcing colonial practices of exclusion, extraction, manipulation, and eradication into engines of abundance that enable us to care better for ourselves, our communities, and our world. Indigenous people have been adapting their knowledge systems to new scientific and technological advances for millenia. Integrating AI into their knowledge practices will be but the latest example of this ongoing innovation (Whaanga and Mato 2020).

In this paper, we would like to outline the Abundant Intelligences project, explain our methodology, describe the scope of the program, and discuss the implications of this kind of endeavor for our technologized futures. The project stems from a problematization of the paradigmatic way in which AI sciences and technologies have imagined intelligence; and responds to the need to redefine or expand the scope of what intelligent action means. This need emerges from the narrow definitions of intelligence that underlie the AI systems and research. The way we respond to this is by turning toward IK systems to address both the problems within the AI world in terms of reproduction of harmful biases, reinforcement of socioeconomic inequalities, neocolonial exploitation, and environmental degradation, and contribute to the field in a substantive manner by offering new insights and creative approaches to the technical challenges that lie within AI research. Our proposition is to fully engage with AI to explore how different conceptions of intelligence could be embodied in these technologies. This position might appear to be in tension with recent calls for decomputerization (Penn 2021; or similar efforts, Strubell et al. 2019; Tarnoff 2019; McQuillan 2022), yet we would suggest that we all point in the same direction: achieving meaningful, equitable, just, and sustainable ways of building these systems we all live with. Our path toward this is to build culturally grounded AI systems that support Indigenous sovereignty and ways of knowing.

On the way, we hope to contribute to reorganizing what intelligence means by way of IK systems that afford a relational way of seeing the world. We aim to show in this paper how our relational approach allows us to ask different questions, engage in particular practices, and orient our research project's overall (or macro as we called it) methodology. Indeed, the program is organized around three axes, the first of which is Integrations which focuses on building relations across not only disciplines but also communities so as to establish a cultural repertoire with which these heterogeneous components could connect and communicate. The second is Imaginaries which builds on previous work 'future imaginaries' (Lewis 2023), which forms the heart of this axis. This is where the project explores novel conceptions by speculative designs of Indigenous AI. The final axis is Intelligences, which brings these Indigenous perspectives to bear on technical challenges that face AI research, and cultivates a critical–technical practice through exploring prototypes. We will present these tenets in detail to account for our methodological approach, describe the impact and limitations, and conclude on a discussion of the implications of the program. Before moving onto presenting the project, we would like to define some terms that are central to Abundant Intelligences, namely Indigenous and Abundance.

1.1 Indigenous abundance

Abundant Intelligences draws on the rich plurality of Indigenous knowledge systems, bringing together diverse sets of thought, culture, and protocol together. We use the term "Indigenous" to denote peoples who maintain historical continuity with societies that pre-date the arrival of European colonizers; who possess strong, long-lasting links to the territories in which they reside; who exercise distinct social, economic, and/or political systems; and who have distinct languages and cultures (United Nations 2015). We use "Indigenous knowledge" (IK) systems to identify those bodies of knowledge that develop out of the contexts of specific Indigenous peoples, have produced well-tested, long-lasting practices for supporting a thriving community (Wilson 2008), and are often but not exclusively articulated through.

> "cultural events as oratory, as performance, as ceremony or ritual, as participating in a social process

such as grieving or celebrating, as the weaving and re-texturizing of relationships, as the re-stating of collective ancient memories, as dreaming and as dialogue with ancestors and the spiritual dimensions of the world" (Smith et al. 2016).

We have chosen the term 'Abundant Intelligences' to describe our approach. By "abundant" we invoke knowledge practices focused on *regeneration*, such that we leave more for future generations than we take; *generosity*, which orients us toward methods that enable and encourage sharing with the other beings in our location; and *reciprocity*, which emphasizes the fundamental fact that we are in a relationship with those beings and that requires us all to work toward sustaining one another (Baker 2018; Enos and Tamanaha 2022; Fujikane 2021). "Abundant" signals a shift from "…the future to a plethora of futures" (Sardar 1999), indicating an expansion of the narrow definitions of 'intelligence' currently favored by dominant AI research paradigms (Monett et al. 2020), so as to better embrace the multiplicity of ways humans and non-humans act intelligently in the world (Brooks 1991; Gardner 1983). We also chose "abundant" for invoking imaginaries centered on sustenance, in both material and spiritual senses. Well-sustained communities possess cultural confidence, foster innovation, imagination, and an openness to new opportunities. 'Abundant Intelligences' thus signals one of our primary objectives: to turn us away from the scarcity mindset which motivates practices of extraction and exploitation (Cohen 2019; Zuboff 2020) central to Indigenous erasure (Crosby 1991; Simpson 2014; Tuck and Gaztambide-Fernández 2013), and toward a future where Indigenous communities have capacity to fashion AI systems that nurture us, and all the beings around us. The opportunities are significant for preserving and supporting Indigenous languages, addressing environmental stewardship and sustainability challenges, providing insight for community health and well-being strategies, realizing the value of IK for contributing to the general public good, etc.

By bridging together normative Western knowledge frameworks and interdisciplinary academic research with traditional Indigenous epistemologies, Abundant Intelligences seeks insight into developing novel approaches to complex research questions and topics of wide-reaching societal importance. The search for effective, robust, and socially just foundations for AI systems requires extensive cross-disciplinary and cross-cultural collaboration. Abundant Intelligences is uniquely positioned to provide the generative spaces for such knowledge creation, integration, and experimentation. It has established a multidisciplinary research network that brings researchers and practitioners from diverse academic fields together with IK holders, cultural practitioners, language keepers, educational institutions, and community vitalization organizations to reimagine AI.

The strongest chances of this kind of research having a significant impact is if it engages Indigenous communities and AI scientists from its foundations. We critique, imagine, design, and prototype *together* to better understand the full spectrum of AI's challenges and its opportunities for better supporting Indigenous communities—and, by extension, all other communities. The knowledge cultivated in the program serves to stimulate debates across numerous domains in the social sciences and humanities engaging with the sociopolitical and cultural impacts of AI. Vital to our success is a robust partnership weaving together Indigenous centered research laboratories from across diverse geographic regions and Indigenous communities to explore new possibilities for collaboration, while working closely with experienced AI researchers to ensure a deep understanding of the technologies involved and lay the groundwork for translating our research, imaginaries, and designs into practice.

We regard true innovation as grounded in regeneration, not extraction and exploitation. IK systems provide access to thousands of years of research and practice from cultures that have proven that regenerative thinking is possible. Understanding innovation in this way provides a path toward seeing how the vibrant knowledge within Indigenous traditions is relevant to current technological challenges.

As AI research leads to systems with ever-greater autonomy and agency, it becomes increasingly urgent to understand how to fit such systems into our understanding of our own being and the being of the entities around us. Indigenous understandings of the complexity of being promise a fruitful avenue of exploration to meet this challenge. As Little Bear observes, "the human brain is a station on the radio dial; parked in one spot, it is deaf to all the other stations [...] the animals, rocks, trees, simultaneously broadcasting across the whole spectrum of sentience" (Hill 2008). Many of the IK frameworks engaged by research team members retain "…the languages and protocols that enable us to engage in dialogue with our non-human kin, creating mutually intelligible discourses across differences in material, vibrancy, and genealogy" (Lewis et al. 2018). These languages and protocols for integrating non-human beings into our (technological) practices provide a means for reimagining how AI fits into our web of relations in ways that are grounded in territory, community, and history.

All of our work is conducted within an Indigenous research framework informed by Linda Tuhiwai Smith's (2012) emphasis on creating reciprocal, long-term relationships with communities; Meyer's (2003) rooting of Indigenous epistemologies in specific territories; Alfred and Corntassel's (2005) call for developing endogenous pathways for expressing contemporary Indigenous culture and reframing

research questions from within an Indigenous worldview; Vizenor's (2008) focus on an 'active present' vs. a passive past; Shawn Wilson's (2008) recognition of research as a fundamentally cultural practice; and Kovach's (2021) highlighting of the importance of story and the situated storyteller to IK practices.

Our focus on Indigenous abundance is not solely a methodological commitment but a praxis that interweaves these frameworks with AI research and development. From our perspective, it is clear that the notion of intelligence is increasingly impoverished under the banner of AI, and bringing in the notion of abundance is a direct response to this. In the next section, we will explore how intelligence is defined and presumed in the AI field to be so impoverished, and our response in bringing relational worldviews to address the intelligence question in its abundance.

2 From impoverished intelligence to abundant intelligences

"Where do you begin telling someone their world is not the only one?" (Maracle 2017).

Our main argument about the intelligence question starts with this claim: the quest to create AI must drastically widen the scope of what is considered to be intelligent action. For example, Stone et al.'s (2016) definition of AI views intelligence as "that quality that enables an entity to function appropriately and with foresight in its environment." We argue that defining 'appropriate' function and useful 'foresight' requires a deep understanding of the different environments in which intelligent machines might operate. Such environments are defined, in no small part, by the cultural structure of specific human communities and their relations to the natural world.

Computer science approaches such questions from relatively narrow foundations. "[H]uman activity is highly flexible, nuanced, and contextualized and…computational entities…need to be similarly flexible, nuanced, and contextualized. However, current systems cannot fully support the social world uncovered by these findings" (Ackerman 2000). Engineering practices favor those ways of thinking (e.g., binary; goal oriented) that are easily amenable to computational implementation, rather than most appropriate to specific contexts. In fact, there are several embedded assumptions in the epistemologies with which we design and deploy our computational systems. These include the user is an individual; the individual prioritizes her personal well-being; culture is an epiphenomenon rather than the phenomenon; text and context can be separated; and that the only useful knowledge is that produced through rational instrumentality.

This makes AI system engineers blind to vital aspects of human existence—such as trust, care, and community—that are fundamental to how intelligence actually operates. This blindness stems from an intellectual lineage heavily infected with Cartesian duality, monotheistic eschatology, and computational reductionism. Separating mind from the body, elevating after-life over present-life, and violently forcing all experience into binary terms to make it (appear to be) computable produces impoverished notions of what constitutes human intelligence.

AI system designers are building worlds for us to inhabit. In the same way that architects design the physical spaces in which we live, they are designing the virtual systems in which we think. These systems are being increasingly tasked with interactions that have deep social, political, and legal consequences, yet the field seems to continue to fetishize rational goal seeking as the definition of intelligence. The question we ask to start our journey toward abundance is this: do we really want to live in computational worlds incompetent with regard to emotion, sociability, and embodiment?

2.1 Mainstream conceptions: intelligence as property

In this section, we discuss how intelligence is operationalized and conceptualized in the AI cannon. Before we go further, we should acknowledge that the 'intelligence' of AI is often contested, criticized, and debated. This should be no surprise, as the name itself makes a claim about intelligence that is foreign to human-centric knowledges: that intelligence may exist in artifice. This claim is constantly subjected to criticism and critique. Some are of the opinion that "AI is neither artificial nor intelligent" (Crawford in Corbyn 2021). Indeed, the goalpost for attaining intelligence—in machine or human—seems to be set in its historical contingency. Historian of science Lorraine Daston's extensive work on the (Western) history of intelligence makes the case that what societies come to consider as intelligence relies heavily on its social interweaving with gender, morality, and organization of labor.[1] She shows how a (constructed and) naturalized notion of intelligence provided a ground on which many binaries of the modern world was built, especially those derived from nature and culture (Daston 1992). Further, introduction of mechanical or automated processes to previously considered intelligent activities, such as calculation, had the effect of disqualifying such activities from

[1] The conjoint histories of AI and division of labor, especially in Charles Babbage's parallel notions of division of labour in a plantation and his analytical engine, has been made subject to recent research. For more on this, please see Pasquinelli (2023); or Whittaker (2023).

the purview of intelligence (Daston 2018). So the notion of an AI in the twentieth century emerged under such contradictions where mechanization increasingly decoupled intelligence from intelligent activity.

That being the case, the field itself does not necessarily deeply reflect on the notion of intelligence; in fact, defining intelligence does not seem to concern most AI researchers. However, there are some from the artificial general intelligence (AGI)[2] community that explicitly engage with the question. One of the most cited works in AI on definition of intelligence come from Shane Legg and Marcus Hutter. They formulate: "Intelligence measures an agent's general ability to achieve goals in a wide range of environments" (Legg and Hutter 2007, p. 12). Their approach considers intelligence as an *effect* of capacities such as reasoning, planning, problem-solving, abstract thinking, and learning. This goes against the common way of thinking of intelligence as a result of having these capacities and brings us close to how we would consider intelligence: as being contingent on the dynamism between an agent and environment. However, Legg and Hutter's definition falls short in our consideration as it takes intelligence to be a property of a singular and individual entity. In their conception, there is a discrete and self-contained agent who 'has' intelligence, and their intelligence relies on how the agent performs in the environment. This view does not consider the relational structures that precede the actor, the web of relations into which the agent always-already arrives. In short, this view does not consider the social, cultural, political, and material environment to be as significant to intelligence as the agent itself.

2.1.1 A note on the dark history of intelligence

One thing to address here in Legg and Hutter's definition is the deep-seated connections between white supremacy and the quest of artificial general intelligence (AGI). As the prevalence of pseudoscientific formulations in AI is increasingly targeted by critical scholars (e.g., Andrews et al. 2024), it becomes clearer how the epistemic failings are inextricably linked with the ethical failings we observe in AI today. AI researchers have been uncritically[3] applying definitions from other fields without a regard for their meaning and context. The Legg and Hutter definition is a good example here: they draw from a 'mainstream scientific definition of intelligence', a public statement published in the Wall Street Journal in 1994, as developed by Linda Gottrfredson.[4] This 'scientific' definition,[5] however, conceals a racist, eugenicist, and white nationalist impetus in the intelligence research community.

Gottfredson's 'mainstream scientific definition of intelligence' is this: "Intelligence is a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience" (Gottfredson, as cited in Legg and Hutter 2007, p. 12). This seems a fairly standard notion of intelligence, perhaps epistemologically rather narrow, but ultimately seemingly workable. However, when we delve deeper to see where this definition leads to, or how it is conceived, we see claims such as

> "Members of all racial-ethnic groups can be found at every IQ level. The bell curves of different groups overlap considerably, but groups often differ in where their members tend to cluster along the IQ line. The bell curves for some groups (Jews and East Asians) are centered somewhat higher than for whites in general. Other groups (blacks and Hispanics) are centered somewhat lower than non-Hispanic whites" (Gottfredson, [1994] 1997, p. 14)".

While it is not very clear what IQ tests actually measure, this strand of intelligence researchers seem to have readily applied their pre-existing racial categories to their findings, and have set the scene for realizing their ideologies through 'science'. This form of scientific racism still reverberates today,[6]and definitions developed under such paradigms seem to be unproblematically employed by AGI researchers. Legg and Hutter's only disclaimer about this is to say that they do not completely agree with Gottfredson's definition (Legg and Hutter 2007, p. 12); however, their conception relies heavily on this framework that is built on the idea of hierarchy between races and the measurability of that hierarchy via intelligence tests.

The intertwinement of the notion of intelligence and white nationalism is not an accident. The ideologies that

[2] The reader should be aware that AGI conversations are controversial, and the AGI argument is usually treated as being esoteric in the research communities.

[3] … and hopefully not maliciously.

[4] Gottfredson constructed this 'mainstream' definition by sending it out to her network to seek their approval. She sent her definition to 131 researchers out of which 52 signed the statement, 48 returned the request with an explicit refusal to sign, and 31 ignored the request. Later it was revealed that only ten people who signed the letter could be considered an expert on intelligence measurement. 20 of these signatories, including Gottfredson, had been receiving funds from the Pioneer Fund, the directors of which have long been concealing the organization's role as the primary source of funding for studies directed at proving the genetic inferiority of Black people (Tucker 2002).

[5] For more on the methodological problems in studies about IQ, mainly the bell curve, please see Dickens et al. 1995; and the consequences of pseudo-scientific discourse, please see Mirza 1998.

[6] See Jackson and Winston (2021) for an exploration of how these claims still continue today.

are specifically shaping and driving current AI research have historically been associated with eugenics, political violence, and ecological risk (Torres 2024; Gebru and Torres 2024). Philosopher Stephen Cave looked extensively at how the concept of intelligence has been historically used to not only legitimate, but also establish power hierarchies. "Concepts such as intelligence are deployed as part of the 'hegemonic ideologies' of superiority and inferiority that legitimate other parts of the matrix" (Cave 2020, p. 30). Tracing the origins of intelligence as ideology, he reveals the intertwinement of the notion with colonialism and nation-state: intelligence was used to justify the decimation of those deemed mentally inferior in the construction of the idea of race, while at the same time serving a move away from an idea of natural aristocracy by emphasizing virtue and talents of individuals. The ideologization of intelligence was most firmly established in the eugenics movement in the nineteenth century, for whom intelligence tests were the main method for deciding who should be allowed to pass on their genes and who should not.

Cave tackles the conjoint histories of the science of intelligence—that is, the abstraction of intelligence and its treatment as a single entity located in the brain with a degree of measure appointed on a scale of value—and of the oppression of disadvantaged groups as appointed to be inferior in the process of that quantification.[7] Even though today mainstream psychometry has moved away from viewing intelligence as the central driver of societies or civilization, there remain strong resonances made especially in the circles of Silicon Valley, or the elite of AI researchers and industrialists in general, who favor a racialized and/or gendered notion of intelligence. Cave warns that "the concept of intelligence remains far from decolonised" (2020, p. 32), as implicit biases that associate different racial groups to different degrees of intelligences are still in circulation. The hegemonic weight of the ideology of intelligence is indeed imbued to a large degree by the AI enterprise, propagating the assumption that intelligence is an abstractable property that is self-contained and self-evident, all the while erasing different notions of intelligence from consideration. Indeed, abundant intelligences is a move away from these hegemonies, as it reveals a collective notion of intelligence that is founded on its constituent relations.

What is missing from most operationalized definitions of intelligence, including Legg and Hutters', is the very cultural context in which all such intelligent operations take place. Mainstream definitions in AI treat intelligence as something that pertains to an individual, and disregard the cultural, social, and environmental conditions in which an intelligence emerges. A big portion of the intelligence question lies in the normative conditions that valorize and provide meaning as well as power to certain actions over others. Yet, these systems do not occur in a vacuum; they are always already entangled with the (cultural, social, political, physical, economic) world around them. It is in this sense that "the whiteness of AI" (Cave and Dihal 2020) is not a surprise to us, as we view these systems themselves as already cultured and cultural entities or beings, and henceforth cannot but manifest or represent the cultures in which they are conceived.

The value-laden history of intelligence is a testament that we need to consider the intelligence question in its wider social and cultural dimension. When one treats intelligence as a property of an individual that can be analytically abstracted and not a collectively established relationality, the wider matrix in which our attributions of intelligence to certain activities or proclivities become obscured. To more accurately tend to the normative and cultural dimension of intelligence, we bring in Indigenous epistemologies.

2.2 A relational ground: Indigenous AI

We turn to Indigenous knowledge systems to challenge the normative manner in which intelligence has been considered. IK systems have considerable potential, as much of them rest on a relational approach. They describe a multidimensional world that is in a flux, and seek out embodiments that can take shape in this constant becoming (Little Bear and Heavy Head 2004). Furthermore, IK insists on retaining the complexity of lived experience. This can make it seem unruly when viewed from within a Western scientific framework, which prioritizes climbing a ladder of abstraction to reach simple universal principles that can be applied across all individuals, communities, and territories. The result is that what an Indigenous person considers worth knowing about a domain may be significantly different from and more multidimensional than what a normative AI scientist considers necessary. This difference in approaches provide a generative ground for considering alternative approaches to creating AI.

Expanding and diversifying the knowledge systems that AI researchers seek to simulate will enable the development of more effective and socially relevant computing systems. As Fox Harrell (2013) writes, "cultural models outside of those …privileged in computing practices might be fertile groundings for innovative results." Indeed, such diversified computing approaches are necessary for pursuing "critical technical practices," in which "technology development is not simply an end in itself, but also reflectively explores the

[7] This does not mean that all psychometric practices are designed to inferiorize certain groups over others. Cave references mainstream psychometricians who argue against an understanding of intelligence as a measure of value.

assumptions and attitudes that underpin ideas about technology and humanity" (Dourish et al. 2004).

Our interest is in drawing on diverse IK systems to orient aspects of AI research toward such critical–technical practices. IK systems are a class of epistemologies reflecting a different understanding of intelligence, offering alternative methods for considering how knowledge is generated, validated, and propagated (Cajete 2000; Descola 2013; Hester & Cheney 2001; Little Bear & Heavy Head 2004; Meyer 2003; Posthumus 2018; Smith 2016; Turner 2006; Waters 2004). Indigenous epistemologies include observe–hypothesize–test iterations of the Western scientific method, but also practices excluded by it. Stories, songs, dance, and lore all embed knowledge about the world and facilitate its rigorous transmission from one generation to the next. Our program engages a multiplicity of IK systems, grounded in specific communities, territories, and histories. The research team itself is composed of individuals from 16 Indigenous communities from across Aotearoa New Zealand, North America, the Pacific, and Africa. We bring those specific contexts and their respective epistemologies and knowledge protocols into the work we do together.

2.2.1 Why Indigenous AI

Abundant Intelligences approaches the AI question from a less traveled path. With perils of AI in high visibility, research efforts have turned to revealing the historical and structural underpinnings of the AI project at large, questioning the feasibility or overall merit of employing these technologies. For example, the environmental cost of AI systems has been a significant point of contention, especially generative AI technologies, but also others, because of their resource-intensiveness (Bender et al. 2021; Strubell et al. 2019). Researchers urge the AI community to center the environmental damage purported by the systems, and turn to green AI that tracks emissions across the AI lifecycle (Kneese and Young 2024), and/or to dismiss these systems altogether (McQuillan 2022).

Another point of contention is the colonialist structures that undergird the production and circulation process of AI systems. Rachel Adams, the founder of the African Observatory on Responsible AI, urges researchers to consider "What does AI mean because of colonialism?" (Adams 2021, p. 179). She builds on the analysis that coloniality is going through a third phase in the arrangement of race, where technocratization of modernity/coloniality is distributed through communication (and transportation) technologies and the power asymmetries that they rest on (ibid). Her intervention exposes the impact of AI on the global south, with her new work focusing on how AI is further entrenching already existing inequalities (Adams 2025). She puts the problem as such: "the drive to dominate in the production and use of AI is revealing of the project's hegemonic impulses, and the neo-Darwinian linearity of the evolution of science which will 'leave behind' those who do not conform to catching up" (Adams 2021, p. 178). The new empire of AI builds itself on an increasingly widening gap between wealthier and poorer nations.

One way to move forward without being paralyzed by this ostensibly omnipotent amalgam of systems that revolve around AI is to resist AI as a monolith. AI, as conceived in the Western research and technology matrices, is often thought of as a singular project. Abundant Intelligences points toward the multiplicity of AI. This is not an effort to "catch up" with the state of the art. Rather, we start from the discontents and carve out a different path for developing technology altogether. By disrupting the power dynamics that are inherent to technology development process, we hope to be able to reveal how AI is not one homogenous enterprise, but rather given form by its forces of production and design, and by the relationalities that enact and realize the particularity of a given system. As we lay out in the methodology section, we forge this path under Indigenous leadership, with community-led design processes. Our attention to the epistemologies and methodologies that organize the design process of these technologies both opens up a space in which to (re)envision AI, and to create capacity for meaningful contribution from Indigenous communities.

This move is not new for the critical AI circles. Feminist AI, for example, is a movement focused on incorporating feminist perspectives into the fundamental aspects of AI development. Computer scientist Alison Adam's feminist critique of AI pioneered the movement, illuminating the conservative foundations of AI while centering gender, race, and class. The current landscape of feminist AI not only integrates such perspectives into our consideration of AI, but it is also "challenging and redefining what constitutes 'intelligence' in AI" (Toupin 2024). Abundant Intelligences is positioned in a similar direction trajectory, joining in the "persistent effort to challenge traditional AI paradigms" (ibid). The program conducts such challenges particularly within the domain of research and design, with the acknowledgment that *not* engaging with these technologies further feeds the power of the existing elites. Without alternatives, the 'normal' conduct of science continues *sans* interruption, reproducing already existing frameworks of knowledge germane to AI.

It is in this sense that the Abundant Intelligences is differentiated from other movements that take on the social, political, and cultural critique of AI to argue against an uptake of these technologies. Our effort lies in exploring how technology could enable greater Indigenous sovereignty in a datafied world, and not leaving this work to non-Indigenous leadership. The program seeks out how technology could enable ways of being in this world that are concrete

alternatives to the dominant mode in which technology is practiced and thought.

The application of Indigenous epistemologies and protocols to research on AI is relatively recent endeavor. In 2016, Abdilla and Fitch articulated parallels between the pattern thinking in Aboriginal Songlines for orally mapping territory and the pattern recognition developed by roboticists. In 2018, Kesserwan suggested that Innu concepts of non-human agency might help us better fit AI into our human contexts, and Lewis et al. drew on Kānaka Maoli, Nēhiyaw, and Lakȟóta relational frameworks to understand how AI systems might be placed within the circle of human and other-than-human relationships. Abdilla et al. and Lewis et al.'s work led to the Indigenous Protocol and Artificial Intelligence (IP AI) Workshops (2019) and *Position Paper* (Lewis et al. 2020), which explored a wide array of Indigenous-centered design approaches to AI. Resonate efforts include Bourgeois-Dolye's (2019) application of Mi'kmaw Two-Eyed Seeing to AI ethics and Yarlott et al.'s (2020) creation of an IK graph for designing AI ontologies. Building on these efforts, our program is the first comprehensive approach to rethinking *and* prototyping AI through Indigenous epistemologies *alongside* accomplished AI researchers, with the potential to transform AI technologies' effectiveness and socio-cultural fitness.

2.3 Research questions

We set out on this journey under the guidance of three main research questions: (1) How can we integrate and adapt existing advanced computational methods into Indigenous knowledge systems? (2) How can we develop new computational practices within Indigenous contexts to support the flourishing of Indigenous communities? (3) How can we use the knowledge we generate to help guide the development of AI generally toward a more humane future? The first question has two aspects, the first of which concerns identification of touch points in terms of the computational methods that are/could be of interest to Indigenous knowledge systems. Exploring how these methods can be integrated into Indigenous knowledge systems requires a nuanced understanding of both the technologies themselves and the knowledge systems of Indigenous communities. Relatedly, the second aspect concerns the need to establish a ground upon which a meaningful encounter could take place between Indigenous knowledge systems and computational practices. What are the conditions under which such integration could take place, and do so in a way that upholds IK?

The second question directs us to explore dynamics that foster abundant intelligences. What are those practices that help communities thrive? This is an exploration of how we can create technologies that are embedded in the meaning worlds of the communities in which they operate. Indigenous communities have unique needs, values, and ways of understanding the world. How could we bring in their values, protocols, and priorities to the practice of computation? This also touches on sustainable development and notions of sovereignty and self-determination. Computational practices developed within Indigenous contexts should prioritize the principles of knowledge sovereignty, ensuring that Indigenous perspectives, protocols, as well as intellectual property rights are respected and upheld. Therefore this question allows us to consider and cultivate those practices that seek to uphold and exercise sovereignty in the digital realm. Moreover, this question may address barriers to technology access and infrastructure within Indigenous communities.

The third question seeks to explore how Indigenous knowledges and practices that foster regeneration, generosity, and reciprocity can inform and guide the evolution of AI systems. This question drives our research to explore novel methodologies, algorithms, and models that integrate Indigenous knowledge with computational methods, and do so in ways that prioritize human well-being, equality, and justice. To what extent these novel methodologies can be applicable in Indigenous contexts? This directs us to develop Indigenous-centered AI design guidelines within a network of reciprocal co-creation relationships between communities of learners and researchers. Another way to ensure that this kind of knowledge guides development of AI is to create capacity within the communities to engage with the complexity of AI technologies at different levels. We strive to work toward a vision where Indigenous practitioners are making the decisions that guide the development of AI themselves, and so a large portion of the question is about creating such capacity.

3 Methodology

In this section, we would like to walk the reader through the main tenets of the research and account for the overall orientation the project seeks out in addressing the research questions.

3.1 Macro methodology

We will collaborate with Indigenous communities to imagine AI systems designed from Indigenous epistemologies and with Indigenous protocols, partner with AI scientists and engineers to devise new approaches to designing AI, and develop capacity within and across Indigenous communities for engaging conceptually and concretely with AI. To accomplish this, we organized the work along three axes: Integrations, Imaginations, and Intelligences. The *Integrations Axis* explores how IK practices and frameworks can be synthesized with the mainstream knowledge frameworks

used by AI researchers. The *Imaginaries Axis* develops future imaginaries and speculative designs of Indigenous AI to guide the conceptualization of novel AI systems better suited to Indigenous flourishing. The *Intelligences Axis* brings Indigenous perspectives to bear on technical challenges currently facing AI research as it attempts to better understand ways of translating human intelligence(s) into machine intelligence(s).

The Integrations Axis explores how IK practices and frameworks can be synthesized with the mainstream knowledge frameworks used by AI researchers. Integrating IK systems with the AI research paradigms is fraught with epistemic challenges. For instance, much IK is not captured by, maintained in, or disseminated through text. Rather, knowledge resides in cultural practices (e.g., stories, songs, dance, and lore). Furthermore, IK insists on retaining the complexity of lived experience, which stands in contradistinction to a Western scientific framework that prioritizes abstraction to reach simple universal principles applicable to all individuals, communities, and territories. Synchronizing expertise, methodologies, and goals across a diversity of IK frameworks, and then further across Indigenous and mainstream AI perspectives, takes time. For the participants to develop and refine common languages and practices allowing them to work productively across epistemic gaps, they must first trust and understand each other's values and goals, through sustained interaction, and in contexts where participants are free to develop common intellectual trajectories.

The Imaginaries Axis develops future imaginaries and speculative designs of Indigenous AI to guide the conceptualization of novel AI systems better suited to Indigenous flourishing. In order to transform AI, we must envision Indigenous futures grounded in community priorities and dreams. We do this through developing 'future imaginaries' (Lewis 2023) that point us toward alternative research and development paths for AI that promote abundance rather than scarcity, exploitation, and control. Future imaginaries are visions of the future shared by a group and used to motivate change in the present. They create vocabularies for envisioning future socio-technological realities and strategies for realizing those realities. Developing future imaginaries allows us to play through different foundational assumptions about how things are and will be with regards to AI. Most importantly, they allow us to "practice the future together" (Brown 2017): to iterate collaboratively through future scenarios wherein AI is based on IK and Indigenous values.

Future imaginaries (FI) workshops form the heart of this axis. Based on the *Future Imaginaries of Indigenous AI* workshops (IP AI 2019), these group brainstorms provide an intellectual and practical sandbox for testing the hybrid methodologies developed in the Integrations Axis to visualize alternative futures that escape the confines of the current AI imaginary, using multiple modes of creative practice. We then develop designs based on the future imaginaries, combining Indigenous design (Witehira 2013; Edith Kanaka'ole Foundation 2017) to ground them in IK, and speculative design (Dunne and Raby 2013) to encourage critical–technical practice. Imaginaries work is highly relevant to science and technology studies' interest in socio-technical imaginaries in shaping present-day technology (Lösch et al. 2019).

The Intelligences Axis brings Indigenous perspectives to bear on technical challenges currently facing AI research as it attempts to better understand ways of translating human intelligence(s) into machine intelligence(s). The Integrations and Imaginaries work lays the foundation for prototyping AI technologies, and it is this technological aspect that we mainly tackle here. We identified five areas of interest to mainstream AI researchers that can benefit from active and rich engagements with IK frameworks and practices, and which engage areas of interest to the Indigenous communities involved. Our research will mainly focus on, but will not be limited to these subjects. These areas are:

- Language: Expanding the range of linguistic structures and language densities that NLP (Natural Language Processing) systems can robustly and appropriately handle. Indigenous languages are typically endangered, and fall into the low-resource data regime. Centering NLP research around them has a number of scientific benefits, including revealing new NLP problems that would not have been considered without dialog and participation with Indigenous communities (Shillingford and Parker Jones 2018). Furthermore, developing hybrid deep learning methods for training on low-resourced languages will empower Indigenous communities to accelerate work on revitalizing native languages and cultures.
- Storytelling: Drawing on Indigenous storytelling and oral traditions to assist in developing (1) interactive narrative technologies (VR/AR, social impact games, learning technologies, etc.) that allow for robust user interaction and agency through compelling narrative experiences, and (2) more robust, contextualized machine understandings of the stories humans tell to articulate and disseminate knowledge. Drawing upon notions such as 'narrative paradox' (Aylett 2000), or the "conflict between pre-authored narrative structures—especially plot—and the freedom [of] a virtual environment" (Louchart and Aylett 2003), we aim to develop cultural computing (Harrell 2013) systems that can both decode the narrative information to better understand local context and encode information to create interactive narratives to supplement existing storytelling practices.
- Environmental stewardship: Exploring how traditional Indigenous land management and stewardship practices can inform AI-driven land management and restoration

systems. Within the AI field, the use of AI to address environmental stewardship challenges dates back to the 1980s (Haupt et al. 2022). AI has been applied to climate change estimation, resource optimization problems, forecasting models, and hydrological prediction. Drawing on IK to enrich complex ecosystem interactions and forecast future ecosystem evolution offers tremendous potential for increasing their efficacy and accuracy, and developing methods for respectfully translating the data embedded in IK practices promises assistance in improving model integrity and forecasting reliability.

- Multi-agent systems: Developing more robust approaches to how diverse agents might interact with each other given socio-cultural context, including modeling of both human and non-human actors. There is currently great interest in AI in developing more sophisticated multi-agent and interactive systems including agent–human interactivity (Abramson et al. 2022) and agent–agent interactions (Zhang et al. 2021). For AI to be truly transformative and beneficial to human society we must ensure that humans are 'in-the-loop', guiding the training of the agents and ensuring that they are incorporating human needs and values into their objectives (Zanzotto 2019). Here, we aim to improve the sophistication of multi-agent and interactive AI systems by incorporating IK perspectives into the frameworks that we use in AI. We will develop systems that are driven by consensus-based goals and natural observation of others' behaviors.
- Socio-neuro AI: Developing better models for understanding how humans draw on their socio-cultural context to learn and make decisions, and how situated socio-cultural intelligences can be modeled into AI systems. Advances in social neuroscience and philosophy of mind point toward the centrality of the socio-cultural context in shaping how we learn and make decisions (Veissière et al. 2020) and how social interactions form an essential component of cognitive abilities (Bolotta and Dumas 2022). The large diversity and heterogeneity of human socio-cultural contexts, as well as the biased allocation of scientific focus to dominant Western-centered forms, constitute important hurdles which need to be overcome when seeking to build novel models that incorporate Indigenous knowledge, and which transform qualitative knowledge into quantitative parameters. This opens clear opportunities for joint collaboration with machines to create Indigenous futures built on novel learning and decision-making algorithms.

3.2 Conduct of research

This section describes the organization of research so as to provide the context and substance to our macro methodology. Abundant Intelligences' international and interdisciplinary team of experts are coalesced into locally rooted research clusters called 'Pods', which collaborate with Indigenous communities and learn from, and with their knowledge holders to bring novel perspectives to AI. Each Pod is anchored in an Indigenous-centered research and media laboratories, bringing together IK knowledge holders, cultural practitioners, language keepers, educational institutions, and community vitalization organizations together with scientists, engineers, artists, social scientists, and humanists. Participants imagine, design, and prototype new computational practices in tight collaboration with their local Indigenous communities.

These Pods employ mixed methods, weaving together research-creation, qualitative research, and quantitative approaches to knowledge production within a context of Indigenous research frameworks. By research-creation, we mean both "research-from-creation" and "creation-as-research" as defined by Chapman and Sawchuk (2012), as well as the ways in which Indigenous research methodologies center creative practices. A major component of the research program involves creative practitioners leading the Pods in developing future imaginaries of AI (Lewis 2016). By qualitative research methods, we mean Indigenous qualitative research which aims to decolonise and Indigenize the research paradigm (Smith 2012). Qualitative research within this paradigm is collective and kept in context within Indigenous protocols, values, beliefs, and the collective (Chilisa 2011), and is founded on culturally safe and relevant approaches to data analysis and interpretation which better reflect the realities of Indigenous communities (Hart et al. 2012; Smith 2012; Wilson 2008). By quantitative research methods, we mean producing statistical data about Indigenous communities 'by and for' them (Walter and Anderson 2013), emphasizing Indigenous-led empirical research on communities' social realities in ways that challenge the colonial statistical erasure of Indigenous peoples.

The Pods are key elements of our methodology and research design. They provide the milieu necessary for the interdisciplinary integrations, workshops, and brainstorming sessions essential to the success of our investigations and reconceptualizations of AI, while acting as key sites for meeting and collaborating with local Indigenous communities, training and increasing these communities' capacities in computational technologies, and building and testing prototypes for novel AI systems. The Pods are based out of media and/or technology research and development labs, many of them Indigenous-led and focused on Indigenous research and research-creation. We currently have four Pods, and hope to eventually have at least six:

Haudenosaunee-Niitsitapi Pod: This Pod is based at the Onkwehonwe Research Environment (ORE) at Lethbridge University (AB) and Western University (ON). ORE researches digital media technologies for communicating

Onkwehonwe (Indigenous ways of knowing and being). Located in Niitsitapi (Blackfoot) and Haudenosaunee (Iroquois) territories, and with both Niitsitapi and Haudenosaunee advisory boards, ORE is a laboratory for exploring artistic visions of the Indigenous future, a place for new interdisciplinary Indigenous scholarship, and a practice-based studio environment for creative innovation and critical studio practice. The ORE AbInt Pod will mobilize AI technology to support the innovation, transmission, expression, and transformation of Niitsitapi and Haudenosaunee creative and cultural practices while simultaneously exploring how these knowledge frameworks help us think differently about AI. In particular, this Pod will work with AI scientists and engineers to develop methods for incorporating Niitsitapi and Haudenosaunee stories (in speech, song, and poetry) into how the AI systems understand the world, and how the underlying computational architectures might need to be reshaped to do so effectively. The resulting systems will be used to animate virtual environments that incorporate culturally important places, events, and objects. This project involves experts in Indigenous digital media, Indigenous epistemologies, language keepers, machine learning, digital media, and art.

Ka Hawai 'i Pae Aina Pod: This Pod is based at Create(x) Immersive Media and Data Visualization Lab at the University of Hawai 'i West Oahu. It facilitates and accelerates existing efforts to weave Hawaiian traditional knowledge and practices with AI systems to perpetuate abundant, resilient landscapes in the Hawaiian archipelago. The conceptualization of soil health as a model system for Indigenized AI emerged among scholars of Hawai'i with the proposition of 'ĀIna (Lewis et al. 2018). A long tradition of Indigenous Hawaiian knowledge and practice centered in the core concepts of aloha 'āina (reverence for a living landscape) and 'āina momona (the intentional cultivation of abundance) exists (Pascua et al. 2017; Winter et al. 2023), yet Western, data-driven, agricultural AI decision support tools focus on extractive productivity rather than relational sustainability. This Pod imagines, designs, tests, and prototypes a series of research and technological development activities that build AI-driven decision support systems grounded in both Western soil health science and IK. It is creating a foundation for future Indigenous AI systems that (1) captures landscape history and interrelation of landscapes embedded in Hawaiian cultural practices as well as Western data collections, and (2) decision support tools that support reciprocal human–soil relationships. It leverages and advances place-based methodologies by building placed-based visualization environments depicting both Hawaiian and Western landscape data in a unified way, innovating AI-driven decision support tools, data physicalization, Indigenous collaborative design, and surround-screen immersion. The Pod includes experts in Hawaiian epistemology, creative practice and ancestral agricultural practices; soil science; Hawaiian culturally based computer science and engineering education; Indigenous culture and computation; Indigenous biosciences; neuroscience and AI; computer science; and data science.

Aotearoa Pod: This Pod is located at the Āpōpō Indigenous CreativeTech Hub (Wellington) and co-hosted by Indigenous Design & Innovation Aotearoa (Wellington) and Massey University (Palmerston North) and supported by Te Hiku Media (Kaitaia). Indigenous team members within the project travel to various community marae (a tribe's communal space) to run and facilitate wānanga (intensive discussions/deliberations). The Pod focuses on articulating, shaping, and designing AI through a Māori lens and is founded on Māori methodologies, epistemologies, ontologies, modes of engagement, practice and language. It mobilizes AI technologies to explore the centrality of hapū (kinship group) and connection in creative, language, cultural, and wellbeing contexts. In particular, this Pod will work with Indigenous AI scientists and engineers to develop methods for incorporating and assessing how AI-based tools integrating an Indigenous worldview can be applied to data. The ultimate goal is to develop AI that brings a more holistic Māori-centric picture of language, culture, health, wellbeing, whakapapa (genealogical connection), and connectivity to Māori data and datasets. Projects hosted by the Pod are grounded in kaupapa Māori methodologies. They use mixed methods with wānanga to shape how the underlying computational architectures might need to be reshaped to inform different kawa/tikanga (shifting customs and practices), place, space, and design (Smith 2012). This Pod is led by experts in Indigenous epistemologies and methodologies; Māori epistemology, ontology, ceremony, practice, and incantation; Māori creative practice; Indigenous natural language processing and community-centered language revitalization; neuroscience; and linguistics and ethics.

Wihanble S'a Pod: This Pod is located at the Wíhaŋble S'a (Dreamer) Center at Bard College (Annandale-on-Hudson, NY). It collaborates with Oceti Sakowin communities such as Lakota communities in Rapid City (SD), and is developing local Indigenous community relationships through its partnership with the Forge Project, a native-led nonprofit organization focusing on native cultural self-determination and leadership to build community, public education, and collective action. The Pod focuses on developing Indigenous protocols to guide the creation and refinement of AI wearable and digital technologies through performance, sound art, and visual art practice. The team at the Wihanble S'a Center aims to imagine, design, test, and prototype a series of research and technological development activities that build AI-driven systems grounded in both Indigenous knowledge and Western dream science. Core research focuses are (1) exploring Lakota art-making practices such as Lakota geometric symbols and Lakota song-making

practices, and (2) human and AI co-creation through visions/dreams, where AI tools collaborate with a human dreamer. The Pod includes experts in Lakota epistemology and creative practices; sleep and dream studies; neuroscience; cognitive science; linguistics; and design.

3.2.1 Data sovereignty

Indigenous data sovereignty is central to the program's operations. At the foundation are First Nations Principles of Ownership, Control, Access and Possession (OCAP) (FNIGC 2015) and CARE Principles for Indigenous Data Governance (CARE) (GIDA 2019). These guidelines prioritize Indigenous ownership and control of data produced by and with Indigenous peoples, and the safekeeping of such data in a manner that collectively benefits the communities involved. We are particularly mindful of how core AI techniques such as Machine Learning require extensive data collection, and that historically this has been done with little regard for the source individuals or communities. We are developing innovative data management frameworks that enable Indigenous peoples to realize the positive benefits from sharing their data within AI research contexts while maintaining control of it. The research team's priority is that Indigenous participants understand how their data might be used in AI contexts; Pods are taking on this responsibility to educate data sharers and develop relevant workshops for general use.

3.3 Micro methodology

At the level of day-to-day research-creation, we are following the methodology we developed to maintain close fidelity to Indigenous community goals and values. Our approach weaves in the communities (of users/designers/thinkers/practitioners) to the process of design and development so as to ensure this. We outline this methodology in six phases that follow each other in theory but are not mutually exclusive in practice: understand; imagine; formalize; develop; implement; integrate.

The work starts with 'understanding', as in understanding Indigenous knowledge frameworks from the community's perspective. This is a critical step in ensuring a meaningful interaction could be sustained between the communities and the designers of the systems they are to live with. To establish such understanding, it is important to build relationships and create trust while expanding and safeguarding the community's (data) sovereignty and self-determination. Understanding is about listening for us, and actively listening at that: listening to Indigenous community members to understand how technology can be designed to better suit their communities; listening to knowledge holders, to understand how cultural practices are knowledge practices; listening across disciplinary boundaries, so the linguist and the historian can understand the computer scientists and the neuroscientist, and vice versa. It is this kind of interactive and embodied 'understanding' that establishes a zone of mutual intelligibility that we seek out.

The second step or aspect of the work is 'imagine' where we create spaces where communities (across disciplines as well as nations) come together to imagine how those knowledge frameworks might be integrated with computational methods. Here we integrate creative approaches and art in inquiring and identifying the touch points between AI and Indigenous knowledge frameworks. We will develop a number of community-grounded imaginaries to expand and illustrate the possibilities of Indigenous-informed AI. Imagining is important here as our work involves finding different ways of making technology, as the already existing pathways for building AI are particularly perilous for the Indigenous communities. We invoke imagination as a way to discover alternatives to the current systems that cannot but fail their 'users'. Especially in this cultural moment that formulaically exploits and controls imagination, it becomes all the more significant to imagine alternative ways of being-together-with technology.

Finding the ways in which IK and AI can work together, a crucial step is to formalize the knowledge framework to make it amenable to computational methods. This work is about translating complex, contextually rich knowledge systems into structured formats that can be processed, analyzed, and utilized by AI systems. This step is where we really get into the materiality of the work, which begins by identifying the key concepts, principles, and relationships within Indigenous knowledge frameworks. This means working closely with Indigenous knowledge holders and community learners, as well as philosophers and artists/practitioners, to elucidate the structure and semantics of their knowledge systems. This symbolic toolbox then is used to create representations that encode the knowledge in machine-readable form. This is the step where work about data sovereignty will be put to concrete use also, as we develop methods for ensuring that our collaborating communities' knowledges are used in the ways they specify.

The formalizations are then used in the fourth stage, 'develop'. This is where the team develops those datasets, models, and algorithms that integrate their knowledge properly with computational methods, reasoning, inferring, and learning from Indigenous knowledge inputs. This requires a multifaceted approach that combines technical expertise and community engagement-mediated cultural practices. What we strive for here is to preserve the integrity of Indigenous knowledge within the computational framework, all the while developing methods for processing heterogeneous data sources.

We then 'implement'. These computational artifacts are prototyped, tested, and iterated on. These models, datasets, and algorithms are validated and refined through iterative feedback loops with Indigenous knowledge holders and community stakeholders. Here we solicit input, insights, and critiques from community members to ensure that the models work in ways that reflect their knowledge, priorities, and worldviews.

This all culminates in 'integrate' where the new technology developed is integrated into community practices. This step is about fostering active participation and co-creation with Indigenous communities, providing spaces for them to contribute their expertise and perspectives, and ensuring that the technology weaves into their existing context rather than imposes upon or disrupts it. We hope this cultivates a sense of belonging, agency, and empowerment among Indigenous communities, ensuring that they create the capacity for shaping the direction and trajectory of the computational paradigm.

3.3.1 Capacity building

A significant component of our methodology is to train future generations of Indigenous researchers and increase the capacity of Indigenous community members to extensively engage with AI. Our program builds capacity with Indigenous undergraduate, graduate students, faculty and community members for engaging with cutting-edge AI research. We will offer a summer school for Indigenous learners, which will provide an opportunity to develop an AI research curriculum that integrates Indigenous cultural knowledge with explorations of advanced technology founded on Indigenous community concerns and values. We consider this capacity building to be a long-term effort, and will support Indigenous learners in returning to their communities to share their knowledge, and Indigenous and non-Indigenous learners joining academia and industry, bringing with them experience with effective knowledge sharing and collaborative knowledge discovery between Indigenous peoples and researchers on the edge of technological exploration.

4 Anticipated impact and outcomes

In this section, we discuss what we expect the impact of the program to be, the outcomes that we gear ourselves toward, and the limitations and risks that lie in our research agenda. The Abundant Intelligences research program's general impact will be to center Indigenous knowledges (IK) and Indigenous community priorities in developing new AI technologies while opening up new, generative avenues of inquiry for AI researchers. Each main stage of our work plan corresponds to outputs that will lay a path for novel possibilities of community-driven AI development. We will produce: (1) a set of methodologies and protocols for interdisciplinary and cross-cultural collaborations and knowledge integrations with Indigenous communities collaborating with AI researchers; (2) a set of imaginaries that lay out different paths for what the Indigenous communities we collaborate with want the future of AI to be, articulated in artworks, writings, designs, and, eventually, high-level technical specs; and (3) concrete prototypes of technical systems that materialize this whole process into technological substrates of AI which bring value for the communities in which they are developed and deployed, while also contributing to advancing the state of AI generally.

These outcomes will have a range of benefits. Abundant Intelligences establishes a platform for bringing together expertise from a multitude of disciplines, localities, and cultures, while knowledge created in the Pods will be mobilized through traditional publishing, workshops, and exhibitions. The project's online presence (e.g., through our website) ensures a robust utilization of digital dissemination opportunities, thus contributing to debates on ethical AI design and emerging scholarship on the social and cultural aspects of AI. Furthermore, it serves as a model for other projects seeking to tackle similar issues through locally rooted research and creation Pods exploring fundamental questions pertaining to AI with a participatory and inclusive approach. The project enables cultural–technical collaborations between Indigenous communities, brings together scientific practice with cultural concerns, and creates a test bed for various technologies imagined in the communities and prototyped in collaboration with world-class AI expertise. The summer intensives and Pod workshops enable Indigenous groups to be more actively involved with the creation and deployment of AI systems.

Specifically within the context of mainstream AI research, the program has numerous benefits including: (1) understanding of how Indigenous epistemologies can address the gaps in mainstream AI research that lead to bias, impoverished models of human intelligence, and brittle solutions that fail on encounter with real-world situations; (2) new visions of AI that move us away from the extraction/exploitation dynamics at the core of current AI research; (3) establishing a network of Indigenous-led, Indigenous-centred collections of expertise in, and capacity with, advanced computational technologies that are community grounded and in active collaboration with AI system builders; (4) developing protocols for productively weaving computational methods into IK practices, and for integrating what is learned by such interweaving into IK systems; (5) articulating protocols by which scientists and engineers can productively, generously, and respectfully co-create and collaborate with Indigenous communities on technologies that benefit those communities; and (6) building a diverse group of Indigenous voices

to advise public policy on issues of AI ethics, regulation, education, research funding, commercial use, and community benefit.

We should also acknowledge that the research program has substantial risks. The most significant one is that integrating IK and computational practices may turn out to be too difficult, or, worse, unsuited to transforming AI research in the ways we think necessary to ensure the technology is of benefit to all. The epistemic gaps might be too wide to meaningfully bridge together; however, it is still important work to experiment in this direction so as to discover such limits. Another risk lies in the program bringing together many diverse communities with their own histories and cultures. We recognize that being Indigenous does not correlate to a monolithic landscape of values; indeed the project supports the diversity of Indigenous thought and practice as a benefit to knowledge creation. But initial relations we have formed could become difficult to maintain across the cultural, geographic, and institutional differences we face. We are also aware of the deep complexities of how IK interacts with Western intellectual property regimes and Indigenous data sovereignty, and foresee challenging discussions on how IK might or might not be shared across the program, and further. Another risk lies in the challenges of successfully integrating participants from computational sciences, natural sciences, humanities, arts and community-based backgrounds, complicated further by the fact that many Indigenous communities are skeptical about sharing their knowledge with academia and industry. We are mindful of the historical alliance between colonialism, capitalism, and research practices where traditional knowledges were extracted from communities to serve Western science and commerce at the expense of those communities (e.g., Abbass et al. 2022). We are attempting to mitigate that risk by our careful choice of team members, collaborators, and partner organizations; planning methodological workshops to clearly establish a program structure that emphasizes reciprocity in all aspects; and co-creating cultural property agreements whereby communities retain the rights thereto, directly benefit from any benefits derived therefrom, and share executive decision-making power over how it is used. We take on the challenge of building systems with appropriate governance grounded in cultural protocols that prioritize greater Indigenous sovereignty over the AI landscape.

Even if the outcomes are less than anticipated above, we see benefits. These include (1) the establishment of a network of relationships between Indigenous communities, scholars working at the intersection of Indigenous culture and digital technologies, and AI researchers working at the frontiers of the field; (2) a diversification of people, knowledge frameworks, and ethical approaches within AI research, most notably in the Intelligences Axis areas, and of direct application to the challenges of AI bias; (3) a significant increase in the number of Indigenous people trained to engage with the complexity of AI technologies from within their own cultural context; and (4) development of experimental models for addressing data sovereignty, data colonialism, and Indigenous cultural property within the context of advanced computational technologies.

5 Conclusion

Our work is about integrating AI into Indigenous knowledge frameworks, and thus making a home for it in the communities themselves. It is about recognizing that the community is where the meaning of intelligence, and thus AI, is negotiated and intentions are set with regard to it. A significant part of that conversation is about who will be doing the work of making the AI accountable, who will look after, care for, and develop these AI. The 'who' question is necessarily tied with the history of mistrust between the communities that come together under this endeavor. Scientists and Indigenous peoples have had their encounters marked by colonial violence and power asymmetries. The way in which that relationship worked before was with a top-down organization where colonizing forces took decisions for the Indigenous people and imposed the results onto the communities. That is why we want to place AI *in* the community, so as to take the means into our hands and develop these technologies 'by' us and 'for' us. That is why a significant portion of the work is about creating capacity in the communities, not only in terms of encouraging and supporting new types of technologists, but also creating that capacity to engage in the conversation, in terms of having the vocabulary, care, and technical skills to contribute to the AI conversation in a way that is transformative.

Ultimately, we are creating a counter movement to the way in which AI is paradigmatically developed. We are contrasting the mainstream view of intelligence as an abstract, brain in a vat model with one that considers it as being embedded in the context of its relational environment. In this perspective, questions of land and culture are all infused with technological questions, working to move the conversation beyond the society vs technology or culture vs nature dichotomies that only serve to strengthen existing epistemological hierarchies. Our research-creation effort recognizes at the outset the need to connect from the lab where the algorithms are developed to the community where the needs and motivations are negotiated and meanings are established. This connection is how we nurture a future of Abundant Intelligences, where advanced technologies such as AI benefit all of us.

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