Reproducibility in Scientometrics: Data Enclaves, Open Code, and Open Education

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Workshop on "Reproducible Scientometrics Research" at ISSI 2017 in Wuhan, China

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Reproducibility of Research: Issues and Proposed Remedies

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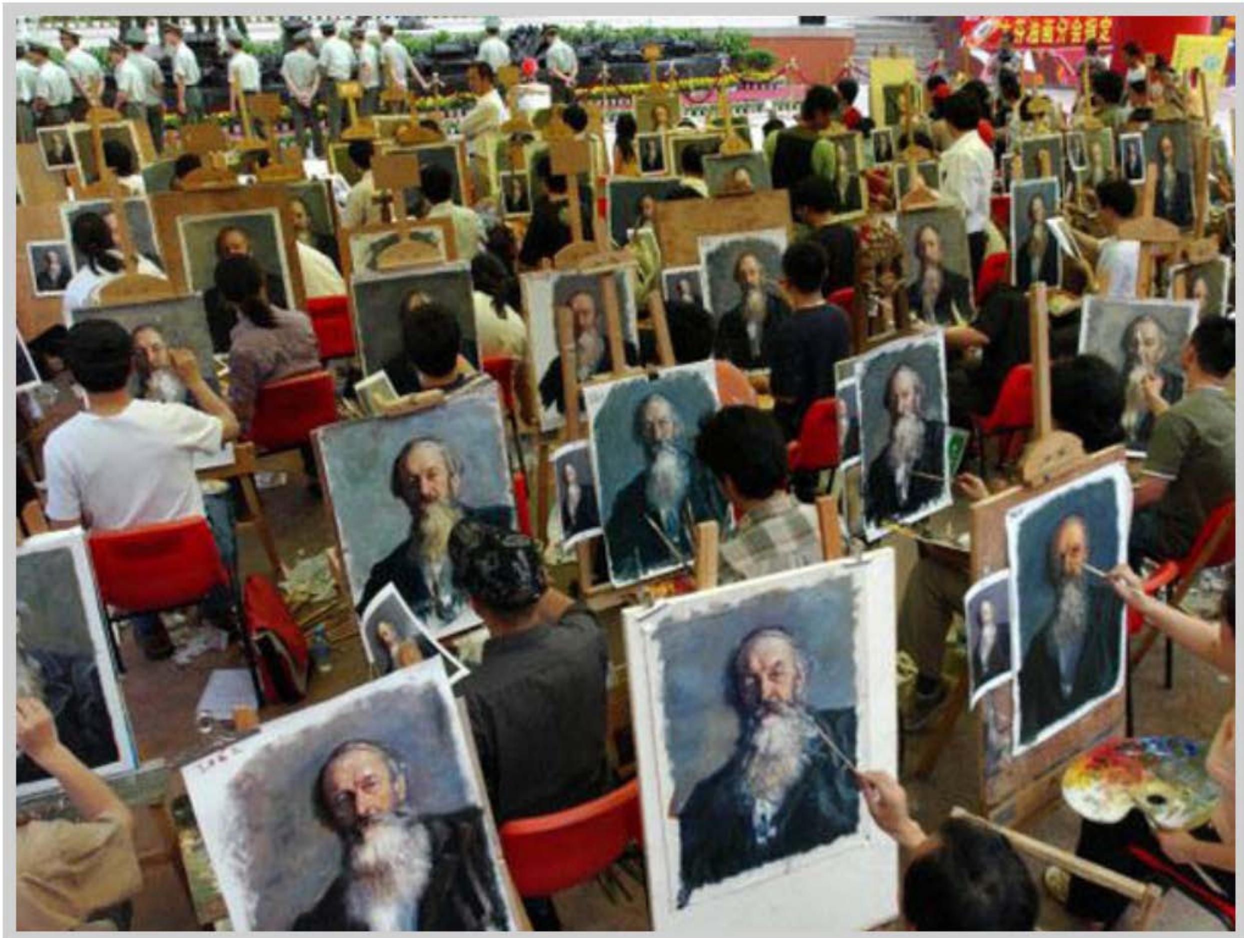

March 8-10, 2017; Washington, D.C.

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Scientific progress despite irreproducibility: A seeming paradox

Richard M. Shiffrin, Katy Borner, Stephen M. Stigler

(Submitted on 5 Oct 2017)

It appears paradoxical that science is producing outstanding new results and theories at a rapid rate at the same time that researchers are identifying serious problems in the practice of science that cause many reports to be irreproducible and invalid. Certainly the practice of science needs to be improved and scientists are now pursuing this goal. However, in this perspective we argue that this seeming paradox is not new, has always been part of the way science works, and likely will remain so. We first introduce the paradox. We then review a wide range of challenges that appear to make scientific success difficult. Next, we describe the factors that make science work-in the past, present, and presumably also in the future. We then suggest that remedies for the present practice of science need to be applied selectively so as not to slow progress, and illustrate with a few examples. We conclude with arguments that communication of science needs to emphasize not just problems but the enormous successes and benefits that science has brought and is now bringing to all elements of modern society.

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Data Enclaves http://cns.iu.edu/workshops/event/161114.html

Web of Science as a Research Dataset

Workshop web site features slides and links to relevant efforts

Date:

November 14-15, 2016

Meeting Place:

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Web of Science™ as a Research Dataset

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Introduction

The Clarivate Analytics Web of Science (WoS) has served as a research dataset for more than 9,000 scholarly articles in the past 15 years alone—across a wide a range of fields and disciplines from toxicology to computer science to economics. Scientists and scholars have been particularly interested in the WoS citation network, a massive graph containing billions of links that can proxy the structure and dynamics of not only scholarly communication, but knowledge diffusion, the evolution of fields, and the career lifecycles of individuals and institutions. To power these investigations, scholars are increasingly employing a number of compute-intensive methodologies, sophisticated big data infrastructures, and so called collaborative "discovery science" tools and techniques. Suddenly, in addition to deep, domain specific expertise, world-class computational knowhow appears to be a new prerequisite for analysis of scholarly data at the scale represented by WoS. While cloud-based computing and tools are more prevalent and accessible than ever before, harnessing these technologies remains both a challenge and opportunity for researchers and data providers (i.e., Clarivate Analytics and similar commercial data vendors and non-commercial aggregators). While the opportunities made possible by scholarly data at the size and scope of WoS for discovery and innovation are limited only by imagination, two general prospects come readily to mind. First, access to these data coupled with the appropriate computational and analytical capabilities opens up a wide range of funding and subsequent publishing opportunities in high impact venues. Second, data providers can pursue new business opportunities, including novel data access models, new types of analytic products, and new kinds of academic/industry partnerships. In this poster paper, we briefly explore 1) the new computational infrastructures that are being developed to enable collaborative research that leverages scholarly datasets such as WoS that are both big and proprietary; 2) some recent findings that have been made possible by these infrastructures; and, 3) new commercial offerings that have been enabled and demanded in response to increasing reliance on the WoS as a research dataset.

New Computational Infrastructures

Research leveraging big, scholarly datasets like WoS presents researchers with challenges related to the data's size, inherently relational format, and sensitive (proprietary) nature. To overcome these challenges, researchers have developed a new generation of enclave supported, high performance, and cloud-based, collaborative research environments that are both elastic enough to provide substantial computational resources when needed while remaining secure enough to protect data providers' commercial interests. Moreover, these environments have evolved to allow geographically distributed researchers to collaborate on research projects in the fast paced, iterative style that has come to dominate research in the era of Big Data—namely, "discovery science".

IUNI WoS Data Enclave

The Indiana University Network Science Institute (IUNI) acquired the complete set of Clarivate Analytics' Web of Science XML raw data (Web of Knowledge version 5). The data was parsed and stored in a well-documented Postgresql database, see entity-relationship diagram, database schema, and data dictionary on http://iuni.iu.edu/resources/web-of-science. The code used to parse the WoS XML format and to save data in the Postgresql database was made available freely on GitHub, see https://github.iu.edu/CNS/generic_parser. All data can be accessed via the IUNI WoS Data Enclave, a secure repository that uses IU's Karst high-throughput computing cluster designed to deliver large amounts of processing capacity over long periods of time. Access to the XML data and the PostgreSQL database is granted to a user's Karst account. IU faculty, staff, and qualifying sponsored affiliates can request accounts on Karst to use the data for academic research and without any sharing of data. A simple web browser based query interface to the WoS dataset was implemented to support custom queries for specific terms, journals, or authors. Datasets can be downloaded in CSV data format compatible with data mining and visualization tools such as Gephi or the Sci2 Tool (http://sci2.cns.iu.edu) (Sci2 Team, 2009). More about the IUNI WoS Data Enclave can be found at http://iuni.iu.edu/resources/web-of-science.

Cloud Kotta

One platform specifically developed with WoS in mind is Knowledge Lab's Cloud Kotta (CK). CK is a secure data enclave and analytics platform that serves the research needs of social sciences (Babuji 2016). By hosting CK in the Amazon Web Services cloud, the developers were able to take advantage of virtually limitless compute, cost-effective storage and the ability to implement a fine-grained security model ensuring the authorized collaborators could access both data and compute resources from anywhere in the world (Babuji 2016). Moreover, CK supports multiuser, rapid ideation and research iteration through a novel Python library that enables specific functions in an analysis code, written in a Jupyter Notebook to be seamlessly and securely submitted to the CK execution fabric (Babuji 2017). By allowing researchers to develop and share analysis code interactively over secure data like WoS, CK has removed the need for deep computational infrastructure expertise. The complete WoS XML dataset was ingested into a relational database housed in CK using a custom parser that has been made freely available on GitHub (see: https://github.com/alexander-belikov/wos_parser). The Cloud Kotta WoS database schema can be found on CK's documentation pages (see: http://docs.cloudkotta.org/dataguide/wos.html). More about Cloud Kotta can be found at http://docs.cloudkotta.org.

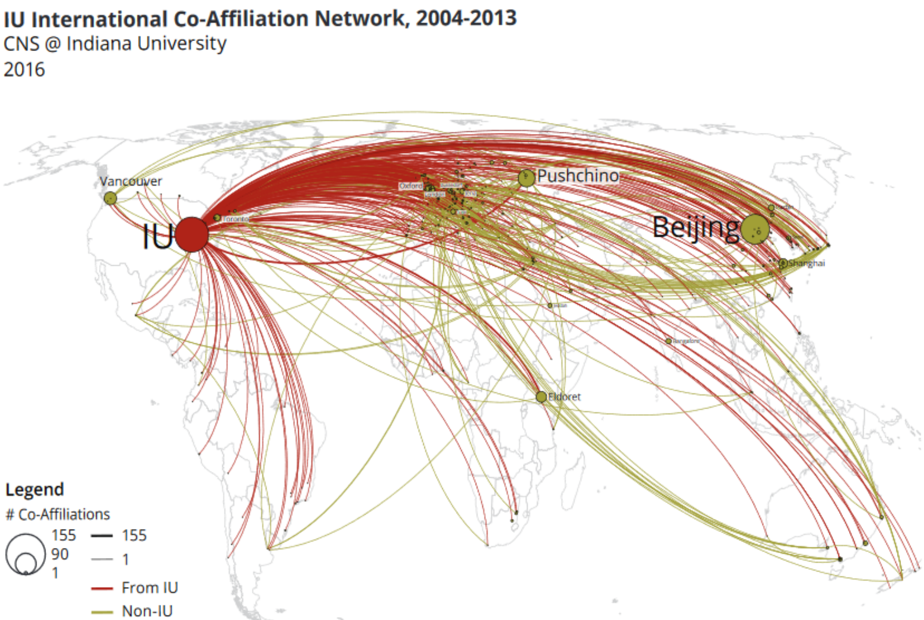

Figure 1. IU Co-Affiliation Network

New Computational Infrastructures

Fostering Global Collaboration

Among others, IU started to use the IUNI WoS data to understand existing and foster global research collaborations. The world map in Figure 1 shows the co-affiliations of authors that listed "Indiana Univ" and at least one other non-U.S. institution as affiliation on 1,590 scholarly papers published in 2004-2013. There are 344 affiliation locations (not counting IU) and 641 co-affiliation links. Nodes denote author locations and are area size coded by degree with the exception of IU, which has 1,592 co-affiliation links. Links denote co-affiliations, e.g., an author with three affiliations IU, X, Y will add three links; the two links that connect IU with X and Y are drawn in red while the link between X and Y is given in green. Links are size coded by the number of co-affiliations with the top-three being Beijing, China (155), Eldoret, Kenya (115), and Pushchino, Russia (90).

Impact vs. Disruptiveness

Researchers at the University of Chicago's Knowledge Lab and Northwestern University's NICO have used WoS data going back to 1900 to study the relationship between team size and impact and the relationship between team size and disruptiveness. This work, currently under review, finds striking differences between the scientific output of large and small teams. Looking across all fields represented in WoS, small teams are shown to disrupt science, patents, and software with new ideas and opportunities, while large teams contribute to existing ones. Figure 2 shows the relationship between impact and disruptiveness of articles (left panel) indexed by WoS, patents (middle), and software (right). In all three spaces, there is a strong, inverse relationship between citations and disruptiveness as team size increases.

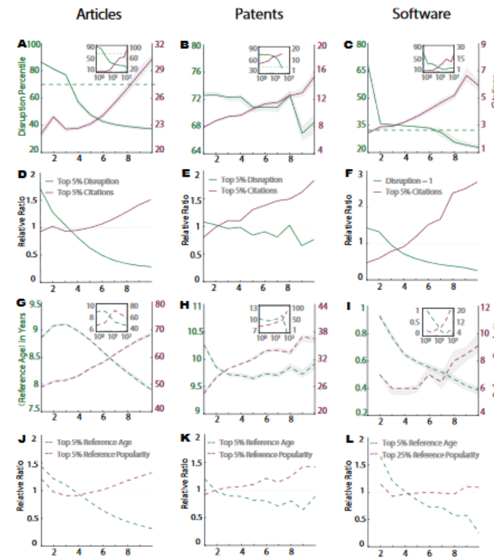

Figure 2. Tracing Inventive Teams

New Commercial Offerings

The value of the Web of Science as a search and discovery tool is well established at thousands of research institutions worldwide. But the commercial opportunities for the use of its high-quality metadata outside of the platform for big data studies are still emerging. When researchers need to study broad-scale trends in science, technology, and innovation, they very often turn to the Web of Science as the most comprehensive citation source to provide over 100 years of consistent, global publication data. Increasingly, user requests for this data take the form of custom reports, curated data sub-sets, and large-scale raw XML delivery. Clarivate Analytics is actively looking at compelling ways to meet these customer demands with new commercial products and data delivery choices. These options must balance scale and ease of use, with security and control over access to the proprietary WoS data. The lessons learned in the development of Cloud Kotta and IUNI WoS Data Enclave will very likely be instructive here, as they have proven their utility and leverage a mix of custom code built on proven commercial cloud services. Both self-service data access and secure use of analytical tools in a cloud "sandbox" seem like attractive features of the environments that could make commercial sense to meet the evolving expectation of Web of Science customers.

Acknowledgements

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Poster at ISSI 2017, http://cns.iu.edu/docs/publications/2017-borner-ISSI.pdf

Data Enclave at IU   http://iuni.iu.edu/resources/web-of-science

Web of Science

The IUNI Science of Science Hub acquired the complete set of Thomson Reuters' Web of Science XML raw data (Web of Knowledge version 5). This data can be used by any employee of Indiana University for academic research and without any sharing of data. Data details and information on how to access the data are given below.

Data Details

1. WOK XML ONE TIME DELIVERY: Science Citation Index Expanded from 1900-2013
2. WOK XML ONE TIME DELIVERY: Social Sciences Citation Index from 1900-2013
3. WOK XML ONE TIME DELIVERY: Arts &Humanities Citation Index from 1975-2013
4. WOK XML ONE TIME DELIVERY: Book Citation Index -- Science from 2005-2013
5. WOK XML ONE TIME DELIVERY: Book Citation Index -- Social Sciences & Humanities from 2005-2013
6. WOK XML ONE TIME DELIVERY: Conference Proceedings Citation Index -- Science & Technical from 1990-2013

Documentation

- Entity Relationship Diagram (pdf)
- Web of Knowledge Schemas (pdf)
- Data Dictionary (pdf)
- Web of Knowledge User Guide (pdf)

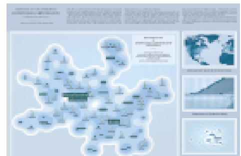
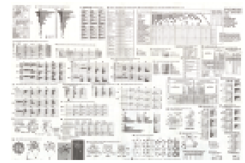
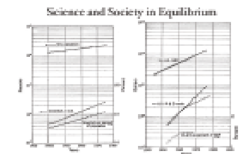
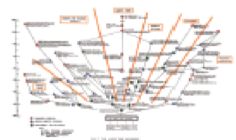
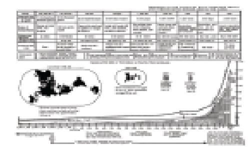
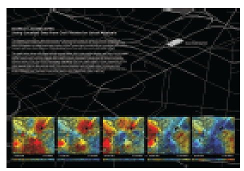
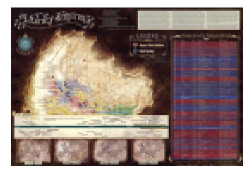
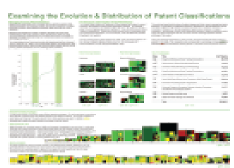
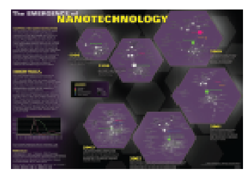
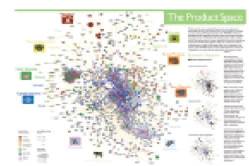
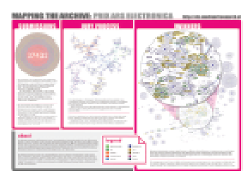
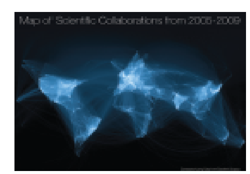
Data Access

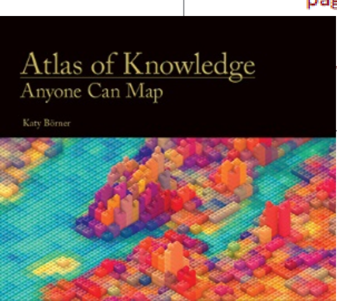
The data can be accessed as RAW XML data or in a Postgresql database via a Karst Data Enclave. Custom datasets can be requested in standard data formats (.csv, .net).
To request data access, please complete the IUNI Web of Science Data (WoS) Access Request Form

Open Code

http://sci2.cns.iu.edu

Tasks

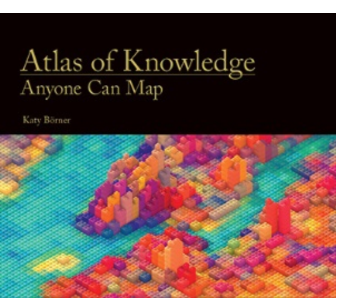
TYPES \ LEVELS	MICRO: Individual Level about 1–1,000 records page 6	MESO: Local Level about 1,001–100,000 records page 8	MACRO: Global Level more than 100,000 records page 10
Statistical Analysis page 44	 Knowledge Cartography page 135	 Productivity of Russian life sciences research teams page 105	 Number of scientists versus population and R&D costs versus GNP. page 103
WHEN: Temporal Analysis page 48	 Visualizing decision-making processes page 95	 Key events in the development of the video tape recorder page 85	 Increased travel and communication speeds page 83
WHERE: Geospatial Analysis page 52	 Cell phone usage in Milan, Italy page 109	 Victorian poetry in Europe page 137	 Ecological footprint of countries page 99
WHAT: Topical Analysis page 56	 Evolving patent holdings of Apple Computer, Inc. and Jerome Lemelson page 89	 Evolving journal networks in nanotechnology page 139	 Product space showing co-export patterns of countries page 93
WITH WHOM: Network Analysis page 60	 World Finance Corporation network page 87	 Electronic and new media art networks page 133	 World-wide scholarly collaboration networks page 157



See *Atlas of Science: Anyone Can Map*, page 5

Visualization Framework

Insight Need Types page 26	Data Scale Types page 28	Visualization Types page 30	Graphic Symbol Types page 32	Graphic Variable Types page 34	Interaction Types page 26
• categorize/cluster • order/rank/sort • distributions (also outliers, gaps) • comparisons • trends (process and time) • geospatial • compositions (also of text) • correlations/relationships	• nominal • ordinal • interval • ratio	• table • chart • graph • map • network layout	• geometric symbols point line area surface volume • linguistic symbols text numerals punctuation marks • pictorial symbols images icons statistical glyphs	• spatial position • retinal form color optics motion	• overview • zoom • search and locate • filter • details-on-demand • history • extract • link and brush • projection • distortion



See *Atlas of Science: Anyone Can Map*, page 24

Visualization Framework

Basic Task Types								
Bertin, 1967	**Wehrend & Lewis, 1996**	**Few, 2004**	**Yau, 2011**	**Rendgen & Wiedemann, 2012**	**Frankel, 2012**	**Tool: Many Eyes**	**Tool: Chart Chooser**	**Börner, 2014**
selection	categorize			category				categorize/ cluster
order	rank	ranking					table	order/rank/ sort
	distribution	distribution					distribution	distributions (also outliers, gaps)
	compare	nominal comparison & deviation	differences		compare and contrast	compare data values	comparison	comparisons
		time series	patterns over time	time	process and time	track rises and falls over time	trend	trends (process and time)
		geospatial	spatial relations	location		generate maps		geospatial
quantity		part-to-whole	proportions		form and structure	see parts of whole, analyze text	composition	compositions (also of text)
association	correlate	correlation	relationships	hierarchy		relations between data points	relationship	correlations/ relationships

Visualization Framework

Insight Need Types page 26	Data Scale Types page 28	Visualization Types page 30	Graphic Symbol Types page 32	Graphic Variable Types page 34	Interaction Types page 26
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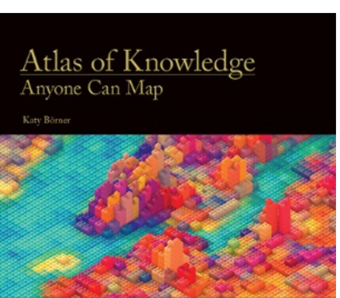
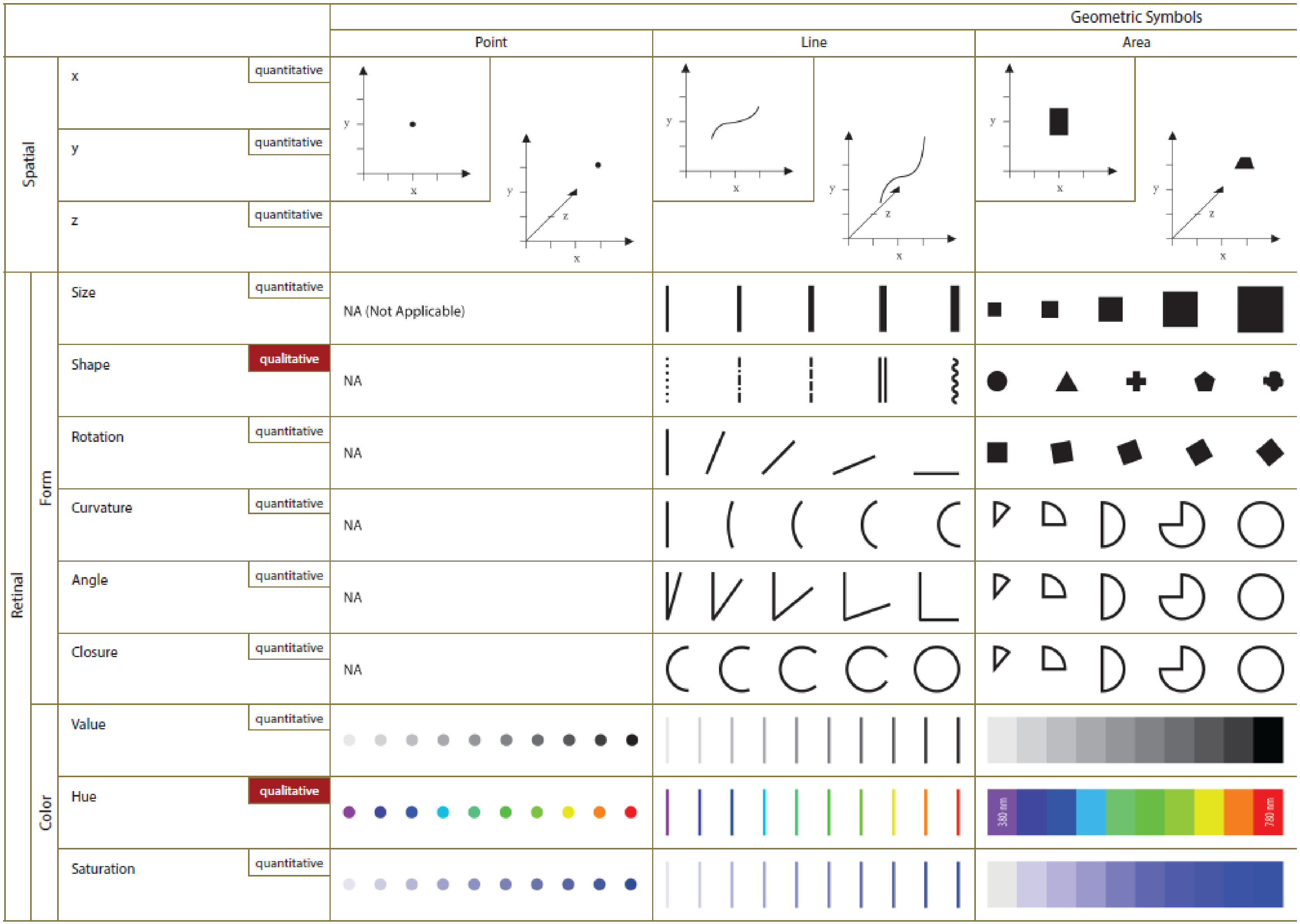
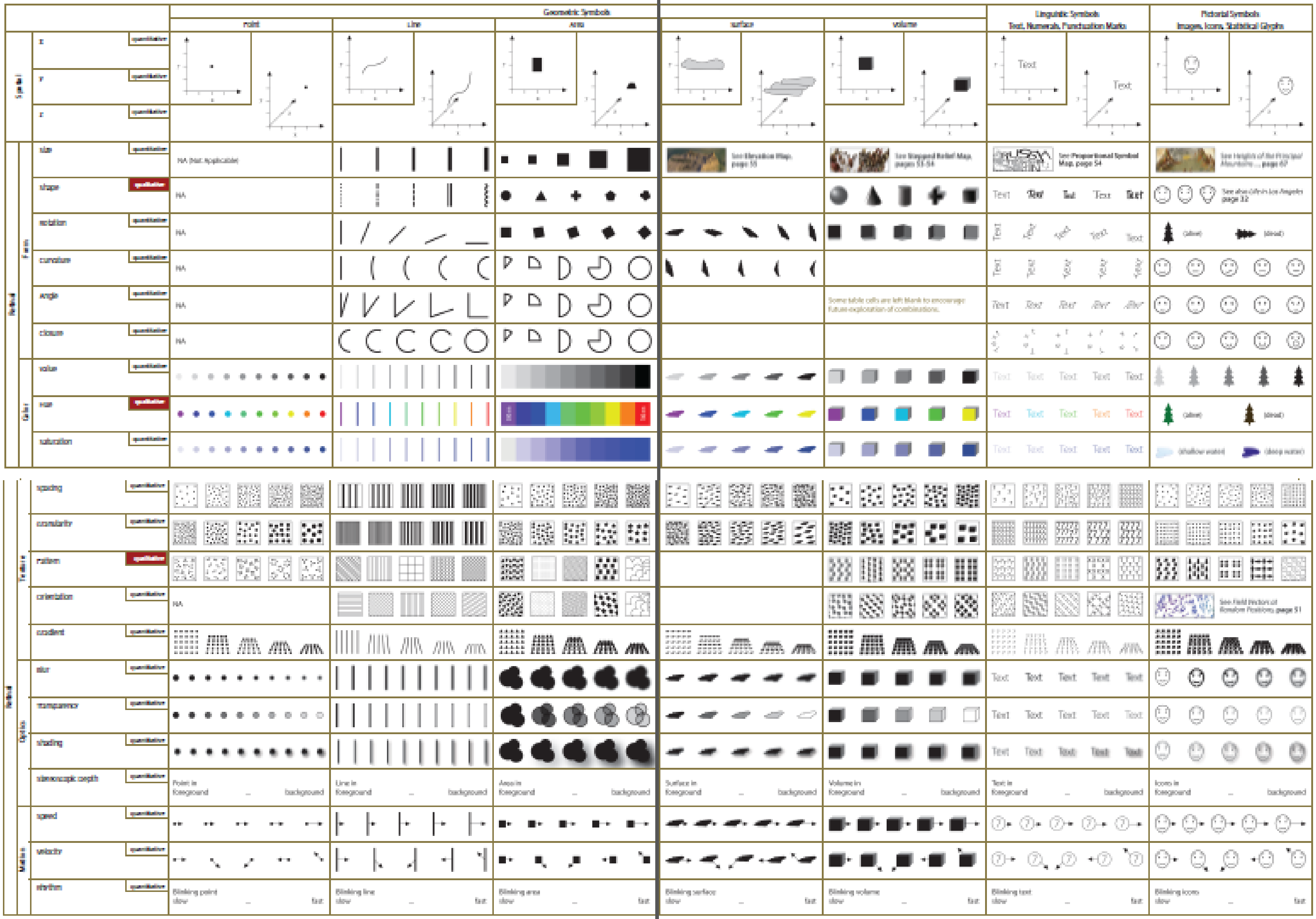


See *Atlas of Science: Anyone Can Map*, page 24

Graphic Variable Types Versus Graphic Symbol Types



Graphic Variable Types Versus Graphic Symbol Types



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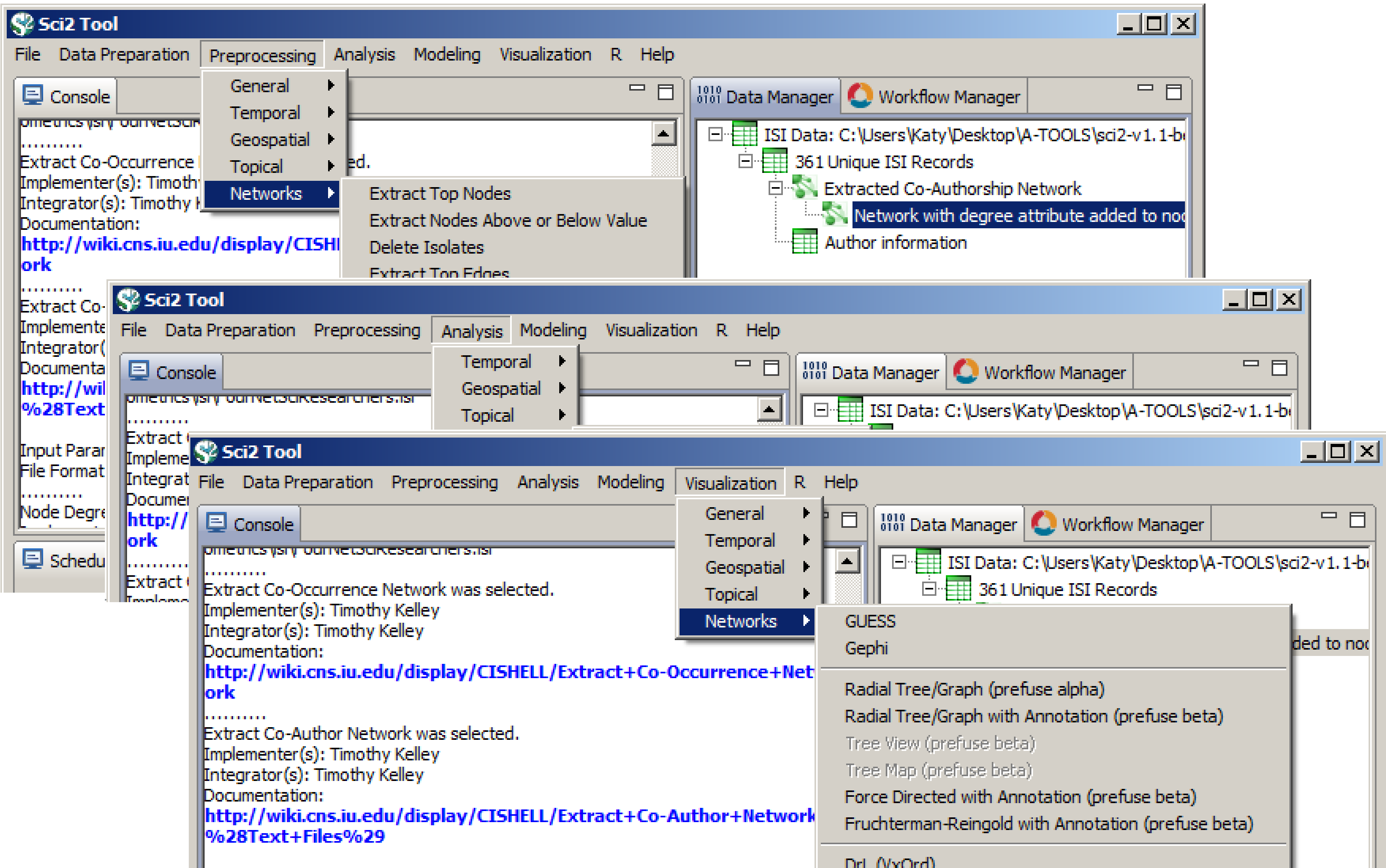

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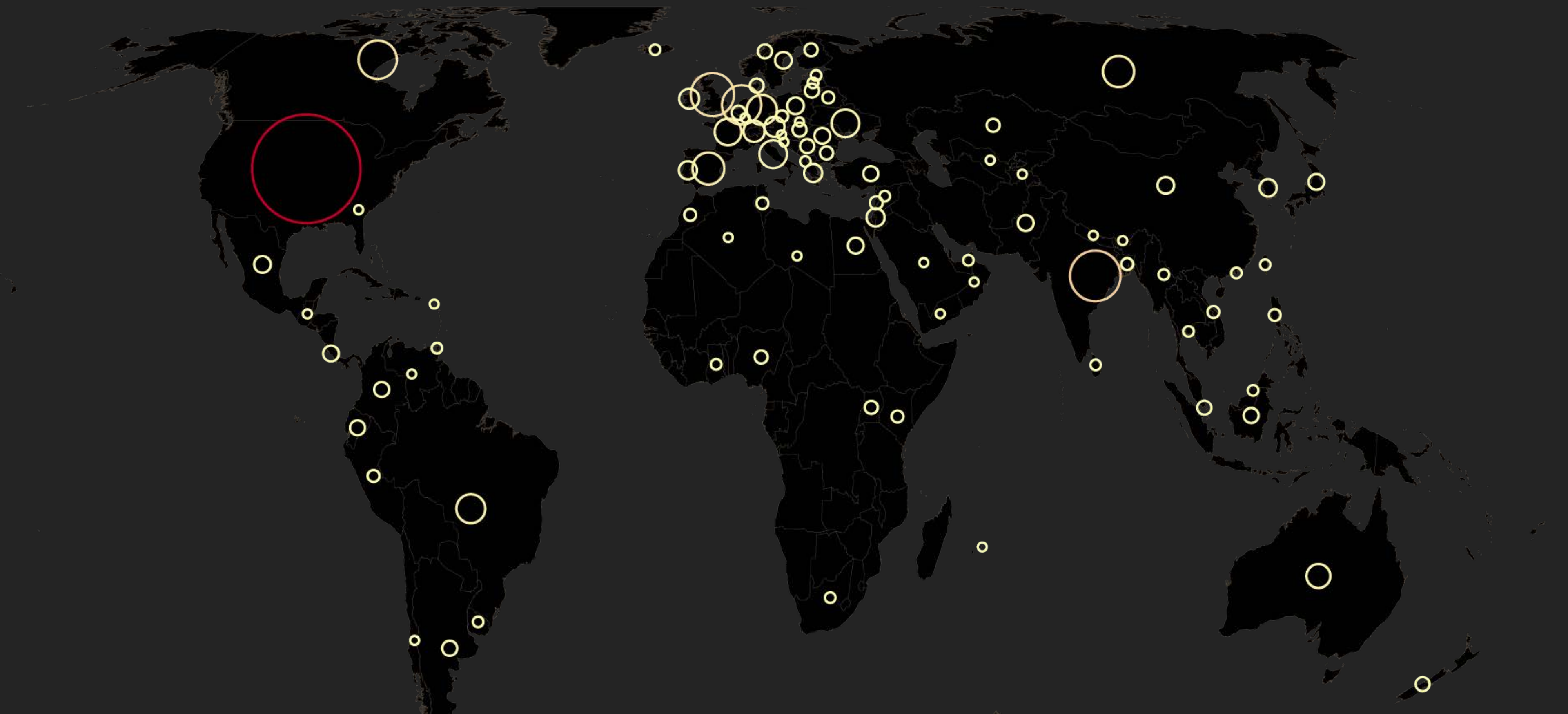
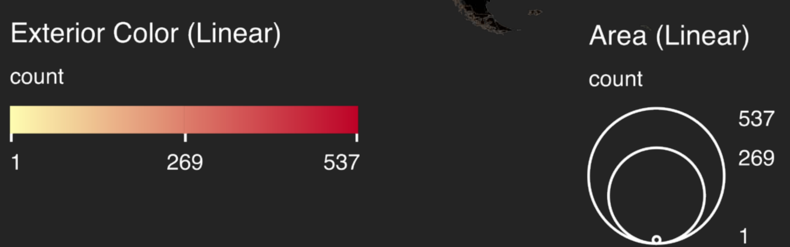
The Information Visualization MOOC

ivmooc.cns.iu.edu





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