3
DIGITAL MAPPING

JEREMY W. CRAMPTON

Digital mapping concerns the art and science of using digital technologies to deal with geospatial data. I say 'deal with' to include digitally mediated processes of collecting data, transforming them, weeding them out and combining them with other geospatial data. And beyond that, sharing and passing forward maps or mappable digital spatial data. Digital mapping may involve the production of maps, whether on a computer screen or displayed on mobile devices – although they may or may not be the ultimate product.

A problem with this sort of definition is that digital mapping is not a historically consistent object. Any definition I might contrive to fit today's digitally mediated landscape is not going to fit yesterday's or tomorrow's very well because the theory, technologies and praxes underpinning digital mapping have been and continue to be in flux. Even the term has changed over time. In the 1980s the terms 'computer-assisted cartography' or 'computer mapping' were used to refer to similar ventures. At that time, Mark Monmonier could confidently identify a 'technological transition' in cartography, and predict a near future where 'digital maps will displace the paper map' (Monmonier, 1982: 4). Looking back further, candidates for the 'first' digital map might include the work of John von Neumann at Princeton, who used the ENIAC computer after World War II to create the first map out of computer-generated data (Hall, 1992). Before that, Bletchley Park's Colossus computer was the first programmable digital computer (1941), and was used to decrypt messages from German High Command regarding the location of U-boats, which were then plotted on a large map.

But these candidates raise more questions than they answer. A search for origins, although it may give us a working timeline, should not obscure more interesting questions of what problems the techniques were meant to address, what forms of knowledge were created, nor indeed the socio-political context of their formation. Nevertheless, it does help us to understand both the history of our present situation and that it has not remained static.

A productive way into digital mapping is to consider it 'spatial media', meaning that geospatial information can be produced, shared and analysed to create value and to act as media for communicating other information (see Chapter 1). The key word here is 'shared'. Digital mapping, especially practised online as part of the geoweb, is a vital part of such 'new spatial media' (Crampton, 2010; Leszczynski, 2015). As spatial media, digital mapping is best understood as socio-technology. In other words, what is at stake are not only questions of technology, but also 'sites of potential relations between individuals; persons and places; and people, technology, and space/place' (Leszczynski, 2015). Spatial media have economic, political and, increasingly, legal ramifications (see Chapter 15).

In apprehending such a collection of issues, some authors interpret digital mapping and spatial media as comprising an assemblage (Dittmer, 2014). This is a complex term, but for our purposes we can use the definition of assemblage as 'a multiplicity which is made up of many heterogeneous terms and which establishes liaisons, relations between them … [i]t is never filiations which are important but alliances, alloys' (Deleuze and Parnet, 1987: 69). In other words, how do a wide variety of actors, institutions and knowledges form and reform and what work do they do in the world?

Two useful ideas can be drawn from assemblage theory. First, what is at stake is defined not only by what's going on within the assemblage, but also by what are known as its 'relations of exteriority' (DeLanda, 2006: 10). We have to look at how our subject (here, digital mapping) is nested and interrelated with other issues. For example, your new Apple Watch may be great at providing you with directions, but what rights does the government have to use it to track your location? To answer this question would mean enrolling legal and regulatory practices, rulings and knowledges. Second, assemblage theory points to capacities rather than properties of component parts. So for example, it is not so much the properties of spatial data we are interested in, as what work they do in the world. Or to put it another way, the relations of the properties to other properties. This has given rise to network theory and the Semantic Web (how meaning arises from these relations) (see Chapter 13). Note that while spatial properties are relatively computationally tractable in a geospatial database (think of a spreadsheet where each row is location and each column a certain property), data capacities are less tractable unless they too can be made calculable – hence the recent burgeoning interest in algorithms as ways to understand how capacities can be made calculable (Amoore, 2011; Kitchin, 2014).

Spatial media also allow us to understand the fact that today digital mapping is not necessarily a desktop-based process. Traditional 'Big GIS' (geographic information systems) such as Environmental Systems Research Institute (Esri), which has $1.4 billion in annual sales (Helft, 2015), is still going strong (although see my comments on 'zombie GIS' below), but the landscape is more diversified in mapping options (see Chapter 2). Online mapping, sometimes known as the geoweb (see Chapter 1), offers many alternatives, some of which are discussed more fully below.

CASE STUDIES

Sometimes the best way to get a feel for a topic is to look at specific cases. If digital mapping is self-evidently tied to the development and exponential increase in computing power (known as Moore's Law), and despite important precursors such as J.K. Wright's categorisation of spatial data, which was later adopted in GIS (Wright, 1944), a significant date in its recent development is 2005. In August of that year Hurricane Katrina struck the New Orleans area, and as devastated residents and others around the world sought updates on where the flooding had hit, they turned to a new online mapping service, Google Earth. Google Earth was launched in June 2005, and because of its ability to share views in small text files called keyhole markup language (KML), it quickly came to be used by the US government to distribute its aerial imagery. This made the virtual globe software very popular.

Google Earth was originally created by a company called Keyhole (named after the US spy satellite programme), which Google had bought in 2001 – hence keyhole markup language (KML). Keyhole was also the name of the company that originally developed the virtual globe, then known as Earth Viewer, and it can be better understood as an assemblage. For instance, Keyhole received start-up funding in early 2003 from In-Q-Tel, a venture capital company funded by the Central Intelligence Agency (CIA), and was almost immediately used in the Iraq war by the National Geospatial-Intelligence Agency (NGA, then known as NIMA). In 2008 I interviewed Avi Bar-Zeev, a co-founder of Keyhole (Crampton, 2008). He pointed out that in addition to funding, Earth Viewer required technology (compressed imagery, sufficient internet bandwidth, a decent user interface/user experience (UI/UX)), expertise (software engineers, a CEO with a background in satellite imagery and links to the US intelligence community) and the right socio-political-economic situation to be successful (the dotcom boom of the late 1990s). There are also unintended consequences, especially around privacy in StreetView (Google originally did not mask people's faces, and was sued and fined for privacy violations and now censors images). In fact, the invention of the technology has pushed the law to new interpretations of geolocational privacy too, especially when combined with other technologies such as the proliferation of commercial drones (small unmanned aerial vehicles or UAVs) (see Chapter 22). (Bar-Zeev later became Senior Manager at Amazon's Prime Air drone delivery service.)

Google Maps was also launched in 2005 and achieved success quickly (it became the largest online mapping company by 2009), again largely because Google wisely decided to 'open' their data through an application programming interface (API). The API allowed people to send a request using a special key for a Google basemap to sit under their own data. In this way, hundreds of thousands of map mashups were developed without the need for specialised software. The mashups lived on web pages and adopted a slippy map style (zoomable and interactive).

A second significant case study is the rise of OpenStreetMap (OSM). OSM is the Wikipedia of the mapping world, and exemplifies spatial media. OSM maps are often used as basemaps in other mapping products, such as ArcGIS, QGIS, Carto and Mapbox. OSM was conceived in August 2004 by Steve Coast, who has admitted that he did not quite know where it would take him. The map, which is now global in scope and clocks in at nearly 50 gigabytes, is contributed to by over two million mappers using GPS units to trace paths. Users can also access digital imagery at the site and trace out buildings, parks, lakes and so on (there is an extensive list of object types). A more recent alternative is to collect imagery by drone, correct the image for distortions (perspective) and add the imagery to OSM as a reference for digitising. A useful tool to do imagery georeferencing is MapKnitter (http://mapknitter.org), offered by Public Labs, which no digital mapper should do without. MapKnitter corrects the image and can export the result as a georeferenced tagged image file format (TIFF) image (geotiff). OSM data are free to use by anyone, for any purpose. If you wish you can change the data by updating them – directly editing the database, or by downloading and modifying them locally. You could even collect new imagery (e.g. by drone), georeference it with free tools such as MapKnitter and add it to OSM.

This process is a significant difference between OSM and Google Maps, to which it is much harder to submit updates after getting some rather controversial entries in a practice known as 'mapjacking' (including an outline of the Android logo urinating on the Apple logo). In this way then OSM may actually have better global coverage than Google Maps (especially in urban areas). Additionally, running and cycling mobile apps such as Strava, which have masses of user data, are a natural fit for importing into OSM (although for reasons of data quality this will probably not be automated without quality controls). On the other hand, Google will continue as a major digital mapping company. Its two-dozen or so self-driving cars (which already drive autonomously on real highways in four US states) mean that it will need to compete in map quality (as well as lasers, radar and sensors); not to mention it has one massive dataset that OSM does not, that is, StreetView. Competitors such as Uber are also focusing on comprehensive mapping databases, and in 2015, an agglomeration of German auto manufacturers, BMW, Daimler and Audi, purchased Nokia's 'HERE' map business (previously known as Navteq) for $3.1 billion. The business of high-precision maps is obviously a significant one as self-driving vehicles become more prevalent.

WHO IS INVOLVED?

Prior to the advent of the personal computer in the 1980s and the widespread adoption of graphic user interfaces (GUI), digital mapping was the province of an elite few. As Monmonier (1982) hinted, digital mapping has come to replace paper mapping to such an extent that the latter has gained a modicum of 'artisanal' quality. (3D printing has also helped.) In one of the earliest textbooks on computer mapping, Monmonier cited over 200 available mapping packages as of 1977. These included those devised by government agencies such as the United States Geological Survey (USGS) and the Census Bureau (which had developed its DIME files of all US streets by the 1970 census), and state governments such as Minnesota, which created a GIS Land Management Information Center in 1977. Harvard's Laboratory for Computer Graphics and Spatial Analysis, a major research lab founded in 1965 by Howard Fisher, also developed software including SYMAP and ODYSSEY (which reputedly formed the basis for Esri's own products). Subsequent presidents of three GIS companies worked at the lab (Jack Dangermond – Esri; Howard Slavin – Caliper; and Lawrie Jordan – ERDAS) (Chrisman, 2006).

By the early 1980s, Dobson (1983) could claim that computers integrated all forms of geographic inquiry. Automation (as he saw it) was 'essentially neutral'

(Dobson, 1983: 135) and would make both the 'humanist' and the scientist more productive through use of new tools. The concern was to integrate mapping, then seen as largely a map display capability, with analysis, or spatial problem solving. (The same concern had led the Harvard Lab to add 'Spatial Analysis' to its original name.) The map by itself was insufficient. In a commentary on Dobson, Cowen (1983) suggested 'that maps as ends unto themselves are of little value to decision-makers' (Cowen, 1983: 339) and this was why an interesting government mapping initiative, the Decision Information Display System (DIDS) failed – it was merely a 'magical map making machine' (1983: 339).

Interestingly, DIDS, which was developed by the National Aeronautics and Space Administration (NASA) for the Carter White House and aimed at integrating data across government agencies for display 'onto a screen for viewing by many people in a large room' (Monmonier, 1982: 146), bears some resemblance in principle to 'Project Cybersyn' (Medina, 2011). Cybersyn was conceived for the Allende government in Chile in the early 1970s by Stafford Beer, a British cybernetician, but was never operational. Although it was not a mapping system per se, Beer envisioned it along the same lines as the Churchill government's 'vast map in the war-time Operations Room' (Beer quoted in Medina, 2011: 34). From a central control room, Chilean officials and everyday workers would be able to access flows of information about the Chilean economy and the public mood about policies – all in real time across a computer network (not the internet, which was barely a year old in 1970, but a series of repurposed Telex machines). Medina (2011: 6) also offers a useful corrective to Dobson's claim of technological neutrality: 'technologies are not value-neutral', she argues, 'but rather are a product of the historical contexts in which they are made'. Both DIDS and Project Cybersyn exemplify some of the grandeur of big data, and no doubt some of its hubris. They also exemplify the need to understand developments in terms of a genealogy rather than a history of firsts: Beer was inspired by Churchill's war-room map, which in turn was inspired by strategic military maps going back centuries. Cybersyn was related to space Mission Control operations rooms, and today's smart cities (see Chapter 19).

Today, Big GIS (e.g. ArcGIS, DIDS, and enterprise GIS) have been supplemented (some would say replaced) by other options. The digital mapping landscape is incredibly diverse and richly functional. While this is partially a question of technology (especially the personal computer, the availability to the public of good GPS since 2000, online mapping technologies, and the advent of the smartphone), it is also a question of philosophy. If Project Cybersyn was meant to give the ordinary worker in Chile a bigger say in the means of production, then it prefigured what would only come later for most, that is, the means of map production for oneself. Goodchild has identified this shift in thinking as 'Volunteered Geographic Information' (VGI, see Chapter 12) and if that term is known mostly to academics, its principles are much more widely practised. VGI inverts the traditional model of mapping where a skilled cartographer collates and processes data, accesses specialised production tools, designs a single map and passes it on to a client. Today, a typical workflow is that an individual collects geolocational data with a smartphone app such as Strava or Fulcrumapp, pools the data with that of workmates, exports it using modern geospatial file formats such as GeoJSON, and imports it into geoweb environments such as Carto or Mapbox. Both these latter two companies are new. CartoDB was founded in Spain in 2007 by an agricultural engineer and a computer scientist for the purposes of better data visualisation (Solana, 2015). Mapbox was founded in 2010 and has made a huge impact on web-based digital mapping, hosting and visualising spatial data, but more importantly allowing developers to design new maps and promoting the cross-platform mapping stylesheet called CartoCSS. Both companies work well with tiling (Mapbox Studio allows custom vector tiles) and OSM and are web-native.

Another option to Big GIS might be to use desktop-based QGIS, an open-source extensible GIS that competes with ArcGIS. Under this scenario, the fears of Dobson and Cowen that the map is insufficient are revealed to misunderstand that the map itself is analysable and provides actionable intelligence. This last point is especially noticeable in the context of the smart city. As we have seen, the rise of the smart-city approach to planning over the past two decades (the term seems to have originated in the mid-1990s), the use of maps and other indicators in what are sometimes called 'urban dashboards' in operations centres has also underlined how digital maps can aid decision-making (Mattern, 2015; see also Chapter 7). Here maps do not stand alone, but are part of an ever-forming assemblage. As Kitchin et al. (2015) point out, dashboards (and by extension digital maps) are 'co-produced' with the wider institutional landscape, and are affected by and in turn affect the city. Here, maps could not be anything other than spatial media.

WHAT IS NECESSARY TO UNDERSTAND ABOUT DIGITAL MAPPING?

In the previous section we discussed some of the significant players and events to do with digital mapping. But how should we understand these developments? In this section I identify three key factors for understanding digital mapping as spatial media: (1) 'old school' Big GIS with black-boxed proprietary software is less dominant; (2) the information and sharing economy means that the map is not the end product, but rather part of a whole series of geospatial services and content that are shared and networked; (3) digital mapping is an assemblage and the individual mapper working alone with bespoke technologies is giving way to the networked collaborator. I discuss these briefly below.

Is GIS dead? Well, yes and no! It was not too long ago that cartographers fretted that GIS would kill cartography, but today companies like Carto and Mapbox, and web-based mapping services such as MapKnitter, mean that cartography (as the art and science of making maps) is resurgent. And I have already mentioned the new markets that both UAVs and self-driving cars are opening. Big GIS – exemplified by Arc/Info and ArcGIS – may be 'dead', but like a zombie, still stumble around out of habit. There are a lot of companies using ArcGIS: over a third of a million according to Esri. GIS is changing to the extent that we can no longer call it 'GIS'. But Esri is a smart company, and has started to make the turn towards the cloud, towards online, searchable data sharing (i.e. not just map sharing) and to 'story maps' or curated maps, images, text and video that tell a meaningful narrative (very useful in journalism, for example). But it will take a while for the supertanker to change course. In the meantime those who need maps but not Big GIS can use lots of different 'little GISs' (for a very useful review of 35 options, see Roth et al., 2015).

Second, the de-emphasis on the map as end product. This has been mentioned several times throughout this chapter, but consider OSM. It is not so much 'a' map but rather a symbolised, ongoing geospatial database that can be viewed, extracted, modified, added as a basemap, and used for navigation or for humanitarian relief efforts (Haiti and Nepal are examples where OSM quickly provided detailed maps through concerted community mapping efforts).

Third, digital mapping comprises an assemblage. Digital mapping as spatial media is by definition a social activity. In the 1960s, cartographers such as Arthur Robinson developed a model of cartography as a map communication model (MCM). The impetus for this was very reasonable, namely that mapping was moving from being a craft industry with highly artistically talented individuals such as Erwin Raisz, Armin Lobeck and Richard Edes Harrison, to something that needed more formal rules of study. The MCM outlined a process whereby an expert mapmaker could produce maps on the production line method, drawing on rules and accepted practices rather than individual artistic talent. Like a factory production line, however, this model centralises production and responds to demand from the marketplace. With the opening-up of mapping by APIs, map mashups, VGI and geoweb mapping companies, this process becomes more networked and shared. It does not mean the end of mapping expertise but it does represent a huge shift (e.g. more towards coding). And the sharing is not at the end of the process but throughout, so that, for example, even primary data collection can be crowdsourced. So if the MCM is Fordism, then today's digital mapping is 'just in time' production or even DIY maker-spaces.

UNDERSTANDING MAPPING IN THE AGE OF THE NEOLIBERAL ALGORITHM

There are two things that appear as if they are going to be important to the future of digital mapping. The first is that while it is easy to say digital mapping comprises an assemblage, we do not know the full implications of that yet. What are its relations to big data? How does digital mapping play a role in the internet of things or the smart city? What is the relative importance of mapping per se to geolocational information more generally for issues such as geoprivacy (see Chapter 22)? How will legal determinations play out with regard to what is legally 'reasonable' geolocational tracking? Given that individuals 'shed' copious amounts of geolocational information in the course of their daily activities, and that it is upon these algorithmic 'data derivatives' that decisions are made (Amoore, 2011), then how can our privacy be assured? Is it a question of 'rights' (even if rights for some means lack of rights for others) such as the (problematic) right to be forgotten? Will countries such as the USA and the UK rein in bulk or so-called dragnet surveillance in favour of more targeted, warrant-driven investigations?

Second, how is digital mapping being reconfigured in the age of neoliberalism? By this I mean the processes of making everything calculable and monetisable, and the way new economic zones are being colonised for value extraction. An example of the latter – in what might actually be the first new space colonised since the scramble for Africa in the 1880s, is vertical airspace and the advent of the commercial drone. Perhaps 600,000 people are in the air at any one time, but this still leaves most of the Earth's volume (1080 billion km^3 according to NASA, compared to 1.4 km^3 billion for the volume of Earth's oceans) available for occupation.

Small companies making unmanned aerial vehicles are not so small any longer (the world's biggest is DJI, which in 2015 sought a $10 billion valuation). DJI, Google[x] Project Wing and Amazon's Prime Air are members of a coalition pushing for more business-friendly regulations in the USA (which currently prohibit flying drones beyond line of sight). If the Federal Aviation Administration (FAA) were to relax its prohibitions on commercial drones, how would geospatial information play a role? More generally, how are the various apps we have in smartphones extracting value from our geolocational data?

To answer these questions we need more, and better, critical histories of mapping as a socio-technological development. Kitchin (2014) has usefully outlined six approaches for thinking critically about geolocational algorithms. In particular he urges that we study how the objects of our research do work in the world (assemblage theory's emphasis on capacities) and the wider socio-technological contexts. These are also useful for researching digital mapping.

REFERENCES

Amoore, L. (2011) 'Data derivatives: on the emergence of a security risk calculus for our times', *Theory, Culture & Society*, 28: 24–43.

Chrisman, N. (2006) *Charting the Unknown: How Computer Mapping at Harvard Became GIS*. Redlands, CA: Esri Press.

Cowen, D.J. (1983) 'Commentaries on "automated geography": automated geography and the DIDS (Decision Information Display System) experiment', *The Professional Geographer*, 35: 339–40.

Crampton, J.W. (2008) 'Keyhole, Google Earth, and 3D Worlds: an interview with Avi Bar-Zeev', *Cartographica*, 43: 85–93.

Crampton, J.W. (2010) *Mapping: A Critical Introduction to Cartography and GIS*. Oxford: Wiley-Blackwell.

DeLanda, M. (2006) *A New Philosophy of Society: Assemblage Theory and Social Complexity*. London: Continuum.

Deleuze, G. and Parnet, C. (1987) *Dialogues*. New York: Columbia University Press.

Dittmer, J. (2014) 'Geopolitical assemblages and complexity', *Progress in Human Geography*, 38: 385–401.

Dobson, J.E. (1983) 'Automated geography', *The Professional Geographer*, 35: 135–143.

Hall, S.S. (1992) *Mapping the Next Millennium: The Discovery of New Geographies*. New York: Random House.

Helft, M. (2015) 'You can't kill Jack Dangermond's company. Try, and it will only get stronger', *Forbes*. Available at: http://www.forbes.com/sites/miguelhelft/2015/03/31/you-cant-kill-jack-dangermonds-company-try-and-it-will-only-get-stronger/ (accessed 21 July 2016).

Kitchin, R. (2014) 'Thinking critically about and researching algorithms', *Information, Communication and Society*. DOI: 10.1080/1369118X.2016.1154087

Kitchin, R., Maalsen, S. and McArdle, G. (2015) 'The praxis and politics of building urban dashboards', *Programmable City Working Paper 11*. Available at: http://ssrn.com/abstract=2608988 (accessed 21 July 2016).

Leszczynski, A. (2015) 'Spatial media/tion', *Progress in Human Geography*, 39 (6): 729–51.

Mattern S. (2015) 'Mission control: a history of the urban dashboard', *Places Journal*. Available at: https://placesjournal.org/article/mission-control-a-history-of-the-urban-dashboard/ (accessed 21 July 2016).

Medina, E. (2011) *Cybernetic Revolutionaries: Technology and Politics in Allende's Chile*. Cambridge, MA: MIT Press.

Monmonier, M. (1982) *Computer-Assisted Cartography: Principles and Prospects*. Englewood Cliffs, NJ: Prentice-Hall.

Roth, R.E., Donohue, R.G., Sack, C.M., Wallace, T.R. and Buckingham, T.M. (2015) 'A process for keeping pace with evolving web mapping technologies', *Cartographic Perspectives*, 78: 25–52.

Solana, A. (2015) 'CartoDB: from Alcatraz to elephants, startup puts open source visualisation on the map', *ZDNet*. Available at: http://www.zdnet.com/article/cartodb-from-alcatraz-to-elephants-startup-puts-open-source-visualisation-on-the-map/ (accessed 21 May 2016).

Wright, J.K. (1944) 'A proposed atlas of diseases', *Geographical Review*, 34: 642–52.