Exploring the geographic information universe:
The role of search technologies

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Abstract. The convergence of Earth-observing media, web technologies, and cheap, portable devices has resulted in an explosion of geographic information. Although powerful, the "geographic information universe" metaphor obfuscates the deeply social and political nature of the socio-technical systems in which the flood of geographic information is produced and consumed. Unlike the physical universe that exists beyond human purposes, the geographic information universe has identifiable access points that define its boundaries and shape its inner structure: search technologies provide the main interface between data flows and users, enabling them to rapidly extract useful fragments of information. This article argues for an inter-disciplinary effort to understand search technologies and their implications for the geographic information universe, both for its inhabitants and its observers.

Keywords: geographic information universe, search, search engines, information seeking, geographic information science

1   Introduction

"The idealized metaphor for the search engine may be a telescope, allowing us to pick out one star from millions and examine it in more detail. Such an optical metaphor suggests a certain degree of transparency; the search engine does not favor one page over another in this view, but simply selects the few pages among millions that most nearly meet a user's needs. Of course, this is not how search engines work." A. Halavais, *Search Engine Society* [6, p. 85]

The nature and structure of the geographic information universe is hard to grasp for several reasons. Rather than a coherent set of datasets, devices, and networks, this universe appears as highly dynamic, fragmented, heterogeneous, and open to frequent disruption and restructuring. New data acquisition techniques, data formats, hand-held devices, and high-resolution sensors are constantly replacing old ones, in a process of creative destruction. As the volume, variety, and velocity of geographic information grows, search technologies have become an unobtrusive and yet central component of the geographic information universe, without which it would be impossible to extract any value from data.

Search tools, despite a general claim of automated objectivity, come with embedded biases, and bring about a number of intended and unintended effects on the geographic information universe. Media theorist Marshall McLuhan noted over and over in his writings that we shape tools, and these tools in turn shape us, and this insight holds true for recent search technologies.

Geography and geographic information science (GIScience) are not new to these debates. The debate around the so-called Critical GIS highlighted the positivist bias embedded in the approach, focusing on what is difficult or even impossible to encode in computational terms. Although search technologies are often mentioned as one of the core aspects of GIScience [3], no broad debate has emerged around them. In the reminder of this article, we highlight the need for a better understanding of search and its effects to establish observatories of the geographic information universe.

2   A search engine society?

Digital search technologies have become a pivotal component of the infrastructure of organizations and individuals throughout developed societies. Searches, particularly text-based queries, are routinely performed to solve an increasing number of tasks, in a stream of websites, articles, images, videos, and datasets. In the complex informational ecosystem that we inhabit, search technologies determine which portions of it are visible and accessible, and which are not, constantly reshaping the flows of information. As Graham et al. [4] argue, "practices, algorithms, and rules of search govern the content, ideas, places, and commercial opportunities to which users are exposed" (p. 187).

While search is a crucial aspect of every information system, whether digital or not, the emergence of general-purpose search engines is a recent phenomenon with wide-ranging effects. Notably, a 2013 report from marketing firm *comScore* indicates that the vast majority of searches in the US are performed on Google (67%), Bing (18%), and Yahoo! (11%), amounting to a staggering 96% of the search market.[1] Google itself processes 5.9 billion text-based searches per day world-wide, increasingly taking into account the users' geo-location and the spatial dimension of web content. Without doubt, these large search engines constitute a central and yet opaque access point to the geographic information universe.

In his critical analysis of what he calls the "search engine society," Halavais [6] claims that search engines are unobtrusive mediators, which rely on obscure and proprietary mechanisms to pick winners and losers in their rankings, reflecting existing biases as well as consolidating new power structures. Along similar lines, Vaidhyanathan [11] analyzed the hegemonic position of Google, emphasizing its outstanding capabilities for pervasive marketing-oriented surveillance and dangerous concentration of informational capital. While some of these criticisms appear debatable, one point should be uncontroversial: search technologies are

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[1] `http://www.comscore.com/Insights/Press_Releases/2013/8/comScore_Releases_July_2013_US_Search_Engine_Rankings`

not neutral, and should be subject to careful scrutiny in the establishment of observatories for the geographic information universe.

3   Search and its facets

Looking specifically at the relationship between search and the geographic information universe, several research gaps are visible. To frame the discussion, it is beneficial to identify a limited number of thematic areas. Although GIScience is a central element in these topics, an inter-disciplinary approach is needed, involving geography as well as information science and media studies.

Spatial search. From an engineering perspective, since the beginning of the discipline in the 1990s, GIScientists have actively contributed to the development of computational search technologies now central in the geographic information universe, ranging from indexing in spatial databases, to digital gazetteers, raster classification and retrieval, and geographic information retrieval. Explicit and comprehensive attempts to tackle spatial search with the tools of GIScience include the Alexandria Digital Library [2], and the SPIRIT Spatial Search Engine [9]. More recently, semantic technologies and ontologies have been proposed as enablers to next-generation geo-information search technologies. Although the promise of better spatial search facilities provides the motivation for much research, no systematic study has been done to understand how spatial search has changed over the past number of years.

Social search. The social dimension of search can be understood from two complementary perspectives. On the one hand, search technologies are becoming increasingly social, tapping users' social and geographic networks and communities to refine the search results. On the other hand, search has an effect on data flows and therefore on society at large, influencing information production and dissemination in new forms of space-time compression. Hence, the social dimension of search introduces new biases and filter bubbles, inside and outside academia, which need careful examination. As geo-location and the spatiality of contents are increasingly pivotal in the nexus of search technologies, these matters should be of utmost interest for GIScientists.

Search gatekeeping. The geographic information universe does not exist in a vacuum, but is the outcome of complex socio-technical systems that include universities, research centers, government agencies, private corporations, and citizens. To understand how these networks come into being and how they interact, it is essential to understand search gatekeeping, i.e. the power structures that surround and shape search technologies, including data trading, ownership, control, and regulation. While this issue might be regarded primarily as a concern for social scientists, it has tangible effects on what data is available and how it is consumed, both for private, general-purpose search engines such as Google and Bing, and for publicly-funded, domain-specific projects such as the U.N. Food and Agriculture Organization GeoNetwork.[2] In this sense, GIScience has an im-

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[2] `http://www.fao.org/geonetwork`

portant role to play regarding the regulation of geographic information and its findability, beyond a narrow technical perspective.

Search effects. Every tool has unintended consequences and produces winners and losers, and search technologies are no exception. A long-established tradition in media studies researches so-called "media effects," i.e. the cognitive, cultural, epistemic, and psychological consequences of particular media technology on its users. In parallel, information science can provide tools to investigate the impact of search tools on information-seeking behavior of individuals [7] and on the findability of online artifacts [12]. In the marketing arena, the burgeoning field of Search Engine Optimization (SEO) shows that search technologies have a strong influence on what information is produced, how it is described and presented, and who has access to it. Understanding the effects of search technologies can illuminate aspects of the geographic information universe that would otherwise remain obscure.

4   Conclusions

Important questions about the geographic information universe remain unanswered. In this article, we have argued for the need to put search technologies under the spotlight. GIScience is ideally positioned between computer science and geography to contribute to this area of knowledge, through inter-disciplinary efforts. Particular focus should be devoted to the new gatekeepers of geographic information, which have become a central part of the informational ecosystem in which information is produced, searched, and consumed. Far from being neutral tools, search technologies have replaced the model of content filtering of old media. In the process of crawling, indexing, and structuring web content, search technologies steer the informational infrastructure with specific characteristics and biases.

GIScience should fruitfully engage with many cognate disciplines in the understanding of the impact of search technologies. Media studies can help contextualize search tools and principles, analyzing the cultural impact of search engines and their imaginary [8]. Information science and communication studies can illuminate the dynamics of online mediated interactions, focusing the increasingly important role of location [1], as well as the perception of authoritativeness of geographic information. To understand the geographic information universe, insights might come from Internet studies, and specifically from what [13] calls "web search studies," which focus on the biases in the exploration, crawling, and indexing of the web. The emergent field of mobility studies is also part of the picture, providing an integrated approach to understanding cultural flows from a spatial perspective [5].

Cognitive psychology, particularly regarding spatial cognition and thinking, can provide the conceptual and empirical tools to investigate the impact of search technologies on users' mental maps and spatial literacy [10]. Last but not least, human geography possesses the ideal theoretical tools to explore the influence of search technologies on the representation of places [14], paying particular at-

tention to issues of power, diversity, and democratic regulation of technology. In turn, such research can point out existing drawbacks and open up new avenues to software engineers and GIScientists to develop novel spatial search technologies. If "laws" (in the sense of general principles) are to be discovered out there in the geographic information universe, we should look very carefully not only *in* the telescope, but also *at* it.

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