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for geographical imagination systems (gis)

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Abstract:

For many, Geographic Information Systems (GIS) and related libraries for programming languages define the terrain of geographical computing today. But what if GIS were locales within wider realms of geographical imagination systems (gis), realms more adequate to diverse theoretical commitments of geographical thought? Examining how various thinkers in spatial theory have conceived of phenomena, space, knowledge, and their entanglements, this article advocates for geographical imagination systems that change the infrastructures of geographical computation and broaden its associated objects of intellectual inquiry. In doing so, it centers questions such as: What if knowledge were understood as interpreted experience? What if phenomena were represented as individuated out of process and internal relations? What if spaces and coordinates were co-produced with phenomena? Interludes juxtapose such considerations with concrete possibilities realized by an experimental prototype gis under development. But, as the article also argues, crucial to the future of geographic computation adequate to geographical inquiry will be diverse creative conversations in code (valued alongside and) intellectually interwoven with scholarly interventions made through mediums such as the written word.

Keywords:
absolute space, geographical imagination systems, GIS, gis, relational space

What kind of computation for what kind of geography?

Human geography offers rich and complex approaches to space as produced, dynamic, situated, and relational. Space, in these conceptualizations, resists being reduced to an empty container in which any point can be precisely located by Cartesian coordinates and whose interrelations default to being described using Euclidean notions of distance. Yet many in contemporary human geography (and others in the social sciences and humanities) accept and turn to Geographic Information Systems (GIS) software to represent "geographic information," calculate with it, and make visual representations of space in the form of maps. Geographic information centers Cartesian and Newtonian understandings of space and worldly phenomena (Sheppard 2005; Bergmann 2016); it foregrounds the conceptual importance of "location" in what the world believes geographic understanding to offer.

Even within the realms of human geography that place more emphasis on conversation with social and cultural theory, we do have inspiring and productive scholarship that has benefitted from engaging GIS. Work within the broad domains of feminist (Kwan 2002), qualitative (Cope and Elwood 2009), and critical GIS (Thatcher et al. 2016) have detourned actually-existing GIS and transformed what we understand to be possible not only within GIS, but also within human geographical inquiry. GIS were never solely positivist, and their story may transcend that of their more martial ancestries (e.g. Cloud 2002). Researchers have pursued fundamental Geographical Information Science, developing theories and methods that may be only loosely tied to what is possible in the GIS software of any given era (Goodchild 1992). Scholars have argued for constructing computational alternatives. Critical geographers, for example, have called for a GIS/2 sensitive to place and pluralism in knowledge (Sieber 2004). Concurrently, qualitative extensions to existing GIS have become increasingly common (Kwan and Knigge 2006; Cope and Elwood 2009; Jung 2015; Martin and Schuurman 2017). And a scientific movement has long existed championing "geocomputation" that avoids the "disabling technologies" of GIS (Gahegan 1999). Nonetheless, we feel it remains urgent to ask: what if GIS were built upon the epistemological and ontological commitments that tend to motivate contemporary human geography in particular—or even on the interpretative social sciences and theoretical humanities more generally?

Our central suggestion in this piece is that we need not settle for GIS, nor their "geographic information," nor their limited cartographic repertoire. Instead, we argue that we can and should pursue broader realms of "geographical imagination systems" (gis). As we suggest, gis, via experiments crossing human and computing languages, can interweave and create concepts, data structures, algorithms, interfaces, and visual practices more adequate to engaging notions of spatiality prevalent in contemporary human geography. gis, following work in speculative computing, may relax the requirement that spatial knowledge be singular and objective. Instead, spatial knowledge and its visual representations can be understood computationally as "partial, situated, and subjective" (Drucker 2009, 5), with absolute space and objectivity as outcomes of a project, not its precondition. Here, we sketch desiderata and potential paths that may help us realize such geographical imagination systems.

The paths toward gis are undoubtedly varied. They may draw upon ongoing attempts in critical GIS and data studies to rethink the concept of geographical information and its basic data structures in order to have knowledge be a positioned, interpretative, and potentially more-than-human affair (Kwan 2002; Sieber 2004; Bergmann 2016; D'Ignazio and Klein 2020). Recent interest within Geographic Information Science in notions of place (as contrasted with space) has also led to research into platial analysis whereby geographical meaning is studied computationally (Goodchild 2011; Gao et al. 2013; Westerholt, Mocnik, and Zipf 2018). Emerging approaches for exploring meaning-making computationally at scale have great promise and will likely find use within gis. At the same time, gis must be predicated on affording not only places, but also spaces, the role of being co-produced with meaning. gis may thus provide for the interpretative construction, collision, and collaging of relational and absolute spaces.

Our conceptualization of gis is informed by diverse computational experiments, both within and outside of geography. gis is less a path toward a clearly stated goal than a gathering of practices that suggest GIS could have developed otherwise, with the recommendation that we build accessible tools that open these practices to experimentation and play. In this article, we introduce a number of theoretical, methodological, and experimental orientations towards geographic scholarship as a means to imagine what a move from GIS to gis might look like. In what follows, we offer vignettes of gis in practice, using interludes to sketch examples from our own experiment into one type of geographical imagination system, a prototype named *enfolding*. We show how a move generalizing GIS to gis can expand possibilities for geographic knowledge, understandings of phenomena and space, and computational inquiry. We offer gis as both a theoretical ideal and a call for multiple, hybridized, and diverse computational experiments in spatial visualization.

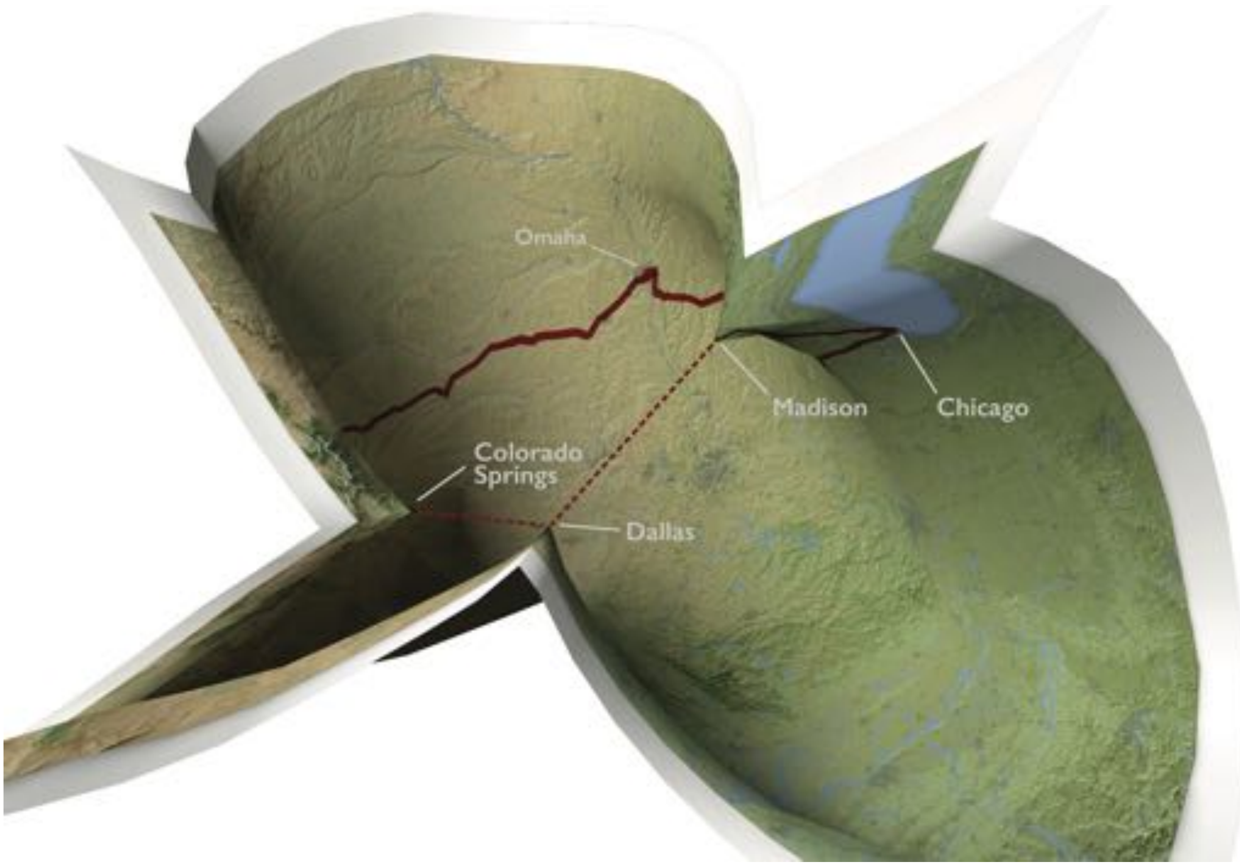

Figure 1: See Interlude one.

Interlude one

Conceptually, gis is not only a prompt for rethinking existing GIS software, but also a call to build new tools. Developing varied experimental geographical imagination systems may benefit from collaborations. We have been working on one such prototype, which we call *enfolding* (Lally and Bergmann 2021; code and a browser-based prototype are at https://foldingspace.github.io/enfolding/). Interludes in this article juxtapose concrete examples from gis with concepts of gis. Inspired by theories of space developed in human geography as well as non-Euclidean approaches to quantitative geography, *enfolding* allows users to bend and fold space according to alternative notions of distance—the resulting image shown here contrasts the temporalities of commercial air and train travel (Figure 1). *enfolding* allows the systematic exploration of various ways of reconciling non-Euclidean distances among points within a map or image with the visual affordances of a two- or three- dimensional display space. It uses dimensionality reduction heuristics such as multidimensional scaling to enable this visualization of complex spatial relations (see also: Gatrell 1983). Whether understood as travel times or any number of other understandings of proximity, changing measures of distance can become the grounds through which spatial relations are thought, and, in this case, visualized.

What kind of spaces?

Geographers have long recognized the limitations of mapping relations, phenomena, and situated experiences of space using Euclidean understandings of distance. As a result, theorizations of non-Euclidean space to understand social, economic, and cultural phenomena have a rich history in the discipline. David Harvey (1969), for example, writes in his quantitative *Explanation in Geography*: "Deciding the future distribution of socio-economic activity on the basis of a physical Euclidean spatial system does not seem a very realistic way to proceed when there is a considerable probability that socio-economic spatial interaction is best mapped into a non-Euclidean geometry" (376). Here, Harvey is echoing a sentiment that appeared at times in quantitative work that preceded his book—notably in the work of Bill Bunge (1966) and Waldo Tobler (1961)—while also prefiguring critiques from humanistic geographers that would follow. Harvey would himself turn to the work of Lefebvre, Leibniz, and others to theorize space as relative and relational in the years that followed *Explanation* (Harvey 1988 [1973]). Similarly, human geographers have often recognized the limitations of static, planar coordinates in understanding spaces produced through human- and non-human relations. But while textual theorizations have and continue to produce rich and dynamic understandings of more-than-Newtonian space, there is still a dearth of relevant and accessible computational approaches engaging such spaces.

It is within the void between actually existing GIS software and theories of space that we locate our own calls for, and experiments with, gis. Some theories of space suggest geometries of relations that can be used as starting points for such experiments. As Marx noted in *Capital*, "A relatively thinly populated country, with well-developed means of communication, has a denser population than a more numerously populated country, with badly-developed means of communication" (1867, 473). Equally, in response to contemporary disciplinary and homogenizing invocations of a "time-space compression" under the influence of systems of communication and transportation, Doreen Massey (1993) developed the concept of "power-geometry." The unevenness of socially-differentiated mobilities, connections, and power relations that such a concept addresses suggests a need to rethink taken-for granted understandings of distance within available GIS. Similarly, Ruth Wilson Gilmore (2007) shows how systems of power produce uneven and relational measures of distance and proximity. In placing a prison in a particular site, Gilmore observes of the nearby community, the idea that "somehow the community could control the inner workings of a prison because of its location struck them as ludicrous; they had learned that *distance is not simply measured in miles*" (228, emphasis added).

While some theories of space explicitly undermine Euclidean understandings of distance, others insist on the situated and socially-differentiated natures of space that are not reflected by GIS. Anne Buttimer (1976), for example, argues for a phenomenological understanding of space as a "dynamic continuum" that resists reduction to a geometric grid. More recently, work in Black geographies has insisted on the entanglement of race and space, undermining the universalizing visions of GIS. Focusing on Chicago, Rashad Shabazz (2015) shows how systems of power and the built environment produce "spatialized blackness," generalizing the logics of the prison to racialized subjects in the city. So too do theories of "paradoxical space" (Rose 1993) and spaces understood as topological (Secor 2013) exceed many computational mapping systems, insisting on blurred boundaries between inside and outside, tied to situated knowledges of always shifting subjectivities. The dynamism and complexity of space as theorized within human geography, of which we can only provide a brief sampling here, offer starting points for critiquing and moving beyond the theoretical and epistemological commitments of existing GIS.

Even if many of the spaces described in human geography prove impossible to map in some strict sense, this does not mean they cannot be interpreted and engaged visually. The interpretive and subjective path that we suggest for gis finds resonance with visual art practices, where data and space become media subject to experimentation, sculpting, juxtaposition, translation, and play. Central to this approach is the insistence that computation need not be thought of as a cold, mechanical operation, limited by narrow ideas of data and mathematics. Rather, we wish to pose computation and software as expressive mediums (Wardrip-Fruin 2012) capable of contributing to the production of spatial theory. In other words, while we find spatial theory in human geography productively challenging in imagining what might be possible through gis, the conversation need not always proceed from theories of space toward tools of gis. Rather, the practices of gis can also inform how space is understood and theorized. It is in this iterative process where gis becomes part of processes of theorizing that we find the potential to create and explore other spaces. What might these conversations yield, and how do they expand upon what we might hope to learn from GIS?

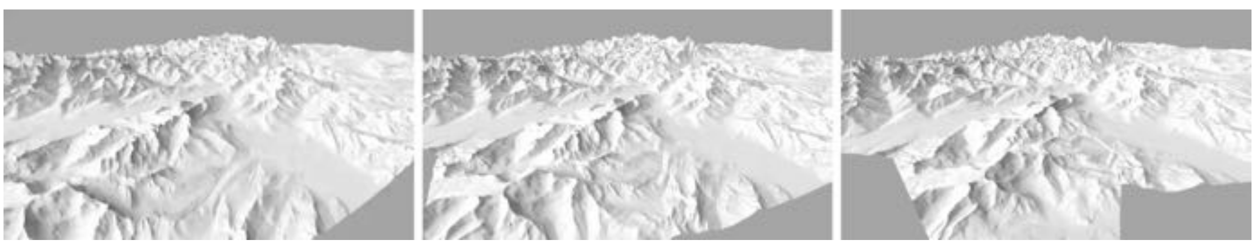

Figure 2: See Interlude two.

Interlude two

The folded, crumpled, collaged, and dynamic maps of *enfolding* insist on the expressive decisions and processes that brought them into being (Figure 2). In contrast to the projected spaces of GIS, gis offers other means of spatial visualization that resist the taken-for-granted objectivity of the basemap or coordinate system. Knowledge, then, is opened to contestation, debate, and reconfiguration over time as maps puts themselves forth as propositions. Space becomes open to other situated positions, open to debate, and hence, open to politics and the social temporalities of meaning-making. As Massey (2005) argues, "*For* the future to be open, space must be open too" (12).

From GIS to gis

Geographic Information Systems provide structured approaches to tracing out the implications of insisting that "geographical information" consists of phenomena that: 1) have intensive properties, while being 2) found in particular geometrical configurations that are located within pre-existing coordinate systems. A central epistemological problem that many information systems attempt to navigate is the integration of knowledge from diverse sources. GIS connects phenomena via space: knowledge that was once entwined with particular knowers and communities and contexts is first alienated into separate data layers, then those layers are then reintegrated by GISystems according to common location. Such functionality is usually intrinsic to the specialized spatial databases at the core of GIS. Many types of databases, spatially-aware or not, integrate knowledge by "joining" objects that appear across multiple datasets. Databases, when not having or relying on spatial information, can find entities that have common properties and assume they share identities, thereby suggesting relationships among what may have been assumed to be separate knowledges of separate entities. Yet GIS can also align and group phenomena by shared location within an abstract coordinate system (or other basic forms of spatial relations; see Peuquet 1988, Egenhofer and Herring 1991). GIS thus allow for spatial proximity to become the integrating concept for knowledge of phenomena gathered from multiple sources. A particular conception of how identity of phenomena and space relate is thus central to "geographical information" and its "systems" in GIS.

The space that organizes knowledge within GIS is encountered through coordinates. The diversity of cartographic projections and associated coordinate systems for locating phenomena captivates those of us who are students of geodesy. Structured by topology and the earth's shape, different mathematical and political compromises are offered by different projections. Yet at the same time, most of these projections are typically enrolled in our intellectual projects as different planar approximations to an abstract universal ideal. Ontologically, the ideal of space in GIS is usually one that is singular and uniform; it is our coordinate systems and imperfectly-spherical earth that have made it easy for us to fall short in our quantifications of location. From this perspective on spatiality, projections with their associated coordinate systems are increasingly antiquated, as we now have three-dimensional display technologies and global satellite positioning systems (Goodchild 2018). To geographical theory, such a space is often termed as absolute or Newtonian, following the key debates between the Newtonians and Leibniz (Leibniz and Clarke 1998).

In contrast to Newtonian space, Leibniz insisted on a relational understanding of space, produced in and through relations among things, which would come to influence contemporary understandings of space in human geography. Whether in geographical imagination systems or in GIS, questions of epistemology, space, and phenomena are intimately interconnected. The centrality of absolute space in computational approaches to geographical knowledge today offered by GIS is likely a historical aberration, a momentary overemphasis of one approach among many. Instead of seeing phenomena as located within a singular prior space and as integrated by their proximities within an exogenous distance metric, geographical imagination systems seek to valorize a range of ways of integrating knowledge of phenomenal interconnections, allowing us to recompose knowledge from multiple sources with diverse positionalities. What additional approaches to handling location and more-than-Euclidean approaches to space can geographical imagination systems draw upon?

Not all uses of coordinate systems and projections are accompanied by aspirations to measuring phenomena with geodetic accuracy and within a universal absolute space. Even quantitative geography, which has been an important source of inspiration for GIS, has long offered a variety of approaches to considering spaces and their representations in coordinates through mathematical and visual means. In Harvey's 1969 *Explanation in Geography*, he argued: "The general argument about the nature of distance in geographic research (Olsson, 1965A; Bunge, 1966) has effectively been resolved. There is no independent metric to which all activity can be referred…. In the discussion of the location of economic activity distance may be measured in terms of cost, in the discussion of diffusion of information distance is measured in terms of social interaction, in the study of migration distance is measured in terms of intervening opportunity, and so on" (210). Similarly, Waldo Tobler engaged such ideas mathematically and cartographically for his entire career, with a dissertation (1961) that engaged distance in terms of velocities and costs, beginning: "the measuring rod of the geodesist or surveyor is less relevant to social behavior in a spatial context than is scaling of distances in temporal or monetary units." His most general theoretical statement on these matters is his call for an "analytical cartography" (2000), in which an analytical development of projections and coordinate systems via anamorphoses is an important means to an end. As Tobler wrote, "the purpose of geographical and analytical cartography is the development of geographical theory, not the inventorying of geographical phenomena" (189).

These important traditions of quantitative geography, which are esoteric and peripheral in contemporary GIS, are central to gis. In GIS, to add a feature to the map, you only need to know its position in an exogenous coordinate system. Objects are always-already individuated; additional knowledge of interrelations is hard to incorporate meaningfully. By contrast, in gis, to add a new feature to the map, you may well need to account for how every point is related to every other point. Taking Tobler's first law ("everything is related to everything else, but near things are more related than distant things" in Tobler 1970, 236) and re-emphasizing its first clause, a gis accounts for how every thing is related to every other thing. Spaces are co-produced with phenomena; phenomena and coordinate systems are entwined. In geographical imagination systems, close relation among phenomena might lead to proximity in an emergent space, whereas in Geographic Information Systems, the relationship is either the converse or it is proximity within an a priori space that often indicates close relation among phenomena.

Concretely, coordinates for entities in gis can be obtained by multiple approaches. Where proximities among phenomena are consistent in various ways (perhaps they are roughly symmetric, obey triangle inequalities, etc.), dimensionality reduction methods may be employed to reduce a complex space to a Euclidean approximation in which the known interrelations among entities approximately hold. Although methods for dimensionality reduction commonly chosen among geographers have been multidimensional scaling (MDS; see Gatrell 1983) and self-organizing maps (SOM; see Agarwal and Skupin 2008), recent advances in data science in the analysis and visualization of high-dimensional data are of potential relevance (Wasserman 2018). At the same time, many spatial relations human geographers consider are neither additive nor even symmetric—consider power, affect, and even some travel times. gis might thus include the juxtaposition of differentiated spaces, as explored in Wood's (1978) "cartography of reality." Spatial relations may also be less specifically centered as being among entities. Spaces may be composed and recomposed through manipulations such as stretching, folding, cutting, and montaging. A call to theorize and develop geographical imagination systems is an invitation to reopen the practices of space used within geographical computation, drawing upon and extending the diversity of approaches, quantitative and more-than-quantitative, that have enlivened spatial theory within geography and beyond.

Geographic Information Systems (GIS)	geographical imagination systems (gis)
Knowledge as objective information—"total, managed, and externalized" (Drucker 2009, 5)	**Knowledge** as interpreted experience—"partial, situated, and subjective" (Drucker 2009, 5)
Phenomena are self-sufficient objects with intensive properties. Relations are epiphenomenal and external.	**Phenomena** are individuated out of process and internal relations. They are known through situated, experiential encounter.
Space has an exogenous coordinate system; always-already individuated objects are located within those coordinates.	**Spaces** are co-produced with phenomena; phenomena and coordinate systems are entwined.

Table 1: From GIS to gis. The two columns are not meant to be read as dichotomous, but rather, the right column highlights possible ways that gis can expand the limited conceptual and operational framework of existing GIS. We are also not implying the abandonment of any of the concepts in the left column, recognizing their incredible usefulness in particular contexts. Instead, the operations and epistemologies of the left column become one possible way of understanding space within the larger umbrella of gis.

In geographical imagination systems, space must no longer be a precondition for knowing objects, but emerges with the phenomena, processes, and subject positionality of interest (see Table 1). If existing GIS has "favoured the primacy of objects over processes" (Gahegan 2018, 21), gis insists on the centrality of processes in producing spaces. Multiple processes and multiple perspectives likely mean multiple coordinate systems; given phenomena likely have multiplicities of coordinates. Consider the time-spaces of a borderland, interpreted from the relative perspectives of those who may cross over it relatively unimpeded versus those for whom travel is greatly uncertain, perhaps impossible. Spaces and coordinates in the latter approach likely diverge rapidly from the first. As discussed below, phenomena may also be co-constituted with spaces, quantifiable or otherwise, that lie beyond coordinates.

With multiple spaces, even if it is possible to say that there are multiple perspectives engaging the "same" phenomena, or multiple spaces in which such phenomena might be intertwined with in different ways, there may or may not be epistemic procedures for reducing difference into objective and identical knowledge—as there was with GIS and its overlays and various (spatial) joins. Instead, geographical imagination systems must engage larger realms of pluralism and interpretation. In doing so, gis may draw upon the negotiations across difference that participatory GIS have developed within an expanded epistemic realm in which difference may well be irreducible (Ramsey 2008; Ghose 2017; Radil and Anderson 2019). Single answers to technocratic dilemmas may or may not be attainable.

Not all spaces need to be engageable through coordinate systems and not all phenomena necessarily need be localizable within coordinate systems. For only some of the key entities in a dataset to have the property of a spatial coordinate reduces the helpfulness of existing GIS, leading to the breaking of norms in the typical data structures used for "spatial data" in GIS—the relational database (which are "relational" in a particular technical sense described by their progenitor E.F. Codd (1970), not at all in the sense that spatial theorists mean.) Geographical imagination systems, then, are unlikely to be limited to engaging relational databases, and will explore alternative approaches to representing geographical data across a broader realm of data structures (see Bergmann 2016). These may include linked data, the semantic web, "capta" (as they are framed by Drucker 2011), graph databases, and other NoSQL approaches (Hart and Dolbear 2013; Robinson, Webber, and Eifrem 2015).

Geographical imagination systems thereby reorder past boundaries between numerical spaces and meaningful places, between spatial and attribute data, and between the quantitative and the qualitative. There is nothing about coordinates or spaces which says that they must be self-consistent or even aspiring to be "real." Cognitive, dream, and literary cartographies engage subjective and cultural spaces, drawing no simple contrasts with objective spaces existing outside meaning-making and cultural artifacts (Iosifescu Enescu, Montangero, and Hurni 2015). Geographical imagination systems foster such supposedly blurry cartographies just as readily as the aspirationally precise ones more widespread today.

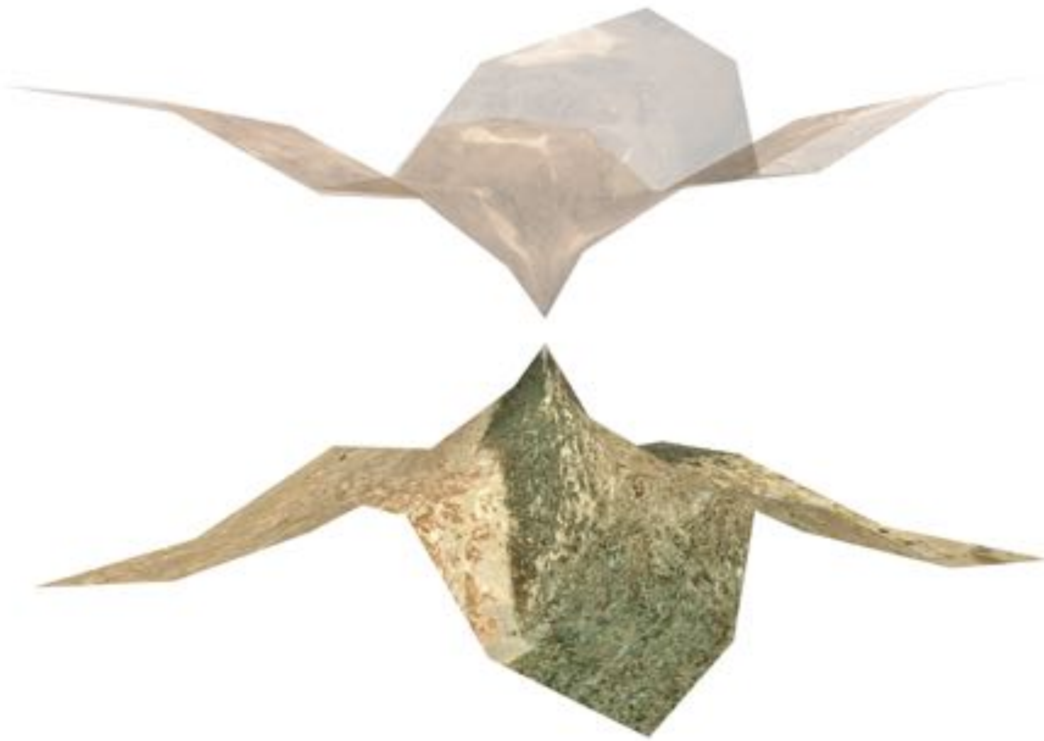

Figure 3: See Interlude three.

Interlude three

enfolding allows for the visualization of wormholes—a figure that Sheppard (2002) has used to illustrate the tight coupling of faraway places under processes of globalization (Figure 3). The wormhole need not imply a symmetrical relationship, but rather, one space may haunt another (see also: Lally and Bergmann 2021). In the case of a drone strike, vision is unevenly distributed, with a pilot who assumes the all-seeing, "techno-culturally mediated" vision of a faraway place (Gregory 2011). On the ground, inhabitants are on the receiving end of the power of the wormhole, unable to traverse the distance in reverse.

For software: toward a flowering of experimental gis prototypes

Our essay does not aspire to prefigure all of the imaginative possibilities for gis. We need a flowering of more-than-Newtonian approaches to geographic inquiry in speculative digital realms. Speculative design is a mode of play—of playing with the impossible, the unimaginable, and the unrepresentable. It is exploratory wandering, just like the writing and reading of texts. It grapples with the impossible problem of representation, which the text also confronts, but is always worth pushing to its limits, coaxing representation into other registers. Like art, it is the possibility of producing new relationships to the world, through affects and percepts (Deleuze and Guattari 1994), as the visual exceeds any semblance of similitude, instead bringing new geographical imaginations forth.

And for this, we need to center a creative process of tool-making and conversation, rendering previously artisanal techniques more broadly accessible. For example, Gahegan (2018) observes that innovative GIScience research often "remains trapped in the hallowed pages of our GIScience journals," (18) never integrating with GIS software. Or consider Daniel Huffman's "Lake Michigan Unfurled" map (https://web.archive.org/web/https://somethingaboutmaps.com/Lake-Michigan-Unfurled), where the coastline of the lake is rendered as a straight line. Experiments such as Huffman's have been inspirational for us in imagining possibilities for spatial visualization, but they also point to the limitations of current mapping software in bringing such visions to fruition. Equally, the centralization of GIS into comprehensive commercial platforms (even with corresponding open-source alternatives) does not provide an adequate model. We call for a plurality of systems whose evolution is just as diverse, open-ended, situated, and unexpected as that of spatial theory.

It is not just a matter of reorienting software towards other modes of theoretical inquiry, but also of remaking the social and material relations that coalesce around geographical computation. In other open-source software projects, we might find paths to learn from. Consider how the open-source language Processing, intended foremost as a way for artists and designers to integrate code into their practices, has been built. In conjunction with software development, The Processing Foundation aims to increase the accessibility of tools and encourage diversity of participation with the project (https://processingfoundation.org/). The success and spread of gis similarly hinges on the proliferation of multiple visions and tools that incorporate other orientations towards spatial thought.

We do need to be active to facilitate writing and maintaining software as a valid, valued, and potentially integral part of the lives of faculty and research computing specialists. There are calls for funding agencies to play larger parts (e.g., in the United States, there are efforts to create a Geospatial Software Institute; in Canada, a Digital Research Infrastructure Strategy is being funded). Disciplinary associations, especially in the digital humanities, have made detailed recommendations as to how digital scholarship can be valued and evaluated as part of tenure and promotion decisions (see, e.g., https://web.archive.org/web/*/https://www.historians.org/teaching-and-learning/digital-history-resources/evaluation-of-digital-scholarship-in-history/guidelines-for-the-professional-evaluation-of-digital-scholarship-by-historians and https://web.archive.org/web/*/https://www.mla.org/About-Us/Governance/Committees/Committee-Listings/Professional-Issues/Committee-on-Information-Technology/Guidelines-for-Evaluating-Work-in-Digital-Humanities-and-Digital-Media.) One can help foster geographical imagination systems through bringing geography departments and disciplinary associations into these conversations just as readily as by writing code or engaging prototypes.

In calling for geographical imagination systems, we seek not only conceptual systems that are dynamic and open, but ecosystems of code that are as well. Not merely open to the select few, guarded by strong invocations of intellectual property and academic prerogative, but open, branching, multiplying, hybridizing geographical imagination systems. Such tools should allow multiple entry points for creative geographic inquiry. We might imagine how one geographer, without needing to know anything about code, could use a gis to explore relational data while engaging social theory. Such a scholar could also make a comment on a system's code repository (which, in 2020, would likely be hosted on GitHub), requesting a new feature. A second geographer could make and modify a branch of the code, producing a new, creative interpretation of that request, rendering new representations and spatial sensibilities possible. When interrogated by others in new scholarly contexts, a new wave of possibilities for code may arise and be commented upon, both in the scholarly literature and in the code repositories. And so unfold the flowers of gis.

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