2

NON-QUANTITATIVE GIS

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ABSTRACT

Despite its relatively weak quantitative functionality, GIS is primarily associated with statistical and quantitative spatial analysis. This creates a particular representation of GIS as linked to traditional understandings of science and technology and, critically, to corporate power and institutions of control. In addition, constructing GIS as solely quantitative prevents it from being used for qualitative analysis, non-quantitative spatial analysis, and progressive research that often (although not always) relies upon non-quantitative research methods. GIS is, however, well suited for particular forms of qualitative research. For example, it allows for a rich visualization of information in the form of maps and other types of graphic data representation. In this sense, cutting-edge research in geovisualization is directly supporting non-quantitative uses of GIS. In addition to geovisualization, other recent research illustrates not only that a qualitative GIS is possible and growing but that it fulfills an important epistemological function. This function consists of the ability to visualize and investigate social phenomena that cannot be represented by quantitative databases (whether governmental, commercial, or user created) or analyzed by traditional quantitative and statistical techniques. Not only does qualitative GIS contribute to furthering our scientific understanding of the world by expanding the range of usable epistemologies, but it also supports research agendas that are committed to progressive politics and challenge the status quo. Finally, qualitative GIS also contributes to advances in social theory because it easily incorporates space into our thinking about the world and allows us to ask research questions that can only be addressed through mixed methods research.

INTRODUCTION

Just a few years ago, critical GIS (geographic information systems or science) scholars had to argue that a qualitative GIS was even possible and that it could contribute to a valid and robust research methodology (Bell and Reed, 2004; Knigge and Cope, 2006; Kwan, 2002a; Kwan and Knigge, 2006; Matthews et al., 2005; Pavlovskaya, 2002). Today, we are contributing to a textbook on qualitative GIS written for a wide audience of students, academics, and GIS practitioners.[1] This remarkable development is related to and enhanced by the recent powerful re-entry of qualitative and ethnographic methods into human geography after a period of relative undervaluing of the humanistic tradition. Major recent methodological texts now include thorough discussions of qualitative research (e.g. Babbie, 2000; Clifford and Valentine, 2003; Cloke et al., 2004; Tashakkori and Teddlie, 2002; see Crang, 2002 for an overview) and the politics of doing such research today are widely debated (Crang, 2002; St Martin and Pavlovskaya, forthcoming b).

A recent emphasis on mixed methods research has also contributed to the emergence of qualitative GIS. Previously opposed to quantitative methods, critical human geographers have re-envisioned their use in conjunction with qualitative modes of explanation (Elwood, 2006a; Kwan, 2002a; 2002b; 2002c; Lawson, 1995; McLafferty, 1995; 2002; Sheppard, 2001; St Martin, forthcoming). Similarly, and also a result of the growing availability of digital spatial data and user-friendly software for their viewing (e.g. Google Earth), geospatial technologies are increasingly incorporated into mixed methods approaches. Combining GIS with qualitative methods allows critical human geographers to use the analytical and representational power of GIS as well as to get around its limitations with respect to certain forms of analysis (see Introduction, this volume).

Qualitative GIS has also made relevant to GIS research the debates in critical human geography about the political nature of production of knowledge and representation initiated by feminist and poststructuralist critics of science (Foucault, 1980; Gibson-Graham, 2000; Haraway, 1991; Katz, 2001; Rose, 1992). Its effects are felt throughout the whole process, from defining research problems and choosing methods to producing findings and interacting with research participants, assistants, and colleagues. In the words of Cindi Katz (1992), knowledge production 'oozes with power'. This could not be more important than in the case of GIS which is, at once, a powerful research and representational tool, a charismatic technology, and a multi-billion-dollar industry. There is also a powerful narrative about 'what GIS is' that defines what it can or should and cannot or should not do (St Martin and Wing, 2007). Therefore, GIS practice and scholarship also result in silencing certain research practices and uses that do not fit these definitions.

This chapter argues for qualitative GIS as a powerful research strategy by exposing some of the silences that are produced by the prevailing narrative of 'GIS as a quantitative tool'. While this narrative grants irrefutable scientific authority to GIS, it also silences its non-quantitative functionality that, I argue, actually constitutes its core in many respects. Breaking silences around the affinity of GIS with *qualitative* analysis opens it up to ethnographic and mixed methods research. The chapter begins by examining GIS as a power relation negotiated in broader epistemological struggles within geography. It then proceeds to deconstruct the prevailing notion of GIS as a quantitative tool and highlight its capabilities for qualitative research, including rich functionality for visualization. Lastly, I use examples from recent research that illustrate that qualitative GIS not only is possible but can also fulfill an important epistemological function that quantitative research cannot.

GIS AS POWER RELATION

GIS indeed represents power to most audiences: it stands for funding and research grants, jobs, information, student enrollments, mesmerizing images on the computer screen, best solutions and locations, and the power to convince. This power derives from the position of GIS at the intersection of science, technology, and visuality. First, GIS is firmly associated with quantitative analysis and the scientific method. Second, its flesh and blood are computers and digital information. And, third, it expresses the very fascination of Western science and geography with vision, seeing, and looking as a primary and supposedly objective way of knowing, which is in fact partial, embodied, and masculinist (Cosgrove and Daniels, 1988; Haraway, 1991; Rose, 1992; Sui, 2000). Similar to cartography (Crampton, 2001), the power of GIS lies in its ability to create visual images of the world based on scientific information, to unveil previously hidden natural and social landscapes with an authority of science. The prevailing image of GIS as a powerful juncture of science, technology, and authority serving big business and the government has been created and sustained by many actors. These include academic departments where GIS is taught, corporations where the technology is developed, and various groups of users from grassroots organizations to businesses and governments worldwide (Kwan, 2002a; Longley et al., 2005; Schuurman and Pratt, 2002; St Martin and Wing, 2007). As a representational tool and a socially embedded technology, GIS is indeed 'oozing with power'.

Not surprisingly, then, GIS has been passionately debated in geography since the early 1990s (see Schuurman, 1999; 2000 for details). These debates concern not only the field of GIS *per se* but also geography's identity as a discipline (Goodchild, 1991; Kwan, 2002a; Openshaw, 1991; 1998; Sui and Morill, 2004), practices of knowledge production and representation (Bell and Reed, 2004; Crampton, 2001; Elwood, 2006a; 2006b; Elwood and Martin, 2000; McLafferty, 2002; 2005; Pavlovskaya and St Martin, 2007; Sheppard, 2005), and the relationships between GIS and economic and social power (Crampton, 2003; Pickles, 1995; 2004; Smith, 1992). In other words, the debates about GIS have been intimately related to epistemological struggles over scientific authority. It is a power relation negotiated by different practices of knowledge production in human geography identified with quantitative and qualitative methods. This understanding helps to explain the passion surrounding GIS, its continued transformations, and even its integration with qualitative methods, the last of which was recently unthinkable but now forms the subject of this book.

Historically, the field of GIS has been associated with quantitative spatial science in geography. Seen as socially and scientifically progressive in the 1950s and 1960s, since the 1970s this tradition has been critiqued by Marxists, by feminists, and later by poststructuralists for scientific and social conservatism. The scientific conservatism resulted from a positivist epistemology while the social conservatism of mainstream social science stemmed from its general support for the economic and social institutions of capitalism, which the new approaches sought to examine critically. It became unthinkable to practice progressive social science while assuming objectivity, a value-free researcher, and clear separation of the subject and the object of the research. Researchers concerned with class, gender, sexuality, and race denounced not only the conservative politics but also the methodologies that were linked to the production of such scholarship, of which quantitative analysis was a major tool. Critical scholars instead turned to the qualitative methods of humanistic geography and recast them within critical geography paradigms (Cloke et al., 1991; Katz, 2001; Livingstone, 1992; Staeheli and Mitchell, 2005). At some points in the philosophy and methods debates of the late twentieth century, choosing a method (e.g. regression analysis or ethnography) represented a choice of not only one's philosophy of science but also one's professional and personal politics.

GIS entered geography in the midst of these debates. It was largely constituted by these debates in a specific way – as a quantitative tool of spatial science. In various texts, the language of GIS is that of science, measurement, spatial data models, spatial analysis, sampling, geocomputation, calculation, databases, data transformation, validation and so on (examples are Clarke et al., 2002; Crisman, 2002; de Smith et al., 2007; Longley et al., 2005). The landscape of the GIS community today is very complex but a number of authors have shown that within it both 'quantitative' proponents and 'qualitative' critics of GIS contributed to this image of the field (Schuurman, 2000; Schuurman and Pratt, 2002; St Martin and Wing, 2007). For the proponents, the connection of GIS to science, quantitative geography, spatial analysis, and computerization validated its growth and has been a source of pride (Clarke, 1999; Goodchild, 1991; Longley et al., 2005). Today, many professors and students equate GIS with geography and see it as a scientific solution to most geographic problems and the most important job skill for graduating students (Flowerdew, 1998; Longley et al., 2005; Openshaw, 1998; Sui and Morill, 2004). Part of this valorization is represented by the shift to the term GIScience (GISc), which has replaced the more mundane term GISystems (Wright et al., 1997), implying a transition from simply a tool to a theory of digital representation of the world and its analysis.

The critics, too, linked GIS to spatial science and quantitative geography. In contrast to GIS academics, however, they focused on the epistemological and social conservatism embedded in its representational, technological, and scientific authority. For many of them, GIS was a problem, not a solution. In their view, GIS reduces places and people to digital 'dots' and enables those in power to make decisions without involving local communities. GIS serves corporate profit making and state interests; facilitates surveillance, control, and warfare; masks social and economic inequality; supports the seeming objectivity of data and analysis; perpetuates a male-dominated field; serves as a successor to imperial cartography; and is an essentially undemocratic information technology due to its high cost, unequal access, and need for expert knowledge (Armstrong and Ruggles, 2005; Crampton, 2003; Curry, 1997; Dobson and Fisher, 2003; Goss, 1995; Kwan, 2002c; Pickles, 1995; 1997; Rocheleau, 1995; Schuurman, 2002; Sheppard, 1993; Smith, 1992; Treves, 2005). Together, all these aspects of GIS practice left no room for its application within Marxist, feminist, poststructural, and postcolonial frameworks. Seen as solely quantitative and technocratic, GIS was overwhelmingly denounced by critical human geographers in the 1990s. In short, despite the normative disagreements of those involved in the debates, GIS emerged as a singular tool to be used within a particular practice of knowledge production (Kwan, 2002a; Schuurman and Pratt, 2002; St Martin and Wing, 2007), a seductive technology firmly linked to quantitative science, power, and capital.

And yet, the situation has begun to change in the past decade or so. A body of knowledge loosely defined as 'critical GIS' has emerged that has enabled innovative, non-quantitative, and progressive uses of and perspectives on GIS (for overview, see Schuurman, 2002; Sheppard, 2005). In some ways, critical GIS is a result of the growing theoretical pluralism of the past three decades. Partiality of knowledge has become an acceptable epistemological stance that necessitates conversation and makes explicit one's responsibility for knowledge production practices. Feminist scholarship, in particular, has transformed social sciences by bringing in the excluded subjects and thoroughly changing research ethics. These developments encouraged GIS scholars to think about the possibilities of GIS within diverse theoretical frameworks.

The assumed vast differences in scientific rigor between quantitative and qualitative methods have also been profoundly rethought on both the qualitative and quantitative sides (see, for example, Baxter and Eyles, 1997; Cloke et al., 2004; Crang, 2002; Poon, 2004). Qualitative research is no longer considered to be a precursor or an afterthought of a large-scale quantitative study, equal in significance to 'coffee-table talk' (Openshaw, 1998). Both approaches today are seen as different but equally powerful research strategies if used appropriately. While one focuses on the power of generalization and statistical representation, the other enables explanation, understanding, and theoretical representation (Strauss, 1995). Both, however, are socially embedded practices and, therefore, can be logical or irrational (Barnes, 2001), sophisticated or simple, large or small in terms of amount of data, spatial scale, time, and labor, as well as sloppy or rigorous. With qualitative methods regaining their authority, geographers began to 'discover' qualitative aspects even in the established quantitative research tools such as GIS – as discussed later in the chapter (see also Elwood, 2006a; Knigge and Cope, 2006; Kwan and Knigge, 2006; Pavlovskaya, 2006).

But in addition to the above, it is the ongoing delinking of epistemology and methods across social sciences that has enabled innovative and non-quantitative GIS practices. The assumed alignments of ontology, epistemology, and methods within a particular paradigm (e.g. spatial science with quantitative methods and feminism with qualitative methods) have been destabilized, and both types of methods are increasingly practiced across different epistemological frameworks. Feminist, Marxist, and poststructuralist geographers found ways to incorporate quantitative analysis (see Hanson, 1997; Lawson, 1995; McLafferty, 1995; Plummer and Sheppard, 2001; Sheppard, 2001) and the strictly quantitative scholars have begun to appreciate qualitative reasoning (Poon, 2004). Today, 'quantitative' no longer stands for 'positivist' even among social theorists (but see Amin and Thrift, 2000) and 'qualitative' no longer means lack of science. The choice of methods became more pragmatic but no less rigorous because the responsibility of researchers for their choices has been made explicit. It is the internal consistency, transparency, and reflexivity of the methods, their ability to acquire and analyze needed information, either quantitative or qualitative, that have become most important. In this context, we can decouple GIS, too, from its assumed epistemological home and imagine its valid uses in other research frameworks.

The related rise of mixed methods in social sciences and geography (Creswell, 2003; Tashakkori and Teddlie, 2002) also opens GIS to new imaginations. In mixed methods projects, researchers use quantitative and qualitative methods either sequentially at different stages or interactively at all stages (Knigge and Cope, 2006). They combine methods to cross-reference and triangulate data but also to consider incongruencies in data as research opportunities. Geographers in particular are increasingly keen to combine different methods with GIS when research goals make it appropriate (Kwan, 2007; McLafferty, 2005; Nightingale, 2003; Pavlovskaya, 2004; Robbins and Maddock, 2000; Sheppard, 2005; St Martin, forthcoming). Finally, the so-called 'spatial turn' in social sciences and humanities has increased attention to the spatiality of human experiences and encouraged thinking about space in non-quantitative and visual terms. The language of boundaries, flows, and territories, as well as that of cartography and maps, has found its way into wider social research and art. Not surprisingly, GIS is now used outside its traditional technical fields and is being rapidly integrated with the latest multimedia and web-based technologies (Peng, 2001; Pavlovskaya, forthcoming).

With all these developments in place, it is vital to articulate GIS as a strategy for mixed methods research that transgresses the established epistemological boundaries. While important work in this direction has already begun (Craig et al., 2002; Elwood, 2006a; 2006b; Elwood and Leitner, 1998; Knigge and Cope, 2006; Kwan, 2002a; 2002b; 2002c; 2007; McLafferty, 2005; Pavlovskaya, 2002; Schroeder, 1996; Schuurman and Pratt, 2002; Sheppard, 2005; Sieber, 2004), it would be too soon to say that GIS has seamlessly joined the diverse practices of knowledge production. The dominant discourse of GIS remains that of a quantitative tool; it tends to alienate and marginalize other research methods; its corporate, military, and state applications prevail; and the industry itself is increasingly dominated by a single corporate developer. Given the representational power of GIS and its rapidly spreading applications, reclaiming geospatial technologies for critical geographies, qualitative research, and progressive politics has been at no time more crucial than it is now.

OPENINGS FOR NON-QUANTITATIVE GIS

Thinking of GIS as a negotiated power relation in the production of knowledge instead of a given, unchangeable technique helps to see GIS as 'constantly remade through the politics of its use, critical histories of it and the interrogation of concepts that underlay its design, data definition, collection and analysis. In other words, futures of GIS are contested and openings exist for new meanings, uses and effects" (Pavlovskaya, 2006: 2004). Below I offer one strategy for enabling new meanings and uses of GIS. In particular, I refocus the prevailing narrative of GIS that constructs it as a quantitative technology on to commonly overlooked and, therefore, silenced non-quantitative functionality. I do so by identifying a series of openings or contradictions in GIS practice that break silences and produce possibilities for qualitative GIS. They show that GIS has much greater affinity with qualitative research than we commonly think.

Opening 1: GIS origins are mainly non-quantitative

To begin, the very origins of GIS are mainly non-quantitative. It evolved from a variety of fields besides quantitative geography and combines diverse bodies of knowledge. They include geography (mapping and spatial analysis), computer science (automation and computing), land use planning and census administration (handling and display of large databases), remote sensing (image processing and land cover analysis), and geodesy and the military (spatial accuracy and georeferencing) (Clarke, 1999; Flowerdew, 1998). In other words, using GIS requires specialized knowledge but this knowledge is different from the expertise in quantitative analysis.

Opening 2: computerization is not quantification

Since their early days, computer technologies have represented science. The beginnings of quantitative geography in the 1950s coincided with and were facilitated by the introduction of computers, and, as an emerging field, spatial science benefited from this association (Barnes, 2000; 2001). Computers created an illusion of accuracy in data and calculation, handled large amounts of information, and, just like scientific data, needed systematically organized datasets. GIS, too, handles large and structured databases, offers specific analytical tools, and is part of expanding information technologies. Yet, modern computing supports a whole range of non-analytical and non-quantitative activities (e.g. paying bills or playing games). Researchers, too, use a broad range of software packages, many of which automate non-analytical tasks (e.g. word processing or bibliographic software) or non-quantitative analysis (e.g. graphic display or qualitative data analysis using ATLAS.ti).

In the early days of computers, GIS programmers were academics who developed software to automate their spatial analyses. The link between GIS and scientific modeling was prominent (Schuurman, 1999). Today, with rare exceptions (e.g. IDRISI), the development of mass-consumption GIS software is in the hands not of academics but of corporations. Creating any computer application requires programming skills but few applications require quantitative spatial analysis. Moreover, most existing spatial analysis algorithms predate computerization and were incorporated into the software long after they were developed. Thus, the two bodies of knowledge – programming and quantitative analysis – are separate types of expertise (see also Crisman's, 2002: iii comment about their conflation).

Furthermore, most of the diverse functionality of GIS (e.g. data visualization and querying, overlays, etc.) is made efficient by automation but remains quantitatively and statistically unsophisticated. Remote sensing software is far more quantitative in this sense because even basic image classification techniques use complex statistical procedures (e.g. cluster analysis, maximum likelihood classification, principal component analysis, etc.), as do many non-spatial statistical software applications (e.g. SPSS or Statistica). Thus, computerization enabled GIS to process digital information but in itself it did not make this information processing more quantitative.

Opening 3: spatial analysis in GIS is non-quantitative

Surprisingly, only a modest share of GIS functionality involves quantitative spatial analysis (Eastman, 2003; Flowerdew, 1998; Openshaw, 1998; Schuurmann, 1999). Even popular GIS textbooks admit that "most GIS packages have contained only rudimentary tools for spatial analysis" (Clarke, 1999: 181). Most GIS users, therefore, have access to only basic techniques such as overlay, linear distance calculations, buffering, determining neighbors, or summarizing data within new geographic boundaries. While very illuminating, these techniques do not require knowledge of advanced mathematics from GIS users. Examples include calculating employment opportunities within a certain distance of women's homes (Hanson et al., 1997), overlaying locations of banks engaged in predatory lending with census data to reveal their target populations (Graves, 2003), and mapping hazardous accident sites by census units to calculate exposed populations (Margai, 2001). In truth, most spatial techniques available in GIS require spatial imagination (e.g. to grasp buffering or overlay), logical thinking (e.g. combining layers in site selection or multi-criteria evaluation), or intuitive grasp (in visual examination) and, therefore, replicate qualitative reasoning common to all geographic research. This affinity with human reasoning has been also obscured for a long time by the unfriendly user interfaces of many GIS programs and applications.

Ironically, much of the recent GIS research seeks to enhance precisely these qualitative aspects. Fuzzy sets theory, artificial intelligence, cellular automata, chaos and complexity theory, agent-based modeling, and Bayesian probability all attempt to model human reasoning that involves multiple connections, blurred ontological categories, uncertainty in decision making, and the pragmatic use of partial knowledge (Ahlqvist, 2004; Openshaw, 1998; Sheppard, 2001). Ironically, as is the case with buffering, for example, the challenge is not in the mathematical sophistication of the technique itself – it is quite non-quantitative – but in designing and mathematically implementing an algorithm that replicates human reasoning (e.g. decisions made under uncertainty) or a conceptually simple spatial operation (e.g. buffering).

Finally, much of GIS literature deals with such methodological issues as ecological fallacy and modifiable areal unit problems (Openshaw and Taylor, 1979; Wong, 2003; 2004), questions of appropriate spatial resolution and locational accuracy (Scott et al., 1997), methods for distance calculations (Wang, 2000), representation of objects as either continuous or discrete, the ontological structure of objects (Fonseca et al., 2000), and so on. While there are GIS-specific tasks such as digital spatial data models (e.g. Ahlqvist, 2004), other issues, again, are common to geographic analysis in general. Matters of conceptualization, they are not in themselves quantitative problems. In the end, despite the consistent labeling of GIS as a quantitative tool, its most commonly used functions are rather qualitative.

Opening 4: digital data are not always for counting

Digital data representation, including GIS databases (spatial and attribute), is usually associated with large numerical datasets, but upon closer examination it also has little 'quantitative' content in itself. All information for computer use must be represented digitally and, therefore, appropriately coded. This means that digital data have embedded histories; they are not neutral descriptors of the world but social constructs, that is they are products of those who created them, their purpose, and their approach. Furthermore, digital data must be coded regardless of whether they are quantitative or qualitative and whether they are to be analyzed quantitatively or not. In word processors, too, letters are expressed with binary code but are not for use in a regression model. They are digital because they cannot be stored and visualized in the computer otherwise. While coding already implies categorization, fixity, and structured ontology (Dixon and Jones III, 1996; Doel, 2001; Jones III and Dixon, 1998; Lawson, 1995), using numbers to express qualitative properties of geographic objects does not yet amount to quantitative analysis. For example, topology lies at the heart of vector models and represents very structured but non-quantitative spatial relationships. Digital data like photographs or sound are non-quantitative too. In short, digital representation does not substitute for quantitative analysis.

Opening 5: database management and querying are based upon geographic location

Suggesting its origins in an empiricist scientific tradition, GIS easily handles large amounts of data (Flowerdew, 1998). Compared to non-spatial database management systems, it organizes data in a unique way – by geographic location. Assembling and structuring spatial 'facts' in a geographic database (e.g. land parcel, TRI, or census data) allow for versatile querying and display of datasets comprising thousands of spatial units and variables describing them. Spatial databases also allow for unique merging of information from different sources. As digital information and especially spatially referenced data continue to explode, the role of GIS in meaningfully organizing these datasets will only increase (St Martin and Pavlovskaya, forthcoming a Sui and Morrill, 2004). This extraordinary ability of GIS to manage and query spatial data is, however, conflated with an ability to quantitatively analyze them.

Database development and maintenance – tasks that consume enormous amounts of time, as GIS textbooks frankly acknowledge (Clarke, 1999) – do not involve quantitative analysis at all. Digitizing and cleaning spatial layers (e.g. snapping nodes, building polygons, or georeferencing satellite data), merging spatial databases, as well as entering, organizing, and verifying attribute data, do require knowledge of geodesy, geometry, data structures, and the subject matter of the database but do not require knowledge of advanced spatial analysis or modeling. Building a GIS database for a qualitative project would require the same technical skills and expertise as for a quantitative project (see Jung, this volume, for an example).

Digital attribute data themselves, too, are often qualitative and include names (e.g. of owners of land parcels, businesses, or street addresses) or types (e.g. of roads, settlements, soils, or polluting facilities). While not suitable for quantitative analysis, such data can, however, be queried and logically manipulated using SQL (structured query language) in order to find geographic features with particular characteristics. Even complex attribute and spatial queries, however, require logical thinking and a spatial imagination rather than statistical or mathematical expertise. SQL also enables numerical manipulation, but advanced calculations are less common in a GIS and, as we will see, are most often performed in a non-GIS environment.

Opening 6: mathematical modeling and statistics are still outside GIS

Even more revealing, the advanced GIS and quantitative geographers seldom use commercial GIS for analysis. They often need specific algorithms that are absent in commercial packages or have their details concealed. GI scientists program their own spatial analytical routines and display the results in the existing GIS software (Flowerdew, 1998; Kwan, 1999a; 1999b; Openshaw, 1998). Further, the community of quantitative geographers is quite different from the GIScience community (Fotheringham, 1997; Goodchild, 1991; Poon, 2004). They publish in different journals (Miller and Wentz, 2003) and use non-GIS quantitative analysis packages (e.g. MatLab, IDL, SPSS, Statistica, or MS Access or Excel) or existing specialized models (e.g. for atmospheric circulation, plume dispersion, or crime 'hot spot' identification), or write programs themselves (e.g. the geographically weighted regression (GWR) software developed by Fotheringham et al., 2002). This is true even for studies that explicitly focus on spatial processes (e.g. Margai, 2001; Plummer, 2000; Poon, 2004). While these routines may eventually become add-ons to GIS, the point is that they are not among the most widely used or initially available GIS functions.

The fact that many statistical techniques including regression analysis simply cannot be applied to spatial data (Getis and Ord, 1996) also limits the quantitative capacity of GIS. For example, proximity generates autocorrelation in spatial distributions and this violates fundamental assumptions of data independence in conventional statistics. Initially developed for non-spatial data, these statistics were imported into geography without proper adjustment (Barnes, 1998; 2001; Flowerdew, 1998; Sheppard, 2001). Thus, ignoring locational information, unfortunately, cancels out the very difference GIS could have made.

Most available statistics, even spatial statistics, also calculate parameters (e.g. autocorrelation coefficients or regression equations) that apply to the entire study region and ignore local variation in their values. This defeats the purpose of geographic analysis and leads to creation of mis-specified or poorly fitting models (Fotheringham, 1997; Fotheringham et al., 2002). In addition, the available methods do not do well in modeling dynamic processes, incorporating individual-level data (Miller, 2003), or representing interactions across geographic scales and networks (Poon, 2004). Only recently have geographers developed advanced geostatistical methods that address these and other problems of spatial modeling (Barnes, 1998; Fotheringham, 1997; Getis and Ord, 1996; Poon, 2004; Sheppard, 2001). These techniques, however, usually are available in software packages separate from GIS or only recently incorporated. Visualizing spatial distributions remains the main functionality that quantitative modelers seek and use in GIS.

Opening 7: visualization can be a qualitative analytical technique

In the end, visualization is arguably the most powerful and widely used function in GIS. Like other tools for graphic data display, GIS makes spatial information immediately accessible to our minds. Scholars prefer to 'see' the data, either quantitative or qualitative, in order to assess their quality, suitability, or completeness, and to 'see' the results in order to decide whether each transformation or query is correct or not. Even in purely quantitative research mapping, value distributions help, for example, identify model mis-specification problems (Fotheringham, 1997). Visual examination itself does not involve mathematical calculation, but is a powerful analytical technique.

More importantly, however, visualization is the source of the seductive rhetoric of GIS, the rhetoric that combines the power of maps with the power of science and technology. Maps communicate spatial information in a particularly synergistic way. Far from simply conveying data, maps convey power because they express the authority to selectively represent people and places (Crampton, 2001; Edney, 1997; Harley, 1992; Lewis, 1998; Sparke, 1998; St Martin, 1995). Placing this power into the realm of information technology, GIS further validates maps as scientific constructs (Lake, 1993; Sheppard, 1993). GIS unveils worlds to researchers, policy makers and the public, worlds made 'true' by the assumed legitimacy of data and visual displays.

Not surprisingly, the GIS industry has always focused on display functions as a way to analyze data as well as conquer hearts. GIS academics, too, have produced vast research on visualization including its technical, computer-related, methodological, cognitive, and social theoretical issues (Knigge and Cope, 2006; Kwan, 2002a; MacEachren, 1994). The recent surge in work on geovisualization and exploratory spatial data analysis (ESDA) in particular demonstrates that visualization is no longer a means to represent analytical results but a means of analysis itself. In the past, cartography served to communicate the results of research to the public as suggested by the map communication model (Robinson and Petchenik, 1976). In this model, the cartographer's task was to best communicate (by properly choosing symbols, colors, themes, scale, etc.) the already derived scientific knowledge to the public who were to passively receive that knowledge. In the past decade, however, Alan MacEachren (1994; MacEachren et al., 1999) has advanced the concept of visualization as an analytical tool linked to an automated data display in GIS. Here, the research process itself becomes a focus. Assisted by computerized visualization, a researcher or a GIS user interactively and iteratively analyzes the data and immediately displays the results in a number of ways. She or he explores both the data and the analytical techniques and, by directly interacting with a GIS, becomes simultaneously the author and the reader of the map (Crampton, 2001). The GIS-based map is transformed from a vehicle for delivering knowledge into an interactive knowledge production practice including the potential to become the primary medium for communication between scientists themselves (MacEachren et al., 2004). The potential of integrating GIS visualization with qualitative analysis is particularly promising (see 'grounded visualization' presented in Knigge and Cope, 2006; also Knigge and Cope, this volume).

Visualization is powerful because it provides opportunities for heuristic (non-logical) understanding of data and processes. While an important component of human decision making, this understanding cannot be achieved by rational analysis but complements it. The visual impact of GIS also depends upon emotions and other irrational sentiments (Kwan, 2002a; 2007) that run counter to the dry logic of quantification. In short, visualization is the most telling non-quantitative functionality of GIS.

To conclude, the most widely used functions in GIS, such as visualization, database development, management, and querying, are not at all quantitative despite that the dominant narratives construct GIS as a quantitative analytical tool. The alternative reading presented above highlights the limited use of GIS in quantitative analysis and points to its unacknowledged potential for qualitative research that I will turn to now.

THEORIZING WITH GIS

The possibilities of a distinctly qualitative GIS within critical human geographic research have been open up by critical GIS scholars. Public participation GIS (PPGIS) scholars, for example, have long been working on making GIS and other geospatial technologies, including internet-based geographic information, more democratic. They seek to empower marginalized groups through the use of these technologies (Craig et al., 2002; Elwood, 2006b; Gilbert and Masucci, 2004). Feminist geographers, however, were among the first to argue against essentializing GIS as a positivist and masculinist technology and for using it in feminist research (Hanson, 2002; Kwan, 2002a; 2004a; McLafferty, 2002; 2005; Pavlovskaya, 2002; Schuurman, 2002; Schuurman and Pratt, 2002). We are witnessing the emergence of a new mapping subject who is a male or female GIS researcher/user working to challenge dominant configurations of social power (e.g. class, gender, race, or heteronormativity) and practicing feminist sensibility and reflexivity in their research (Pavlovskaya and St Martin, 2007). This research is particularly open to the qualitative potential of GIS because it aims to incorporate unprivileged and often non-measurable forms of experience not included in quantitative representations. Feminist GIS scholars have also worked to incorporate qualitative analytical functionality into GIS (see Knigge and Cope, 2006; also Knigge and Cope, this volume).

In this section, I suggest further possibilities for expanding the strengths of qualitative GIS. In particular, I consider how GIS can fruitfully enrich qualitative explanation by incorporating spatiality. I then discuss the recent work that exemplifies how qualitative GIS can visualize non-quantifiable experiences, feelings, and emotions; harness the rhetorical power of mapping by visualizing unprivileged ontologies; and ask questions that can only be answered through the combination of qualitative data and GIS-based analysis (that is, a 'mixed methods' approach).

Incorporating non-Cartesian spatiality

Concern with space and scale continue today in critical geography in the form of debates about the spatio-temporalities of human worlds (Harvey, 2006; Herod and Wright, 2002; Marston et al., 2005) as well as in GIScience in the form of ontologies research (Fonseca et al., 2000). The waves of 'spatial turn' have brought space as a key category into social sciences and humanities that also turn to using GIS and other geospatial technologies (Bol, 2004; Chambers et al., 2004; Pavlovskaya, forthcoming). This presents an ideal moment for GIS to realize its potential as a representational tool of critical geography. But a fundamental dilemma arises: GIS is associated with an absolute concept of space defined by a Cartesian grid, while critical human geography views space as produced by social relationships and experiences (see Harvey, 2006; Miller and Wentz, 2003). Can a GIS view space in anything but Cartesian terms?

Space is conventionally conceptualized in GIS as 'absolute', Euclidean, or Cartesian space that contains clearly defined objects with precise location and where processes operate on a number of fixed and analytically separate scales (e.g. local, regional, national, or global). This absolute space, associated with spatial science, enables formal analysis of spatial patterns and relationships, such as the distance decay function. As Miller and Wentz (2003) show, such conceptions prevail despite the fact that other representations of space within GIS are possible. Accordingly, GIS most often is used to do exactly this: to map and analyze spatial patterns in Euclidean space. Occasionally, it is used to visualize processes defined by relative positions of places and geographic objects, including connections, flows, networks, and movement. Mainstream GIS, however, has very limited capabilities for modeling flows and movement (mainly as cost–distance or network analysis). In critical geography, 'relational' space, along with time, is inseparable from social processes (Harvey, 2006; Massey, 1985) and may embrace non-measurable properties of place, human experience, and social power. Understanding these aspects of space requires qualitative modes of explanation prominent in Marxian, feminist, post-structural, and postcolonial approaches. GIS, however, is rarely used to represent 'relational space'. Furthermore, GIS does not represent people well because its objects are spatial features with attributes (e.g. discrete vector features or raster cells). It is difficult to model people's behavior or connect experiences to discrete spatial objects (Dorling, 1998; Kwan, 2004b; Miller, 2003; Openshaw, 1998; Poon, 2004). And people, obviously, are the main concern of human qualitative geography.

And yet, despite these major challenges, GIS also offers possibilities to qualitative modes of explanation. It does so precisely because it creates inherently spatial representations. It is possible, I believe, to find use for these representations in critical human geography or extend the representations themselves beyond the absolute space of spatial science. To do so, many important questions need to be addressed, within both human geography and GIS. How can we represent spatially complex connections, power relations, and collective meanings? How can the partiality of GIS representations open up to contestation and dialog with other partial representations? How can alternative mappings be created with, by, and for the disempowered social actors whose spatial experiences are not commonly represented? How can the authority of GIS-based representations be made less exclusive? How can the results of qualitative analysis of space be represented? How can we create powerful geographies of relational spaces using the absolute space of current GIS? Graphics often aptly communicate concepts, but representing a theoretical argument spatially is rare. The examples below illustrate some of these challenges.

Visualizing non-quantifiable experiences

In order to overcome the bias of GIS databases towards numerical information, feminist and other critical human geographers have begun to use unconventional spatial data such as narratives, in-depth interviews, hand-drawn maps, graphics, photographs, videos, as well as voices and sounds (Dorling, 1998; Kwan, 2002a; Sheppard, 2001). Using these methods, they create analytical representations of people's experiences, movements, and even such hard-to-quantify phenomena as emotions or webs of daily economic practices. Looking to model daily movement through urban space, Mei-Po Kwan (2002a) revived Torsten Hägerstrand's space–time geography approach which she applied to her analysis of women's daily travel. To implement GIS-based modeling of their movement, she combined urban land use and street network data with qualitative information from travel diaries kept by the respondents. Kwan visualized the three-dimensional life paths representing the daily travel of women from different ethnic and socio-economic groups. She concluded that not only are the uses of urban space gendered (a fact obscured by conventional urban models) but the differences between women from different class and racial backgrounds are also profound (Kwan, 1999a; 1999b; 2002a). In another project, Kwan (2007) visualized in a GIS the variations in safety of urban space as perceived by a Muslim woman after 11 September 2006. In this project, Kwan used emotion as a main type of data, acquired through ethnographic research, to be modeled and mapped.

In a project that explicitly combines GIS with an ethnographic study of low-income urban households, Matthews et al. (2005) designed a database that summarizes in-depth interview information and links it to places that people talk about in their interviews. This work has augmented the presentation of ethnographic data and added context by displaying census and crime information for the neighborhoods where the respondents lived. Matthews et al.'s work advances the interdisciplinary framework of a 'geoethnography' that combines geospatial technologies with urban ethnography. In a non-urban context, Hong Jiang (2003) combined an ethnographic study of villagers in Inner Mongolia with a remote sensing analysis of landscape change. She found that these approaches complemented each other such that she could weave a more compelling and complex story of landscape change.

Kevin St Martin (2005; 2008; forthcoming; and with Hall-Arber, 2007; in press) integrated GIS with ethnographic research while studying the potential for community management in the fishing industry of the US Northeast. In this participatory research project, community researchers (primarily women who were themselves fishers, fishermen's wives, or local advocates of their fishing communities) interviewed fishers about their fishing histories, communities, and local environmental knowledge using GIS maps as referents. National Marine Fisheries Service vessel trip report data (geocoded data reporting fishing trip locations) were analyzed quantitatively using density mapping and percentage volume contour (PVC) calculations to delineate the territories of particular fishing communities. Project participants were asked to comment on the accuracy and meaning of the resulting maps relative to community. Questions included whether project participants saw these fishing grounds as sites of common histories, shared knowledge, cooperation, and community formation; and whether or not the maps depicting a shared space produced a sense of community where none had previously existed.

In another example, Marie Cieri (2003) examined the sense of place produced by queer tourist industry propaganda in comparison to that directly experienced by lesbian tourists. She juxtaposed commercial tourist maps and tourist guide narratives with the hand-drawn spaces and stories told by her respondents (Figure 2.1).[2] She found that the queer tourist industry conflates lesbian and gay male spaces and reduces both to spaces of consumption, in contrast to the spaces with multiple meaning lived by the lesbian women.

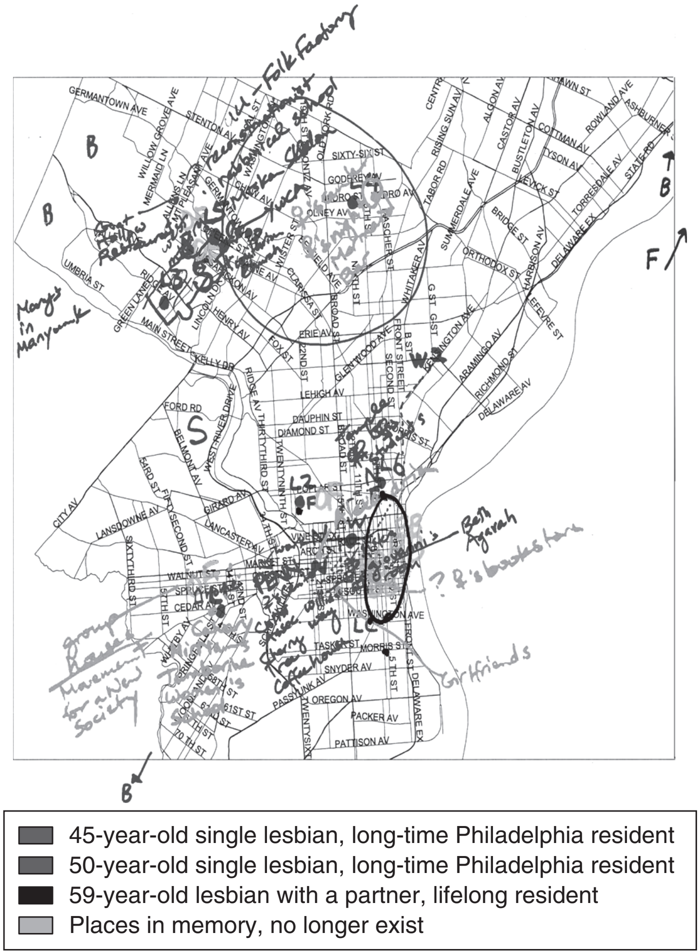

Figure 2.1 NW Philadelphia and center city: superimposed maps by three lesbians

In my own research on urban transformations under postsocialism (Pavlovskaya, 2002; 2004), I created maps of the multiple economies of Moscow households using ethnographic information from in-depth interviews (Figure 2.2). These maps show that in each household a wide range of economic activities is present both under socialism and especially, after the collapse of socialism, in the market-based economy. These activities included formal and informal employment for wages, informal and unpaid domestic production of goods and services (e.g. cooking, childcare), and exchanges of goods and services via networks of family and friends. While formal work for wages remains the primary concern of urban and economic policy and research, most other necessary and very time and labor intensive economic practices remain invisible and, therefore, under-theorized and ignored. Mapping networks of support in single- and two-parent households (Figure 2.3) also revealed that single parents were often successfully employed because they had to secure networks of

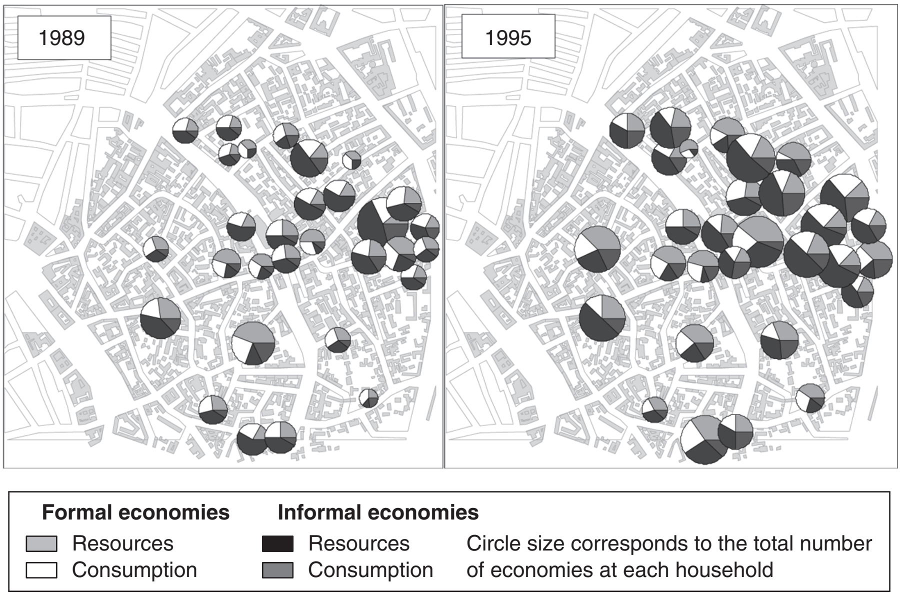

Figure 2.2 Multiple economies and households, 1989 and 1995, downtown Moscow

extended family and friends in order to have any kind of work. That was in contrast to two-parent households where a traditional division of labor that privileges male employment over female employment remained intact.

Integrating interview data into a GIS in the above examples also served to include the respondents as co-creators of representations based on their experiences. These alternative representations differ in important ways from the conventional depictions of economies, households, danger and crime, natural resources, social services, or consumption patterns that are based on indicators computed from large and impersonal statistical datasets.

Visualizing unprivileged ontologies

No less important is a visualization strategy that creates social ontologies that are invisible for conventional theories and methods. Mapping such phenomena, relationships, and landscapes (e.g. the daily paths of women, experiences of Muslim women, territories at sea used communally, lived lesbian spaces, informal household economies, or daily networks of support) makes them visible and, therefore, 'real' and significant theoretically and politically. In other words, 'positioning' these unprivileged phenomena on the map using a GIS that merges scientific authority with visual impact performs an ontological function: it 'creates' the landscapes produced by these processes and legitimizes them. The power of GIS to constitute such worlds is particularly appealing for critical geography because of its concern with including and representing the excluded.

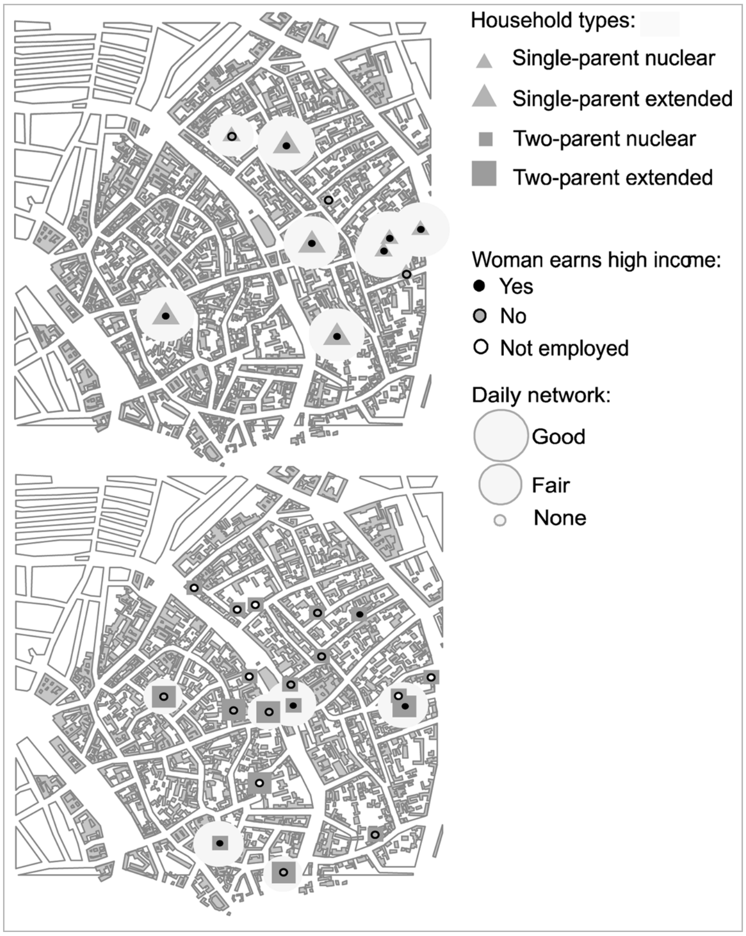

Figure 2.3 Household support networks, 1995, downtown Moscow

Mixed methods

Thinking of a qualitative GIS as a mixed method opens further possibilities. The effect of combining quantitative and qualitative methods with geospatial technologies goes beyond gaining more by adding different types of knowledge or even complementing partial knowledges. Mixing these methods can achieve two more important (although related) goals. One is the ability to ask research questions that could not be asked if only one method is used. The second is to actually look for inconsistencies in partial knowledges produced by different techniques and treat them as research opportunities, as opposed to error or incompleteness of data. In this case, discrepancies become openings into an inquiry about social power configurations that produce these different representations and their effects.

Feminist political ecologist Andrea Nightingale (2003) specifically focused on the inconsistencies in the accounts of changes in forest cover based on aerial photography and the ecological histories of villagers in Nepal. She found that villagers participating in community forestry programs tended to emphasize positive changes that occurred under community management. They were invested in keeping the forest under local control as opposed to its possible transfer to a national-level management. Rather than being a matter of fact or truth, an analysis of discrepancies becomes a story of political power and control over local resources.

Work by Paul Robbins (2003) and with Tara Maddock (2000) also focuses on differences in definitions of forest by remote sensing professionals and villagers in India. What professional foresters identified as forest on a satellite image did not qualify as a forest for local villagers because it consisted of replanted (indeed, invasive) species that did not provide the same livelihood as the original forest. Similar to Nightingale's work, the discrepancies in representation between satellite images and ethnographies of community resource use indicated that multiple truths about the 'forest' expressed a politics of control over resources.

Kevin St Martin's work (2001; 2008; forthcoming) on fishing territories in New England reveals, for example, that the grid-based ocean space of the National Marine Fisheries Service comes from its concern with the maintenance of quantities of fishing stock in a borderless ocean, while fishers' oceans have much more intricate and complicated geographies. These discrepancies are evident in the struggles between fishing communities and government management over seasonal closures of particular areas. The closures are designed to protect fish populations from predacious fishers, who are thought to be endlessly mobile individuals capable of catching unlimited quantities of fish. This is in contrast to thinking about them as embodied men and women who fish in particular places they know best and whose livelihood depends on access to these places. This second vision of fishing territories as bounded and harvested by local communities makes a case for greater involvement of these communities into fisheries management.

These examples show that GIS may incorporate experiential and marginalized spatialities that are best elicited by ethnographic and other qualitative methods. Using mixed methods, GIS also opens the inconsistencies in data derived from different sources to investigation of the social power dynamics that produce different representations. In other words, GIS may provide ways to address relational spaces of power, whether they are or are not bound to a Cartesian grid. These questions are at the core of current human geography concerns.

CONCLUSION

This chapter approached the subject of using GIS in qualitative research by treating GIS, similar to other research methods, as a power relation. The dominant view of GIS as a quantitative technology, then, is not grounded in its innate properties but is a result of negotiations between differing practices of knowledge production. The critical examination of the functionality of GIS presented in this chapter reveals that in many ways GIS is intimate with non-quantitative data and modes of analysis, while its application in quantitative geography and spatial analysis, has been surprisingly limited. Most academic and other users rely on its areas of functionality that can serve qualitative researchers equally well, such as visualization, integration of different types of data, querying, and basic spatial analysis.

The challenge is to open GIS to qualitative research so that complex relationships, non-quantifiable properties, unprivileged ontologies, and fluid human worlds can be represented spatially and better understood. Re-imagining GIS as a flexible tool for creating diverse human geographies not solely confined to the 'absolute space' of spatial science has already begun. As the examples above show, GIS could be used by critical human geographers engaged in qualitative research and focusing on relational spaces of social power. While it is far from providing answers to all questions, GIS can be fruitfully combined with other research strategies. It can incorporate experiences elicited through ethnographic work and other qualitative research methods. It can use non-quantitative data (such as images, video, sound, narrative) in combination with more standard datasets, such as census data (for an example, see Jung, this volume). As a powerful representational tool, GIS can reconstitute unprivileged social ontologies by placing them within the authoritative field of science and technology. It also enables mixed methods approaches that integrate geospatial technologies with qualitative and quantitative research. And, finally, as a mixed methods medium GIS encourages researchers to seek to understand power dynamics and authority clashes that produce always partial and often conflicting spatial representations of human worlds.

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NOTES

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