Cartography as an Academic Field: A Lost Opportunity or a New Beginning?

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Abstract:  
This short essay considers the fact that maps are everywhere today, but cartography as an academic field is typically not viewed as central to leveraging dramatic increases in locational information. A contention is made that cartographers can and should be thought leaders in all things locational and the role of cartography in advancing the new field of visual analytics is presented as one opportunity for cartography to make an impact.

Keywords:  
geovisual analytics, HCI, location-based services, analytical reasoning

Introduction:  
Cartography, as an academic field (and as a profession) should be at the center of the dramatic increase of place in every facet of our lives—but it is not. What happened? One answer is that the discipline is too small to meet all the needs. But, that answer bypasses the dramatic advances in GISystems over the years and the fact that the Esri User Conference attracts more than 15,000 participants while the ICA Conference in Paris (2011) attracted approximately 1,300. Since the advent of GISystems in the 1960s, developments in cartography have proceeded largely in parallel to those in GISystems, but on a smaller scale. Cartographers who have engaged with GISystems and related technologies have often focused more on critique of the bad maps in GISystems than on taking a lead in integrating maps into place-based geoinformation technology and its applications.

Cartography has a set of new opportunities to take a leadership role related to all aspects of locational information. Maps and location-based services are everywhere today. Our phones, cameras, and tablets are GPS-enabled, personal financial transactions (from ATM withdrawals to buying a coffee at Starbucks) are geo-located, social media users can tie their posts to location, and place references are routinely extracted from unstructured text. Maps have become a ubiquitous component of many technologies that support a wide range of activities from advancing science, through responding to emergencies, to location-based coordination with friends on a Saturday night. And, in spite of the order of magnitude difference in professional meeting size cited above, it is maps rather than GIS that capture attention. In the Google Trends search below (run in April, 2013), queries for “maps” make those for “GIS” seem invisible and even swamp those for “basketball”, which peaks every March during the College tournament in the U.S., and “soccer”, which only surpassed “maps during the 2006 world cup (Figure 1).
In addition to the general public interest in maps, I have encountered appreciation for cartographic research advances from at least a subset of researchers in other “visualization” disciplines. One example is a keynote by Pat Hanrahan (the CANON Professor of Computer Science and Electrical Engineering at Stanford University) at ACM SIGSPATIAL in 2009 on “Cartography and Information Presentation: A Graphics/Visualization Perspective”. In his abstract, he says “The first part of the presentation describes how cartographic thinking has informed information visualization. Information visualization research has benefited enormously from the work of great cartographers including Jacques Bertin and Eduard Imhof.”

While our historical cartographic roots remain important, as do well-designed maps as the end products of a professional cartographer’s skill, we should not live in the past or restrict our focus only to the map as an end product. An orders of magnitude bigger opportunity exists for academic and professional cartographers to be creators of dynamic and flexible map-based analytical tools that leverage the increasingly massive and heterogeneous sources of geographic information being generated today. Similar opportunities exist to be authors of dynamic map applications that enable users to create their own custom (and well-designed) maps. Additional opportunities exist for cartographers who carry out empirical research focused on understanding cognitive issues that underpin use of interactive map-based applications and those who apply usability engineering approaches to insure that the applications (and maps within them) meet user needs and engage those users.

The start to this essay may have seemed pessimistic. But, I am actually quite optimistic about the future of cartographic research and practice … if we are collectively proactive in re-creating the role of cartographers as thought leaders in strategies to represent the world and enable understanding of its dynamic human and environmental processes.

A challenge for cartography:
Dramatic increases in location information and in devices to collect and deliver that information are creating a wide range of opportunities and challenges for cartographic research and practice. With the remainder of this short essay, I will highlight just one developing research domain that needs more cartographic expertise, Visual Analytics.
Visual Analytics has been defined as “the science of analytical reasoning facilitated by interactive visual interfaces” (Thomas and Cook, 2005, p. 4). Geovisual analytics focuses on visual interfaces to analytical/computational methods that support reasoning with/about geo-information – to enable insights about something for which place matters. Maps are typically central to geovisual analytics, but the emphasis is not on maps as representation but on maps as interface. Specifically, within geovisual analytics, the map is primarily an external cognitive artifact that connects human reasoning with computational methods to expand the scale and complexity of information sources that can be utilized and that, ideally, provides a framework to support reasoning about place and spatial relationships among places.

One example of a geovisual analytics application, from research underway in the GeoVISTA Center at Penn State, is the SensePlace 2 web application targeted at support of situational awareness for crisis management. In this application, the map provides an interface to computational tools that process Twitter data collected as potentially relevant to a range of crisis/emergency situations. Figure 2 below depicts one view of an analysis sequence in which a query for “explosion West” was posed the day after the explosion of a fertilizer plant in the town of West, Texas in the U.S. In SensePlace 2, the map provides a gridded overview of the frequency of tweets
in our repository (with cell darkness depicting the number of tweets that mention any place in the cell). We collect approximately 4 million tweets per day and automatically extract place, person, and organization entities, disambiguate and geocode the places, and store the results in an index using Apache Solr (http://lucene.apache.org/solr/) with additional spatial data stored in a PostGIS database (http://postgis.net/). More details can be found in papers that describe the goals and design of the system (MacEachren et al., 2011a; MacEachren et al., 2011b). My intent here is not to explain the system in detail but to point to the cartographic research challenges that remain to be addressed. Two key challenges fundamental to meeting the goals for geo-visual analytics (not the only challenges, but important ones) are to develop methods and tools: (1) that support an analytical reasoning process through interactive map-based interfaces and (2) that provide an interface to computational methods that can cope with massive data. Each poses cartographic research challenges. SensePlace 2 can be considered to be a geovisual analytics application in its goals to support kinds of reasoning undertaken to build crisis situational awareness and its use of a visual interface to computational/analytical methods. But, the implementation of SensePlace 2, as a prototype application, has raised more questions about the two challenges than it has answered, particularly from a cartographic perspective. Below, I offer a few ideas about what cartography and cartographers can offer to the broader visual analytics community related to these challenges.

**Analytical Reasoning:**

Cartography has a long history of perceptual research focused on how map symbolization is seen and interpreted as well as a growing body of research focused on higher-level cognitive aspects of map understanding. Cartography is well placed, therefore, to take a lead in research directed to analytical reasoning facilitated by interactive visual interfaces. However, our past work only provides a starting point because little attention has been given to the role of maps or other visual displays as vehicles to support reasoning. Many unanswered questions exist about the role of maps as external cognition devices to enable reasoning about spatial phenomena and related processes and about the map symbolization and design factors that make the most difference for effective reasoning.

Beyond work in cartography, there has been a large body of research in qualitative spatial reasoning carried out in GIScience (e.g., Freksa, 1991; Wallgrün, 2010) that, if integrated with cartographic perspectives on how maps are understood could produce the basis for a solid conceptual approach to interactive visual interfaces that enable analytical reasoning focused on space and place. Reasoning is often an extended process; thus map-based interfaces to support reasoning must go beyond representation of information to also include knowledge-representation and management support (e.g., Gahegan and Pike, 2006) that is integrated with the map and other views.

Supporting a process of map-based reasoning requires attention to map interaction and how that interaction connects to both data and stored knowledge. While interactive maps have been common for more than two decades, we have only just begun to scratch the surface on formalizing the understanding of interaction needed to develop interaction design guidelines. The broader challenge of developing a comprehensive science of interaction for visual analytics generally was outlined by Pike, et al (Pike et al., 2009), but progress within visual analytics toward the goals outlined has been slow. Within cartography, recent research by Roth (2012, in press) has synthesized perspectives from multiple disciplines to consider three components to interaction: its objectives (what the user is attempting to do), its operands (the “things” that interaction is applied to), and its operators (the kinds of interaction applied). But, although some progress has been made, we do not yet have a solid conceptual framework for understanding map interaction as a factor in support of analytical reasoning nor do we have design guidelines for interactive interfaces that are effective in this support.
Map-based interfaces to computational methods:
For more than a decade, attention has been given to the role of map-based geovisualization tools as an interface to computational methods that can scale analysis to very large data volumes (Andrienko et al., 2001; MacEachren et al., 1999). While map-based interfaces are now commonly integrated into systems that apply computational methods, there has been limited research on the maps themselves in such systems. It seems likely that map design matters as much when maps act as an interface to computational methods as when their primary role is simply to represent data. But, it also seems likely that what we know about maps to represent is only partially relevant when the focus is on maps as interfaces.

We need to develop an understanding of how to design maps that support “human-in-the-loop” work with data mining, simulation, and other computational methods. Endert, et al (2012) provides a recent (non-geographic) visual analytics example of the potential of interactive visual interfaces to computational methods. Specifically, they implement and assess strategies for semantic, user driven interaction with a computational text clustering algorithm that adjusts the cluster parameters based on user interaction. Other authors who focus on explicitly geographic computation have demonstrated success at implementing steerable models (e.g., Nino-Ruiz et al., 2012). But, while both lines of research demonstrate that user input to computational methods can enhance to power of the computational methods, limited attention has been given to design of the interactive interfaces to support these tools. As with support for analytical reasoning, a science of map-based interaction is essential in order to develop strategies for designing effective interactive interfaces to computational methods. We need guidelines for design of map interaction that are comparable to those for design of the look of maps and we need to determine how the appearance of maps needs to dynamically adapt to support iterative work with computational methods.

Final thoughts:
It is an honor to have been invited to contribute to this milestone in the history of The Cartographic Journal. I read my first Cartographic Journal paper during my beginning graduate school days in 1974. I started receiving The Cartographic Journal in the mid-1970s and purchased all back issues along the way. While I cannot claim to have read all published papers over the years, I have read, cited, and prompted students to read many Cartographic Journal papers and have been pleased to contribute several myself. The invitation to do this essay is special since I believe that this Anniversary issue signals a renaissance for academic cartography. I look forward to the next decades of The Cartographic Journal, and to its reflection of advances in our field.

I will end with a call for those doing cartographic research to look outward as well as inward. It remains important, of course, to continue publishing research results in The Cartographic Journal (and in other cartographic journals). The advent of digital access to our journals means that work in these outlets is more likely to be seen by non-cartographers than ever before. But, to have an impact proportional to today’s importance of maps and to grow as a discipline, we need to reach out to GIScience more broadly and to associated fields. We should publish not only in cartography outlets, but in outlets associated with visualization, human factors, human-computer interaction, and those in all fields for which maps are important. So, I encourage research cartographers to be proactive in bringing our perspectives to the attention of a wider audience while we continue to raise the profile of The Cartographic Journal.

Biographical Notes:
Alan M. MacEachren is Professor of Geography, Affiliate Professor of Information Sciences & Technology, and Director of the GeoVISTA Center (http://www.GeoVISTA.psu.edu) at the Pennsylvania State University. He is PI for the Penn State component of the US Department of Homeland Security VACCINE Center of Excellence.
MacEachren’s research foci include: geovisual analytics, geovisualisation, geocollaboration, spatial cognition, human-centred systems and user-centred design. He is author of How Maps Work: Representation, Visualization and Design, Guilford Press, 1995 and Some Truth with Maps, AAG, 1994; and co-editor of additional books (including Exploring Geovisualization, Elsevier, 2005) as well as of eight journal special issues (including the Journal of Visual Languages and Computing on ‘Challenging Problems of Geospatial Visual Analytics ’, 2011). He was chair of the International Cartographic Association (ICA) Commission on Visualization (1999–2005) and is an ICA fellow. He was a member of the US NRC, Rediscovering Geography Committee (1993–1997), on the NRC Computer Science and Telecommunications Board Committee on the Intersections between Geospatial Information and Information Technology (2001–2002) and was a member of the National Visualization and Analytics Center R&D Agenda panel (2004–2005). He was Associate Editor of IEEE TVCG (2007–2011) and is an Associate Editor of Information Visualization (2001–present).

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