Computers, Environment and Urban Systems 57 (2016) 106–117

Contents lists available at ScienceDirect

Computers, Environment and Urban Systems

journal homepage: www.elsevier.com/locate/ceus

Online interactive thematic mapping: Applications and techniques for socio-economic research

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ARTICLE INFO

Article history:
Received 15 June 2015
Received in revised form 23 November 2015
Accepted 13 January 2016
Available online 22 February 2016

Keywords:
Interactive mapping
Web cartography
Open data
Socio-economic data
Urban analytics
Open source software

ABSTRACT

Recent advances in public sector open data and online mapping software are opening up new possibilities for interactive mapping in research applications. Increasingly there are opportunities to develop advanced interactive platforms with exploratory and analytical functionality. This paper reviews tools and workflows for the production of online research mapping platforms, alongside a classification of the interactive functionality that can be achieved. A series of mapping case studies from government, academia and research institutes are reviewed. The conclusions are that online cartography's technical hurdles are falling due to open data releases, open source software and cloud services innovations. The data exploration functionality of these new tools is powerful and complements the emerging fields of big data and open GIS. International data perspectives are also increasingly feasible. Analytical functionality for web mapping is currently less developed, but promising examples can be seen in areas such as urban analytics. For more presentational research communication applications, there has been progress in story-driven mapping drawing on data journalism approaches that are capable of connecting with very large audiences.

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http://dx.doi.org/10.1016/j.compenvurbsys.2016.01.002

1. Overview

The use of online mapping and spatial search has become ubiquitous, with hundreds of millions of desktop and smartphone users regularly accessing mapping services.[1] Furthermore spatial data and mapping is also widespread in social media, with users sharing and tagging geolocated media through various crowdsourcing applications. These 'geoweb' tools amount to a revolution in how the public view, create and interact with geospatial data (Goodchild, 2007; Haklay, Singleton, & Parker, 2008). Yet while platforms such as Google Maps and OpenStreetMap present huge topographic databases of the globe, there are no such comparable global mapping platforms for socio-economic data, such as demographic, economic and environmental indicators. Socio-economic mapping platforms are typically limited to a single nation-state at a particular data scale, with a lack of indicator breadth and analytical functionality.

The potential advantages of using web mapping tools to integrate socio-economic data into global and national platforms could be substantial in terms of facilitating research and allowing the public to compare and contrast locations across the world using a range of indicators. There are many interest groups concerned with socio-economic representation and analysis, from international and national governance agencies to universities, environmental science institutes, national statistics bodies, Non-Governmental Organisations (NGOs), think-tanks and similar organisations. The global mapping of socio-economic data was an important part of Al Gore's original 'Digital Earth' vision (Gore, 1998) that anticipated online mapping innovation, but thus far global data integration has focussed overwhelmingly on topographic and remotely sensed data.

Several barriers have been restricting developments in online socio-economic cartography. Innovation in web mapping has been driven mainly by large tech companies (Plewe, 2007) seeking market share in lucrative spatial search and mobile markets, with socio-economic mapping given comparatively little attention. Furthermore there are challenges with socio-economic data itself, in terms of access restrictions, online sharing restrictions and integrating data between nation states (Kitchin, 2014; Masser, 2005). Due to the high costs of national censuses, socio-economic data can be limited, particularly in the global south (Linard & Tatem, 2012). Finally there has been a lack of easy-to-use software tools capable of creating high quality thematic mapping sites.

In recent years a number of trends have emerged that are overcoming many of these barriers. The open data movement has been central to the release of a wide range of public sector datasets for free in standardised and shareable form (Kitchin, 2014). In addition to data releases, there has been significant technological and software innovation allowing sophisticated thematic maps to be delivered within standard web browsers (O'Brien, 2015). Much of the innovation is being driven by open-source software, with free and powerful tools that are expanding the user-base of online cartographers (Steiniger & Hunter, 2013). Finally the aesthetics and techniques of thematic mapping and related visualisations have become increasingly mainstream through media and business trends such as data journalism (Weber & Rall, 2012) and visual analytics (Thomas & Cook, 2006). Together these innovations are expanding the scope of online geovisualisation capabilities to embrace both socio-economic datasets and the visualisation and spatial analysis techniques to explore them.

This paper provides an overview of the recent innovations in online socio-economic data and interactive thematic mapping tools. Workflows for producing thematic mapping sites are defined, alongside a classification of the interactive functionality for research applications. Case studies of recent thematic mapping sites from academia, government and research institutes are reviewed, illustrating what can be achieved and opportunities for future developments.

2. Review contexts

Firstly the research applications of online interactive mapping are discussed, and related to established scientific roles for cartography. This is followed by an overview of the main data and software innovations that are underpinning recent developments in online interactive mapping.

2.1. Online interactive mapping for research

Cartography is used in several areas of scientific research, and these roles can be categorised according to the stages of scientific enquiry in which they are applied (Roth, 2013). Applications during early exploratory stages of research aid 'visual thinking' (DiBiase, 1990), allowing data to be better understood and assisting hypotheses formulation. MacEachren (1994) defines such exploratory cartographic tasks as 'revealing unknowns', entailing high levels of human–map interaction by specialist users for their own analysis. Cartography is also frequently applied during later presentational stages of research for 'visual communication', where a single optimal solution is presented to a wider audience (DiBiase, 1990). Presentational applications involve 'presenting knowns', involving low human–map interaction for a public audience (MacEachren, 1994).

As online mapping allows results to be shared with potentially large public audiences online, it has advantages for the latter presentational research roles. Online research maps are most commonly static images of results, which are relatively straightforward to produce and for viewers to understand. This relative simplicity contrasts with the greater user engagement required for interactive maps. Interactive mapping is defined here as cartography where users can change aspects of the map representation, thus requiring a two-way relationship between the map and the map user (Roth, 2013). Interactive cartography is more closely aligned with the exploratory stages of scientific analysis where human–map interactions are high level and iterative, complementing hypothesis formulation and related tasks (MacEachren & Monmonier, 1992). These exploratory tasks are typically undertaken using desktop GIS and geovisualisation software which offer comprehensive tool suites of cartographic and spatial analysis functions.

[1] Market leader Google Maps claims to have over a billion monthly users across all platforms (Google, 2012). Apple, Microsoft, Yahoo and OpenStreetMap also provide large global mapping services.