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Posthuman Cartography? Rethinking Artificial Intelligence, Cartographic Practices, and Reflexivity

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Artificial intelligence (AI) is catalyzing growing disruptions in contemporary cartography and beyond. Unlike previous mapping technologies, the current wave of AI enables producing maps without explicit programmed rules, which extends and, in some cases, surpasses human intelligence. This transformative capacity has the potential to reshape not only the practices of map-making but also the power structures of the actors involved. In this light, we propose posthuman cartography as a potential perspective to examine the emerging trend in cartography characterized by a codependency between human and machine intelligences. This theoretical perspective challenges traditional human-centric approaches, proposing instead to view mapping as a network of relations that include both human and nonhuman actors. It also highlights the importance of recognizing AI as significant actors in mapping praxes, as well as the need to acknowledge the shifting power structures influenced by AI. We further advocate for a reflexive approach that tackles the ethical challenges posed by AI and other technological disruptions in contemporary cartography. *Key Words: AI, cartography, ChatGPT, ethics, posthumanism.*

Cartography in the past century relied heavily on computational algorithms coded by humans, mainly cartographers, to automate tasks such as data classification, label placement, and map generalization (Tobler 1959; Dobson 1983; Goodchild 2000; Sui and Morrill 2004). Although these algorithms reduced repetitive work, they are limited to following predetermined rules, requiring human cartographers to remain intensively involved in the cartographic process. In contrast, the influences of artificial intelligence (AI) on cartography over the past five years have been transformative (Robinson et al. 2023; Harrie et al. 2024; Kang, Gao, and Roth 2024; Wu et al. 2024). Geospatial artificial intelligence (GeoAI) for cartography and mapping has been featured at major conferences—such as the American Association of Geographers (AAG) Annual Meeting, AutoCarto, and the Association for Computing Machinery (ACM) Special Interest Group on Spatial Information (ACM SIGSPATIAL)—and in a recent handbook (Gao, Hu, and Li 2023). Generative Adversarial Networks (GAN), ChatGPT, Gemini, Llama, Dall-E 3, and MidJourney, as well as their custom versions for cartography such as MapGPT, further enable machines to create maps from simple prompts without relying on human-coded rules (Tao and Xu 2023; Q. Zhang, Kang, and Roth 2023; Chen et al. 2024; Y. Zhang et al. 2024). The increasing ability of AI to mimic, and sometimes even replace, human intelligence for autonomous decision-making is challenging traditional human-operated cartographic practices and driving new modes of geographic knowledge discovery (UC Santa Barbara 2023).

The rise of AI as a new form of intelligence is opening new horizons for theoretical, methodological, and technical developments in cartography. Earlier mapping technologies, such as automated cartography and geographic information systems (GIS), follow relatively transparent, human-directed processes from data to map creation, with cartographers being the primary decision-makers and machines acting mostly as passive tools. Existing cartographic and geographic literature has extensively examined the subjectivity and biases of cartographers—shaped by race, class, and gender—and the problematic claims of neutrality in these technologies, along with their sociotechnical impacts (Pickles

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1995; Harley 2008; Crampton 2010). AI, particularly generative AI such as ChatGPT, differs fundamentally by functioning as "black boxes," making autonomous decisions without clear transparency about how these decisions are made and what influences them. This shift complicates the understanding of the cartographic process, as decision-making extends beyond cartographers to include machine intelligence. New actors and power dynamics are introduced, potentially embedding biases and harms that the cartographic community has yet to fully recognize (Janowicz, Sieber, and Crampton 2022).

We therefore introduce the term *posthuman cartography*[1] as a potential perspective to navigate the nuances of the emerging trend that features an increasing codependency between human and machine intelligences in cartography. Here, posthumanism refers to perspectives that challenge traditional human-centric views of the world by questioning the distinctions between humans and nonhumans (Hassan 1977; Haraway 1991; Fukuyama 2002). In geography, posthuman (or more-than-human) perspectives often focus on the blurred boundaries between humans and biotechnology, animals, plants, and geological processes, which further extend to examining how technologies and environmental changes influence human–environment interactions, power dynamics, and ethics (Coyle 2006; Whatmore 2006; Wilson 2009; Boyd and Straughan 2023). Despite the transformative potential of AI, however, it has not received sufficient attention in such posthuman discourses. Bridging this gap is crucial, as posthumanism provides a unique perspective to examine the evolving relationships between humans and AI, offering a powerful tool for cartographic and GIScience communities to understand broader societal implications beyond the technology itself.

Posthuman cartography acknowledges AI as an important co-producer of maps and reexamines cartographic practices that have historically been centered on human intelligence. This exploration of human–machine interconnectedness can trace its roots to cybernetics and systems theory in the mid-twentieth century and is closely related to Haraway's (1985) theory of the cyborg, an assemblage of human and machine. Drawing from posthumanism that criticizes historical practices using race, ethnicity, and sexuality to hierarchically define humanity (Haraway 1991; Wilson 2009; Braidotti 2013), posthuman cartography further examines potential exclusions of narratives from marginalized groups—including women, LGBAQA+, indigenous communities, people of color, and differently abled people—in the collaborative mapping between humans and AI, aiming to promote inclusivity and diversity. Through this examination, posthuman cartography aims to understand how the increasing role of AI brings about new forms of power structures in cartographic theories and praxes, and reflects on the complex interplays of social, cultural, and technological factors in shaping spatial representations.

Posthuman cartography poses new ethical questions about the societal impacts of AI technologies on human and nonhuman stakeholders, including considerations of privacy, autonomy, and justice. For example, there are growing concerns about national security due to the widespread use of deepfake satellite imagery facilitated by generative AI, particularly in military applications (Zhao et al. 2020; Zhao et al. 2021; Gilbert 2023). In addition, issues related to personal privacy emerge from the extensive utilization of personal data during AI training (Lin 2024). Addressing these ethical challenges involves engaging the network of human and nonhuman actors involved in collaborative mapping to recognize the new forms of marginalization and injustices that could emerge from their practices, fostering a sense of responsibility and reflexivity in their actions. This reflexive approach to posthuman cartography forms a vital part of a broader discussion concerning the ethical implications of new technologies and spatial media within cartography and GIScience (Sheppard 1993; Crampton 2003, 2009; Dodge, Kitchin, and Perkins 2009; Crampton 2010; Goodchild 2015; Wilson 2017).

In the following sections, we review posthumanism and its relevance to cartography and geography. We then provide a detailed discussion of posthuman cartography, which examines the collaborative cartographic practices with AI within a network of human and nonhuman actors involved, exploring new power dynamics and ethical challenges emerging from these actors and the interactions between them. Finally, we discuss the role of reflexivity in addressing the sociotechnical impacts of posthuman cartography.

Posthumanism, Geography, and Cartography

Posthumanism emerged during the late twentieth century amidst rapid developments in biotechnology and cybernetics as well as the rise of the postmodernism movement (Hassan 1977; Haraway 1991; Hayles 1999;

Fukuyama 2002). It challenges the radical anthropocentric view that humans are fundamentally different from and superior to nonhuman actors. Instead, it recognizes all experiences, including those of nonhuman actors such as machines, animals, and potential unknown life forms, as valuable sources of knowledge. An important focus in posthumanism is on the interconnectedness between humans and machines or technologies. For example, Haraway's (1985) cyborg theory examines how the boundaries between humans and machines are becoming increasingly blurred, suggesting that humans are already cyborgs in a sense, with technologies playing an integral role in our lives.

This idea of cyborgs extends to contemporary discussions about AI, highlighting its increasing integration into human daily experiences, not merely as a passive tool but as an actor demonstrating autonomous intelligence. Recent advancements, such as ChatGPT-4 passing rigorous Turing tests (Turing 1950; Mei et al. 2024), demonstrate AI's capability to match or even exceed the average human's abilities in areas such as altruism and cooperation. As AI continues to take on social and cognitive functions once attributed solely to humans and evolves into roles such as coscientist (Boiko et al. 2023) and copilot (Dakhel et al. 2023) for collaborative tasks traditionally dominated by human intelligence, it increasingly embodies the concept of the cyborg and emerges as an important posthuman actor.

Posthumanism has also influenced the contemporary feminist movement by revealing the historical denial of women's rights, education, and recognition as equals and critiquing traditional understanding of gender and humanism, emphasizing the fluidity and plurality of identities beyond the human-centric lens (Haraway 1991; Braidotti 2022). This influence extends to a broader study of the difference, which questions the traditional notion of what it means to be human and critiques exclusion and marginalization through sexism, racism, classism, ageism, homophobia, and ableism (Braidotti 2013). In Western history, the term *human* has often been associated with Whiteness, maleness, heterosexuality, and citizenship (Foucault 1975). Posthumanism seeks to challenge and disrupt this exclusive view of humanity, emphasizing instead the diversity of experiences and perspectives that shape our understanding of the world.

Posthumanism has been extensively studied in geography. This is reflected in the emergence of posthuman geographies and more-than-human geographies, which aim to deconstruct the radical anthropocentric hierarchy and advocate for the recognition of nonhumans such as animals, plants, landscapes, and place as equal actors with humans in the study of human–environment and society–nature relations (Braun 2005; Whatmore 2006; Panelli 2010; Larsen and Johnson 2016; Robertson 2018; Boyd and Straughan 2023). Posthumanism provides a new way of thinking for environmentalism by recognizing the agency and significance of nonhuman actors in shaping environmental processes. It also expands moral considerations to include nonhumans in environmental issues such as climate change. In addition, many existing posthuman studies are deeply connected with postcolonial and critical race studies, which reflect on historical colonial narratives about place and the exclusion of indigenous voices in geography (Panelli 2010; Sundberg 2014; Larsen and Johnson 2016).

Critical cartography, although not explicitly termed *posthuman*, embodies many ideas that fall under the umbrella of posthumanism. For example, it addresses the blending of human and machine roles seen in computer cartography (Monmonier 1985) and Web mapping (Oviatt 1997). Posthumanist views are also evident in seeing maps as social constructs influenced by power dynamics (Harley 1989, 1990, 2008), questioning their construction, representation, and inclusion or exclusion of perspectives (Wood 1992; Pickles 2004; Dodge, Kitchin, and Perkins 2009; Crampton 2010). Posthumanism is also deeply connected with countermapping (Peluso 1995), queer mapping (Brown and Knopp 2008), feminist mapping (Kwan 2002; Kelly 2019), and indigenous mapping (Rundstrom 1995), which empower marginalized communities to use maps as tools for representing their own spatial knowledge, experiences, and perspectives. None of the existing work, though, addresses the growing trend of AI increasingly complementing human intelligence and being an active co-producer in map creation, nor explicitly recognizes such a symbiosis between human and AI as a formal form of posthuman. This study aims to introduce posthuman cartography as a means to bridge this gap, drawing on the rich development in posthumanism to help understand the broader social implications of AI in cartography.

Posthuman Cartography: Maps as Network

Posthuman cartography encompasses two primary dimensions in response to the increasing integrations of AI in cartography. First, it represents a shift away from traditional human-centric approaches to mapping and cartography, recognizing the equal involvement and agency of nonhuman actors, particularly AI, in cartographic practices. This perspective recognizes that AI systems are not just tools but active contributors to map creation and interpretation, underscoring the need to understand how AI perceives, processes, and represents spatial information. Second, posthuman cartography involves critically examining the power dynamics inherent in the collaborative mapping between AI and humans, seeking to identify instances where certain voices, perspectives, or experiences are marginalized or excluded. It advocates for the inclusion of diverse voices and perspectives in collaborative mapping between AI and humans, recognizing that different stakeholders might have unique insights and knowledge to contribute. By challenging exclusionary practices and promoting inclusivity, posthuman cartography aims to create maps that better reflect the complexity and diversity of experiences and landscapes.

This study delves into the two dimensions of posthuman cartography by conceptualizing maps and mapping as a dynamic network of interactive relations between humans and nonhuman actors, with the goal of shedding light on the evolving roles of AI and humans in cartographic practices and their influences on how places are mapped. Viewing maps as dynamic practices is not new and is deeply related to nonrepresentational theory in cartography, which suggests that maps are not mere representations but actively shape our perception of the world and our place within it (Del Casino and Hanna 2006; Kitchin 2008; Thrift 2008). Our approach extends beyond existing research by considering not only human-initiated "practices" but also the roles of nonhumans, such as AI and the data used to train AI models, which are often overlooked yet profoundly shape contemporary cartography.

We use actor-network theory (ANT), a framework in social sciences and technology studies that investigates how complex networks of interactions between actors shape social processes (Latour 2007), to analyze the network of human and nonhuman actors in map-making. The main reason we choose ANT is its perspective of defining nonhumans as actors equal to humans and discussing the interactions between actors to form a network, rather than viewing actors as functioning in isolation. In this study, we characterize maps as a network by detailing the key actors involved and their interactions in shaping cartographic practices. We want to note that the actors and interactions discussed here are not exhaustive. Some critical actors, such as environmental entities, are not covered in this analysis. Our goal, however, is to highlight certain prominent actors and interactions to initiate conversation and encourage reflection on the emerging power dynamics and inequalities in map-making. This analysis is intended as a starting point rather than a definitive account, inviting further exploration and open dialogue.

The Actors

Posthuman cartography involves a diverse network of actors, both human and nonhuman. Nonhuman actors include but are not limited to training sets and AI models, whereas human actors consist of data annotators, AI scholars, public end users, and organizations such as research institutions, tech giants, and government agencies that shape the development, application, and regulation of AI technologies. New power dynamics and inequalities are embedded within and among these actors. Here, we introduce each to establish a foundational understanding of their roles in posthuman cartography.

Training Sets. Training sets provide the data needed for AI models to learn patterns for autonomous decision-making. In cartography, they often comprise maps collected from existing sources, such as satellite imagery, historical maps, and thematic maps, as well as their ground-truth labels, such as annotations of roads and settlements (Arundel, Li, and Wang 2020; Chang et al. 2022). Training sets can be biased, however, and not representative due to biases embedded in existing cartographic practices. The History of Cartography project, initiated by Woodward and Harley in the early 1980s, highlights how historical maps reflect power structures and exhibit human biases in decisions about symbolism, scale, color, and other design elements (Harley 1988, 1992, 2002; Wood, 1992). Biases and exclusions continue to exist in digital mapping today, exacerbated by the "digital divide" rooted in the historical, social, and cultural contexts of computer technologies (Crutcher and Zook 2009; Graham and Dittus 2022). Stephens (2013) illustrated an example of gender divide in user-contributed digital mapping platforms (e.g., OpenStreetMap), where males are more likely to be aware of, use, and contribute to these platforms and become gatekeepers of local geographic knowledge. Without careful consideration of what (not) to include in training sets, there is a risk of model overfitting due to imbalanced, gendered, and racialized data, potentially leading to the generation of maps that perpetuate and amplify dominant discourses and biases, while failing to represent the diverse cultures, experiences, and perspectives that exist in spatial representations.

AI Models. AI models learn patterns in data and make decisions without relying on human-coded rules. An important recent development in AI is the emergence of foundation models, a type of generative AI trained on vast amounts of unlabeled data that is multimodal—capable of generating text, audio, and visuals based on user prompts (Bommasani et al. 2021). Examples of such models include ChatGPT, DALL-E 3, and MidJourney. Foundation models are gaining attention in geography, with research focusing on geo-foundation models to address geospatial challenges such as spatial heterogeneity and spatial data representation learning (Xie et al. 2023). In cartography, there is also growing interest in foundation models, as evidenced by the rising use of ChatGPT and DALL-E 3 for map creation (Tao and Xu 2023; Q. Zhang, Kang, and Roth 2023) and development of custom versions for cartography such as MapGPT (Chen et al. 2024; Y. Zhang et al. 2024).

Foundation models incentivize homogenization, as the same models are repeatedly used across various applications. As pointed out by Bommasani et al. (2021), though, such homogenization is a double-edged sword: Centralization offers efficiency, but it also poses risks, turning these models into potential single points of failure that can cause widespread harm. Recent studies have identified significant disparities in the quality of spatial answers generated by ChatGPT, particularly concerning rural and indigenous areas in the United States (Atkins et al. 2024; Kim et al. 2024). In cartography, this disparity in quality risks further deepening existing inequalities in how certain communities and spaces are represented, perpetuating biases that have long influenced the field. For example, Y. Zhang et al. (2024) showed that DALL-E 2 generates maps biased toward specific geopolitical identities, which can stoke nationalism and reinforce xenophobic or otherwise biased geopolitical discourse.

Data Annotators. Human workers play an important role in identifying, segmenting, and labeling data used to train AI models. An emerging trend among many organizations is to outsource data annotation, often considered "low-skilled" tasks, to ad hoc digital labor. Amazon Mechanical Turk (MTurk),[2] a crowdsourcing digital labor market, is a primary platform for this outsourcing, where AI entities (or "requesters") enlist remotely located workers to collect and annotate data for training purposes. Despite AI's dependence on the large digital labor force for data annotation, this labor often goes unnoticed as breakthroughs in AI are often celebrated as mere efficiency gains in technology. In many countries (e.g., the United States), the value of digital labor is not formally acknowledged by labor laws. Individuals who work in digital labor are often considered self-employed, which means minimum wage laws generally do not apply to them. For example, although Amazon pays all of its U.S. employees at least fifteen dollars per hour, it has not commented on the pay policy for workers on MTurk (Newman 2019). In addition to low wages, these workers often endure other precarious working conditions such as long hours and job insecurity. With a growing body of digital workers hailing from the Global South, the trend of the digital economy transferring data and value from the Global South to the North has fostered a form of "digital colonialism" that can perpetuate economic inequalities and reinforce power imbalances, ultimately disadvantaging local communities (Casilli 2017).

AI Scholars. Traditional cartographers, with expertise in translating complex geographic data into meaningful and visually appealing maps, have historically held primary influence and authority in mapmaking. The rise of AI, however, has shifted much of this influence to AI scholars and professionals. Although a growing number of cartographers are gaining expertise in AI and incorporating it into their work, most AI scholars who develop, test, and deploy these models come from computer science backgrounds without specialized knowledge in cartography. This shift introduces a new layer of decision-making and expertise into the mapping process.

The historical landscape of science and technology has been marked by gender and racial imbalances, characterized by a predominant representation of White males (Beyer et al. 2003; Beyer 2014; Margolis 2017). Despite recent diversity initiatives, AI remains largely White and male, with limited representation from women and people of color (Lecher 2019; Cave et al. 2023). This lack of diversity mirrors the masculine bias long criticized in cartography, where male dominance has historically shaped geographic representations, privileging men's geographies, spaces, and experiences to establish truth claims and sustain political power (Haraway 1991). Since the late twentieth century, feminist geographers have pioneered new cartographic methods to represent women's spaces (Rose 1993; Kwan 2002), which runs parallel to other countermapping endeavors such as queer mapping, Black mapping, and indigenous mapping (Rundstrom 1991; Butler 2018; Gieseking 2020). As decision-making increasingly shifts from traditional cartographers to AI scholars, however, concerns arise about how efforts to challenge the "male gaze" and Whiteness in cartography will be integrated into the evolving AI landscape. Without proactive measures, AI-driven maps risk perpetuating the overrepresentation of dominant gender and racial perspectives, potentially sidelining or misrepresenting marginalized spaces and experiences.

Public End Users. Public end-users have a dual role in interacting with AI for map-making. They actively use AI models—particularly foundation models—to generate maps by providing prompts, while also engaging as readers of those maps. This interaction mirrors the public's engagement with ChatGPT, where users not only receive information but also input guidance through prompts and offer feedback through comments or buttons. The democratization of AI access has broadened the user base beyond researchers and professionals, inviting anyone interested in creating unique visual content—even those with limited experience in AI or cartography. These map creators often become the same individuals who read and interpret maps generated by others, fostering a new dynamic and interactive community.

The increasing involvement of public end-users in map-making reflects a broader trend toward decentralization, shifting mapping practices from professionals to a diverse range of individuals. This trend is reminiscent of other developments in cartography and geography, such as participatory mapping (Chambers 2006) and voluntary geographic information (VGI; Goodchild and Li 2012; Sui et al. 2012), both of which aim to incorporate diverse perspectives and local knowledge into maps and spatial analyses, empowering communities to contribute to the creation of geographic information. Disparities in access to new digital media and technologies persist, however (Crutcher and Zook 2009; Stephens 2013; Graham and Dittus 2022). In the United States, one in three people lack Internet speeds fast enough to use Zoom, much less the latest AI-enabled technologies. The digital divide is even more pronounced in the Global South, where over half of the population in many African countries remains without Internet access. These disparities will likely perpetuate unequal influence and visibility among regions and communities in the AI-driven map-making landscape.

Research Institutions, Tech Giants, and Government Agencies. Research institutions (e.g., OpenAI, DeepMind), tech giants (e.g., Google, Amazon, Meta), and government agencies (e.g., military) play crucial roles in shaping the trajectory of AI through their influence on its development, application, and regulation. In particular, tech companies have been at the forefront of recent advancements in AI technologies. The rise of neoliberal policies and financial globalization has created environments conducive to monopolistic practices, greatly amplifying the global market power of these corporations. By dominating the collection, control, and monetization of essential infrastructure, data, and resources, these corporations have developed centralized power in advanced AI technologies, allowing them to largely dictate AI's technological trajectory, influence policy and regulation, and determine who benefits from its development and deployment (Pasquale 2015; Crawford 2021).

Throughout the history of cartography, economic and political dynamics have consistently influenced mapping practices across various organizational levels. In the private sector, commercial interests have driven the production of maps tailored to profit-driven activities, such as insurance and tourism, exemplified by the Sanborn Fire Insurance Maps in North America. Meanwhile, government agencies have created maps for military, transportation, and other functions at local, regional, and national levels, as seen with the UK Ordnance Survey. Historically, maps have long served as instruments of authority and legitimacy (Harley 2008) and have also been employed for surveillance, enabling corporations and governments to monitor populations and behaviors (Monmonier 2004). As AI becomes increasingly integral to map creation, these established power dynamics not only persist but also grow more complex, with organizations that develop and control AI technologies gaining significant influence over how maps are produced and used.

The Interactions

Posthuman cartography is also shaped by interactions between human and nonhuman actors. A detailed examination of these interactions can help the actors involved better understand the shifting network of relationships that fosters new power dynamics and ethical challenges in this emerging trend of cartography.

Data–Model Interaction. The interaction between data and AI models involves training these models with proper training sets to detect patterns, relationships, and features, which are then applied to generate maps. AI research and development have focused on balancing model complexity to ensure that the patterns extracted are both informative and accurate, addressing problems such as overfitting and underfitting. One critical consideration in this process is the potential bias in the training sets that AI models might replicate in the maps they generate. For instance, Mehrabi et al. (2022) identified seven types of data biases that can lead to biased outcomes when used in model training. In cartography, representation bias is particularly relevant—this occurs when nonrepresentative samples are used in model training, leading to the exclusion of perspectives and voices from minorities or certain communities. The use of larger and more complex models trained on vast amounts of indiscriminate Internet data is likely to exacerbate this issue, as these training sets, despite their size, often contain inherent representation bias (Bender et al. 2021). Kim et al. (2024), for example, illustrated how widely used generative AI systems such as ChatGPT perpetuate representation bias in their training data, resulting in poor accuracy and literacy for rural and underrepresented areas.

Human–AI Collaboration. Human–AI collaboration in data annotation relies heavily on digital labor for collecting and labeling data for model training, predominantly with annotators based in the United States (Chan et al. 2021). In recent years, an increasing number now come from the Global South, including countries such as India and Kenya, with reports of exploitative practices, such as low wages and long working hours (Ipeirotis 2010; Rashtchian et al. 2010). This shift raises concerns about compromising not only worker rights but also data quality (Denton et al. 2021; Kauffman and Williams 2023). In addition, the predominance of U.S.-based annotators can lead to potentially biased data when labeling information about regions outside their direct experiences, due to a lack of awareness of the historical and political nuances that shape mapping in these regions (Difallah, Filatova, and Ipeirotis 2018). For example, labels for disputed territories often depend on the political perspectives of the map maker, a complexity that is often overlooked by ad hoc annotators (Monmonier 1991b; Graham and Dittus 2022). This disconnect between annotators' experiences and the data they label can further skew the voices and perspectives represented in training sets, particularly against developing countries, resulting in unequal benefits from the digital economy and AI advancements, and reinforcing digital colonialism (Kwet 2019).

Human–AI collaboration extends beyond data annotation to the development and refinement of AI models by scholars and professionals, whose design choices—such as optimization functions, regularization techniques, and the use of statistically biased estimators—can embed biases into these models (Mehrabi et al. 2022). Discussions of algorithmic bias in cartography remain limited, but insights from generative image AI, particularly in art, highlight how these models often fail to adequately represent diverse cultural and historical knowledge (Srinivasan and Uchino 2021). Many AI models now seek value alignment to ensure their goals and behaviors align with human values, yet critical normative challenges arise: Who decides which values should guide AI, and how are these decisions made (Firt 2023)? With persistent gender and racial disparities in the AI workforce, there are concerns about whether AI models in map-making are able to reflect the perspectives of marginalized communities and accommodate countermapping practices such as indigenous and queer mapping, or if they continue to perpetuate biases such as the "male gaze" and Whiteness.

User–AI interaction is important in shaping map outputs and user experiences, with public end users serving as both map makers and readers, facilitated by AI mediation. The increasing democratization of AI has led to the "deprofessionalization" of map-making, expanding participation beyond professionals to individuals without formal training to engage in map-making for various purposes—from artistic expression (Kang, Gao, and Roth 2019; Lundman and Nordström 2023) to personal storytelling (Ginestet 2023). Unequal access to AI technologies and varying levels of expertise, though, means that those with more knowledge and resources wield more influence over map-making. In addition, issues such as spoofing and falsification affect the reliability of maps created through user–AI interaction. For instance, generative AI has enabled individuals to create deepfake satellite imagery with intentionally falsified geographic information at regional or even national scales, which has political implications from elections to military (Zhao et al. 2020; Zhao et al. 2021).

Interaction with Organizations. The interactions between research institutions, tech giants, government agencies, and other human actors shape the power dynamics of map-making. Throughout the history of mapping technologies, particularly GIS, concerns have persisted about access and control, as these tools have been widely used by the military, governments, and corporations to reinforce power structures, surveillance, militarism, and commercialization (Pickles 1995). Recent literature has highlighted how AI permeates political life and contributes to a shift toward undemocratic governance and increased inequality as it becomes centralized among major tech companies and governments (Pasquale 2015; Crawford 2021). The expansion of AI in military applications, such as the use of deepfake satellite imagery, amplifies these concerns (Vincent 2021). In light of these developments, it is imperative to critically examine the tangible influence of various organizations over AI technologies used for map creation, as well as the intentions and social implications associated with such influence.

Reflexivity in Posthuman Cartography

Posthuman cartography raises ethical concerns about the impacts of AI technologies on both human and nonhuman lives, as the role of AI expands beyond technology to influence various populations. Navigating these issues requires reflexivity—an ongoing practice of recognizing and critically examining one's own biases, values, and position in developing and using AI for map-making. Reflexivity also involves understanding how power structures and social hierarchies shape and are embedded within maps, echoing long-standing discussions in cartography and geography on the influence of social contexts on spatial representation (Haraway 1991; Harding 1991; Rose 1997; Crampton 2010; Kwan 2016).

One common approach to fostering reflexivity is through codes of ethics. Discussions on professional competency, responsibility, and ethics in cartography and GIScience trace back to the 1990s (McHaffie et al. 1990; Curry 1991; Harley 1991; Monmonier 1991a; Craig 1993; Crampton 1995). Organizations such as the International Cartographic Association (ICA) and the Urban and Regional Information Systems Association (URISA) have developed ethical guidelines stressing obligations to society, employers, colleagues, and individuals (URISA 2003; DiBiase et al. 2009). In 2021, the AAG reinforced these efforts by hosting a summit that led to a report and research agenda on the ethical considerations of location-based technologies (Goodchild et al. 2022). Recent AI ethics initiatives—such as the Asilomar AI Principles (Future of Life Institute 2017), the IEEE's Global Initiative for Ethical Considerations in AI (IEEE Standards Association 2024), and the European Union's Artificial Intelligence Act—offer potential frameworks to adapt current ethical codes in cartography and GIScience to account for the impact of AI.

Rapid technological advancements often outpace formal guidelines, however, and many emerging codes of ethics for new technologies such as AI are criticized for converging around a limited set of principles that are often contested and lack coherence (Munn 2023). For example, transparency is a common principle in ethical codes for cartography (Yao et al. 2024) and AI (Balasubramaniam et al. 2023). In practice, though, transparency can conflict with proprietary constraints and privacy protections, leading to ethical codes that advocate for openness but leave significant gaps regarding what information should be disclosed, to whom, and at what level of detail. In this sense, the reliance on ethical codes alone can create a false sense of security for the actors involved by suggesting their AI is risk-free while the potential harms remain unchecked.

To address these challenges, reflexivity must go beyond static ethical codes to become an ongoing, active practice. This means that stakeholders should do more than simply familiarize themselves with ethical codes; they must take proactive steps to understand and mitigate inequalities and marginalization within the broader network shaping map-making. This network spans beyond traditional cartographers to include data annotators, AI scholars, training data sets, and AI models—each bringing new power dynamics that can potentially reinforce existing inequality and exclusion. Reflexivity, therefore, requires all participants to critically evaluate their own biases, experiences, and perspectives, while actively confronting blind spots that could perpetuate marginalization. Such reflexive practices resonate with approaches such as countermapping and participatory mapping, which are designed to challenge dominant narratives and promote inclusivity in cartography.

Concluding Remarks

Over the past five years, AI has become increasingly integrated into cartography, evolving from passive tools into autonomous actors in map-making. This trend is exemplified by the growing use of foundation models such as ChatGPT and their cartographic derivatives such as MapGPT. Unlike previous mapping technologies such as GIS, which follow a clear, linear, data-to-map workflow, these AI models, especially foundation models, introduce human-like decision-making but often operate in less transparent ways, making it difficult to fully understand their internal decision-making processes. This opacity raises concerns about potential biases and harms embedded within maps they create that could remain undetected or unaddressed.

This study proposes posthuman cartography as a perspective for understanding the growing codependency between AI and humans in map-making, as well as for navigating the emerging sociotechnical implications of this trend. By examining the evolving power dynamics and inequalities among human and nonhuman actors and their interactions, we aim to draw attention from the cartographic community to look beyond the technology itself and consider how emerging mapping technologies such as AI can be harnessed to foster justice and inclusivity in the discipline. In line with recent advocacies for humanistic GIS (Zhao 2022), "Care with GIS" (Zhao 2024), and "3Es" (ethics, empathy, and equity) in GIScience (Nelson et al. 2022), we hope this work will contribute to a conscientious approach to posthuman cartography—one that recognizes and respects diverse perspectives and contributions in map-making.

Apparently, AI applications in cartography and map-making are still in the early stages, and there is not a lot of empirical research available to support a comprehensive review of the topic. It is worth noting, however, that the primary goal of this article is by no means to provide a comprehensive review of existing work or empirical research on a specific impact of AI. Instead, we aim to bring attention to this emerging trend in cartography, and to initiate a conversation about its sociotechnical consequences as it develops. Such proactive thinking is critical for the healthy development of the discipline, rather than waiting for extensive empirical research to be conducted. Sheppard (1995) emphasized the importance of "thinking ahead" as he argued for the need to consider the future developments and social consequences of GIS in their early stages. He cited the development of the atomic bomb as a cautionary example: What began as pure science ultimately led to devastating social consequences that were only fully recognized after it became a deadly weapon, by which time significant destruction to humanity had already occurred. This reminds us to always be vigilant with today's technologies, which, although not necessarily as destructive, are still able to transform the discipline and society in different ways.

Our proposed posthuman cartography can be improved through the following considerations. First, the environmental actor plays a critical role, as AI infrastructure often entails significant environmental impacts, including high energy and resource demands for data storage, model training, and deployment, as well as considerable carbon emissions from large-scale AI systems (Kaack et al. 2022; Heikkilä 2023; Li et al. 2023). The climate implications and sustainability concerns associated with AI technologies deserve further investigation within the framework of posthuman cartography, particularly as we strive to balance technological advancements with environmental responsibilities. Second, posthuman cartography also appears in literature as a means of mapping the intellectual landscape of posthumanism itself. This involves documenting and comprehending the diverse scholarly approaches and genres within the realm of posthuman studies (Sharon 2012; Gerlach 2024). Third, recent years have seen a trend calling for a critical examination of posthumanism to provide cultural geographers with a socially accountable and rigorous approach to human–nonhuman relations (Falcon 2023). Moving forward, we aim to engage these dimensions more deeply to broaden the scope and impact of posthuman cartography.

We should also acknowledge that although we try to contextualize our discussion of posthuman cartography across different times and geographies (e.g., considering data annotators in both the United States and the Global South), certain examples, viewpoints, or considerations could still be missing. Inevitably, our work is shaped by our own identities and experiences, which influence the lens through which we approach this topic. Our intention, however, is not to present a definitive framework for the future of AI in cartography. Rather, we hope to offer a perspective that invites discussion, critique, and continuous refinement, as well as inspires reflection and awareness within both the cartographic and broader geographic communities about AI's evolving role in map-making. Ultimately, we hope that posthuman cartography will inspire more scholarly attention toward building a theoretical foundation for cartography in the AI era.

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Notes

1. We choose *posthuman* over *transhuman* because the former implies moving beyond the human and embracing a postanthropocentric approach, which aligns with our intent. Transhuman, on the other hand, typically refers to enhancing humans through technologies such as AI.
2. See https://www.mturk.com.

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