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Critical Geographic Information Science (GIS)

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Abstract

Critical GIS combines the technical held of geographic information science (GIS) with heterodox social theory. The result is a rich held whose technical focus incorporates cartography, computation, big data, and information science, with theoretical moorings in critical human geography, feminism, STS, and scholar-activism. A series of critiques of the technoscientific nature of traditional GIS undergird the formation of critical GIS as a subdiscipline and continues to contribute to its evolving definitions. One notable challenge for any definition of a critical GIS is the continued development of the technologies of GIS itself and the social, political, and economic transformations that reflect and feedback into the continued evolution of technology. Critical GIS is thus dynamic but has rich histories that include critiques and contributions of scholars that mirror and technology studies (STS), feminism and GIS, ontology, research, and participatory GIS (PGIS).

Definition: Critical GIS

Critical GIS combines the technical field of geographic information science (GIS) with heterodox social theory. The result is a rich field whose technical focus incorporates cartography, computation, big data, and information science, with theoretical moorings in critical human geography, feminism, STS, and scholar-activism. A series of critiques of the technoscientific nature of traditional GIS undergird the formation of critical GIS as a subdiscipline and continues to contribute to its evolving definitions. One notable challenge for any definition of a critical GIS is the continued development of the technologies of GIS itself and the social, political, and economic transformations that reflect and feedback into the continued evolution of technology. Critical GIS is thus dynamic but has rich histories that include critiques and contributions of scholars that mirror and technology studies (STS), feminism and GIS, ontology, research, and participatory GIS (PGIS).

Critical Cartography

The subdiscipline of critical cartography sits at the root of critical GIS and is often attributed to the works of JB Harley and David Woodward, notably their edited volume *The History of Cartography* published in the late 1980s. The pair met in the 1970s and began developing their critique together. JB Harley's article titled "Deconstructing the Map" and published in *Cartographica* two years after the edited book, advanced the notion of critical cartography even further. These works spawned conversations and critiques of maps and specifically cartography. Building from both Jacques Derrida and Michel Foucault, Harley concluded that maps were not territorial, but instead socially constructed, and thus representations of social relations. These findings are in-line with two other important works published shortly after in the early 1990s. Sociologist and STS scholar John Law was publishing related work in the late 1980s and early 1990s which focused on representations of power and documented the ways European powers used maps to reify or enact power over territory. Denis Wood's 1992 book *The Power of Maps* similarly showed how maps were not impartial, but instead concretize and project the interests and world view of the map maker. Woods illustrated this concept by invoking everyday concepts such as property lines, voting and taxation districts, and enterprise zones. Understood by these authors, maps are deliberate actions, signifying the ways in which maps, and the ideological practice of cartography, re/produce particular knowledge(s).

In the 1980s and 1990s, computers and GIS software helped increase the accessibility of map making, and to some degree began the on-going process of democratizing GIS and shifting notions of GIS expertise. During this time, GIS grew as both a set of courses in Geography and Urban Planning departments and as a skillset for students. Human geographers became concerned that GIS was directing the epistemologies of the broader geography discipline, invalidating much of the work of human geographers. Between 1990 and 1994, critiques questioned the claims of GIS, building from the concerns of mapping's use to enact power. These critiques problematized the

proliferation of a GIS and its epistemological and ontological implications for Geography and society. The tone of these critiques are notably ornery and dismissive, attacking the often grandiose claims of GIS. This near rejection of GIS by human geographers is what scholars point to as the first inklings of critical GIS as a subdiscipline. Yet, this tension proved productive and through the National Science Foundation, the US-based National Center for Geographic Information Analysis (NCGIA) created Initiative 19 GIS and Society as a means to promote discussion between an array of scholars, "critics" and "GISers," as an attempt to resolve tension within the discipline. Tom Poiker of Initiative 19 organized a "GIS and Society" workshop in November 1993 in Friday Harbor, Washington with Eric Sheppard and John Pickles to bring scholars together to discuss the societal impacts of GIS.

Two key texts came out of the 1993 Friday Harbor meeting which helped capture the discussion and usher in a new reflective and collaborative era of critical GIS. The 1995 book *Ground Truth*, edited by John Pickles, and a 1995 special issue of *Cartography and GIS* titled "GIS and Society" and edited by Eric Sheppard demonstrated scholarship that advanced the analysis of everyday and scholarly implications of GIS. Another key text published in 1991 from STS scholar Judy Wajcman titled *Feminism Confronts Technology* helped shape the critiques themselves. Collectively, the Friday Harbor group sought to reconstruct and contribute to GIS and thus organized around technical, philosophical, historical, political-economic, and socio-cultural topics. Within these topics, scholars sought to complicate the technological determinist perspective of GIS. Out of these works began a generative period of critical GIS, so much so that Nadine Schuurman cataloged 40 articles in 1995 alone addressing these topics within GIS. From the original 1993 Friday Harbor meeting, scholars organized subsequent NCGIA Initiative 19 meetings. A 1996 meeting at the University of Minnesota in Koinonia convened to develop a broader research agenda for GIS and society. A 1997 meeting at the University of Maine convened to discuss one of the emergent topics from the Koinonia meeting devoted entirely to public participation GIS. During this second era, 1995-1999, scholarship not only honed critiques but opened up new possibilities for use of new understandings and uses of GIS, exemplified by the growing recognition of public participation GIS as a method further extending critical GIS' feminist roots.

The "town-hall" gatherings of the 1993 Friday Harbor meeting played a pivotal role in generating scholarship on critical GIS, but also set a precedent for in-depth and congenial discussions from diverse sets of geographers, non-geographers, critical theorists, and GIS scholars. This cross-fertilization of a diverse amalgamation of voices is what Nadine Schuurman, Francis Harvey, and others consider to be a unique discourse around critical GIS as a subdiscipline. Nadine Schuurman captured the contributions and critiques of these GIS debates in the 1990s in an article published in 2000 in *Progress in Human Geography*. If the 1993 meeting helped usher in the second era of Critical GIS, the diverse, congenial town-hall type meetings between 1995 and 1999 helped usher in a third era of critical GIS. At the University of Kentucky, Francis Harvey organized a meeting in 1999 which included STS scholars Susan Leigh Star and Geoffrey Bowker, deepening the cross-fertilization between critical GIS and other disciplines. In 2000, Francis Harvey edited a special issue of *International Journal of Geographical Information Science* with select articles from this meeting titled "The Social Construction of Geographical Information Systems." This special issue marks the third era and a new generation of conferences. At Hunter College in 2001, Mei-Po Kwan, Francis Harvey, and Marianna Pavlovskaya organized a conference on critical GIS then edited a 2005 special special issue of *Cartographica* with conference papers. In the UK in 2001, David Unwin sponsored a conference titled *Spatial and Temporal Representation in GIS* to expand representation in GIS and incorporate temporal analyses, again bringing together both "critics" and "GISers." Peter Fisher and David Unwin collected contributions from this conference in a 2005 edited book *Re-presenting GIS* which included contributions from Francis Harvey, Nadine Schuurman, Michael Batty, and Joanne Sharp among others.

Between 2000 and 2013, critical GIS as a subdiscipline splintered as the scholarly topics and possibilities generated from the second era each demanded their own rigorous development. These splinters include contributions from Sarah Elwood and Meghan Cope in a qualitative GIS, Jeremy Crampton, John Pickles, John Krygier, Alexis Bhagat, and Lize Mogel on critical and radical cartography, Mei-Po Kwan on feminist geovisualization, Agnieszka Leszczynski, Sarah Elwood, Nadine Schuurman, and Geraldine Pratt on feminism and GIS, and Jeremy Crampton

and Nadine Schuurman on security and geosurveillance. This incomplete but illustrative list demonstrates how the conversations that emerged from critique led to distinct but adjacent discussions. In 2014, a coalescing fourth era began when Jim Thatcher, Luke Bergmann, Britta Ricker, Reuben Rose-Redwood, and David O'Sullivan organized a "Revisiting Critical GIS" meeting at Friday Harbor, Washington with the purpose of reflecting on, and revisiting, the prompts from the original Friday Harbor meeting. Francis Harvey and Eric Sheppard, both at the original meeting, were also in attendance. Twentynine of the thirty attendees co-authored a reflection published in 2016 in *Environment and Planning A*.

This meeting differed from the 1993 meeting as it sought not to ease tensions within the discipline, but to bring together scholars to coalesce voices in critical GIS while simultaneously acknowledging the independent splinters, a process the attendees recognized as a repetition with difference. Emergent topics included the theoretical questions of possibility, social justice, de/quantification (and critical data studies), digital and geo-humanities, the political economy of GIS, diversity of attendees and inclusiveness of the conference, and an emphasis on critical human geography. New conversations emerged as attendees arranged and rearranged splinters and their own experiences to form new questions. In 2017, Matthew Wilson's book *New Lines: Critical GIS and the Trouble of Map* sought to formalize the revival of critical GIS with the intention of developing a manifesto. At the 2018 American Association of Geographers meeting, Taylor Shelton and Dillon Mahmoudi organized a session titled "Mapping Injustice." Out of this diverse set of presentations, they organized a 2019 "Doing Critical GIS" conference held in Baltimore with Sarah Elwood which sought to reconvene a conversation on existing modes and future possibilities of a critical GIS. Scholarship from this era has also found influence outside of critical GIS per se. Two additional conferences in 2019 include the "Community Geography" conference organized by Jerry Shannon held in Atlanta and the "Mapping Injustice" conference held by Media and Communication scholar Gregory Donovan at Fordham University in New York. All three of these conferences included topics of mapping and GIS in broad contexts including community and participatory activism and mapping, public histories, racism and oppression, queer geographies, colonialism, issues of representation, pedagogy, digital geographies and the geoweb, geocompuational science, geodata infrastructures, smart urbanism, and other understandings of the human condition. The continued efforts by critical GIS scholars to create inclusive and congenial spaces for potentially contentious conversations yield broad dissemination of the ideas of critical GIS, continuing to spur new and exciting directions across disciplines.

STS, Geography, and Computer Science

While critical GIS has its roots in critical cartography, the conversations by critical GIS scholars in the 1990s was heavily influenced by the phenomenon of the science wars. Like human geographers and the "GISers," the broader context of the science wars stemmed from dismissal and distrust between social scientists and the traditional "proper" sciences. STS scholars were at the forefront of this debate and they heavily influenced critical GIS, yet to subsume critical GIS as an outgrowth of the science wars would dismiss the effort by geographers to build from disagreement. Like GIS and human geography, traditional science was widely perceived to have epistemological superiority over social science while disregarding the way in which science is culturally, politically, and economically influenced. Here is were STS scholars made major contributions, especially for geographers, demonstrating how traditional sciences, and their epistemological claims, are socially constructed. Yet, STS scholars make their claims from outside the traditional sciences like biology, chemistry, and physics.

This brief overview of the science wars is insufficient to capture all the nuance of the debates but is important to distinguish the STS critiques from the critical GIS critiques. While geographers borrowed from STS to critique early GIS, their contribution is challenging the epistemological claims of GIS from *within* geography and the impacts these claims have on both society and the discipline. Scholarship in critical GIS attempts to understand the technical and social practices that contribute to the on-going development of GIS as a system and as a science. Further, Nadine Schuurman and Geraldine Pratt argue that the role of critical GIS scholars is one of care, because scholars simultaneously critique and invest in the future of the critical GIS. STS, critiquing from the outside, as little if any

investment in the disciplines they critique. In a 2001 article in the *Annals of the American Association of Geographers*, David Demeritt proposed heterogeneous constructivism as a way to acknowledge that social practices and reality influence and construct natural systems and geographical phenomenon. Heterogeneous constructivism thus plays an important role for critical GIS research as a tool to go beyond the social constructivism of GIS to include its reconstruction.

Despite the advances of both critical GIS scholars and STS scholars, the science wars of the 1990s continue to reveal themselves in new forms. Continued development of GIS software alongside developments which increase computational power and data storage afford new epistemological claims by geographers and computer scientists of machine learning algorithms and their counterpart of big (geo)data. These computational advances allow researchers to search for and find patterns in the data. Michael Batty, for instance, proposed a science of cities suggesting that all cities follow inherent natural laws in their growth and development. Armed with more than two decades of critical GIS and STS scholarship, the obvious critiques were swift and detailed. Still, within the larger media, the arguments made in this fashion enjoy a higher order in society's imaginary of an epistemological hierarchy. Using machine-learning on large data to construct natural laws ignores the social construction that goes into human training of machine-learning algorithms, what types of algorithms are possible from existing constructions of machine-learning, deciding on what data are collected, how that data are abstracted and represented, and whether the resulting patterns are in fact patterns or coincidental noise.

Previous research echo these same tendencies and critiques. For example, the continued development of cartographic simplification came at the expense of model generalization. Mei-Po Kwan demonstrated that spatial analysis methods available in GIS software were gender-biased as they failed to capture and display the space-time boundaries and constraints in women's lives. The deliberate development of particular computational advancements make possible these this revival of a seemingly settled debate. Within geography, Elvin Wyly has called this a new quantitative revolution and proposes the idea of a strategic positivism as a method to engage with these debates in a form that is compatible with the heterogeneous constructivism proposed by David Demeritt. Wyly argues that the new post-positivism co-opted and ideologically reframed much like positivist spatial science. Acknowledging the reality of natural phenomenon, a strategic positivism seeks to understand social constructions of science and data to differentiate useful constructions from dangerous constructions. The purpose being to create possibilities to imagine and develop constructions of society and space that are emancipatory. Other responses to the various resurgent claims take place within the splintered topics that together form critical GIS rather than under the ideological banner of critical GIS itself. Current work seems to again be coalescing under the banner of critical GIS in response.

Feminism and GIS

Critiques from within geography have a stake in future of GIS as a technology, while external critiques need not concern themselves. As mentioned earlier, a feminist approach to the ongoing develop of a critical GIS is akin to critiques from *within* geography. A feminist approach centers care, eschewing moral or intellectual superiority, and shifts the focus away from demonstrating fault or error and instead in the reproduction and active development of a new critical GIS. The purpose of a feminist critique thus seeks to pursue a critical GIS that can produce new emancipatory truths.

The history of critical GIS is thus one of a feminist approach(es) to critique with deliberate attention to care and reconstruction. Further, feminist scholars have sought to understand the technical expertise necessary to tactically appropriate the technology to advance goals for social justice, much in the same way that Wyly reflects on the need to strategically co-opt postpositivism to advance goals of emancipatory potential. Mei-Po Kwan's work explicitly addressed the shortcoming of GIS, arguing that critical GIS needs to build from a reflexive technical understanding to excavate truth. Her work on visualization of space-time made significant contributions to both feminist geography but also to the broader GIS literature.

Meghan Cope and Sarah Elwood's work on qualitative GIS opened a new method which sought to integrate qualitative data with spatial data, blurring traditional distinctions between the two. Nazgol Bagheri's work exemplifies this by building a GIS which integrates narratives, drawings, and photos. Her work made methodological contributions, but like Mei-Po Kwan's work, she demonstrated how a feminist GIS enriches feminist discourses and practices. Nadine Schuurman and Geraldine Pratt wrote on the feminist ethic of care within GIS, again pointing to the need for reflexivity. Monica Stephens showed that the crowdsourced data of Open Street Maps reveals detailed information on masculines spaces of consumption and while silencing feminized places of care. Sarah Elwood and Agnieszka Leszczynski document these and other forms of feminist spatial praxis, inclusive of feminist and critical GIS, in their work on feminist digital geographies. Further, a 2018 edited volume titled *Time for Mapping, Cartographic Temporalities*, includes contributions from that advance mapping of space-time with particular attention to the knowledges that digital mapping might foreclose or reveal.

Critical GIS and Ontology Research

Classification and abstraction remain important questions in the ontologies of GIS. The earliest critiques of GIS called for an examination of the ontological and epistemological issues that arise from GIS as a technology. GIScientists addressed these early critiques but do so within the discursive regime and technology stacks that already underlie existing GIS frameworks. The concepts and critiques of GIS require humans to abstract and reduce the concepts so that they become machine readable. This process highlights a significant division between the social and technical. Nadine Schuurman points to concepts such as subject–object dualism, or epistemological intransigence which fail to translate into abstracted machine-readable formats. One of the outcomes of this ongoing division, is the development of multiple ontologies rather than representing a phenomenon from multiple coinciding perspectives.

Two examples help illustrate this point. A remote-sensing vegetation classification developed for the European Union (EU) may not travel well across borders outside the EU. It may also suffer from bias if it the developers were from one particular country. This classification system could not classify some Irish vegetations, could not identify some vegetation in Russia, or may lose its usefulness within the EU with the onset of climate change or changing geopolitics. Scholars developed the classification system under a set of limits and cannot fully represent reality. Ontology research in GIS seeks to capture multiple understandings with a minimal loss of meaning. The second example builds from the crowdsourced categories of places in OpenStreetMaps. Monica Stephens demonstrated how feminized places were missing, yet the categories of potential place types were developed from a particular reference, further complicating the map. The challenges of these social categories cross borders or cultures remain a problem.

Technologically, graph theory has taken a forefront as a potential method to resolve some of these issues. One scenario might restructure existing geospatial data to list many different types of links between semantic objects, yet another might to include building node-arc relationships to identify conceptually near elements are near concepts. Importantly, visualization focuses on representing multiple understandings through these multiple relationships, and data might be accessible via a graph query language. A focus on relationships over traditional spatial metrics can expand the produce new understandings of place. Luke Bergmann, David O'Sullivan, and Nick Lally are developing a prototype software program called "enfolding" to visualize how relationships between places might fold the map. They call their work a Geographic Imaginary System because of the potential for new ontologies to produce new imaginaries and new possibility. While graph databases and graph query languages already exist, they do not capture the complexities of graph theory. Yet still, opportunity exists to develop a geo-informed graph query language and data structures. This on-ongoing ontology research agenda continues to push critical GIS and GIScience forward.

Participatory GIS

Participatory GIS (PGIS) as a key contribution of critical GIS seeks to promote the empowerment of citizens through collaborative planning as a means to give voice to traditionally marginalized groups by technocratic elites. This shift in knowledge production seeks to improve planning outcomes toward social justice by expanding "who is at the table" policy-related knowledge gathering and decisionmaking processes. Including communities and broadening accessibility have been a key concern of PGIS and critical GIS more broadly. Today, PGIS is both technological and social, including a series of tools, and a set of best practices and approaches.

As STS and critical GIS scholars have argued, because the development, design, and implementation of GIS is social, the technological components must also be incorporated in the sociopolitical context of its application. GIS can be both empower and marginalizing for community groups, both shaped and shaping local planning power relationships. PGIS praxis focuses on the value of GIS for marginalized groups, toward emancipatory means and social justice. PGIS research focuses on the nature of PGIS applications, seeking to improve and develop on the technologies, approaches, and institutions that support community empowerment.

One of the aims of PGIS is to uncover local knowledge and collaboratively incorporate it into the planning process. PGIS is not a extractive process of local knowledge, but instead a method to build a plans which can better benefit local communities. This process also serves a way to disseminate information to community members and community groups, ensuring their continued tenure. A key component is then for practitioners to facilitate conversation between perspectives toward productive and inclusive planning efforts. PGIS involves computer-based systems of collecting information and a series interactive community events. The histories public participation are documented elsewhere, but PGIS incorporates the same important steps of problem definition, defining potential resolutions, and then collaborating on action. By purposefully seeking to increase public involvement and diversity in public planning processes, PGIS represents the growth of GIS research scholar-activism and centering critical GIS in contributing to new understandings of the potential of technology in democracy.

One tension of PGIS is the use of volunteered geographic information (VGI) to inform public planning processes without the necessary collaborative planning process which incorporates discussion, allowing for multitude of community members to ask new questions. The use of VGI can be beneficial for planners and community members alike, however, it does not constitute PGIS and runs the risk of reproducing existing inequalities and erasing local data in favor of easily quantifiable data. Further the arrangements under which corporations collect VGI from residents raise questions on who and how people are represented, who is missed in the data and why, the unequal power relations between corporations and consumers, and the problems with conflating consumers and residents.

The assumption that better information allows for better outcomes is a basis for PGIS, however, the process from which better information becomes better outcomes is of paramount importance. This differentiates PGIS from using machine-learning on big geodata (or VGI) to produces knowledge because of the collaborative, rather than technocratic, nature of PGIS. The better information allows for community members to be better informed, ask better questions, build understanding across communities and groups, and conceptualized an outcome with beneficial outcomes. Interaction with technology takes on a central role as a method to disseminate and collect information, requiring technology interfaces to be accessible by beginners and sufficient for experts. PGIS has become the most important and visible expression of critical GIS. PGIS is an example of the ways in which critical GIS and benefit society while also contributed to the development of new critical GIS. The development of accessible interfaces for dissemination and collection of spatial information has resulted in the dissemination of GIS and mapping, contributing to the continued democratizing of the GIS more broadly.

Emerging Frontiers of Critical GIS

Critical GIS has become an integral part of geography and continues to make contributions to the broader discipline. In separate writings in 2005 and 2006, Eric Sheppard and David O'Sullivan concluded that critical GIS scholars must be aware of its history and how it developed, both the social and technical aspects of it. In 2009 and 2011 Elvin Wyly argued that this historical understanding was necessary to co-opt and direct GIS for emancipatory

means. In 2014 and 2018, Sarah Elwood and Agnieszka Leszczynski similarly showed how feminist thought had necessitated an understanding to actively shape the technology for new social understandings. Each of these important contributions echo some of the earliest scholarship on critical GIS and its contributions in question the power of maps, representation, and the technology itself.

Three new directions mark an exciting extension of critical GIS. First, as technology continues to play an increasing role in everyday life, the creation of the Digital Geographies Specialty Group and the profound influence of feminist critical GIS scholars Sarah Elwood and Agnieszka Leszczynski in interrogating the structures and affect of digital technologies. Second, critical data studies and its confluences with counter-mapping, queer interventions, and surveillance. Recent work from Jim Thatcher, Jack Gieseking, Craig Dalton, Tim Stallman, and Jeremy Crampton speak directly to this. Third, as PGIS proliferates and technologies change, Jack Gieseking is interrogating how we think about the public histories of participatory mapping and how do we capture those places?

STS, critical geography, feminist geographers, ontology research, and the successes of PGIS have continued to hone the goal of critical GIS scholars to further develop functionality while simultaneously democratizing GIS. These contributions sought to engage both theoretically and technically with the systems and science of GIS, an always incomplete task for future generations of critical GIS scholars as advances in technology and theoretical understandings continue to be developed.

Glossary of Specialist Terms: science wars; participatory GIS (PGIS); feminist GIS; volunteered geographic information (VGI); geoweb; geosurveillance; geocomputation; strategic positivism; machine-learning; counter-mapping

Additional Websites

https://github.com/RevisitingCriticalGIS
: The Revisiting Critical GIS 2014 Conference Website

https://www.antievictionmap.com/
: The Anti Eviction Mapping Project (an example of critical GIS)

http://www.propertypraxis.org
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