

From the margins of GIS: limitations, challenges and proposals

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Abstract

Some of the most exciting progress to address central limitations in GIS is currently originating from the margins of cartographic traditions. This article explores the potential of a proactive engagement with mapping technologies from peripheral positions, such as humanist, feminist, decolonial, queer, and black perspectives, to overcome what we identify as five intrinsic challenges of GIS: the representation of place; emotions; scales; time and change; and relational approaches. The proposals deal with specific concerns that do not fit in existing GISystems and suggest how a creative engagement with mapping technologies further expands our understanding of what GIS could be.

Keywords: critical GIS, GIS limitations, scales, emotions, time and change, place, relationality

I. INTRODUCTION

Critical engagements with mapping technologies have expanded the possibilities of GIS for research, reimagining, and developing alternative ways to visually represent spatial data beyond the limitations imposed by cartographic language and GIS (Kwan, 2002). In parallel, GIS practices are rapidly transcending the confines of geography and cartography studies, incorporating other voices and perspectives into the debate on the limits of GIS¹ (Elwood, 2022; Kelly et al., 2023). Despite critiques of visibility and cartography led to an initial rejection of mapping technologies, maps, qualitative GIS, and visualizations, these are increasingly used as critical research methods in diverse fields such as feminist urban planning (Sweet and Ortiz Escalante, 2015; Carpio-Pinedo et al., 2019; Gargiulo et al., 2020); migration and gender studies (Kelly, 2019; Dos Ventos Lopes Heimer, 2021; Guhlincozzi, 2022; Fileborn, 2021); or digital humanities (Allen and Queen, 2015; Dunn, 2017). The development of new geospatial technologies and web mapping platforms have also opened new possibilities in digital activism and research, with participatory mapping (Ferreira and Salvador, 2015; Sletto, 2015; Temper et al., 2018; Anti-Eviction Mapping Project, 2018; Falco et al., 2019); spatial data visualizations (Bagheri, 2014; Franke et al., 2017; Dmowska et al., 2020); or digital storytelling (Alavez and Caquard, 2023; Heck and Tsai, 2022).

From the margins of GIS, scholars have been investigating and developing creative visual tools and strategies to solve inherent limitations of GIS that align with methodologies, theories, and conceptual frameworks rooted in Feminist, Indigenous, Black, Latinx, Queer, and Humanist perspectives. Here we build on feminist epistemologies for our understanding of knowledge as situated and partial (Haraway, 1988), as it is geographical knowledge (Rose, 1993), and also for the conception of margins as those perspectives that have been marginalized but also are sites of resistance (hooks, 1990), places from which it is possible to challenge dominant narratives. Thus, we argue that the notions of space that sustain mainstream GIS are partial, instead of universal or neutral, and we focus on the developments made from the margins of GIS, both before and beyond the institutional geospatial culture, as a way to rethink our understanding of what GIS could be and to expand the limits of using GIS for research.

¹ Throughout this paper, we will use GIS to refer both to GISystems, the software used to represent, analyze, and visualize geospatial data and to GIScience, as the scientific discipline based on those technologies.

Geographers have been dealing with limitations in GIS since its beginning (Gahegan, 2018; O'Sullivan et al., 2018) and some constraints have been identified and somehow addressed. For example, the Modifiable Area Unit Problem (Openshaw and Taylor, 1979; Fotheringham and Wong, 1991) or uncertainty in GIS (Couclelis, 2003; Kwan, 2012b, 2012a; Derbyshire, 2020). However, other limitations require questioning prevailing assumptions about what GIS is and what can be done to reimagine GIS differently (Lally, 2022). A narrow perspective about how GIS works may obscure or disregard alternative possibilities while capitalizing on the credibility of existing GIS software to promote a particular biased and oppressive understanding of the world.

Building on the contributions from the margins, we reexamine specific limitations of GIS that not only condition their potential to analyze, represent, and communicate effectively spatial knowledge, but also fail to incorporate other ways of knowing, interpreting, and representing informed by diverse forms of theory and praxis. To do so, we identify five challenges that lay at the core of GIS a) how to represent complex meanings of place; b) how to collect and represent emotions; c) how to include scales such as home or the body; d) how to address time and change; and finally, e) how to integrate relational approaches.

For each challenge we provide examples of innovative and alternative approaches and initiatives that challenge, rework and reimagine others ways to engage with spatial technologies. We are inspired by Wilson's suggestion to draw attention to those "minor GISciences" as a way to think and act differently with and against GIS (Wilson, 2021), by McKittrick's proposals for "rebellious methodologies" for relational knowledge-making (McKittrick, 2021) and by "glitch feminist politics" that explore the radical and creative potential of rethinking mapping and GIS starting from positions, bodies, and epistemologies that don't find a place in conventional mapping and GIS software (Russell, 2020; Leszczynski, 2020).

II. PLACE

Place has been identified as the "next frontier" for GIS, after much more attention has been given to "space" than to "place" in its approaches to data collection, organization, analysis, and decision-support (MacEachren, 2017). GIS has limitations to operationalize place meanings and integrate vague definitions of place (Blaschke et al., 2018). The type of "geographic information" that mainstream GISystems embody consists of objective descriptions of individuated entities referenced within the coordinates of an absolute, Cartesian space (Lévy et al., 2016; Roche, 2016). This restricts the potential use of big and user-generated datasets for GIS representation and analysis, as they contain references to location more platial than spatial in nature (Capineri, 2016; Westerholt et al., 2020; Ballatore and De Sabbata, 2020; Calafiore et al., 2021; Zhao, 2022; Chishtie et al., 2023). Recent efforts aim to complement GIS practices with "Platial Information Systems", enabling the capture, manipulation, and communication of information about places in ways distinct from how a GIS communicates geometries and their associated attributes (Mocnik, 2022).

Tensions between the concepts of space and place in GIS are increasing also due to the demands of scholars who want to use digital tools within their own epistemologies and do not find in GIS a useful way to represent the complexities of place. Leszczynski (2009) distinguishes between "infological" views of the world, which are fuzzy and resistant to quantification, and "datological" views, which can be quantified. Place, understood as "lived space", transcends mere geographic location, shaped by relations, identities, practices, and emotional connections in space (Tuan, 1975; Massey, 2005; Cresswell, 2005). Despite the importance of geographical context and human interactions in space for geographers, GIS still has limited capabilities in representing these embodied and emotional dimensions

of place. These complexities are erased in the visual language used in GIS through accumulated layers of homogenizing categories, aggregated data, and placelessness (Pearce, 2008).

Then, a crucial and persistent problem for anyone interested in using visualizations or maps to represent place is how to overcome the intrinsic limitations imposed by a Cartesian coordinate system that excludes spatial information that cannot be placed in an exact latitude and longitude. While Indigenous communities have successfully used "Western" geospatial technologies to claim their land rights or protect their tribal resources, the use of cartographic language and spatial structures to present positivist representations of space can negatively affect Indigenous conceptions and representations of place due to differing ontologies and epistemologies (Pearce and Louis, 2008). On the contrary, Indigenous feminist spatial practices disrupt the colonial relations of power that mapping and counter-mapping often reinforce through practices of unmapping and (re)mapping beyond digital mapping technologies (Iralu, 2021).

Humanist scholars are at the forefront of exploring innovative digital and non-digital visualizations to represent the intricate and multifaceted aspects of lived experience in place. Computational methods, including data visualization or GIS, are becoming common research tools in humanistic inquiry (Bodenhamer et al., 2010). Nevertheless, these encounters have also been a stimulus to rethink many assumptions often left implicit in their work when engaging with the digital (Drucker, 2011; Lunenfeld et al., 2012). Spatial humanists have embraced the challenges of depicting place by developing new ways to use maps and GIS, for example through "deep maps" (Bodenhamer et al., 2015), "sensitive mapping" (Olmedo, 2017), or hand-drawing (Bagnoli, 2009; Tratnjek and Rekacewicz, 2016). Combining digital and non-digital methods offers the opportunity to develop new languages to explore alternative ways to conceptualizing the spatial qualities of our datasets.

A notable example of how to capture the complex meanings of place is the visualization called "I Was There, Places of Experience in the Holocaust", by Knowles and Westerveld, as part of their proposal for "inductive visualizations" (Knowles et al., 2015; Westerveld and Knowles, 2021). The map provides a visual representation of the diverse locations mentioned in two interviews with Holocaust survivors, shedding light on the significant places tied to their memories without the constraints imposed by the mathematical and cartographic models that govern geographic representations in GIS. It combines the locations of the largest places, such as cities or concentration camps, with other more intimate, fuzzy or small places, such as barracks, woods, rooms, or even pockets, that hold great significance or evoke strong emotions for the survivors. While the authors' ultimate objective is to develop a digital interactive application capable of reading, displaying, and conducting basic analyses on places and their topological relationships extracted from oral history transcripts, their initial efforts begin with a static, partly hand-drawn map. Colors, sizes, and opacity of the lines and circles are used in the "Holocaust map" to indicate the significance and importance of each place for the survivors in their memories, rather than according to their actual size. The result is a cartographic exploration of the spatiality and temporalities of the Holocaust from the perspective of the victims.

The new visual grammar used in the visualization provides a better representation of the complex and varied mental geographies and relational meaning of places in the testimonies than conventional maps. Creative representations can be better suited to represent specific details of the memories, instead of flattening and obscuring the diversity of meanings of each place into conventional symbols. For the authors of the Holocaust visualization, "the aesthetics of maps generated with GIS programs tend to convey an impression of precision, certainty, and detachment that runs counter to the messy complexity of lived experience" (Westerveld and Knowles, 2021: 2109). Likewise, cartographer Meghan Kelly has also experimented with symbolization and sketch mapping techniques to highlight places mentioned in the stories about borders during the Syrian refugee crisis, where traumatic events occurred. She adopts an iterative design approach, translating narratives about borders into graphical interpretations

(Kelly et al., 2023). Kelly draws upon feminist theory, border studies, and feminist design to develop a complex symbolization of borders to include their porosity, imprecision, and variability due to the differential intersections of gender, age, and socioeconomic status of the testimonies (Kelly, 2019).

Research into Black geographies has also been important to recognize the existence of overlapping and contradictory spatial imaginations, embracing a world where multiple senses of place and multiple geographical knowledges coexist (Allen et al., 2019). Similarly, calls to decolonize the map involve cartographically documenting and prioritizing Indigenous experiences of place both historically and in the present, for example by reclaiming and reintroducing in maps Indigenous toponymies and ancestral memories that have been erased by colonialism (Rose-Redwood et al., 2020). As data feminism insists, the most complete knowledge comes from synthesizing multiple perspectives, giving priority to local, Indigenous, and experiential ways of knowing (D'Ignazio and Klein, 2020), and thus it is necessary to continue exploring creative ways to represent the complexities of place.

III. EMOTIONS

GIS and maps have been presented as neutral, scientific and objective technologies and representations (Kitchin and Dodge, 2007). GIS typically focuses on representing spatial data, such as locations, physical features, and statistical information, without considering the emotional dimension. The task of collecting and representing emotions in GIS continues to pose a significant challenge for qualitative researchers (Kwan and Knigge, 2006). Feminist critiques of science have long highlighted the exclusion of embodiment in scientific knowledge and the importance of legitimizing and including affect and emotions in digital visualizations as crucial qualitative ways of knowing and understanding (Elwood and Leszczynski, 2018; D'Ignazio and Klein, 2020).

The essence of emotional mapping lies in recognizing the profound interconnections between emotions, spaces, and places (Bondi, 2005; Pánek et al., 2017; Caquard and Griffin, 2018; Steger et al., 2021; Foley, 2022). Emotions play a key role in (re)producing social inequalities and can serve as pointers to intersectional inequalities considering both geographical and emotional perspectives (xxx). Emotions also need to be considered during the mapping process: to take advantage of the potential of maps to collect emotional data; to consider the emotional dimension during interviews; and to use the persuasive nature of and affective responses to map design (Griffin et al., 2017; Pirani et al., 2020; Fish, 2021).

Scholars are expanding what GIS could be and how mapping practices can be informed by feminist research principles, using them as an elicitation method in interviews (Literat, 2013; Barton, 2015; Moore-Cherry et al., 2015; Wikstrøm, 2023); as a creative way of interviewing that is responsive to participants' own meanings and associations (Bagnoli, 2009; Germes and Klaus, 2021; Baumann et al., 2022); or as a strategy to reduce power imbalances between interviewers and respondents (Barton, 2015). Maps can also facilitate conversations and can help to manage the emotional and affective intensity during the interview, potentially enabling them to reduce the risk of emotional discomfort (Fileborn, 2021). Participatory, tactile or hand-drawn maps even allow the possibility "to be vulnerable without being verbal" (Iverson, 2019: 2).

Digital storymapping archives and collaborative web maps also offer the potential for building visibility, representation, recognition, empowerment, and solidarity for/in communities (Kirby et al., 2021). While digitality and mapping interfaces help activists coordinate their struggles, increasing attention in participatory and collaborative mapping projects is focused on how digital technologies can become transformative and restorative practices (AEMP, 2018; Desborough, 2018; Kidd, 2019; McLean et al., 2019; Sletto et al., 2021). Collaborative mapping can reveal, for example, silenced dimensions of street

harassment, violence, or oppression by disrupting hegemonic discourses and considering the value of emotions (Ferreira and Salvador, 2015).

The potential benefits of crowdsourcing digital mapping about emotions have been further demonstrated in projects such as the HarassMap, a collaborative map that tracks incidents of sexual harassment and violence in Egypt (Cochrane et al., 2019). The map breaks the silence against the normalization of this violence and provides a safe anonymous platform for survivors to share their experiences and sentiments of frustration and fear. However, anti-sexual harassment activists see the HarassMap not as an end in itself. It works as a data collection method, as an awareness-raising tool, as a tool to inform about the services and information the victims can need and finally, as a means to enable other forms of strategies.

Although the impact of these types of maps is clear, mapping the complex relationship between lived experiences and places requires us to reconsider our cartographic tools and cartographic language when capturing and representing emotions (Hermann and Pearce, 2010; Kelly, 2019). Emotional data is often qualitative, subjective, and narrative in nature, while GIS traditionally relies on quantitative, measurable, and structured data. Instead, since official databases and quantitative approaches to spatialities tend to exclude emotions and affect, GIS needs to complement "mappable" data with other sources of data and narratives about place and emotions that can help recover the stories and everyday experiences of the subaltern (Kwan, 2002). Moreover, it is crucial to avoid reductive approaches to mapping that can reinforce existing inequalities or reproduce public space as a gendered "threatspace" (Fileborn, 2021).

IV. SCALES

Scale is a fundamental issue in GIS and mapping practices, as well as in geographical studies and for those scholars concerned with spatialities. However, the impacts of the scales used in GIS and cartography for research have been relatively unexplored (Giesekeing, 2018; Whitesell and Faria, 2020), with exceptions such as Wood's (1978) experiments for a "cartography of reality". The flexibility to work at different scales in GIS systems proves invaluable for analyzing complex datasets with varying resolutions, but data scale incompatibilities can lead to wrong conclusions, particularly when overlapping official aggregated data with ethnographic data collected at the individual level (Bagheri, 2014), or when trying to understand the spatial dimensions of complex socioeconomic phenomena highly localized or underrepresented (Brown and Knopp, 2006; Fiedler et al., 2006). Moreover, intimate scales, such as the body, home, or other private spaces are difficult to map and therefore, missing in GIS analysis except in a few cases (Pavlovskaya, 2002; Kwan, 2008). In consequence, researchers using GIS are obliged to choose between focusing on some particular scales at which data is available or focusing on deep single case studies.

The success of GIS in analyzing and representing phenomena in a Newtonian space has also given ontological importance to arbitrary boundaries, such as administrative units (Bergmann and O'Sullivan, 2018b), or fixed conceptions of relevant scales, such as the neighborhood. This rigidity limits alternative ways to measure the wider socio-spatial context of people, placing individuals at the center of the approach (Petrović et al., 2020). Official data is usually collected and aggregated at some particular scales, rendering some of them more relevant and visible and others, like the scale of home, disregarded in GIS, and Geography in general, despite its central role as a place where complex social processes are (re)produced (Blunt and Varley, 2004; Johnson, 2006; Brickell, 2012). Feminist geography has challenged and made central social and spatial relations phenomena that are often framed as "simply-intimate" (Pain, 2014). Feminist and queer scholars have also effectively spotlighted the numerous dimensions that define human life (including domestic or everyday life, the body, family, informality, life stages,

illness, and care) and the importance of understanding private and everyday spaces, where gender, social and sexual norms are reproduced and transgressed (Bondi, 1998; Marston, 2004; Pascual-Bordas, 2023). However, these dimensions have frequently been overlooked or marginalized in geographical research and also in GIS (Twigg, 2004; Dowling and Blunt, 2006).

The importance to include the body as a crucial analytical scale in visualizations and GIS has two main objectives. The incorporation of the body is, first, a way to unmask the oppressive effects of the apparent universalism, neutrality and objectivity of the visual and cartographic gaze. D'Ignazio's and Klein (2020) proposal to 'Bring Back the Bodies' in data visualization reminds us of the importance to situate knowledge in specific human bodies and to denounce the "God-trick" of the visions from nowhere that give the appearance of neutrality and objectivity to the data by those bodies in power (Haraway, 1988; Rose, 1997). Some bodies in data visualization and GIS are thus extracted, absent, uncounted and rendered invisible (D'Ignazio and Klein, 2020). Moreover, Black scholars denounce the simplification and relegation of certain bodies, such as black bodies, to spaces inevitably associated with their skin color, reducing them to a solely corporeal identity (Mahtani, 2014).

Secondly, the consideration of the body as a relevant scale in research helps to incorporate a "global intimate" approach into GIS and cartography, as theorized by feminist scholars (Mountz and Hyndman, 2006). An unfixed and relational understanding of scale reveals how processes of power are "shaped, constructed, and remade through the everyday" (Whitesell and Faria, 2020: 5). GIS priority to specific scales of representation and analysis may give the impression that race, gender or other power relations are irrelevant instead of present everywhere (Parker, 2016; Peake, 2016). Using bodies as a scale in maps and GIS breaks these silences and situates these scales at the same level in research.

Body mapping and "cuerpo-territorio" are mapping methods that situate the body as the unit of analysis of spatial dynamics, emotions, violence and inequalities. Bodies can be deployed as decolonizing and critical methods, as they are sites of both normalization and resistance since social norms of gender and sexuality are inscribed on the body. Body mapping is a creative and often therapeutic technique used to explore and represent an individual's physical and emotional experiences through the creation of visual representations of the human body where participants draw or write (Jager et al., 2016; Jokela-Pansini, 2021). Body mapping is not just about the end product; it's also a reflective process. Creating the map can be a therapeutic way for individuals to explore and better understand their own bodies, emotions, and experiences, and it is also a very cost-effective method that ensures better recall, richer narratives and reduces power-based inequalities in qualitative research, for example to explore reproductive, maternal and sexual health topics respectfully (Mayra, 2022).

"Cuerpo-territorio" ("Territory body-earth or body-territory") has become both a mapping method and an epistemological proposal that prioritizes the body as the unit of analysis of social and spatial dynamics, especially those related to colonialism, extractive activity and gender-based violence (Cabnal, 2010; Cruz et al., 2017). Cuerpo-territorio shares some aspects with "body mapping", but it also needs to be approached considering the context where it started, Latin American feminist and Indigenous communities committed to a decolonial praxis for knowledge production (Cruz et al., 2017; Ecuador, 2018; Zaragocin and Caretta, 2021). It considers the body as a territory: where various forms of violence happen, but also as a site of resistance, transgression, and creation against the exploitation perpetuated by capitalist and patriarchal systems (Rodriguez Castro, 2021). In her research called "Travelling Cuerpo-Territorios", Dos Ventos Lopes Heimer develops an embodied decolonial feminist methodology to research migrant women's multi-scalar experiences of intimate and state violence(s) and resistance, proving the potential of using the body as an analytical and representational scale in critical migration and border studies (Dos Ventos Lopes Heimer, 2021, 2023).

V. TIME AND CHANGE

GIS is primarily designed for managing static spatial data. Despite promises of real-time GIS and smart city technologies, geospatial technologies may struggle to represent time, change, and temporalities (Peuquet, 1994; Townsend, 2013; Shields, 2018; Miller, 2020). Time remains a problematic and somehow neglected dimension in GIS despite efforts and proposals to develop a temporal and more dynamic GIS (O'Sullivan, 2005; Miller, 2020). Most importantly, GIS limitations to integrate time and dynamic processes in analysis are becoming not only methodological issues but also political ones, as some of the most pressing issues of our time are about dynamic change – migration processes, climate change, capital flow (Rankin, 2020). Likewise, Wilson states how “unsettling temporal linearity in GIScience remains an important pathway to realize political and radical agendas for the field” (Wilson, 2022, p. 1431). However, there are some relevant exceptions, both historical (see for example (Wigen and Winterer, 2020) and more recent (Goodchild, 2013; Kwan, 1999), that show how static maps accommodate time in surprisingly versatile ways and even capture the subjective experience of temporality (Drucker, 2009).

One of the ways maps can integrate time and different temporalities is through narratives and storytelling (Pearce, 2008; Caquard, 2013; Roth, 2021; Fish, 2020). Maps can tell and communicate stories and experiences erased from official narratives, destabilizing them. Maps can document the accumulative temporal impact of gentrification, but at the same time can visualize struggles to remain at home and build collective resistance to regional processes of eviction and dispossession (Maharawal and McElroy, 2018). Similarly, mapping transmigrant journey's experiences questions the notion of the border as a static element and it also confronts the securitization and fixity of migration routes, hidden in the visual rhetoric of official cartographies (Campos-Delgado, 2018).

Queer approaches to GIS have also pointed out how mainstream forms of cartographic representation insidiously closet and invisibilize queer folk (Brown and Knopp, 2006; Giesecking, 2018). Queer temporalities and queer archival research projects challenge conventional notions of time to claim sexuality and space as constitutive parts, for instance, of urban historical geography (Brown and Knopp, 2008; Freeman, 2010; Giesecking, 2020). GIS and mapping has played a significant role in making visible queer spaces and places, particularly from the past. As Brown and Knopp claimed, “GIS can be an integral part of a politics of uncloseting urban (and other) spaces that are otherwise heteronormatively represented and imagined” (Brown and Knopp, 2008: 55). Collaborative digital mapping platforms have also been used by critical queer scholars to put past emotions into meaningful, transformative relation with the present. In “Queering the map” platform (queeringthemap.com), the crowdsourced map is not just a mirror of locations of experience but a site with which users may signify places of meaning otherwise blank (Kirby et al., 2021).

Furthermore, mapping can be anticolonial praxis (Vasudevan et al., 2022). Lucchesi (2019) argues how maps are particularly useful for communicating indigenous experiences of colonial violence and genocide because they are acknowledged as an authoritative method by both settlers and indigenous communities. Therefore, maps offer a versatile medium for conveying indigenous experiences to nonindigenous audiences due to their capacity for interpretation, alternative narratives, and nuanced understandings of space and time, making them uniquely suited to reflect indigenous relationships with the land.

Complementary, mapping can reveal connections across and in scales, times, and places by revealing the interconnectedness of race, practices of domination and social and economic systems of racial capitalism (Gilmore, 2007; McKittrick, 2011). A relevant example that uses the power of maps to connect the past and present of human life and prison life is the “Million Dollars Block” Project (Cadora and Kurgan, 2006; Kurgan, 2013). The project addresses a complex issue, the geography of incarceration and

return in the United States. It uses mapping to invert the language of crime “hot spot” maps in cities to show the disproportionate concentrations of incarceration in poor and isolated city blocks. By mapping the home addresses of people as they are admitted to prison, which are also the addresses to which they will most likely return upon release, and by correlating that with the amount of time they spend in prison (and hence the cost to the state), a socio-spatial temporal pattern appears. Prisons are not considered merely as physical institutions where individuals are incarcerated but encompass the broader systems of racial capitalism as they are connected, spatially and temporally, with other elements of public infrastructure and the cycle of life, such as education, housing, health, and family (McKittrick, 2011).

VI. RELATIONALITY

GIS ontology has favored the primacy of objects and static maps over the representation of dynamic processes and relations between places, scales, and times (Gahegan, 2018). In GIS, spatial proximity is very useful to integrate knowledge of phenomena gathered from multiple sources. But as a consequence, relations between distant places in GIS are of secondary importance, intellectually and representationally (O’Sullivan et al., 2018). Representational models in GIS have been object of rethinking to include relational and multidimensional conceptualizations of space (Shelton, 2018). Proposals such as “speculative computing” have attempted to rework visualization, data, interfaces, and analysis to visualize relational, topological, and other non-Euclidean spaces (Thatcher et al., 2018). In the project “*enfolding*”, for example, users can redefine Cartesian measures of distance and fold space using multidimensional scaling in two or three dimensions (Bergmann and Lally, 2021; Lally, 2022).

Efforts in facilitating visual and geospatial tools not limited by Cartesian coordinate systems are particularly relevant for theoretical commitments with humanistic, feminist, and critical scholarship. As Gahegan claims, “It seems nothing short of a tragedy that the decades of work on qualitative and topological spatial reasoning have yet to find a home in any comprehensive GISystem” (Gahegan, 2018: 23). For contemporary human geography, distance has been a plural, situated and more-than-Cartesian concept (Simandan, 2016) and the notion of space as constituted by relations (Massey, 2005).

Feminist geographers have employed varied metaphors and strategies to explore relationality in research and make connections and encounters across scales, times, and places (Katz, 2001; McKittrick, 2011; Parker, 2016). Approaching poverty relationally, for example, can overcome the issues of ignoring how the processes that both produce and result from concentrated poverty are never confined to the bounded territory of the area of concentrated poverty itself (Elwood et al., 2016). As illustrated by Shelton (2018), spatial analysis and maps can be effectively used to adopt a more processual look at how both poverty and wealth are coproduced in diverse places through relational processes that transcend fixed scales of analysis (Shelton, 2018).

An example of these counter-topographies (Katz, 2001) that connect distinct places to particular processes are the Relief Maps (xxx; www.reliefmaps.upf.edu). They are a tool for collecting, analyzing and visualizing data on intersecting inequalities and their spatialities from an emotional perspective. First developed as a tool for data collection by hand, the digital development uses multiple dimensions of place (location, locale, and sense of place) to relate social processes with its geographical dimension (Agnew, 1978). Through an interactive tool, participants create their own Relief Map on the spatial distribution of the effects of different axes of inequality such as gender, race, sexual orientation or class in places of their everyday life. By displaying a visual image of accentuated and flat lines that go from comfort to discomfort, places are linked to each other by power structures that both take place in them and that produce them. Also, in its more recent version, it contains a map where participants can locate

their lived experiences in particular places, allowing the identification of different scales and the use of qualitative data in GIS.

VII. FINAL REMARKS

Much has been said from a critical point of view on the shortcomings of GIScience and GISystems (e.g., Pickles, 1995; Schuurman, 2000; O'Sullivan, 2006; Crampton, 2010; Wilson, 2015; Thatcher et al., 2015; Pavlovskaya, 2018). Here we have offered a propositional approach that, while recognizing the oppressive and unjust effects GIS and maps have had for minoritized groups (Hunter, 2015; Allen et al., 2019; Hawthorne, 2019; Alderman et al., 2021; Scott, 2021), shows that some of the most exciting progress in cartography and GIS are currently originating outside the conventional boundaries of cartographic traditions. It comes from "vibrant margins" from where to draw inspiration "from their intersections and emphasis on expressive vocabularies, questions of power, and attention to process." (Kelly et al., 2023: 3). And they address, in creative and innovative ways, what have been identified as central limitations of GIScience and the GISystems.

Scholars are reclaiming the necessity to rethink and expand the concepts, spatial epistemologies and narratives constructed about what critical, counter, and transformative cartography have been and could be (McKittrick, 2011; Alderman et al., 2021; Kirby et al., 2021; Elwood, 2022). Beyond the professional geospatial cultures, rigidly constructed around ideas about what constitutes a map, GIS, and spatial analysis, we find numerous mapping traditions that engage in their own culturally specific cartographic practices (Lucchesi, 2018; Alderman and Inwood, 2023). These "vibrant margins" come mainly from Indigenous, Black, Latinx, Feminist and Queer perspectives but are also disciplinary: proposals that go beyond the confines of Geography and include Digital and Spatial Humanities (Bodenhamer et al., 2010; Knowles, 2014; Dunn, 2017), Archeology (Hacıgüzeller, 2012), Data studies (D'ignazio and Klein, 2020) and Design (Drucker, 2011; Costanza-Chock, 2020). Moreover, as we have shown, some of these innovations also come from geographic and linguistic contexts that subvert Anglo-American hegemonies, challenging epistemic and theoretical assumptions that may draw fruitful paths to reconsider some established limits of GIS.

Many of these practices have been erased, silenced, or displaced to the outskirts of mainstream cartographic Western traditions. Decolonizing and queering the map, while recognizing the technological and theoretical contributions of Indigenous, Black, Latinx, and Queer cartographers, remains one of the most crucial tasks for both conventional and critical traditions of geographical and cartographical thought and praxis (Elwood, 2021; Oswin, 2019). Contributions from outside geography provide opportunities to rethink what GISystems have achieved and what still needs to be addressed.

Proposals are at the same time an opportunity for formally trained cartographers and GIS users, many of them still strongly attached to specific spatial structures, cartographic symbolization, and fixed scales, when representing and analyzing spatial data (Bergmann and O'Sullivan, 2018; Shelton, 2022). GIS practitioners and scholars can broaden their horizons beyond conventional GIS software by engaging with these alternative ways to understand and analyze spatial data. Approaches from the margins may precisely challenge some conventions in GIS, which restrict and narrow their functionality. Additionally, they may reproduce structures of domination and invisibilities in the production of geographical knowledge.

Recent calls are being made to develop a fundamentally different geospatial science by diversifying our professional networks, incorporating empathy for others into our professionalized practices, and promoting inclusive education in GIS (Nelson et al., 2022). There is a growing realization that many of the institutional settings of GIS are responsible for creating cultures of exclusion and marginality in the

profession (Chomintra, 2022). A "critical GIS praxis" requires more than just adding more voices and bodies to the debate; pedagogies for teaching critical GIS require that we "unsettle the technology, its techniques and practices, its cultures of interaction, and its presumed social implications" (Elwood and Wilson, 2017: 15). It is also about creating moments to push back against a singular understanding of GIS and mapping, exploring how mapping impacts communities in terms of inequality and opportunity (Alderman and Inwood, 2023), and must include a discussion of those structures and how to address them directly in day-to-day mapping workflows (Kelly and Bosse, 2022). Ultimately, it is essential to emphasize that dominant GIS practices are partial and situated, involving specific ways of understanding place, scale, time, and relationality, rather than a universal and place-less perspective. In this sense, acknowledging the partiality of mainstream GIS conceptions and recognizing the multiplicity of perspectives coming from the margin can contribute to a more precise understanding of the world.

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