

A Theoretical Framework for Fallibilism and Generative AI in Cartography

Dennis Edler ^{a,*}, Jule Drews ^a, Karsten Berr ^b, Olaf Kühne ^b

^a Cartography / Geomatics Group, Institute of Geography, Ruhr-University Bochum (RUB), Germany – dennis.edler@rub.de, jule.drews@rub.de

^b Urban and Regional Development, Institute of Geography, Eberhard Karls University Tübingen, Germany – karsten.berr@uni-tuebingen.de, olaf.kuehne@uni-tuebingen.de

* Corresponding author

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Abstract:

Generative Artificial Intelligence (AI) represents a transformative branch within the expansive domain of Artificial Intelligence, dedicated to the creation of original content across a diverse spectrum of media, including text, images, music, and videos. Unlike analytical or rule-based AI systems, which are designed to interpret data or identify patterns, Generative AI leverages advanced machine learning models such as Generative Adversarial Networks (GANs) and transformer architectures like the Generative Pre-trained Transformer (GPT). By analyzing vast datasets, these models generate outputs that closely imitate human creativity, often blurring the line between machine-generated and human-created content. This evolution marks a pivotal shift in AI, moving beyond reactive and predictive functionalities to embrace creative processes that fuel innovation in science and research. In cartography, for example, Generative AI is being used to automate thematic mapping, simulate urban growth through GANs, and apply style transfer techniques to create visually consistent map designs. These applications demonstrate not only the creative potential of AI in spatial representation but also the epistemological risks which are associated with data-driven automation.

The rise of Generative AI requires a theoretical reflection on its potential and limitations (Kühne and Edler, 2025). One particularly relevant framework is fallibilism, an epistemological stance that underscores the inherent fallibility of human knowledge. Fallibilism contrasts with certism, which posits that humans can achieve certain and absolute knowledge about themselves and the world. This distinction is critical in the context of Generative AI, as these systems are inherently shaped by the quality of their underlying data and algorithms. Biases, inaccuracies, and gaps in datasets are common vulnerabilities of Generative AI models, compounded by human factors such as the formulation of imprecise prompts or subjective interpretations (Knoth et al., 2024). In AI-generated cartographic outputs, such vulnerabilities could manifest as misrepresentations of terrain, distorted spatial hierarchies, or biased urban representations. This may particularly occur when training data lacks geographic diversity or when prompts encode cultural assumptions.

Adopting a fallibilist perspective, encourages researchers to critically examine these uncertainties, question assumptions, and embrace the ‘fluidity of knowledge’. By doing so, outdated hypotheses can be replaced with improved ones, fostering methodological transparency and enhancing the reliability of scientific results. This approach not only mitigates the risk of misinterpretation but also reinforces trust in scientific practices, particularly in sensitive application areas, by promoting traceability and accountability.

In geo-information sciences, and specifically in cartography, fallibilism serves as a vital lens for analyzing the subjectivity inherent in map-making. Maps are not objective or definitive representations of reality, as scholars of Critical Cartography have long emphasized (Crampton and Krygier, 2005). Instead, maps and map elements are constructed from specific datasets, models, and assumptions that may contain errors or omissions (Drews et al., 2024, Karsznia et al., 2024). This subjectivity becomes even more pronounced when Generative AI is used to produce maps, where model outputs are not only shaped by data but also by algorithmic abstractions, such as inferred boundaries, interpolated objects, or stylized elements that may obscure real-world complexities. Additionally, mapping conventions define what is depicted, how it is represented, and whose perspectives are prioritized. This can lead to a marginalizing of alternative spatial narratives, such as those of minority groups. This further underscores the interpretive nature of cartography and also the need for more inclusive mapping practices.

A fallibilist approach in cartography calls for a systematic reflection on the uncertainties and potential biases embedded in maps. By acknowledging these limitations, researchers and practitioners can better assess the validity of map-based conclusions and address the influence of subjective worldviews on their work.

The integration of fallibilist principles in cartography has significant practical implications, especially in socially critical applications such as urban planning, disaster management, crime prevention, and environmental policy. Maps frequently serve as foundational tools for decision-making in these domains, and inaccuracies or biases can lead to flawed outcomes. By applying fallibilist perspectives, cartographers can, for example, recognize interpretative limits (understand the constraints of map representations and their susceptibility to error), critically evaluate models (scrutinize the assumptions and methodologies underpinning mapping practices), address uncertainties (proactively acknowledge and communicate potential errors, fostering a culture of transparency and accountability). Such an approach can contribute to more informed, ethical, and responsible decision-making, ultimately enhancing the societal value of cartographic outputs.

This theoretical study explores the established theories of fallibilism and their intersections with Generative AI, applying these insights to the field of cartography. By examining the challenges and opportunities of integrating fallibilist perspectives, the discussion highlights the potential of pragmatic or neo-pragmatic fallibilism to enrich AI-driven cartographic practices. Embracing this reflective stance not only supports methodological robustness but also paves the way for innovative applications that prioritize both scientific rigor and societal impact.

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