Feminist Visualization: Re-envisioning GIS as a Method in Feminist Geographic Research

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Despite considerable progress in recent geographic information systems (GIS) research (especially on public-participation GIS), the critical discourse on GIS in the 1990s does not seem to have affected GIS practices in geographic research in significant ways. Development in critical GIS practice has been quite limited to date, and GIS and critical geographies remain two separate, if not overtly antagonistic, worlds. This suggests that critical engagement that seeks to conceive and materialize the critical potential of GIS for geographic research is still sorely needed. In this article, I explore the possibilities for this kind of critical engagement through revisiting some of the central arguments in the critical discourse from feminist perspectives. I examine whether GIS methods are inherently incompatible with feminist epistemologies through interrogating their connection with positivist scientific practices and visualization technologies. Bearing in mind the limitations of current GIS, I explore several ways in which GIS methods may be used to enrich feminist geographic research. I propose to reimagine GIS as a method in feminist geography and describe *feminist visualization* as a possible critical practice in feminist research. I argue that GIS can be re-envisioned and used in feminist geography in ways that are congenial to feminist epistemologies and politics. These alternative practices represent a new kind of critical engagement with GIS that is grounded on the critical agency of the GIS user/researcher. *Key Words: critical GIS, feminism, feminist geography, GIS, visualization.*

> Richly evocative figures exist for feminist visualizations of the world as witty agent . . . We just live here and try to strike up non-innocent conversations by means of our prosthetic devices, including our visualization technologies.
>
> —Haraway (1991, 199)

The critical discourse on geographic information systems (GIS) in the past decade or so has raised important questions about the value of GIS in human geographic research. While many maintain that the development and use of GIS constitute a scientific pursuit capable of producing objective knowledge of the world, others criticize GIS for its inadequate representation of space and subjectivity, its positivist epistemology, its instrumental rationality, its technique-driven and data-led methods, and its role as surveillance or military technology deployed by the state. The debate between GIS researchers and critics in the 1990s, however, does not seem to have affected GIS practices in geographic research in significant ways (Schuurman 2000; Kwan 2002b, 2002c).

By this I do not mean that there has been a lack of response from GIS scientists and practitioners. On the contrary, both GIS researchers and critics have been involved in major research initiatives that attempt to address the limitations of GIS and its negative impacts on society—from issues of ontology, representation, and scale to the social and political implications of GIS for various social groups (e.g., Sheppard and Poiker 1995; Burrough and Frank 1996; Quattrochi and Goodchild 1997; Obermeyer 1998; Egenhofer et al. 1999; Goodchild et al. 1999; Mark et al. 1999; Sheppard et al. 1999; Winter 2001). Among recent studies, research on public-participation GIS (PPGIS) has made significant progress beyond the antagonism in the early phase of the critical discourse (Harris and Weiner 1998; Craig, Harris, and Weiner 2002). This literature has addressed issues such as the simultaneous empowering and marginalizing effect of GIS in local politics, representations of multiple realities and local knowledges, and the scale-dependence of power-knowledge in GIS (e.g., Elwood and Leitner 1998; Weiner and Harris 1999; Sieber 2000; Elwood 2001; Ghose 2001; Aitken 2002; Weiner, Harris, and Craig 2002).

Insights from this literature, however, have yet to bear significantly upon GIS practices in geographic research at large and on the relationship between GIS and critical geographies in particular. Despite several calls for the integration of GIS practices with critical social theories (e.g., Sui 1994; Miller 1995; Yapa 1998; Johnston 1999), development in critical GIS practice in geographic research has been quite limited to date. GIS and critical geographies remain two separate, if not overtly antagonistic, worlds. Nadine Schuurman and Geraldine Pratt (2002, 292) aptly describe the situation as "the binary split of two solitudes." In a similar vein, Susan Hanson (2002) and Sara McLafferty (2002) argue that GIS and

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feminist geography are unconnected and uncommunicative and that the possibility that both may have the potential to enrich each other has been ignored. The critical discourse on GIS in the 1990s has stimulated much debate and critical reflection on GIS technology and methods, but it does not seem to have led to the kind of changes for which critics have called (Kwan 2002b, 2002c). Critical engagement that seeks to conceive and materialize the critical potential of GIS for geographic research is still sorely needed.

In this article, I explore the possibilities for this kind of critical engagement through revisiting some of the central arguments in the critical discourse from feminist perspectives.[1] I examine whether GIS methods are inherently incompatible with feminist epistemologies through interrogating their connection with positivist scientific practices and visualization technologies. Bearing in mind the limitations of current GIS, I explore several ways in which GIS methods may be used to enrich feminist geographic research. Further, I reflect upon critical issues pertinent to the use of GIS-enabled visualization as a geographical method and describe *feminist visualization* as a possible critical GIS practice in feminist research. I suggest that GIS can be re-envisioned and used in feminist geography in ways that are congenial to feminist epistemologies and politics. These alternative practices represent a new kind of critical engagement with GIS that is grounded on the critical agency of the GIS user/researcher.

Feminist Geography and GIS

Feminist geography has witnessed tremendous growth in the last two decades. It is a highly diverse and innovative subfield of geography, with practitioners from a variety of epistemological and methodological perspectives (e.g., Jones, Nast, and Roberts 1997; McDowell and Sharp 1997; Moss 2002b). While at least three broad strands of feminist geography can be identified in the literature (McDowell 1993a, 1993b; Mattingly and Falconer-Al-Hindi 1995; Moss 1995; Pratt 2000), the most active of these in recent years is arguably what Pratt (2000) describes as feminist geographies of difference—a strand that is attentive to the construction of gendered identities across multiple axes of difference (e.g., race, ethnicity, age, sexuality, religion, and nationality) and the geographies of the body.[2] Research in this strand mainly draws upon cultural, post-structural, postcolonial, and psychoanalytic theories, while turning away from objectivist epistemologies.

Although they work with different substantive foci and methods, feminist geographers tend to share some common concerns.[3] First, they hold that the material and discursive construction of gendered identities is crucial for understanding difference in the lived experiences of individuals (Women and Geography Study Group 1997). Second, any claim to transcendent objectivity or truth is considered untenable, since all knowledge must be acquired through knowers situated in particular subject positions and social contexts (Haraway 1991; Harding 1991). Instead, feminist geographers recognize the partiality and situatedness of all knowledge and the importance of critical reflections on one's subject position relative to research participants, the research process, and the knowledge produced (reflexivity) (Hanson 1992; England 1994; Gibson-Graham 1994; Gilbert 1994; Staeheli and Lawson 1995; Rose 1997; Nast 1998). Third, feminist geographers do not hold particular research methods as distinctively feminist (see Harding 1987). Instead, they emphasize the need to choose research methods that are appropriate for the research questions and data (Lawson 1995; Cope 2002; Kwan 2002d). Increasingly many feminist geographers advocate the use of multiple methods in a single study, since the weaknesses of each single method may be compensated for by the strengths of another (D. Rose 1993; McLafferty 1995; Moss 1995; Rocheleau 1995). Fourth, feminist geographers share a commitment to progressive social change that reduces social inequality and oppression of marginalized groups in general and gender inequality in particular. An important element of this commitment is an integration of feminist theory and practice in various forms of activism (Moss 2002a).

Examining GIS from feminist perspectives is significant for several reasons. First, some of the most trenchant critiques of science and vision have come from feminist writings (e.g., Irigaray 1985; Pollock 1988; Mulvey 1989; Haraway 1991; G. Rose 1993), and they have been used in the critical discourse on GIS (e.g., Bondi and Domosh 1992; Goss 1995). Addressing the tension between these feminist critiques and GIS methods is therefore essential before GIS can be reimagined as a method in feminist research. Second, feminist geographers have contributed to the deconstruction of binarisms in geographical discourse and methods (e.g., G. Rose 1993; Lawson 1995). As GIS is often considered part of quantitative/spatial analytical methods and placed as the opposite to qualitative methods/critical theories, examining GIS from feminist perspectives may help redress this kind of dualist thinking. Lastly, several feminist geographers have used GIS in their recent research (e.g., McLafferty and Tempalski 1995; Hanson, Kominiak, and Carlin 1997). An examination of these studies may reveal some of the ways in which GIS and feminist geographic research can enrich each other.

Feminist Critiques of Science and GIS

An important issue concerning whether GIS methods are appropriate for feminist research arises from their presumed epistemological affinity with quantitative/scientific methods and positivist modes of knowledge production. Some critics have argued that GIS is rooted in geography's quantitative revolution and thus inherits its positivism and empiricism (e.g., Taylor 1990). They consider GIS to be basically a tool for quantitative spatial analysis and for answering sets of questions similar to those that quantitative methods answer (e.g., Dixon and Jones 1998). They assert that the use of GIS methods in geographic research is driven by the intent to seek for universally applicable principles or to make generalizations about the world. They argue that GIS cannot be used to understand subjective differences among research participants because of its assumption of subject-object dualism (e.g., Lake 1993). If GIS methods are inherently positivist and universalizing and cannot be used to understand difference and subjectivities, it is quite difficult to conceive any role for GIS methods in feminist geography—at least in feminist research that focuses on the geographies of difference.

Some GIS critics have drawn upon feminist critiques of science to argue that the mode of knowledge-production enabled by GIS is not only positivist but also masculinist (e.g., Curry 1995b; Goss 1995; Roberts and Schein 1995). The most influential works used by critics include those by Evelyn Fox Keller (1985), Sandra Harding (1991), Donna Haraway (1991), and Judy Wajcman (1991). These feminist theorists have provided trenchant critiques of science, especially on the relationship between the social construction of science and cultures of masculinity—for example, the way scientific objectivity has been defined reflects a particular understanding closely associated with certain cultural (but contestable) attributes of maleness. For Haraway (1991, 189), scientific objectivity as conventionally understood is predicated on the positionality of a disembodied master subject with transcendent vision, which she describes as "the god-trick of seeing everything from nowhere"—where the knower is capable of achieving a detached view into a separate, completely knowable world through the use of their "optics of inquiry" (Barnes and Gregory 1997, 20; see also Haraway 1997). This kind of knowledge denies the partiality of the knower, erases subjectivities, and ignores the nexus of power-knowledge in its discursive practice. Feminist critics see this mode of knowledge production as masculinist.

Based upon these feminist critiques, Susan Roberts and Richard Schein argue that GIS is a masculinist technology. In their critiques of global imagery in the context of GIS marketing, they (1995, 189) assert that "A GIS is a gendered technology relying on scientific knowledge . . . The technology is socially constructed as masculine in the same way that the camera itself has been recognized as an extension of a 'redoubtable masculine will' implying (or forcing) the subject's 'surrender.' " In terms reminiscent of Haraway's (1991, 189) thesis of situated knowledges, Liz Bondi and Mona Domosh (1992, 202) argue that the Cartesian space-time grid of GIS implies the existence of an external vantage point and that the mode of knowledge production enabled by GIS is masculinist. It is important that feminist critics consider GIS methods—or, more precisely, the mode of knowledge production enabled by GIS—to be positivist and masculinist. In light of these criticisms, it is crucial to re-examine the link between GIS methods and positivist/masculinist epistemology (and ontology), and to ask whether GIS methods are inherently positivist, universalizing, and unable to be used to understand difference (without denying that particular GIS applications can be positivist).

Several issues are pertinent to this critical reflection. First, the connection between GIS methods and positivist/masculinist epistemology is neither necessary nor inevitable. Past debates on the connection between positivism and quantitative/spatial analytical methods in geography are particularly relevant in this regard. Geographers including Robert Bennett (1985), Geraldine Pratt (1989), Victoria Lawson (1995), and Eric Sheppard (2001) have cogently argued against a necessary connection between quantitative geography and positivism. They question the essentializing characterization of all quantitative methods in geography as positivist practices. For Lawson (1995, 451), quantitative methods have been conflated with a particular epistemology (positivism) under the quantitative revolution and "a technique for gathering information has been conflated with a theory of what can be known." She suggests that using mixed methods in feminist research can be part of the process of separating techniques from ontological positions. For Bennett (1985, 219), "[T]here is not a close or one-to-one correspondence between what quantitative geography should be and positivism." He suggests that one major aspect of the confusion seems to arise from the particular representation of quantitative geography by David Harvey's (1969) *Explanation in Geography*, which depicts quantitative geography as primarily inductive, searching for universal laws and claiming to be an objective science. In a similar vein, the epistemological critiques of GIS in the early 1990s seem to be reactions to Stan Openshaw's (1991, 622, 625) representation of GIS as "data-driven and computer-based knowledge-creating technologies" that can "put geography back together again." The oppositional polemics in this debate, however, seem to have

denied the possibility for GIS practices to be based upon positions other than positivism or masculinism.

Second, the connection between GIS methods and positivist/masculinist epistemology is historically and spatially contingent. It was in the particular social and political contexts within which GIS was developed and used, and through complex processes of social contest and negotiation, that GIS assumed its particular form in particular application contexts (Latour 1987; Harris and Weiner 1998; Chrisman 1999; Martin 2000; Sieber 2000; Craig, Harris, and Weiner 2002). Each use of GIS technology or methods represents a unique combination of technological, scientific, social, and individual perspectives. Its use as a military technology, its role as a token of positivist science, and its instrumental rationality emanate largely from such concrete and specific historical and social construction. To argue that all or any of these constitute the inherent or immutable nature of GIS is to ignore the specificity of this history—for very different kinds of GIS could have been developed under different sociopolitical interactions—and to foreclose the possibility for GIS methods to be reimagined as critical practices for feminist geographic research.

Third, the critical agency of GIS users/researchers can play an important role in reimagining and developing alternative GIS practices. Insisting that GIS technology or methods assume particular epistemologies represents a form of technological determinism—the use of a particular technology necessitates a particular mode of knowledge production—where the possibility for GIS users/researchers to assume other perspectives is entirely ruled out. This view erases the very subjectivities and agency of individual GIS practitioners, who may be willing to adopt a critical sensibility and to renegotiate GIS as a critical practice. One of the crucial tasks for feminist GIS users/researchers is to break the positivist/masculinist connection that was historically constituted and to engage in the development of critical GIS practices that are congenial to feminist epistemologies and politics. The purpose of using GIS in feminist geographic research is not to discover universal truth or law-like generalizations about the world, but to understand the gendered experience of individuals across multiple axes of difference. It aims at illuminating those aspects of everyday life that can be meaningfully depicted using GIS methods.

Feminist Critiques of Vision and GIS

The second issue concerning whether GIS methods are appropriate for feminist research is their reliance on vision and visualization as an important means of knowledge production. Much has been written about the objectifying power of an elevated vision (in both metaphorical and material sense) and the visual appropriation of the world in modern science and geography (e.g., Cosgrove 1985; Jay 1992, 1993; G. Rose 1993; Gregory 1994). Luce Irigaray, for instance, argues, "More than any other sense, the eye objectifies and it masters" (Irigaray 1978, cited in Vasseleu 1996, 129). Michel de Certeau (1984, 92) describes the experience of seeing an object from an elevated vantage point as "looking down like a god" where "imaginary totalizations" are produced. Roland Barthes' (1979) reflections on visitors' experience of the Eiffel Tower and Michel Foucault's (1977) analysis of panopticism are equally instructive about the power of an elevated vision and the objectifying gaze (see also Bryson 1983; Lefebvre 1991; Duncan and Duncan 1992; Grosz 1992b; Jameson 1992)

Feminist theorists have written trenchant critiques of the decorporealized vision in modern technoscience. Haraway (1991), for example, highlights the primacy of sight and the reliance on visual technologies in modern society for establishing truth claims and sustaining political power. As she (1991, 189) asserts, "Vision in this technological feast becomes unregulated gluttony; all perspective gives way to infinitely mobile vision." She argues that such a disembodied and infinite vision represents a conquering male gaze from nowhere. Drawing upon psychoanalytic theory, feminist geographers have examined the relationships between geography's visual practices and the masculine desire for and pleasure in looking. Rosalyn Deutsche (1991, 10), for instance, criticizes Harvey's (1989a, 1989b) "visual conceit" as a form of voyeuristic gaze. She (11) describes such a disembodied gaze as "distancing, mastering, objectifying," where control is exercised "through a visualization which merges with a victimization of its object." In her cogent critique of landscape studies in geography, Gillian Rose (1993, 98–99) argues that the masculine gaze "sees a feminine body which requires interpreting by the cultured knowledgeable look . . . The same sense of visual power as well as pleasure is at work as the eye traverses both field and flesh: the masculine gaze is of knowledge and desire" (see also Harding 1991; Grosz 1992b; and, on male gaze by cultural critics, Berger 1972; Pollock 1988; Mulvey 1989).

The critique of vision, articulated largely in terms of Haraway's ocular metaphor and the Foucauldian trope of surveillance, has been applied to GIS visualizations and remotely sensed images (e.g., Goss 1995; Pickles 1995; Curry 1997). Feminist geographers have also been critical of the use of vision or visualizations in GIS practices. Bondi and Domosh (1992, 202–3) assert that the promise of GIS to produce singular representations from a

myriad of interconnected variables represents "a god's eye view" that entails "the distancing of a unitary self from the object of vision." They (203) argue that GIS's "emphasis on vision as the sense that bestows on the perceiver a unitary and apparently external positions" is a specifically masculine obsession that demotes other senses more closely associated with the feminine. Reflecting on the use of satellite images, Dianne Rocheleau (1995, 463) argues that "[W]hen the gaze begins from space, and when the gaze-from-space is uninformed by the logic of gendered livelihoods and landscapes, then the erasure of women's place in the mapped spaces is all but certain." These criticisms not only highlight the objectifying power of GIS-based visualizations, but also call into question the suitability of GIS methods for feminist research. If the vision enabled by GIS is incorrigibly disembodied and masculinist, the use of GIS methods will only serve to perpetuate the objectifying gaze of the masculinist master subject.

In light of these critiques, the use of vision and visualization as an important means of knowledge production in GIS constitutes a major concern for feminist geographers. Before exploring how this issue may be addressed, it is, first of all, important to recognize the historical and social context of the critique of vision and to avoid "an ahistorical condemnation" (Nash 1996, 151) of all visualizations as objectifying or masculinist. As Catherine Nash (1996, 153) argues, "There is no inherently bad or good looking." For Gillian Rose, the dominant visuality (or scopic regime) is neither inevitable nor uncontested. As she (2001, 9) suggests, "There are different ways of seeing the world, and the critical task is to differentiate between the social effects of those different visions." Given that objectification can also occur through other means, such as the use of language,[4] the problem is less the use of vision or GIS-based visualizations per se than the failure to recognize that vision is always partial and embodied and to acknowledge the risk of privileging sight above the other senses—or, as Haraway (1991, 195) puts it, "only the god-trick is forbidden."

Recent writings of feminist theorists provide critical inspiration for addressing the critique of vision when using GIS. First, the vision enabled by GIS can be reclaimed from the abstract, disembodying practice of masculinist technoscience through recorporealizing all visualizations as embodied and situated practices (Nash 1996; Nast and Kobayashi 1996; Rose 2001). Haraway (1991, 199, 195) calls this appropriation of vision in modern technoscience "feminist visualizations," which are grounded in "the view from a body . . . versus the view from above, from nowhere, from simplicity." Jennifer Light (1995) also suggests a proactive redefining of technology that entails the creative act of re-envisioning its potential use. Julien Murphy (1989, 107) proposes a "feminist seeing" that "confronts and moves beyond the distance, destruction, and desire that permeate the look of oppression." Feminist geographers can therefore engage in the appropriation of the power of GIS's visual technologies and "participate in revisualizing worlds turned upside down in earth-transforming challenges to the views of the masters" (Haraway 1991, 192).

Recent works on alternative practices in critical, feminist, and postcolonial cartography provide significant insights that may help inform the development of alternative GIS visual practices (e.g., Harley 1988, 1992; Wood 1992; Blunt and Rose 1994; Nash 1994; Rocheleau, Thomas-Slayter, and Edmunds 1995; St. Martin 1995; Krishna 1996; Pinder 1996; Dorling and Fairbairn 1997; Huffman 1997; Seager 1997; Sparke 1998). The purpose of these alternative cartographic practices—variously called *other maps* or *counter-maps*—is to re-present the world in ways that question or destabilize dominant representations, which are often imbued with various silences (especially on subaltern groups) and insensitive to the effects of oppression and violence (Nash 1994; Sparke 1998). At the level of practice, Rose (2001) presents a helpful account of critical visual methodologies—including content analysis, discourse analysis, and psychoanalysis—that can be used to provide some guidelines for enacting critical visual practices when using GIS. A major concern in this context is how to practice reflexivity with respect to the visualization process and the images created using GIS, in addition to being attentive to one's positionality with respect to research participants, the research project, and the knowledge produced. Rose (2001, ch.1) identifies three sites that, I argue, can be the focus for practicing reflexivity when using GIS methods: (1) the site of production, where we reflect on our meaning-making visual practices; (2) the site of the image itself, where we examine the exclusions, silences, and marginalizing power of our representations; and (3) the site of audiencing, where we consider how our images encourage particular ways of looking, and how meaning may be contested or renegotiated by various audiences (Kwan 2002c).

Second, new GIS-based visual practices can be developed for representing gendered spaces. Strong evidence exists in the writings of feminist cultural and art critics that women tend to represent spaces and construct spectator positions differently when compared to men (e.g., Doane 1982; Pollock 1988; Stacey 1988; Broude and Garrard 1994; Neumaier 1995; Rose 1995).[5] In an analysis of the scene location and spatial ordering in the impressionist paintings of Berthe Morisot and Mary Cassatt,

Griselda Pollock (1988, 56) concludes that "[T]hey make visible aspects of working-class women's labour within the bourgeois home" and that their spaces are characterized by proximity and compression, instead of vast spaces in which the viewer's position is hard to infer. Rose (1995) examines how the work of three women artists (Jenny Holzer, Barbara Kruger, and Cindy Sherman) offers ways of seeing that are constructed, not through voyeurism, but through intimacy and care. Feminist geographers using GIS methods can experiment and create new visual practices, especially those that can better represent gendered spaces and help construct different spectator positions when compared to conventional GIS methods.

Third, historical studies of the experiences of women travelers hint at the possibility of a more reflexive mode of visualizing geographic data (e.g., Blunt 1994; Morin and Guelke 1998). In her discussion of the experiences of Victorian women explorers, for instance, Domosh (1991) alludes to the possibility of a feminine way of seeing based upon the understanding that women travelers often had different goals, routes, and destinations while traveling in foreign lands than those of men. Further, these women often spoke of the empowerment they felt when they were exploring. Thus, "even the exploitative appropriation of European exploration was not without the possibilities for developing other kinds of connections" (Bondi and Domosh 1992, 211). Based on these accounts, and given that the use of GIS technologies and methods often involves the exploration of cartographic images and high-dimensional graphics in a GIS's cyberspatial environment, it seems that different kinds of interactions between the GIS user and GIS technology are possible. This hints at the contestability of the GIS user-technology relations that can be a basis for creating alternative GIS visual practices for feminist research.

My experience in viewing a three-dimensional image of the World Trade Center site on the Web after the 11 September 2001 attack may help illustrate this point. The image was created from elevation data collected by a plane flying at 5,000 feet above the site using light detection and ranging (LIDAR) technology (Barnes 2001; Chang 2001). The 3-D topographic image shows the remains of the World Trade Center building structures and the craters that drop 30 feet below street-level at the site. Although the text accompanying the image marveled at the technological achievement and usefulness of LIDAR technology in this context (which I fully acknowledge), I was instead overwhelmed by a deep sense of grief that led me to ponder on the meaning of such a tragic incidence for the victims, for those who were affected, and for myself as a feminist geographer and GIS user/researcher. My reaction was a result not only of viewing the image but also of reading numerous chilling stories told by people from their personal experience of the calamity (including media reports, photos and news on the Web, and messages on several electronic discussion lists). These data vividly wove together a tragic story that is evocative of critical reflections and emotions.[6] This suggests that GIS users can interact with GIS-created images in a relatively embodied manner, and that GIS-based visualizations are not necessarily devoid of context or meaning. When complemented by contextual information on the ground and at microscale (e.g., stories about the lived experiences of individuals), GIS visualizations can establish important connections between large-scale phenomena (e.g., urban restructuring or land-cover change) and the everyday lives of individuals (see also Jiang 2001; Pavlovskaya 2002).

Feminist Geographic Research and GIS Methods

As I argued earlier, the purpose of using GIS in feminist geographic research is not to discover universal truth or law-like generalizations about the world, but to understand the gendered experience of individuals across multiple axes of difference. It aims at illuminating those aspects of everyday life that can be meaningfully depicted using GIS methods. As major GIS data models were designed to handle digital spatial data and many of the core functionalities of GIS were developed for analyzing quantitative information, earlier debate on the role of quantitative methods in feminist geographic research is still highly relevant (e.g., Lawson 1995; Mattingly and Falconer-Al-Hindi 1995; McLafferty 1995; Moss 1995; Rocheleau 1995). For instance, GIS methods can be used to reveal "the broad contours of difference and similarity that vary not only with gender but also with race, ethnicity, class, and place" (McLafferty 1995, 438). They can be used to support arguments in political discourse for initiating progressive social and political change, and to indicate research areas that urgently require attention and suggest directions for in-depth qualitative research. GIS methods can also help discover the gender biases in conventional quantitative methods. Further, as GIS is capable of displaying and overlaying many layers of data, it can be used to reveal spatial contexts, depict spatial connections, and hint at the complex social relationships among people and places. The strength of GIS methods lies in helping the user/researcher to identify complex relationships across geographical scales.

That said, GIS methods have many limitations when used in feminist research. For instance, there are no

readily available procedures in current GIS for representing gendered bodies, women's knowledges or desires, or the complex processes involved in the social construction of space (Lefebvre 1991; Massey 1993; G. Rose 1993; Gregory 1994). It is also impossible to avoid the unequal power relations between the researcher and researched when relying only on secondary data (McLafferty 1995). It is important to acknowledge these limitations and their implications when using GIS methods. The malleability of GIS software allows some possibilities for alleviating these limitations. Specific strategies include: (1) complementing secondary data with other contextual information; (2) collecting primary quantitative and/or qualitative data from individual subjects; (3) developing dedicated algorithms instead of using inappropriate but readily available procedures in current GIS; and (4) practicing reflexivity with respect to the knowledge production process and the representational tactics (including the production and use of visual materials such as GIS-created maps and images). Using multiple methods in a particular study would also allow a more nuanced understanding of the research problem than using only GIS data and methods.

It is also crucial for feminist geographers to be attentive to ethical and privacy issues when using GIS methods (Crampton 1995; Curry 1995a, 1995b). This is especially true for studies of human subjects or establishments that are "hidden, secret, or concealed" (e.g., lesbian or gay venues; Brown 2000, 62), since disclosing their identities or locations through GIS mapping may put them at unforeseeable risk. Procedures should therefore be taken to protect the privacy and anonymity of this kind of subject or establishment.[7] Another privacy risk in the use of GIS maps is the possibility of recovering the identities of subjects from map symbols through a process of reverse engineering called *map hacking* (Armstrong and Ruggles 1999). Feminist GIS users may need to be vigilant in recognizing this kind of problem and informed by recent research on methods for hiding subjects' identities.[8]

With these caveats in mind, I describe in what follows some possibilities for using GIS methods in feminist geographic research.[9]

Linking Geographical Context and Women's Everyday Lives

The ability of GIS to incorporate information about the geographical environment across spatial scales renders it a useful tool for feminist research. As geographic data of urban environments at fine spatial scales (e.g., at the parcel or building level) can be assembled and incorporated into a GIS, it is possible to link the trajectories of women's everyday lives (including activities locations and travel routes) with their geographical context at various geographical scales. This would allow a mode of analysis that is more sensitive to scale and context than are conventional methods. Further, when individual-level data are available, GIS methods can be attentive to the diversity and differences among individuals. This mode of analysis contrasts significantly with conventional aggregate analysis and permits an understanding of women's situations "at a level that does not obfuscate their daily lives through maps and language drawn from instrumental, strategic logic" (Aitken 2002, 364).

As McLafferty (2002) suggests, GIS provides a tool for representing and visualizing not only the proximate geographical context of women's lives but also environments beyond the scope of women's daily experiences (see also Jiang 2001). For Hanson (2002), GIS enables description and representation of context at levels of detail and scale flexibility that are difficult to achieve without using GIS. My recent studies indicate that GIS may help reveal complex links among women's experiences at various spatial scales—for example, how gender relations within the household interact with larger, urban-scale accessibility patterns through the mediation of fixity constraint (Kwan 1999a, 1999b). In his analysis of the potential of GIS for scale-sensitive research and local activism, Stuart Aitken (2002) argues that GIS can be used to help interpret women's daily trajectories that link their experiences inside and out of the home (thus connecting the private and public spheres).

Several recent studies suggest the possibility of scale- and context-sensitive GIS-based feminist research. An example is Hanson, Kominiak, and Carlin's (1997) study on the impact of local context on women's labor-market outcome in Worcester, Massachusetts. The study examines whether the proximity to home of a large number of jobs in female-dominated occupations increases the probability that a woman will work in a gender-typed occupation. It computed the number of jobs in female-dominated occupations locally available to each woman using a person-specific spatial interpolation method and a job-search space defined by a realistic estimate of the distance traveled to work for each woman. Using this GIS method, Hanson and colleagues (1997) are able to avoid the problem of using overgeneralized census data while conducting their analysis at the individual level. The study concludes that local employment context is important for part-time workers with a college education and young children at home. It illustrates the fact that significant questions in feminist research can be addressed by developing and using innovative GIS methods that incorporate the geographical context into the analysis.

Supporting Women's Activism through GIS-Based Research

As GIS is increasingly used in the public decision-making process, especially in the context of urban planning, an important area in which it can play a role in feminist research is empowering women's activist groups in local politics. As Hanson (2002) argues, the availability of GIS technology may strengthen activism and challenge traditional power relations and forms of governance. Feminist GIS users/researchers can play a role in supporting women's local activism in several ways. These include: (1) assembling, codifying, and coalescing women's local knowledges and experiences; (2) performing GIS analysis that women's activist groups do not have the skills or resources to undertake; (3) preparing data and analytical results to facilitate the articulation of the course of women's activist groups; and (4) disseminating results to assist the formation of a collective consciousness that enhances the effectiveness of women's activist groups in the political arena.

Few studies have documented the role of feminist GIS-based research in local politics to date. A community-initiated GIS project at Hunter College that aims at understanding the spatial tendency and potential environmental causes of breast cancer in the community of West Islip on Long Island, New York provides one good example (Timander and McLafferty 1998; McLafferty 2002). The project was launched on request by a group of women who were worried about a possible breast-cancer problem in their community after seeing high breast-cancer incidence among themselves. It uses individual data collected by a group of women activists through door-to-door surveys to answer specific questions arising from their fears and concerns—for example, are breast-cancer cases clustered near a hazardous site? For these women, as McLaffery (2002, 265) stresses, "[M]apping and GIS became important tools for acquiring knowledge outside the realm of daily experience and for connecting their personal experience of health and illness to a wider social and political agenda." As arguments and explanations that refer to "broader patterns, conditions, and relationships . . . frequently command greater legitimacy and influence" in local politics (Elwood 2001, 12), GIS-based research has the potential to empower women's activist groups.

Feminist geographers, however, need to be aware of the possibility of a marginalizing effect as the scale of politics shifts up (e.g., from community groups to city or regional planning). As GIS researchers have observed, participatory politics involving the use of GIS technology can disenfranchise certain groups while empowering others (e.g., Elwood and Leitner 1998; Harris and Weiner 1998; Ghose 2001; Aitken 2002). This often happens because groups that have better command of technical and political skills (e.g., government agencies) will tend to have more power and influence in political discourse than those that do not (e.g., inner-city neighborhood groups). In the case of the Long Island project, community-based breast-cancer coalitions succeeded in capturing public attention and gaining federal funding (McLafferty 2002). But as the grassroots-based GIS project evolved into a U.S. $27 million federal initiative, the power of the women activists dwindled, as several powerful groups (e.g., government agencies) were also on the GIS advisory board. Feminist GIS users/researchers need to be aware of this kind of problem. Conceiving strategies that assist activist groups in scaling their participatory GIS up to a higher level of politics will also be an important element in projects that seek to empower women's activist groups through GIS-based research.

Using Qualitative Data to Construct Cartographic Narratives

Although GIS can handle only digital information and has limitations in representing the diverse and complex experiences of women's everyday lives, recent development of digital technologies has greatly expanded the kind of information with which it can deal. In other words, "digital" now includes a much wider array of representational possibilities than merely numerical or quantitative data. Qualitative data such as digital photos, voice clips, and video clips can be linked or incorporated into a GIS. In studies using qualitative methods, subjects' handwriting, hand-drawn maps, and other sketches collected through ethnographic methods can also be incorporated into a GIS. The use of GIS, therefore, does not necessarily preclude the use of contextual qualitative information of subjects or locales. Indeed, a comparison of GIS software with qualitative data-analysis programs, such as NVivo or ATLAS.ti, would find many similarities (although the latter focus mainly on the coding and analysis of textual data). For instance, both types of programs adopt a highly visual approach, provide links to integrate various types of qualitative data (photos and voice clips), support a suite of query tools including Boolean operators (or, and, not), and emphasize exploratory data-analysis.

In ethnographic research, GIS has been used to incorporate qualitative data into geographic databases. For example, in an ongoing, multisite study of low-income and welfare-recipient families and their children, family ethnographic field-notes are linked with neighborhood

field-notes and other contextual data in a GIS (Matthews, Burton, and Detwiler 2001). The integration of GIS and ethnography has allowed researchers of the project to visualize and better understand the complexity of the lives of low-income families and the strategies they adopt in negotiating the welfare system. GIS has also been used in the construction of biographical narratives. An example is the Ligon history project that was initiated to preserve the history, culture, and memory of an inner-city high school (Ligon High) in Raleigh, North Carolina (Alibrandi, Thompson, and Hagevik 2000). Besides documenting the African-American perspective of life during Ligon High School's pre- and civil-rights eras, GIS was used in the project to create a series of historical *life maps* that describe the biography of an alumnus.

In light of the expanded representational capabilities of current GIS, GIS methods can be used in feminist research for composing spatial stories or biographical accounts of women's lives (de Certeau 1984). GIS may also provide a digital environment for the interactive interpretation of ethnographic data or local knowledges in which research subjects are active participants. As this mode of GIS production is more open to the articulation of different voices when compared to current GIS discursive practices, alternative GIS practices can be conceived for enhancing GIS's potential for polyvocality. For example, in a study of community integrated GIS (CiGIS) for land reform in Mpumalanga Province, South Africa, Dan Weiner and Trevor Harris (1999) incorporate views and local knowledges of different groups of subjects—in the form of sketch maps compiled through participatory mental-mapping workshops—into a multimedia GIS (see also Rundstrom 1995 and Ismail 1999 for difficulties in representing knowledges of indigenous peoples).

Mapping Women's Life Paths in Space-Time

As contemporary feminist geography is particularly attentive to the construction of gendered identities and the geographies of the body, the extent to which GIS can represent gendered spaces and bodies is a major concern. Despite recent advances in GIS technology and research, current GIS data models still have serious limitations for representing entities as complex and fluid as gendered spaces and bodies. The most likely possibility is to use vector or object-oriented data models to represent the body as discrete geometric objects (e.g., stationary bodies as points and moving bodies as lines).

This representational schema, however, is problematic in light of the recent work on the geographies of the body (e.g., McDowell and Court 1994; Duncan 1996; Pile 1996; Nast and Pile 1998; Butler and Parr 1999; Valentine 1999; Longhurst 2001). For instance, the lines for representing moving bodies in the Cartesian space of a GIS are clearly delimited and seem to suggest unlimited spatial freedom (G. Rose 1993). The abstract geometry of points and lines cannot reflect many significant aspects of women's experiences (e.g., the fear of violent crime), and they are blind to the power relations that permeate public space and have impacts upon women's lives (Valentine 1989; Pain 1997). The representation of space and the body in current GIS therefore calls into question how GIS methods can be useful for understanding women's everyday lives.

Given these limitations, it is difficult to imagine a GIS production that can do justice to the contribution of feminist theories of corporeality and subject formation (e.g., Butler 1990, 1993; Young 1990; Grosz 1992b, 1994; Bordo 1993; Gregson and Rose 2000). Believing that GIS methods can be a helpful visual device for illuminating certain aspects of women's everyday lives, however, I propose two directions for addressing GIS's limitations in this context. First, the lines representing women's life paths in space-time in a GIS can be reimagined as *body inscriptions*—inscriptions of oppressive power relations on women's everyday spatiality and inscriptions of gendered spatiality in space-time (Laws 1997). As Elizabeth Grosz (1992a, 242) argues, "[B]odies reinscribe and project themselves onto their sociocultural environment so that this environment both produces and reflects the form and interests of the body." The geometry of women's life-paths and the processes of identity formation and women's experiences of places are mutually constitutive. The movement of women's bodies in space-time is also an active element in the production of gendered spaces (Spain 1992; Nead 1997). Through this reimagining, the lines representing women's life paths in space-time are no longer abstract lines in the transparent Cartesian space of GIS. Instead, they are the material expressions of women's corporeality and embodied subjectivities—a mapping of their bodies onto space-time that emanates from their prediscursive practices of everyday life (Pile and Thrift 1995). In this light, I argue that feminist geographers can *appropriate* GIS methods for illuminating women's spatiality, while recognizing the apparent privilege given to the physicality of the body by GIS methods.

Extending the representational capabilities of current GIS comprises another direction for overcoming some of its limitations for representing gendered spaces and bodies. For instance, I have mapped movements of women's bodies in space-time as continuous trajectories using 3D

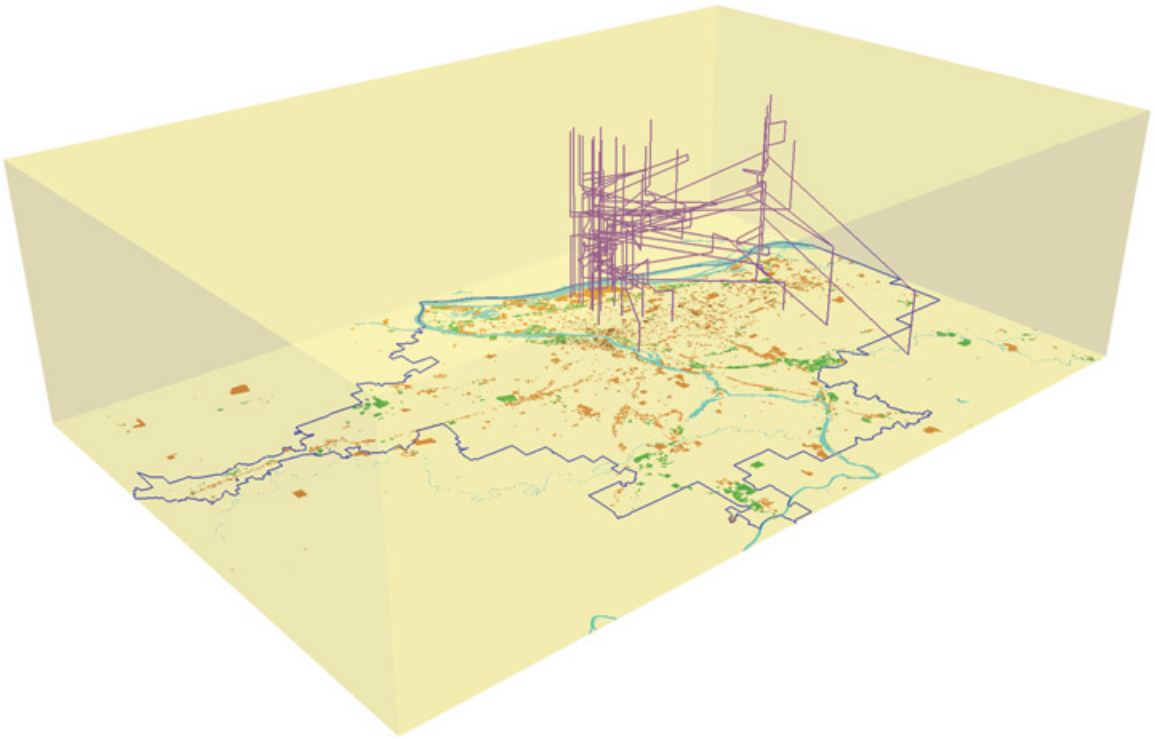

Figure 1. The space-time paths of a sample of African-American women in Portland, Oregon.

GIS in a series of studies (Kwan 1999a, 2000a, 2000b, 2000c; Kwan and Lee forthcoming). The *body maps* I have produced look like Hägerstrand's (1970) space-time aquarium, where women's body movements are portrayed as life paths in a 3D space.[10] Figure 1 shows, as an example, the daily space-time paths of the African-American women in a sample of households in Portland, Oregon (Figure 2 provides a close-up view of downtown Portland). Geovisualizations performed using this method indicate that not only do the homes and workplaces of these women concentrate in a small area of the entire metropolitan region, but their activities locations are much more spatially restricted when compared to those of all other gender/ethnic groups (Kwan 2000c). The *closeted spatiality* of African-American women in the study area suggests that urban space can be racialized in a manner that goes beyond what the socioeconomic processes in the housing and job markets can fully explain.

I have extended this kind of body-mapping in subsequent studies. In a study of human extensibility in space-time (Kwan 2000b), I developed a multiscale representation of a person's extensible body boundary using 3D GIS. In another study (Kwan 2002a), I constructed cartographic narratives with 3D GIS to tell stories about Muslim women's experience of the urban environment after 11 September 2001 using both quantitative and qualitative data collected through in-depth interviews. The study suggests that many representational possibilities of GIS remain unexplored.

Revealing the Gender Biases of Conventional Quantitative Methods

As many quantitative methods in geography are based on the abstract logic of spatial organization and assumptions that ignore the complexities of life situations among different individuals, analytical results can deviate considerably from what people actually experience in their everyday lives. Since GIS can take into account certain complexities of an urban environment (e.g., variations in facility opening hours and the ease of travel in different locales and at different times of the day) and incorporate some behavioral attributes of individuals into dedicated geocomputational algorithms (Weber and Kwan 2002), GIS methods can better approximate real-world behavior and can be used to reveal the gender biases in conventional quantitative methods.

In a project that examines the impact of women's space-time constraint on their employment status and access to urban opportunities in Columbus, Ohio, I argue that conventional accessibility measures are not adequate for studying women's accessibility (Kwan 1998,

Figure 2. A detailed view of an area close to downtown Portland, Oregon.

1999b). Based on locational proximity to a single reference point (e.g., home or the workplace), these measures ignore the sequential unfolding of women's daily lives in space and time and the restrictive effect of fixity constraint on their access to urban opportunities in a particular day. Instead of using conventional measures, I formulate three space-time accessibility measures that take these factors into account. I develop a geocomputational algorithm to implement these measures in a GIS environment. It uses the activity diary data I collected from a sample of individuals in Columbus, Ohio and a geographic database with parcel-level details. The results from using space-time measures reveal considerable spatial variations in women's accessibility patterns, while men's accessibility patterns mainly follow the spatial distribution of the urban opportunities in the study area. The results from using conventional measures, however, do not indicate this kind of gender difference in accessibility patterns. The study concludes that GIS-based space-time measures are more sensitive to women's life-situations when compared to conventional measures, and that conventional accessibility measures suffer from an inherent gender bias and therefore are not suitable for studying women's accessibility.

As these conclusions would not have been possible without using GIS, applying GIS methods in feminist research has potential for revealing the gender biases in conventional concepts and quantitative methods in geography. In other words, GIS methods may allow feminist geographers to expose the discursive limits of certain geographical methods without invoking ontological or epistemological arguments (Derrida 1976; Barnes 1996).

Conclusion

Although GIS and feminist geography may have the potential to enrich each other, they have remained two separate worlds to date (Hanson 2002; McLafferty 2002). Despite their limitations, GIS methods can play a role in addressing certain issues in feminist geographic research. Through revisiting earlier critiques of GIS and hinting at some possibilities for alternative practices, this article calls for a different kind of critical engagement with GIS—one that seeks to re-envision and re-present GIS as a feminist practice, and one that is actively involved in the creation of GIS practices informed by feminist epistemologies and politics. Recent writings of

feminist theorists and methodological debates in feminist geography provide important guidelines in grounding GIS practices in feminist epistemologies and research methodologies. They suggest that feminist GIS users/researchers need to acknowledge and deal with the limitations of GIS methods, the power relations GIS entails, the difficulty of practicing reflexivity, and the ethical or moral implications of the knowledge produced. The question is perhaps less one of the possibility of feminist GIS practices than one of how this potentiality can be realized.

At the level of practice, an urgent need exists to go beyond the conventional understanding of GIS as a largely quantitative practice and to recognize the potential of such realization for disrupting the rigid distinction between quantitative and qualitative methods in geographic research. As I have argued elsewhere (Kwan 2002c), GIS can be a site for deconstructing the dualist understanding of geographical methods (as either quantitative or qualitative) and for enacting *feminist visualization*—the material practice of critical visual methods in feminist geography. Further, as Schuurman (2002) and I (Kwan 2002c) have argued, an important element in feminist critiques of science and vision has been lost in the critical discourse on GIS in the last decade or so. Haraway (1991, 192) not only provides a trenchant critique of modern technoscience and visual technologies, but also emphasizes through her "cyborg manifesto" that feminists can reclaim the vision and power of modern technoscience (GIS technologies included) and participate in "earth-transforming challenges to the views of the masters." Perhaps much would be gained through teasing out the implications of her (1991, 4) question: "Can cyborgs, or binary oppositions, or technological vision hint at ways that the things many feminists have feared most can and must be refigured and put back to work for life and not death?"

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Notes

1. Many perspectives can be identified within critical geographies. These include postcolonial, post-structuralist, feminist, socialist, queer, and other radical perspectives. I focus mainly on feminist geography because it is an important area of my research interests and I can draw upon my experience in writing this article. Some of my arguments (e.g., on reflexivity) in this article are perhaps also relevant to other critical perspectives.
2. A vast literature on the geographies of the body has emerged in the last decade or so. Drawing upon diverse theoretical perspectives (e.g., post-structuralist and psychoanalytic theory), this literature challenges and destabilizes much of our conventional understanding of the relations among the materiality and spatiality of the body and processes of identity and subject formation (see Longhurst 2001, ch. 2 for a helpful introduction).
3. The common concerns identified here are necessarily overgeneralizations, as considerable difference exists among feminist geographies associated with variations in race, sexuality, class, and national context. See, for example, Janice Monk (1994) on different feminist geographies in different countries.
4. Calling or naming can also produce objectified and oppressed subjectivities. See, for instance, Louis Althusser's (1969) notion of interpellation (linguistic objectification). See also the discussions of interpellation by Kaja Silverman (1983), Stephen Melville (1996), and Heidi Nast (1998).
5. This section refers to various kinds of gender differences—the way women represent spaces, construct spectator positions, and experience travel differs from that of men. These gender differences, as reported by feminist scholars, are drawn upon as a point of departure for thinking about the possibility of alternative GIS practices. They by no means imply an essentialist understanding of women's experience, nor do they suggest that the complexities of gendered experience can be captured in terms of the binary categories of women and men.
6. See Kay Anderson and Susan Smith (2001) for the importance of recovering the role of emotions in the production of geographical knowledge. Rosalind Picard (1997) also provides an interesting perspective on the possibility of incorporating emotions in computing.
7. For instance, while Michael Brown (2000) admitted that GIS was a helpful tool in his study on sexualized urban space

(with a focus on the closeted spatiality of gay venues) in downtown Christchurch, New Zealand, he was deeply concerned about the ethical implications. To avoid disclosing the exact location of the gay venues on maps, he used their mean center to represent their spatial tendency instead of using the dot symbol to plot the location of each venue.

8. See, for example, Marc Armstrong, Gerard Rushton, and Dale L. Zimmerman (1998) on geographical masks.
9. Although each example is used to illustrate one purpose for using GIS methods, I do not mean to suggest that it is the only or the most important purpose for the study in question. Further, discussion in the following five subsections focuses largely on women's everyday lives and experiences. This, however, is more a reflection of my own research interests than a presupposition that feminist research or geography deals only with women's experiences (although women's diverse experiences constitute a major concern in feminist geography). For instance, feminist geographers have made significant contributions to the study of gendered construction of nature and space (e.g., G. Rose 1993), masculinities (e.g., Butz and Berg 2002), and capitalism (e.g., Gibson-Graham 1996).
10. Despite Gillian Rose's (1993) critiques on this kind of time-geographic representations, geographers have found them useful in various contexts (e.g., Hanson and Hanson 1993; Gregory 1994; Adams 1995; Miller 1995; Hannah 1997; Laws 1997; Dorling 1998; Rollinson 1998; Kwan 2000c). Such 3D representations also seem to be helpful for illuminating the complex interactions between space and time in women's strategies for coping with their daily fixity constraint (Kwan 1999a).

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