

Mad Maps: A Revolution in Geographic Information Dissemination and Use

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INTRODUCTION

Maps have been around since the dawn of mankind. Knowledge and memory of location and navigational abilities are fundamental to animals. Some of these abilities in animals are still not understood except as being phenomenally sophisticated.

Being able to represent and convey location and navigational information to others through cartography is a relatively modern invention, exclusively human. Is it any wonder that after centuries of slow progress in cartographic representation that maps should not also become a part of the information technology explosion? Having maps delivered from past centuries into a handheld device like an iPhone is indeed a wonder. Using a cellular phone to find, map and automatically call the nearest available taxi is a wonder.

What does this wondrous new technology mean:

- Can we read maps better?
- Do we have a better sense of place?
- Is our spatial sense enhanced?
- Is spatial information more available/accessible?
- Is the quality of available spatial information better?
- Can we manipulate spatial information more readily?
- Is spatial information being put to effective new uses?

This paper is about technology and maps and what that means to us. But first I will review several key aspects of traditional maps to set a context for our understanding.

TRADITIONAL MAPS

Data Density

Maps tend to be extremely high in what Edward Tufte of Yale University calls *data density* or the concentration of information in a unit of area. In his volume, *The Visual Display of Quantitative Information*, he demonstrates this with a 27 square inch line map of the 30,000 communes of France which requires 9,000 coordinate numbers per square inch.

Perhaps the complexity of a map can be summed up by contemplating what it would take to try to describe in a narrative form the information and spatial relationships shown on a map. Not only would it be incredibly lengthy, but it also would be amazingly difficult to comprehend. Whereas, a glance at a map says it all.

Scale

Clearly map scale has a bearing on what information it contains: a large scale map may show individual buildings, parking places and shrubs, whereas a small scale map, which covers a much bigger area, may show primary roads, railroads, urban areas, political boundaries, etc.

When a map is drawn or printed on paper, it has a fixed scale – reduce or enlarge a particular map very far and chaos often reigns ... it becomes either illegibly crowded or silly for the low density of information. One remarkable exception to this is the *Cartes nationales de la Suisse*, paper map series at 1:25,000. Through a remarkable combination of contours, hachures, stippling, shaded relief, color, and precision, these are maps comfortably viewable over a wide range of scale.

Clarity and Aesthetics

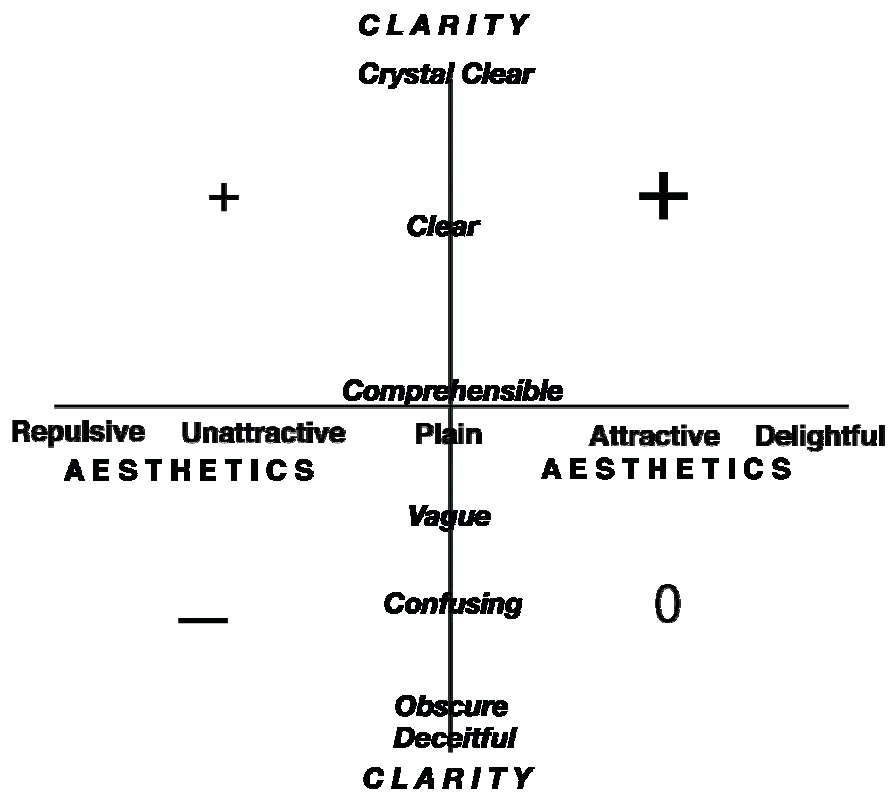
Indeed clarity and aesthetics are two of the primary criteria for judging maps – accuracy being the third. In the diagram, Figure 1, we have two axis with the least desirable maps in the lower left and the most in the upper right. I point out the lowest characteristics along each axis – repulsive appearance and deceitful content. Appearance can be flawed by garish colors, sloppy work, poor choice of color, improper font size, low legibility, poor printing, unconventional feature labels, etc. Clarity can be ruined by inaccurate data, poor choice of map style, deceptive projection, lack of accurate scale or north arrow, confusing or missing legend, and the like. Perhaps the most common deception is that of the Mercator projection in which the round earth is flattened to a complete rectangle. The highest latitudes are profoundly distorted such that, for example, Greenland is shown to be about ten times as large as it should be.

Great advances for clarity and aesthetics in cartography has come from the evolution of conventions for how to label map elements or features. For example, canals are typically shown as two hairline parallel lines, roads are broader lines, fences are lines with X's on them, railroad routes are shown with tie-like cross-bars, shorelines show parallel lines which imply waves, forest are drawn trees or solid green, and vineyards are little green bars. Even what features to depict on maps has evolved. The location of inns was often supplemented by the locations of taverns in the 19th century.

Yet some map labeling practices are misleading. For example, it is common practice to indicate the lowest lying areas as green. Green may make the map handsome, but it implies to many a biological element – lush vegetation! That somehow does not correspond to the low-lying Sahara Desert or the icy far north.

Figure 1.

Evaluating the Clarity and Aesthetics of Maps and Graphics



Placement

World maps always pose a challenge to the cartographer: where to split the world? Is it done through the Atlantic, through the Pacific, or through Asia in order to center the Americas? Another cartographic challenge comes in designing an atlas: How does the cartographer divide up the world to fit on the paper?

Orientation

Most modern maps are oriented with up being due north. The Al-Idrisi map viewable in the in Bahrain National Museum, is a copy of a recompilation of a 12th century map of the Mediterranean, see <http://www.henry-davis.com/MAPS/EMwebpages/219A.html> . It is hard to comprehend because south is up. Globes or world maps made with south up, give preeminence to the downunder and are confusing to most people accustomed to north being up, see <http://www.sandonline.co.uk/UpSide%20Down%20World.gif> .

Linear Maps

Some interesting maps have avoided the real representation of two dimensions in favor of a path-of-travel orientation for river travelers and travelers on Japan's historic Hokkaido Road. River rafters understand that everything of importance is straight ahead or just to the right or left of straight ahead no matter which way the river turns. One intriguing historic example of a linear map was the Routefinder for 1920s drivers in the United Kingdom. Tiny scrolling maps mounted in a wristwatch-like frame showed the driver what was next and the miles covered. See <http://strangemaps.wordpress.com/?s=routefinder> . Another example is a Roman map showing the perimeter of the Mediterranean in the 3rd century; the Peutinger Map is a 1-foot wide scroll some 22-feet long.

Dimensions

Recall that although maps are fundamentally two dimensional on flat paper, thus intrinsically ignoring elevation, a great many maps do, in fact, depict relief or topography. This has been done in a variety of visually satisfying and unsatisfactory ways. Relief or topography has been shown by little schematic sketches, later refined with hachures, and later still with contour lines. Contours are precise measures of elevation, which allow for the construction of cross-sections and longitudinal profiles of especially great use to travelers by non-mechanized means, such as on foot, and to scientists who seek an accurate representation of natural phenomena, and to engineers who need to design on the basis of measurement and calculation. Sometimes contours are visually enhanced with shaded relief, as one might see a sunlit landscape.

And, with each map being a snapshot in time, a series of maps may be considered four-dimensional.

Indicators of and Tools for Geographical Knowledge

Maps are extremely significant because they are manifestations of the geographical knowledge of their time. They also reflect audience interest, such as the production of nationalistic French military atlases during Napoleon's reign. Through maps, one can trace frontiers and exploration as well as the development of knowledge of the natural and anthropogenic world.

Maps are also about taking advantage of technologies in printing. The democratization of maps really accelerated with the arrival of lithography in the mid-19th century as a cheap method of production. Thus the family world atlas, and the student or school atlas, became commonplace, democratizing geographic understanding. Often they were accompanied by fabulous explanatory texts, historic timelines, aristocratic genealogies, illustrations, and depictions of celestial and planetary movements. And in the 20th century, perhaps the ditto, mimeograph, and copy machines were the final big pre-digital step in making it easy to share parts of maps and assign map exercises to students.

Maps have decided the fate of nations, armies, explorers, and even recreationists and drivers. But it is the coincidence of map-related phenomena that may be the most interesting. For example as mentioned above, in the mid-19th century, lithography, which allowed the low-cost printing of accurate color large format maps, came into existence. Coinciding was the ever-increasing use of contours for accurate depiction of elevation, allowing cross sections to be drawn. Also coinciding was a rising tide of geological thought that was based upon the concepts of landscape evolution, geologic formations, and geological and geomorphological processes. Rather suddenly, geologists could accurately map and conveniently share their findings with others; as a consequence, the earth sciences advanced rapidly.

Print Media

For centuries maps have been printed on high quality paper. Eighteenth and 19th century maps, for example, are often on rag paper and are often as bright and pliable as they were originally. Another example is maps printed on silk for pilots who might be shot down over enemy territory.

Quality

Maps rely upon description. The clearer the description, the more supported by actual measurements, the more refined the categories of information, and the more accurate, the better the potential for a fine map. A fine map also relies on the skills of the cartographer, the use of clear and attractive mapping conventions, and the mapping technology – formerly the quality of ink, paper, pens, and printing.

Purposes

Maps have many purposes. While they have a long military history, they also were tools for demonstrating power ... showing knowledge as a sign of power. Two examples are the famous Map Room of the Vatican, and the use of globes by Europeans to impress the 19th century Japanese to encourage them to open their ports to trade.

Maps have long been a planning tool for navigation and trade. Property rights and government administration rely on maps. More recently, maps are used for mineral and resource exploitation,

promoting resource protection, highway navigation, and infrastructure of all types. From air to sea to land, from undersea to space, maps are core tools in our understanding.

TECHNOLOGY AND CHANGE

So what is happening with maps today? Like so much in our technology-driven society, it is in a wild rush with many uncertainties. Established standards are falling by the wayside, older conventions no longer apply, new opportunities abound, the meaning of geographic literacy is in flux, and despite some confusion, change progresses rapidly with digital maps.

There are two main components to contemporary maps. One is the professional realm of mapping and analysis in GIS or geographic information systems. The second is everyday uses of maps and geographic information by the public.

GIS – GEOGRAPHIC INFORMATION SYSTEMS

Description

GIS is map creation, display, and output software-based systems that provides the opportunity to overlay information and manipulate it. A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. It is a decision support system.

It fundamentally consists of points, lines, and polygons, representing, for example, on a state scale, a point for the location of a city, a line for a highway, and a polygon for a county. And there are image layers such a topographic maps, soils map, or aerial photographs, which can provide a backdrop to the other displayed data. GIS is like the old map overlay, except with large numbers of overlays and accuracy over a wide range of scales

The key which makes geographic information systems really different from other graphics software is that everything shown has a precise location in earth space, i.e. precise coordinates tie every feature to exact locations on the earth. Very complex mathematical algorithms allow for the display of the data in a common map projection. The key is that everything fits together in a realistic properly inter-related spatial manner.

GIS has a large array of tools that simplify tasks which would be daunting to do any other way. A display taking a couple of seconds showing, for example, soil types in relation to vegetation type, could take days if not weeks to draw by hand. Many things GIS does cannot be done accurately by hand.

Uses

As a consequence of this power, GIS brings an ever-growing body of information into the scope of not only what professionals use, but what lay people use as well. Often the products which people use, such as tourist maps, are artistically enhanced versions of GIS originals such as is done by Red Paw Technologies, see <http://www.redpawtechnologies.com/index.shtml> . One of the keys to the usefulness of GIS is that it can be updated in real time by downloading and it treats the map components as objects that can be readily deleted or added or changed as the world changes. GIS is very wide-ranging and used by hundreds of thousands of businesses and agencies.

GIS provides the spatial or mapped data functionality for a huge array of activities including:

- resources management and inventory
- emergency response
- marketing and franchising
- sales and membership analysis
- census
- utilities planning and management
- trucking and delivery services
- traffic display and management
- site planning
- land use planning
- zoning
- assessor's mapping
- hazardous materials management
- groundwater modeling
- water distribution systems
- watershed analysis
- vehicle tracking
- archaeology
- document indexing
- security
- wildfire and crime tracking and resource allocation
- biological communities and migration
- species distribution and densities
- health studies and epidemiology
- climate and weather
- archaeological site characterization
- humanitarian aid
- travel tracking
- sustainability analysis
- crop potential
- fisheries
- pest control management
- hazard assessment
- slope/aspect analysis

- energy resources

Fortunately there is a GIS vendor at the SLA conference. Geographic Research Inc. is in booth 1149 and they can show you what GIS is about especially in regard to how libraries use their product, see <http://www.geographicresearch.com/> . ESRI (Earth Sciences Research Institute), the biggest GIS company by far, has a presentation on how GIS is used at http://www.esri.com/company/gis_touches/everyday.html. Another overview of GIS is at <http://www.gis.com/> .

Past, Present, and Future

Over the past forty years I have watched GIS evolve. Due to lagging technology, high initial costs, government charging for and restricting access to imagery, and corporate attitudes and priorities, it has progressed slowly, being very late to embrace the graphical user interface and slow in becoming user-friendly. But it is coming into its own and the visions for GIS expressed decades ago are becoming a reality. Dramatic improvements in user interface means that increasingly these resources are getting to be within the grasp of students, citizens, and managers of all levels. GeoSpatial Solutions, for example, has their application called *GeoIrrigation*, for irrigation districts. It makes water and property and infrastructure information readily accessible to all the water district's staff, see <http://geospatialsolutions.com/gis-solutions.shtml> . More and more data is becoming available for free. Also the products of GIS are increasingly accessible to lay people. Indeed live traffic maps are just a GIS application, projecting one layer of information on top of a base map, see <http://maps.google.com/maps>, to zoom in and click the Traffic button.

Uses in Libraries and Schools

Originally GIS was used in libraries to facilitate patron use of U.S. Census data and other digital materials in the library's collection. It has also been used for planning library facilities. But GIS in libraries has more recently been providing the GIS tools, and helping the patrons/users find the data they need to work. This has increased the GIS vendor choices and allowed users to utilize their own data. Now this functionality is increasingly available for free over the Internet, especially the data acquisition side. But libraries have a special role to play in acquiring local data sets and facilitating access. Library GIS has been used in for cardholder mapping/analysis, for example, to create service area boundaries, locate new sites, or guide collection development. Since counties and cities often have GIS departments, they often provide free online access to GIS useful to citizens, although they may choose to use the library's computer for that access.

Quite aside from college instruction in GIS technology and applications *per se*, GIS instruction in schools, focuses on the interpretation and manipulation of geographic information. GIS lessons provide school-age children with exposure to the effects of geography on the world's problems and new ways to investigate issues that interest them. Typical examples include:

- Analyzing U.S. State Population Change, 1790-2005

- Extreme Temperatures in the U.S.
- 10 Most Populous Cities: Spatial Statistics
- Historic Cherokee Relocation

EVERYDAY PUBLIC USES OF GEOGRAPHIC INFORMATION

Contributions of and Access to Geographic Information

Non-GIS uses of geographic information in this high tech era are extensive and growing rapidly. A search under Google Images for maps of any place is usually rewarding and demonstrates the vast numbers of maps now available to view for free. Many of these maps are the product of substantial amounts of labor.

In that the Internet has given almost anyone a place to express their point of view and make a contribution, rather than restricting it, it also opens a lot of doors for individuals and organizations to contribute. From Wikipedia to blogs, from Google Earth to individuals, the geographic information is pouring in and being readily used. For example, there is a group of devoted lay geographers who have been building a large database with highly accurate elevation and location data for the highest mountains of the world. Others contribute photographs of locations around the world for people to view or use.

Geography-related websites are typically maintained by individuals or by groups such as government (especially the U.S. Geological Survey), academic departments, scholarly groups, university libraries (e.g. <http://www.lib.berkeley.edu/EART/MapCollections.html#electronic>), conservation organizations (e.g. <http://www.bto.org/birdtrack/dailyresults/index.htm>, and <http://audubon2.org/cbchist/map.html>), human rights organizations (e.g. <http://www.amnestyusa.org/lgbt-human-rights/country-information/page.do?id=1106576>), user groups, and private collectors (e.g. <http://www.davidrumsey.com>). These sites provide their own data and links to numerous related sites. Many of these are excellent sources of geographical data. Companies also have significant amounts of valuable spatial data for sale.

Over time the array of information available for GIS and other mapping applications will grow. In the foreseeable future, government and academia will be the primary free data provider because of the high cost of compiling statistical data and digitizing GIS layers. The democratization of map-making, making it online and ubiquitous, has led to an explosion in innovation and has been supported by the free Internet for information distribution and access. And wikis will contribute substantially as illustrated by the array of layers contributed by individuals and organizations that are available through Google Earth Community.

Google Earth is an example of a modified GIS of remarkable robustness because of its:

- global and celestial scope
- speed
- no-cost

- zoomability
- ease of adding privately-compiled information
- accuracy and
- quality of display.

Incidentally, the data compiled in Google Earth is readily transferable to GIS and vice versa.

There is, as in so many disciplines, a gradual blending of what resources are available to lay people and to professionals. This is an immense help in promoting the serious contributions of amateurs and their organizations to professional knowledge. Likewise, it is helpful in promoting professional values among amateurs.

Manipulation Software

Another key is in the availability of software that allows you to take a geographic data set and make a map of it virtually instantly, reflecting your personal interests. Nicest of all you can see the work of others. Some of these can be remarkable tools for educational purposes.

One example is the National Atlas where you can compile your own map, see

<http://www.nationalatlas.gov/> . Show/®USA has free area-proportionate mapping for U.S. states at <http://show.mappingworlds.com/usa/> .

Animated Maps

Animated maps can also be very educational for dynamic events. We are all familiar with dynamic weather maps. Other applications include all types of natural processes and human dynamics. Historic events are often much more instructive when animated. An animation of the Battle of Gettysburg, for example, shows the complexities of the battle and the potential for this type of mapping, see <http://www.historyanimated.com/GettysburgAnimation.html> .

GPS – Global Positioning Systems

A big partner in this geographic revolution is the Global Positioning System or GPS. Most people are familiar with the car navigation GPS. This is a modern version of the wrist watch Routefinder from the 1920s, only safer to use and infinitely more versatile. The cell phone telling and showing you the nearest Burger King when on a road trip is another example. The iPhone has an application which tells you the location of the nearest available taxis and calls them for you. The GPS in your phone may tell your location instantaneously to emergency services. Your cell phone or other digital camera may tag each photograph not only with the time but location of the photograph, allowing it to be downloaded to automatic mapping on Google Earth. Clever innovations like 360° landscape photographs that make you feel like you are there, are GIS/GPS georeferenced, giving them a location on earth, see

http://worldwidepanorama.org/worldwidepanorama/wwp_all/map/index.html .

GoCar, another GPS innovation, offers audio tours of major cities in special vehicles which automatically guide you and tell you where you are, and then explains automatically what is significant about your location. These are GPS-triggered automatic tour guides, see <http://www.gocartours.com/sanfrancisco.html> .

GEOSYNERGY

Because Google Earth can be readily accessed and is ubiquitous, it is an excellent platform for viewing the power of *geosynergy*. Synergy is basically the idea that the sum is greater than its parts. Geosynergy, is the demonstration of value added by the geographic linkage of information either through spatial relations (e.g. a is next to b) or spatial coincidence (e.g. this is the location where a and b intersect). Thus through mapped locations, place names of the past link to those of the present, a vegetation base map shows us the likely vegetation viewable in a georeferenced landscape photograph, a current town has a place on a historic map that precedes the town's creation, etc. Geosynergy is the integration of information by virtue of it sharing a common georeferenced location or relationship.

In the past, geosynergy was limited to what limited features the cartographer chose to put on their static map, at a fixed scale, showing a point in time. It was about spatial relationships and had much less to do with spatial coincidence. And the printed map's distribution was greatly constrained.

The expanded opportunities through geosynergy is at the core of what technology is doing to maps. Now many of the constraints that have limited the usefulness of maps have fallen by the wayside. Today, geosynergy in Google Earth is the collaboration of thousands of contributors, and is in no way static, at a zoomable scale, profoundly accessible, fast, fully flexible as to what to display when, user guided, spanning time, easy to distribute, and geographically linkable to all kinds of information. It is full of opportunities. Google Earth also uses imagery as the underlying base map. As a real picture, it is familiar and takes little skill to interpret. It also has something to offer to everyone: a view of their neighborhood if not their home.

While corporate and government endeavors have provided many of the tools for this revolution in geosynergy, great contributions of data and programming and the presentation of data come from individual or small group efforts. See, for example, Professor Tom Elliott's project to map place names from the Classical Periods, <http://pleiades.stoa.org/places> . And visit the David Rumsey Historical Map Collection, www.davidrumsey.com which contains over 20,000 digitized historic maps (dating from 1700 to 1925) online in high resolution. A portion of these have also been georeferenced in Google Earth where they can be viewed (with varying transparency) on top of the new earth image or on top of one another. For example, you can see historic San Francisco maps projected on top of image maps or street maps.

CONCLUSION

At the outset of this paper, several questions were posed. The answers, based on the above discussion, reflect the consequences of recent technological changes in geographic information and maps.

Can we read maps better? It is doubtful that traditional paper maps are read better today because of more interaction and access to geographic information. People use paper maps less for navigation and rely more on GPS maps, which, because they automatically rotate to show forward as up, could be considered relatively spatially-mindless to use. On the other hand, surely more people are familiar with image-based maps due to exposure on Google Earth and similar systems.

Do we have a better sense of place? The opportunities for developing historic and synergistic understandings of places is rapidly growing with an ever-increasing amount of georeferenced materials being put online. GPS-based audio guidebooks will help people recognize the cultural and historic significance of places through which they pass. Increasing access to maps in handheld devices enhance the opportunities to view the features of interest for a particular locale, while there. The tying together through geosynergy of maps, aerial views, panorama and landscape photographs, statistical descriptive information, videos, news stories, etc., can contribute new dimensions to a sense of place.

Is our spatial sense enhanced? Our spatial sense of the diversity and vastness of the world is readily enhanced by these new resources. Our understanding of direction and proximity is likely a bit confused by the ability to rotate and rescale images. However, perhaps our sense of relative scale is improved by zooming.

Is spatial information more available/accessible? Access to and availability of geographic information has vastly improved. However, there remains plenty of room for more data and improved tools and displays.

Is the quality of available spatial information better? A chronic problem with digital spatial information is the absence of adequate metadata or descriptive text. Mapped data are often not dated, sources are not provided, legends lack adequate descriptions, and similar deficiencies abound. It is unclear if metadata standards will gradually be used more or if the proliferation of geographic information will continue to ignore them. But spatial data is often now collected with more accurate devices, such as GPS or satellites and as a consequence, is of higher quality.

Can we manipulate spatial information more readily? Absolutely yes and especially large quantities of data.

Is spatial information being put to effective new uses? Systems such as Google Earth facilitate new possibilities for geosynergy. The large suites of mapping tools, the increasing ease-of-use of GIS software, and geosynergy make spatial projects much more feasible for everyone. The enthusiastic public response to Google Earth and Internet mapping opportunities speaks for itself.

In summary, we are in a revolution speeding forward due to open access, creative people, and advanced technologies. The meaning of geographic literacy is changing while the opportunities and tools for geographic education and expression continue to grow. As a librarian, one of my greatest concerns is quality control for disseminated geographic information and this remains a very weak area. As a geographer and a librarian, I am thrilled by the immense new opportunities to access and use geographic information in both traditional and new ways.