COMMENTARY: GISCIENCE TEN YEARS AFTER *GROUND TRUTH*

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Several publications were responsible for the shock-waves that ran through the GIScience community in the early 1990s, including the exchanges between Openshaw, Taylor, and Overton (Openshaw, 1991, 1992; Taylor and Overton, 1991), Jordan's comment that GIS was "easily justified but non-intellectual expertise" (Jordan, 1988), and Smith's essay on the military roots of GIS (Smith, 1992), but none brought them all together better than the book assembled and edited by Pickles (1995). Like many others, my initial inclination was to respond to the critiques by defending and counter-attacking, and at Luc Anselin's urging I made an early effort to reply to Taylor's critique (Goodchild, 1991; Taylor, 1990). But an invitation from Pickles to write a chapter for his book (Goodchild, 1995) was the first indication, to me at least, that a constructive dialog was more likely to help the cause of GIScience, and that the critiques were going to have a lasting impact – GIScience would never again be quite the comfortable retreat for the technically minded that it had been in the past.

Ground Truth had many dimensions, and many more have been added through the publications, conferences, and presentations in the years since it appeared. The four papers in this collection address four of them, but there are many more, and I would like in this commentary both to offer my own thoughts on the four papers, and also to address other issues that stem from the early critiques and continue to demand the attention of GIScience. I would also like to comment on the need for new studies of the impacts of emerging technologies, particularly Google Earth and RFID (Radio Frequency Identification).

The Four Papers

Of the four, the paper by Sarah Elwood most clearly demonstrates to me the impact of *Ground Truth*. GIS has always been a tool for planning, of course, and the early influence of McHarg (1969) and members of the Harvard Graduate School of Design demonstrate that much of the early motivation for GIS stemmed from its potential as a tool for design. But the chapters of *Ground Truth* pointed to many weaknesses in the ways GIS was being used, particularly to the ways in which it further privileged those in power, who had easy access to it, and marginalized others. The field of Participatory GIS has emerged out of this critique, and in many ways owes its existence and its marching orders to the book. As the paper makes clear, it has its own clearly defined and evolving research agenda that is sharply distinct from the mainstream of GIScience – and yet is now accepted as an important part of that mainstream.

The paper by Nadine Schuurman and Agnieszka Leszczynski also reflects the critique, arguing as it does that metadata, that essential component of any search and discovery process, are far more than the mere documentation of technical characteristics. While the dominant standard (the Content Standard for Digital Geospatial Metadata of the Federal Geographic Data Committee, http://www.fgdc.gov/standards/projects/FGDC-standards-projects/metadata/base-metadata/v2_0698.pdf) and its derivatives may reflect

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the production processes of the federal agencies responsible for the acquisition and compilation of some forms of geographic information, the average researcher, and increasingly the average citizen, clearly needs to know far more about the context, lineage, and meaning of data. Moreover the standard is now being used to describe not only the more traditional, cartographically oriented forms of geographic information, but dynamic data sets that record movement, transactions, and flows. Standards have the effect of codifying and constraining, whereas geographic information is evolving rapidly, demanding a much more flexible approach to metadata that reflects changing needs and expanding context. Metadata necessarily expand as the size of the potential community of users expands, and as the understanding of meaning becomes more problematic. While we have traditionally thought of metadata as comparatively sparse and succinct, I recently heard of a major database project within DARPA (the Defense Advanced Projects Research Agency) that envisions a ratio of metadata to data of 1.5:1 – 1.5 terabytes of description, lineage, and context for every 1.0 terabyte of data.

While these two papers can trace their motivations directly to issues raised in *Ground Truth*, the remaining two reflect not so much specific problems as a fundamental paradigmatic shift that the book was at least in part responsible for instigating. The social critique of GIS emphasized that GIScience has three components rather than one – besides the obvious technological component, GIS is a collaboration between the human mind and the machine, in the context of society. The concern with "expert systems" that can be found in the GIScience literature of the late 1980s and early 1990s, and in the published research agenda of the NCGIA (National Center for Geographic Information and Analysis; Abler, 1987), suggests a belief in the fundamental superiority of the

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computer as more objective, more powerful, and more precise than the weak and fallible human mind. Today this position would be untenable, and instead we tend to see computing as a way of augmenting rather than replacing human abilities. Humans have had thousands of years to evolve their cognitive and communication skills; by comparison computers are crude machines, good at some simple tasks but hopeless at others.

Problems of cognition and communication lie behind the paper by Mark Gahegan and William Pike, which is perhaps the most technical of the four, but in which the authors are at pains to tie their approach to *Ground Truth*. Digital technology, and particularly database technology, comes to us from the computing mainstream and from a tradition that is dominated by the need to handle large numbers of similarly structured records. Indeed the first assumption of the object-oriented paradigm, that now dominates database design, is that all things are instances of classes. While this may be a reasonable assumption when dealing with credit-card transactions, property records, or cows in a dairy herd, it is surely in conflict with the very early stages of knowledge acquisition and with processes of scientific discovery, when it may not be possible to assemble information into a rectangular table in which the rows denote well-defined and essentially similar cases, and the columns denote types of knowledge about each case. The danger of course is that a user armed with a GIS will see the world through a lens defined by the constraints and principles of database design, as supplied by the computing mainstream. Instead, the authors argue strongly for a more fundamental approach that begins by asking about the nature of geographic knowledge.

GIScience can be seen as an offshoot of information science, and indeed some GIScientists now occupy positions in departments and schools of information science. One of the arguments for GIScience has been that it represents a particularly well-defined area of information science, and that as a result it may be possible to make more substantial progress than in the larger discipline, and perhaps eventually to generalize the results of GIScience to the larger context. But this argument masks another that has surfaced from time to time since *Ground Truth*: to what extent are the questions being raised within the social critique, and within fields such as Participatory GIS, questions that are also being asked within the larger context of information science? Are we in danger of ignoring the larger context, creating unnecessary duplication, and perhaps rediscovering what is already known? An early text by Obermeyer and Pinto (1994) was at pains to place a discussion of the social issues of GIS within the broader context of social science theory, and Melissa Gilbert and Michelle Masucci follow a similar path in their paper, asking what we can learn about GIS from the broader context of ICT, and what GIScience can in turn contribute to the broader context.

Other Themes

Several themes have emerged from *Ground Truth* and the paradigmatic shift that it prompted, but are not addressed specifically in the four papers, so in this section I would like to review a selection of the ones that seem to me most important. First, none explicitly mentions the apparent denial of the military roots of GIS that Smith (1992) finds so evident in his earlier essay. Yet if anything the military connections of GIS have become stronger since his paper was published. Today, the U.S. National Geospatial-Intelligence Agency, formerly the National Imagery and Mapping Agency and primarily responsible for mapping foreign countries in support of military and intelligence operations, is rapidly becoming a force in domestic mapping as well, yet without the essential openness of the U.S. Geological Survey, which has traditionally played the role of national mapping agency. Google Earth, of which more later, has its roots in work for the military, and civilian software and data are now increasingly utilized for military and intelligence operations.

The surveillance theme which is so evident in several of the chapters of *Ground Truth* is not mentioned, yet again it seems increasingly important, particularly in the aftermath of the events of September 11, 2001. We surrender locational privacy whenever we use a credit card, ATM card, or store convenience card, whenever we cross the U.S. border, whenever we drive through an automatic toll barrier, whenever we book an airline ticket, or whenever we turn on our cellphones. These concessions are often made in the interests of convenience. Moreover our own security is arguably strengthened in some circumstances, such as when we call 911 from a cellphone, or when a credit-card company uses locational patterns of purchases in space and time to detect misuse. A friend recently had the unfortunate experience of having his account in a bank in Berlin drained by thieves after he used his ATM card in a machine in Dublin airport that had been tampered with, and would have been very pleased if the Berlin bank and the one that houses his U.S. account had been able to compare notes on the locations and times of his apparent withdrawals.

As I argued earlier, questions of representation remain high on the agenda in this new post-*Ground Truth* GIScience. We continue to work almost exclusively in Cartesian space, and to argue that positional accuracy within an absolute Earth frame is an essential characteristic of GIS. Yet absolute location is almost irrelevant to many social processes, which depend only on relative location and are invariant under displacement, rotation, and in some cases even scale change. Spatial statisticians often reduce space to a matrix **W** that records only the distances between places, or some functional transformation of them, and sociologists often replace space with social networks that may or may not have any relationship to the GIScience concepts of distance and topology. Much was written in the early 1990s about the potential of new kinds of GIS that would represent space in ways that were more appropriate to indigenous peoples, such as the linear spaces of Chatwin's Australian songlines (Chatwin, 1987) or concepts of land occupancy among the Inuit, and about GIS designs that would "think as humans do" and reflect the realities of *naïve geography* (Egenhofer and Mark, 1995). But very little has come of these ideas, and to date it seems that when GIS is adopted by indigenous peoples it is very much like the Cartesian GIS we know so well.

Another thread has emerged in efforts to support the process of search and discovery, in such projects as the Alexandria Digital Library (http://www.alexandria.ucsb.edu) and the various geo-portals that have been constructed around the world (Maguire and Longley, 1995). Search within a computational system is often designed as a Boolean process – one formulates a request, and then receives a list of "hits" that satisfy the request, perhaps ranked using some appropriate criterion of goodness of fit, as Google does. But this is very different from the processes used by humans to search and discover, such as the browse process that we employ in libraries. Human discourse is vague, adaptive, and extended – we negotiate in multiple stages rather than presenting our needs and receiving our results. Computers replace the extended and often confused process by which we learn the meanings of terms and languages with precise, instantaneous translators. In the broader community, however, a number of ideas are emerging under the rubrics of *folksonomy* and *emergent semantics* that may well offer interesting potential for interoperability problems in GIScience.

New Technologies

Finally, I would like to comment briefly on the issues raised by new technologies, and particularly Google Earth and RFID. Google Earth is an evolution of an earlier technology marketed as Earthviewer, and has had enormous impact since it appeared in early 2005. Its impact on GIS has been aptly described in a lead article in *Nature* (16 February 2006) – it has brought the ideas of GIS to a whole new generation of enthusiasts who have been empowered to build their own applications. Moreover, it raises a series of interesting questions of a social nature. What, for example, determines the variability in Google Earth coverage, from high resolution in some areas to much lower resolution in others – whose agenda is being served here? What features are visible in Google Earth coverage, and what does it make invisible (abundant reports of curious Google Earth sightings can be found on the Web, see for example http://www.theregister.co.uk/2006/01/23/flying_car/)? Who does it empower, and who does it marginalize? What applications are being built on Google Earth, and by whom and for what purposes?

RFID is a new technology that may eventually replace the familiar bar-code on products, packages, and even farm animals. An RFID tag does not require an explicit physical action to be read, and can therefore be concealed. Major retailers are now requiring that suppliers tag their goods, and stories have appeared in the media about schools that have experimented with tagging their pupils (http://www.wired.com/news/privacy/0,1848,66554,00.html), and night-clubs and theme parks that have tagged their customers (http://www.rfidbuzz.com/news/2004/chip_the_vip.html; http://www.rfidbuzz.com/news/2004/finding_kids_with_rfid_at_legoland.html). RFID causes concern for several reasons. A person may not be aware that he or she has been tagged, and may not be aware that the tag has been read, or by whom.

Yet at the same time RFID opens a vision of a world in which increasing numbers of objects are visible in a virtual sense, and capable of providing information about themselves. Sensor networks that can monitor various aspects of the environment are a subject of current research (http://www.cens.ucla.edu/) and offer enormous potential for monitoring (see, for example, the Firebugs project at the University of California, Berkeley, which is exploring the monitoring of wildfire, http://firebug.sourceforge.net/). A *spatial* or *geospatial web* (http://www.onpointradio.org/shows/2006/01/20060103_b_main.asp) can be defined as a future network with the following characteristics:

- A large number of sensors reporting their locations and additional information about local conditions;
- A server that compiles information from sensors and distributes it via the Internet;
- A population of users who are able to integrate data from numerous servers.

In another version the sensors are people who report various aspects of their environment to the central server. The term *citizen science* has often been used to describe this kind of collaborative data-gathering, and can be applied to activities as diverse as the Christmas Bird Count, the GLOBE project (http://www.globe.gov), and the updating processes that are now used by some vendors of geographic information.

Conclusion

The four papers present an interesting cross-section of current research in the post-*Ground Truth* era. Many other aspects of current geographic information technologies also have real and potential impacts on society, and demand substantive research agendas. Moreover, I think it is at least as important for GIScience to reflect and comment on future technologies, and to anticipate their impacts. Much of the initial critique of GIS centered on its use for science – for knowledge creation – and particularly for knowledge creation in the discipline of geography. Yet the impacts of these technologies extend far beyond the realms of academe, and their reach into everyday life is increasing steadily. Millions use GIS functions every day to find hotels, obtain driving directions, or examine prospective home purchases. While academic geographers are by and large sensitized to issues of social context, the same cannot be said of researchers in other disciplines, workers in planning offices, or the general public. Most courses in GIS offered by academic institutions now include some attention to the issues raised by *Ground Truth*, but Google Earth has made GIS accessible and useable by people with no academic background in GIS, cartography, or geography. The time has come to make the basic principles of GIScience accessible to a much larger community, through such mechanisms as general-education courses for undergraduates, online resources such as Wikipedia, general-interest books, and courses in secondary and even primary school.

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