

Macroscopes for Making Sense of Science *

Extended Abstract[†]

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ABSTRACT

Interactive data visualizations known as macroscopes have great potential as tools for exploring, understanding, and communicating science [1]. Macroscopes empower individuals to interact with data in order to better understand it from multiple perspectives. Joël de Rosnay [2] first introduced the concept of the macroscope in his 1979 book, *The Macroscope: A New World Scientific System*, where he describes macroscopes as tools “not used to make things larger or smaller, but to observe what is at once too great, too slow, and too complex for our eyes.” The Cyberinfrastructure for Network Science Center, in partnership with Indiana University’s Advanced Visualization Laboratory, developed a touchscreen kiosk to showcase the macroscopes in the international science mapping exhibit, *Places & Spaces: Mapping Science* [2].

The exhibit showcases best examples of visualization techniques from a range of disciplines in order to stimulate the development of new algorithms, workflows, and techniques for visualizing the fields of science, technology, and innovation. New exhibit pieces are selected with the input of an advisory board of prominent data visualization experts from both academia and industry.

The 2016 collection of interactive data visualizations showcases innovative examples of how to visualize large scientific data sets with user-friendly interfaces for interacting with data, developing new questions, and discovering new insights. It includes a diverse collection of interactive visualizations that draw on multiple types of data, ranging from geo-tagged social media posts to metadata from a digital library to citation counts and ship transponder data.

The first macroscope uses social media posts to map smells across 12 cities. Humans can differentiate thousands of different odors, yet city officials and urban planners deal only with the management of a few bad odors. In creating *Smelly Maps* [3, 4, 5, 6, 7, 8], University of Turin computer science professor Rossano ¹ Schifanella and Bell Labs researchers Luca Maria Aiello and Daniele Quercia teamed up to introduce a new stream of research that celebrates the complex aromas of our cities and makes it possible to use this information in urban design.

To map urban smellscape, the project team first created a lexicon of smell-related words. Then, they gathered geotagged social media posts from Flickr, Instagram, and Twitter that included smell-related words. Finally, smell information was mapped by street segment.

The second macroscope provides a visual approach to the vast digital collections of the HathiTrust Digital Library, a collective “elephant’s memory” or storehouse of knowledge. Run by a consortium of international research libraries, HathiTrust serves as a shared and growing repository for digital copies of more than 14 million publications that span 2000 years. Visualization software developer David Reagan, curator Lisel Record, and information scientist Katy Börner developed this visualization to provide access to the geographic and temporal diversity of the collection using freely available metadata.

Yellow circles show publication locations, with the size of the circle showing how many publications were printed in that location. Lines connect publication locations to places where that language

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is spoken, illustrating the connection between publication location and potential readers.

The third macroscope concerns itself with collaborative scientific research activity at the world's top institutions. While it may be simple to estimate which research institutions are at the top of their game, it is hard to create a statistical model to measure and map this. Lutz Bornmann, a sociologist of science at the Max Planck Society; Rüdiger Mutz, a Swiss researcher in social psychology and higher education; Moritz Stefaner, an independent data visualization expert; and Félix de Moya Anegón, senior researcher at SCImago, took up the challenge and created Excellence Networks [9, 10, 11].

This interactive web application shows how universities and other research institutions collaborate. Institutions in the SCImago Institutions Rankings were categorized by subject area. Each institution was then mapped in relation to its collaborators. The resulting networks show how successfully—in terms of citations—an institution has collaborated with others working in the same field.

Created by FleetMon, a company that provides live vessel tracking, the last macroscope animates a week of ship traffic on the seven seas as seen from space [12]. The movements of hundreds of thousands of vessels were captured using shore and satellite-based tracking data from FleetMon and its partner, Luxspace.

Many cargo ships, tankers, ferries, cruise ships, yachts, and tugs carry transponders that transmit their locations. That data is then made available to amateur ship spotters and maritime businesses alike through the interactive FleetMon Explorer tool. Using the tool, one can follow the flow of jet fuel and agricultural commodities around the globe, track a fleet of cruise ships in real time, or monitor traffic at ports around the world.

In sum, while much of what is phenomenal about these visualizations is hidden “under the hood,” and not immediately visible to a casual audience, advanced data mining techniques and algorithms are necessary in order to create these visualizations. Advanced computing provides the engines for such macroscopes, which in turn bring the power of computational research to scientists and policymakers who can then use large scale data sets to advance their areas of research or hone their expertise. This dramatically broadens the field of people who can use large scale data sets to develop new insights and facilitates scholarship in a variety of disciplines.

Advanced research computing pushes the boundaries in terms of working with large data sets and providing complicated linkages between the raw data and a meaningful interface. Additionally, insights from large scale data sets lay the foundation for advancing scientific disciplines on any number of fronts. The ability to understand and visualize large data sets makes new insights possible and inspires novel questions.

KEYWORDS

macroscope, data visualization, data set

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