Geographic Information Science: Visualization, visual methods, and the geoweb

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Abstract

This review considers two recent trajectories of research on the geospatial web: efforts to develop appropriate methodologies for working with the new forms of geographic information that are part of it, and studies of its cultural, social, and political significance. In both arenas, visualization and visual methods are central. I show how methodologies drawn from quantitative and qualitative approaches to geovisualization in GIScience offer productive ways of working with geoweb-based information in research, and examine recent efforts to use critical visual methods to study the geoweb as visual practice.

I Introduction

> ... geographic information systems operate in a plurality of visual regimes. (Yusoff, 2005: 381)

> Mashups elude our traditional ways of knowing and seeing. (Wilson, 2009a: 165)

These quotations underscore the centrality of visual ways of knowing to GIScience, and suggest that the geoweb presents new challenges in this arena. Much of the tremendous volume of spatially referenced media being created and shared through the geoweb is strongly visual in nature, including photographs, video clips, maps, and artwork (Goodchild, 2007; Van Oostrom, 2009; Goodchild and Janelle, 2010). Virtual globes and online mapping services, such as those provided by Google Earth or Google's MyMaps platform, provide ready access to high-resolution satellite and air-photo imagery via the internet, as well as street-level and other panorama-style photographic views

(Dodge and Perkins, 2009). As we seek to use these new forms of information in research, and to understand their cultural, social, and political implications, visualization and visual methods are at center stage. Singleton (2010) and Goodchild and Janelle (2010) emphasize scientific information visualization techniques as a way to handle these very large and complex data sets. Jung (2010) argues that qualitative geovisualization practices also hold promise for working with the diverse media that are part of the geoweb. Sparke (2010), Leszczynski (2010), and Elwood (2010) suggest that the geoweb is being used to foster new forms of visual politics, in part because of the repositioned status of maps

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amid other representations of geographic information and also the emergence of 'lay' cartographers.

In these and other discussions of the geoweb, two pressing questions are evident. First, what methods will allow us to work with information from the geoweb as a vast new source of evidence for research, especially user-generated geographic content or 'volunteered geographic information' (VGI; Goodchild, 2007)? Second, what visual forms, practices, and politics emerge from the geoweb, and how and why do they differ from those of more conventional cartographic and GIS-based visual regimes? Research on geovisualization and visual methods in GIScience and human geography has much to offer, and, as I will show below, is already central to geoweb research.

II Visual methodologies for geoweb-based data

Realizing the potential of VGI and other geoweb-based information as a data source of unprecedented size and currency requires developing appropriate methodologies – a challenging proposition given the very large, heterogeneous, shifting, multimedia, and often unstructured nature of these data (Goodchild, 2007; Elwood, 2009; Hudson et al., 2009; Goodchild and Janelle, 2009). We are only beginning to see the emergence of methodologies specifically directed to the geoweb, yet existing work in geovisualization and qualitative visual methods has long grappled with these very challenges. While I focus primarily here on visualization and visual methodologies from within geography, a host of other methods will also prove useful for working with VGI. In particular, the emerging field of 'e-social science' is poised to contribute. E-social science develops internet-based tools and services to help researchers find, access, share, and develop meaningful explanations from newly 'massive' scales and complexities of digital data that are emerging through Web 2.0

(Halfpenny and Procter, 2009; Ackland, 2009). Techniques from information visualization, geovisualization, and spatialization offer ways of reducing the complexity of information in very large databases, to try to discern patterns and relationships, as well as ways to explore and retrieve data when semantics are vague, unstructured, or difficult to pre-define (Fabrikant and Buttenfield, 2001; MacEachren and Kraak, 2001; Skupin and Fabrikant, 2003; Skupin and Borner, 2007).

Recent work in geospatial visual analytics has focused on combining visualization, spatial data mining, and statistical methods to these ends (Andrienko et al., 2009; Mennis and Guo, 2009; Virrantaus et al., 2009). Guo (2007), for instance, uses visualization and statistical techniques to discern mobility patterns from massive highly granular data sets on individuals' daily movements, with a goal of using such data sets to inform public health responses to pandemics. Increasingly, these approaches employ the internet as both a source of information *and* an environment to support interactive exploration of spatial information. Kramis et al. (2009) have developed an internet-based system for interactive geovisualization of large data sets. Purves et al. (2007) are developing ways to incorporate text-based spatial information mined from the internet into more formally structured spatial databases such as gazetteers. They use density surfaces to try to determine the 'fit' of linguistic terms mined from the web. Finally, Bailey and Grossardt (2010) use information visualization to analyze large multivariate data sets from public participation meetings held in urban and regional planning. One of their methods involves creating three-dimensional surfaces that help identify dominant preferences expressed by very large groups of people, in often vague and contradictory terms, an approach that seems highly transferable to working with VGI.

Combined data mining and geovisualization techniques are already being used to work with information from the geoweb. Zook and Graham (2010; see also http://www.floatingsheep.org)

have developed a method that searches the internet for Google Maps placemarks associated with a keyword (such as 'church', 'swine flu', or 'pizza', in some of their recent examples), and then counts and compiles the retrieved instances. These data may then be represented in thematic maps that evidence a range of social, cultural, and political geographies. Hardy (2010) offers another technique for large-scale studies of VGI, specifically efforts to analyze the relationship between locations of contributors and the locations about which they contribute information. He uses IP addresses of Wikipedia contributors and geotags for their contributions or revisions to establish 'geo-signatures' for hundreds of thousands of contributions, and uses Google Earth's virtual globe to support visualization and exploration of the results. Currid and Williams (2010) have applied GIS-based methods for identifying 'hot spots' to large data sets comprised of georeferenced images, a rapidly growing new data source from the geoweb.

In addition to these large-scale quantitative approaches, scholars in the social sciences and digital humanities argue that qualitative geovisualization methods are equally important in our efforts to draw meaning from information on the geoweb (Rumsey, 2009; Jung, 2010). A range of such efforts is already in evidence. Following Elwood and Cope (2009), what defines these approaches as qualitative geovisualization is not absence of numeracy. Rather, it is their integration of multiple modes of representation – visual, textual, numerical – and iterative interpretive analysis of these representations to tease out what they reveal about social and material situations. Most of these qualitative geovisualization methods emerge from qualitative GIS, but could clearly be applied to georeferenced multimedia drawn from the geoweb.

Gregory (2009) uses interpretive visual analysis of geolocated photographs and literary texts as a way to examine multiple meanings associated with specific places by various authors, an approach that could easily be applied to some forms of geoweb-based data. Cidell (2010) shows how geolocated 'content clouds' representing key words in documents (such as newspaper articles) can be used to explore how issues or events are understood or scripted differently in different places. Watts (2010) georeferences small quotes drawn from ethnographic interviews to better understand the spatial and temporal unfolding of an event such as an urban riot, and the different ways in which people may have experienced it. In this same vein, computer-aided qualitative GIS (Jung, 2010; Jung and Elwood, 2010) and geonarrative analysis (Kwan and Ding, 2008) adapt existing geospatial technologies for interpretive analysis of geographic information expressed as narratives, texts, photographs, drawings, videos, or animations. Madden and Ross (2009) are among the first to apply qualitative geovisualization to information gathered from the geoweb. Their study of civil war and internal displacement in Uganda integrates high-resolution satellite imagery from virtual globes, VGI provided by NGO staff working in the area, and qualitative data from Ross's fieldwork, later georeferenced for incorporation in a spatial database.

In sum, two trajectories of geovisualization research can usefully inform development of methods for working with information from the geoweb in research: those that emerge in the traditions of information visualization and spatialization, and those that involve qualitative visualization. These approaches are suited to different forms of research. The first is useful for simplifying large complex databases to understand patterns and aggregate trends, while the second lends itself to interpretive analysis of social and spatial meaning. Together they support use of geoweb-based data in a diverse range of research.

III Studying the geoweb as visual practice

The previously discussed literatures lend themselves to research *with* geoweb-based information. There is also a growing body of research

about the geoweb. Here again, the visual is central, with a great deal of this research focusing upon the cultural, social, and political significance of visual practices emerging through the geoweb. This work is strongly informed by critical cartography and critical GIS research that has challenged accounts of visual representations and epistemologies as inherently objectifying, masculinist, or positivist. These scholars counter that visualization, even 'seeing', has an epistemological hybridity (Kwan, 2002; Kitchin and Dodge, 2007; Elwood and Cope, 2009; Wilson, 2009b). From this perspective, geospatial technologies and representations may be reappropriated for critical visual methods (Aitken and Kwan, 2009), used to activate affective or non-representational dimensions (Kwan, 2007; Aitken and Craine, 2009), and used in art- or performance-based expressions of spatial knowledge and experience (Propen, 2006; Lauriault and Wood, 2009). Studies of the geoweb as visual practice are closely related, examining the role that geovisual representations might play in social and political practices mediated through the geoweb, and considering how and why these politics and practices may differ from those that have grown up around GIS-based geovisualization.

Much of this research studies the geoweb as a basis for activism, outreach, and raising awareness of social and political struggles, and charts its use with a host of new practices, such as 'information intervention' (Parks, 2009), 'crisis mapping' (Liu and Palen, 2010; Meier, 2010), and 'imagery activism (Baker and Williamson, 2006). A number of scholars suggest that the geoweb offers a platform to further human rights activism, noting a number of applications that compile and disseminate crowdsourced information about state-sponsored violence (Crampton, 2009a, 2009b; Okolloh, 2009; Sparke, 2010). Internet-accessible high-resolution satellite imagery and virtual globes have received a great deal of attention, especially Google Earth's 'Global Awareness' layers. Created by NGOs and activist groups, these layers disseminate information

about their activities or concerns at various locations in the world. Users can zoom to sites within a layer, and typically open windows with additional text, photographs, and hyperlinks to further information. While the 'Crisis in Darfur' layer has received the most attention to date, Global Awareness layers have been developed by the Appalachian Mountaintop Removal project, the World Wide Fund for Nature (WWF), UNICEF, the Global Heritage Fund, and many others. Lin (2010), studying the nature and variability of geoweb cyberactivism, offers a notable move beyond Google's suite of applications in discussing the different visual politics that are advanced through VGI posted to interactive mapping websites by human rights activists working within China in contrast to those originating from outside China.

Conclusions about these geoweb-based awareness and activism initiatives vary widely. More positive readings, such as Okolloh (2009), suggest that the ability to share 'crowd-sourced' geographic information over the internet to many and distant actors, as well as the ability to combine overhead large-area views with more immediate 'on the ground' views in virtual globes provides a potent new toolkit to mobilize potential advocates. Other accounts are more mixed. Madden and Ross (2009) show that high-resolution images drawn from virtual globes can be used to support legal claims of genocide in the international court system by evidencing the systematic nature of persecution. They note, however, that this imagery cannot show the *intent* of the perpetrators, another required dimension of successful claims in this legal context. They argue, as does Parks (2009), that while virtual globe and other high-resolution imagery have a potential role in efforts to resolve or seek reparations from political violence, it is a role with distinct limits. More critical perspectives on these practices note that awareness cannot be assumed to generate mobilization or action, and warn that these multi-media visualizations reproduce problematic

geographical imaginaries and promote a sort of voyeurism (Parks, 2009; Kingsbury and Jones, 2009).

Within these efforts to understand the role and impacts of geoweb-based visualizations in activism, outreach, and any number of other social and political practices, a key challenge will be explaining how and why particular practices emerge. Why, for example, might multimedia mappings of user-contributed crisis information promote awareness or mobilize advocacy (if indeed they do so), and under what conditions? One answer might lie in the forms of sociality that may be fostered through the internet. Bosco's (2007) work with an Argentine human rights and remembrance group suggests that the internet offers a virtual space in which reciprocal emotional bonds may be created, thus facilitating the emotional labor that Bosco argues is central to mobilizing and sustaining geographically distant communities. While his argument is developed from personal narratives shared over the internet, we can easily imagine how the geoweb might lend itself to similar dynamics, perhaps in new ways because of the multimedia representations that may be drawn together.

In studying visual practices emerging around the geoweb, Kingsbury and Jones (2009) urge us not to focus solely upon its use for activism, resistance, or the most immediately obvious forms of politics. They note that the geoweb is also implicated in new forms of play, performance, parody, and paranoia, especially in the many ways in which people use virtual globe imagery. Many make games of searching geoweb imagery for nude sunbathers, purportedly hidden military sites, or hay bales arranged in farm fields to form obscenities. This imagery, Kingsbury and Jones remind us, is also being widely used in the visual arts, and further, can itself be a sort of absurdist visual art – as in their example of appended satellite images in one platform that show half of a river flowing freely in summer, while its other half remains frozen in winter. Crampton (2009a, 2009b) discusses numerous examples of geospatial technologies and representations used in the arts, as do Caquard et al. (2009).

Within these discussions of the significance and impacts of the geoweb's visual practices, several scholars argue that the geoweb is implicated in a cultural repositioning of visual epistemologies. Perkins and Dodge (2009) and Kingsbury and Jones (2009) argue that the accessibility and potential mutability of satellite imagery available through the geoweb dramatically alter the visual epistemologies associated with such imagery. In this context where images from different times and sources may be seamlessly appended or radically modified, 'seeing' is no longer 'knowing'. This represents a break from assumptions of rational scientific objectivity formerly associated with satellite imagery and other geovisual representations. To explain this shift, Perkins and Dodge (2009) argue that virtual globe imagery signals its representational authority by way of being 'close' and photorealistic, whereas maps do so by invoking the disciplinary authority of cartography in their design and symbolization. Perhaps evidencing the presence of these new visual epistemologies, Parks (2009) shows that since the release of Google Earth and other virtual globes, the news media no longer use satellite imagery as a directly examined artifact or form of documentation, but rather as a gateway that is quickly bypassed en route to other visual and textual representations. While presumptions that high-resolution earth imagery is objective and represents the 'real' are *disrupted* by visual practices and artifacts of the geoweb, they are not completely displaced. Baker and Williamson (2006) and Parks (2009) clearly show that such visual representations are still afforded this authority in many contexts.

These early studies of the geoweb as visual practice rely on multiple sources and types of evidence and employ diverse modes of analysis, yet nearly all show some engagement with critical visual methods (Rose, 2007). Parks (2009)

uses discourse analysis of images associated with map objects in the Google/United States Holocaust Memorial Museum's Crisis in Darfur layer, while Perkins and Dodge (2009) and Kingsbury and Jones (2009) integrate multiple modes of analysis and sources of evidence, carrying out discourse and content analysis of user-generated online maps, virtual globe imagery, and blog texts related to these maps and images. Dodge and Perkins (2009) make a broader call for use of critical visual methods in cultural studies of virtual globe imagery, to consider how image framing, modes of assembling imagery, and interfaces for exploring and experiencing visual artifacts make it possible to perceive some sites and meanings, while rendering others invisible or obscured. In recent years, geographers have called for more robust engagements with visual methods in the discipline (Crang, 2003, 2005; Rose, 2003, 2007), and efforts to deploy critical visual methods in geoweb research contribute to these ongoing efforts to widen qualitative methods beyond its long-standing emphasis on text.

IV Conclusion

Geoweb research should continue to rely on a diverse range of visualization practices and visual methods. 'The visual' is central both to the geoweb itself *and* to our efforts to use these new forms of information in research. As we move forward, I emphasize two points. First, most early research on the geoweb has focused upon Google Earth and Google Maps based applications as its objects of inquiry. Expanding our focus beyond virtual globes and beyond Google's social, political, and corporate practices stands to open the door to a fuller accounting of the geoweb. Second, we need to retain and thoughtfully engage with the multiple meanings of visualization that are part of geography, where 'visualization' may refer to practices originating from scientific information visualization, qualitative methods, or the visual arts

(Burns, 2009). In the best instances, dialogue among scholars in human geography and GIScience around concepts that are afforded multiple meanings in these fields have moved us to stronger and more nuanced theorizing, as is evident in debates over 'ontology' (Crampton, 2009c; Leszczynski, 2009) and 'representation' (Sparke, 2010).

So must it be with 'visualization'. There are signs already of this productive multiplicity. Skupin and Borner (2007), writing on geospatial visual analytics, draw a link with art, noting a shared reliance on visual representation to draw out particular aspects of meaning and experience. Aitken and Craine (2006) chart a shared territory between semiotics in film studies and cognitive and behavioral approaches to geovisualization. The geoweb has emerged in parallel with exciting new work on visualization, visual ontologies, and visual epistemologies in the sciences, social sciences, and arts and humanities. In our efforts to understand what is at stake in the geoweb, for geography and for society more broadly, we must continue utilizing these new conceptual resources in creative and integrative ways.

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