

Atlas of Knowledge: Anyone Can Map

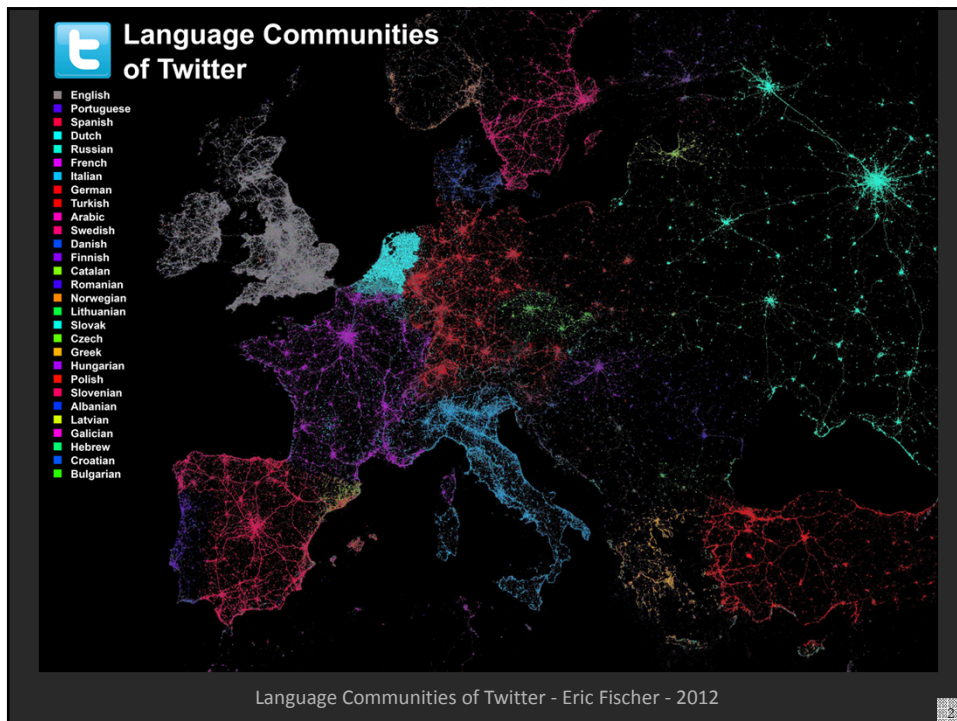
Katy Börner

Victor H. Yngve Professor of Information Science
Director, Cyberinfrastructure for Network Science Center
School of Informatics and Computing, Indiana University, USA

Mundaneum Online Art Talk
4pm CET April 22, 2015

Followed by a conversation with specialists
Dr. Andrea Scharnhorst (KNAW-DANS, The Netherlands) and Almila Akdag (KNAW-DANS, The Netherlands; UCLA, USA)

Language Communities of Twitter - Eric Fischer - 2012



Map of Scientific Collaborations from 2005-2009



Computed Using Data from Elsevier's Scopus

Olivier H. Beauchesne, 2011. Map of Scientific Collaborations from 2005-2009.

LEGEND



CLICKSTREAM MAP OF SCIENCE

This is the first map created from large-scale, world-wide, scholarly usage data. It visualizes the collective flow of scientists' movements from one journal to another in their online navigation behavior.

The MESOR project (www.mesor.org) collected a database of nearly 1 billion user requests received by the web portals of some of the world's most significant publishers, aggregators and large scholarly publishers, among them Thomson Scientific (Web of Science), Elsevier (Scopus), JSTOR, Inspec, University of Texas (2 campuses), Health Publications, and California State University (23 campuses). All usage logs acquired by the project reflect content-render requests that identify the individual publications of individual scientists navigating from one article to the next.

Pairs of journals are connected when they have a high probability of being followed by each other in users' clickstreams. The circles represent individual journals. A line between two circles indicates that they are strongly connected in their direction. The colors indicate the scientific domain a journal belongs to according to their Dewey Decimal and JCR classification codes that were mapped into the Query Research Center's Arts and Architecture, Sciences (AAS) to allow classification at various levels of detail. The size of circles corresponds to the strength (degree centrality) of a journal's connections in the map. The map is brought by the Fruchterman layout algorithm that treats connections like springs, connected nodes are even tighter, but they are not allowed to get too close.

This map is divided from color, size and therefore also reflects the actors of those who read the journals for career publication, practitioners and researchers. As a broad practitioner-driven domain such as nursing, social work, and human studies are a primary interest. The same is accurate in the social sciences and humanities emerge as two distinct clusters that are connected via various topics to practitioners in any domain. Most domains are highly interdisciplinary, but this is more so the case for the social sciences and humanities. Surprisingly, mathematics and computer science are not represented in one specific cluster, but spread out through the map.

Like citation maps, this map is based upon a particular sample of the scientific community, albeit one that includes interdisciplinary scientists and practitioners and a much greater sample of publications. From MEDLINE data of 1980s and 90s, we created a matrix of 6 million connections between approximately 100,000 journals. From that matrix we selected only 50,000 connections with the highest number of observations, ranging from approximately 400 to 170 observations. This based 4 connections pertained to the 2,307 most used journals. This procedure may introduce a bias towards interdisciplinary connections. The map should therefore be considered as a map of scientific activity, but as is shown by the flexibility of tracking scientific activity from usage data, the type of methodology still provides unique insights into the real time structure of scientific activity as it can be observed from scholarly consumption.

When we cut the AAT taxonomy of the top level, only two domains remain: natural sciences (blue) and social sciences and humanities (yellow/red). Some journals along the boundary of the above-mentioned domains (green) tend to not correspond to their location in the map. This indicates either that particular journal is highly interdisciplinary sector has been assigned a classification that does not correspond to how scholars actually use the publication or that it is a journal that is not in the top level of the AAT taxonomy.

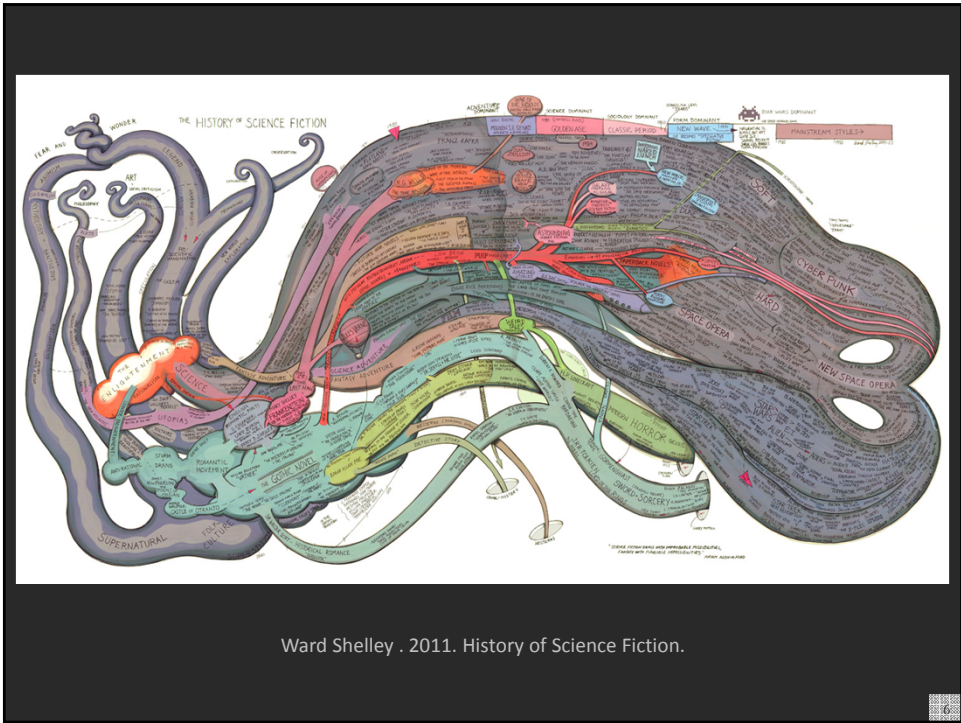
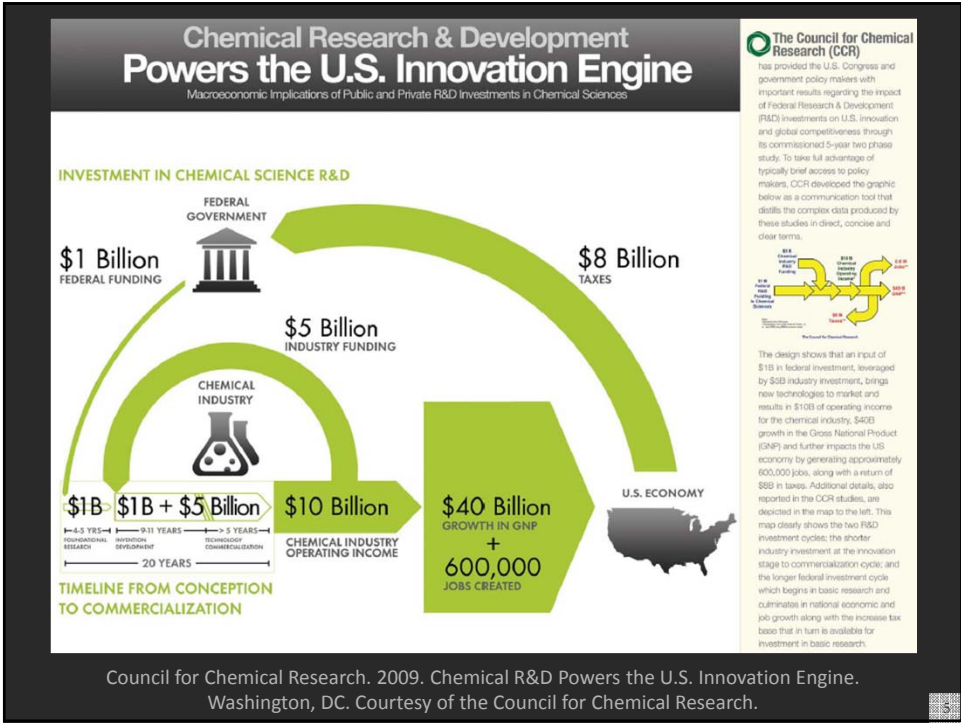
DATA 03/01/08 - 02/01/07

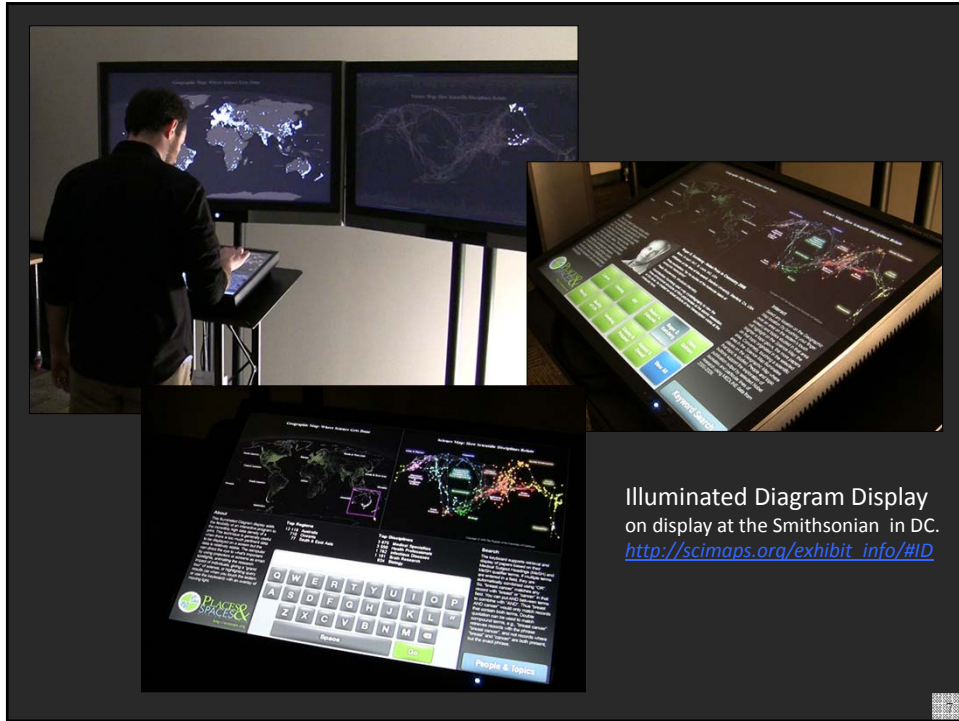
356,000,000	user requests
6,700,000	connections from raw data
97,632	articles in raw data
50,000	top connections for map (p=177)
2,307	journals for map

More information on this map can be found in Bollen, J., Van de Sompel, H., Hagberg, L., Bettencourt, L., Chute, R., Rodriguez, M.A. and Balakireva, L. (2009) Clickstream Data Yields High-Resolution Maps of Science. *PLoS ONE* 4(5), e6003. doi:10.1371/journal.pone.0050433 (freely available online)

Design credit to: Armin D. Christ

Bollen, Johan, Herbert Van de Sompel, Aric Hagberg, Luis M.A. Bettencourt, Ryan Chute, Marko A. Rodriguez, Lyudmila Balakireva. 2008. A Clickstream Map of Science.





Geographic Map: Where Science Gets Done

Science Map: How Scientific Disciplines Relate

About

This illuminated diagram display adds the flexibility of an interactive program to the incredibly high data density of a print. This technique is generally useful when there is too much pertinent data to be displayed on a screen but the data is relatively stable. The computer can direct the eye to what's important by using projectors or screens as smart spotlights, animating the research impact of individuals, giving a "grand tour" of science, or highlighting query results (as when you touch the lectern or use the keyboard) with an overlay of moving light.

<http://scimaps.org>

Top Five Continents

- North America - 4,000 records
- South & East Asia - 3,589
- Australia - 2,421
- Africa - 2,208
- South America - 1,562

Top Five Scientific Disciplines

- Math & Physics - 4,000 records
- Health Professionals - 3,589
- Social Sciences - 2,431
- Aeronautical, Chemical, Mechanical & Civil Engineering - 2,208
- Humanities - 1,562

Input your search query here.

Go

Search

The keyboard supports retrieval and display of papers based on their Medical Subject Headings (MeSH) and MeSH qualifier terms. If multiple terms are entered in a field, they are automatically combined using "OR". So, "breast cancer" matches any record with "breast" or "cancer" in that field. You can put AND between terms to combine with "AND". Thus "breast AND cancer" would only match records that contain both terms. Double quotation can be used to match compound terms, e.g., "breast cancer" retrieves records with the phrase "breast cancer", and not records where "breast" and "cancer" are both present, but the exact phrase.

People & Topics

Geographic Map: Where Science Gets Done

Science Map: How Scientific Disciplines Relate

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Elinor Ostrom - Nobel Prize in Economic Sciences 2009

Born: 7 August 1933, New York, NY, USA

Affiliation at the time of the award: Indiana University, Bloomington, IN, USA, Arizona State University, Tempe, AZ, USA

Prize motivation: "for her analysis of economic governance, especially the commons"

Field: Economic governance

Contribution: Challenged the conventional wisdom by demonstrating how local property can be successfully managed by local commons without any regulation by central authorities or privatization.

Interact

Select any location on the Geographic Map location (by bushing your finger over an area on the lectern's touch screen) and topics studied in that area will highlight on the Science Map: the brighter a topic glows, the more papers on that topic originated in the selected area. Conversely, touching a scientific area in the Science Map illuminates places on the Geographic Map where that topic is studied. People and topic buttons support the exploration of publication output by selected Noble laureates and particular lines of research using MEDLINE data from 2000-2009.

Cancer	Cloning	HIV	Robert G. Edwards	Roger D. Kornberg	Elinor Ostrom
Obesity	Quality of Life	Smoking	Stanley B. Prusiner	Ahmed H. Zewail	View All

Keyword Search

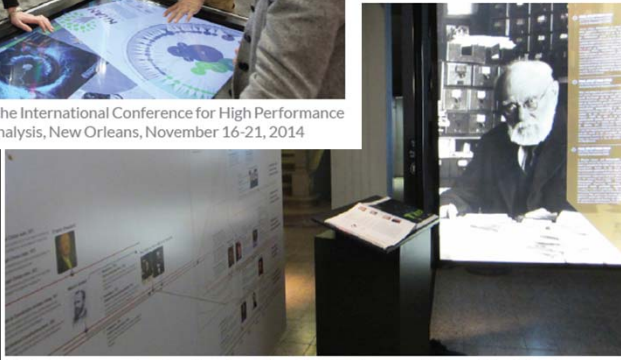
<http://scimaps.org>

Mapping Science Exhibit on display at MEDIA X, Stanford University

<http://mediax.stanford.edu>, <http://scaleindependentthought.typepad.com/photos/scimaps>



Places & Spaces maps on a touch table at the International Conference for High Performance Computing, Networking, Storage, and Analysis, New Orleans, November 16-21, 2014



Visionary approaches timeline from the Atlas of Science on display at the Mundaneum Museum, Mons, Belgium

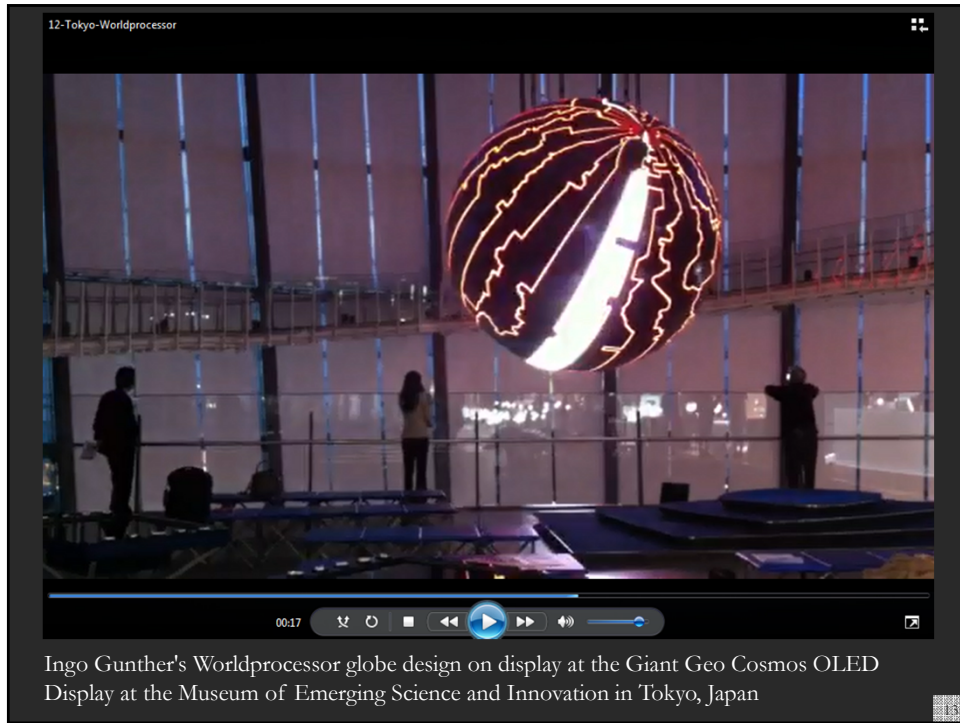


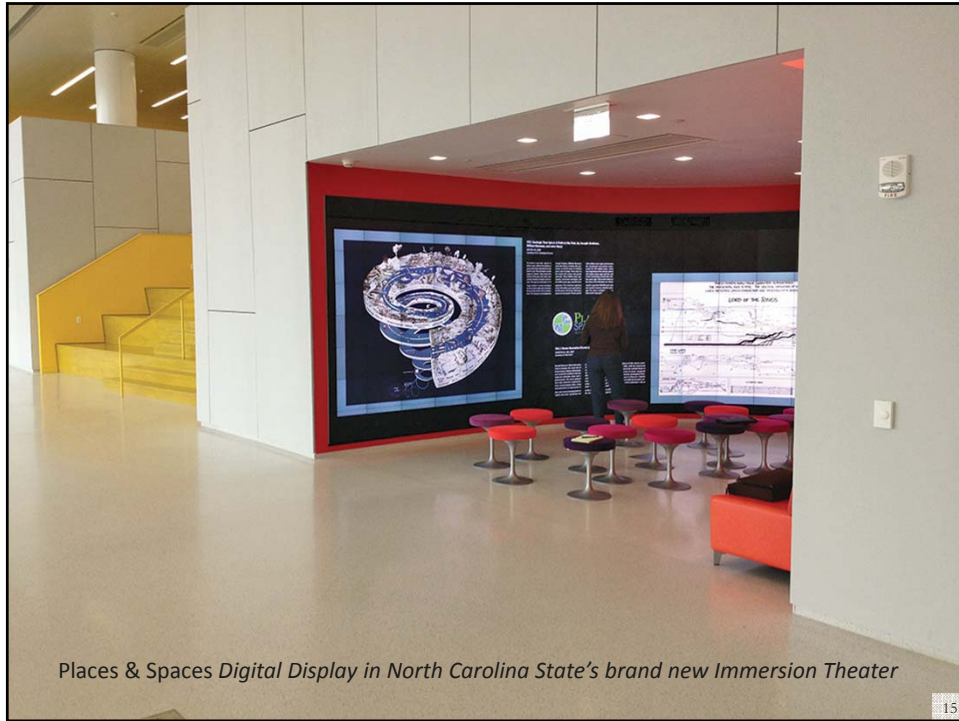
Katy Börner and Norbert Heber attend a screening of *Humanexus* at the Festival de Cannes, Cannes, France, May 20, 2014



International Science & Creativity Conference, Seoul, Republic of Korea, December 3-7







Places & Spaces: Mapping Science Exhibit

<http://scimaps.org>

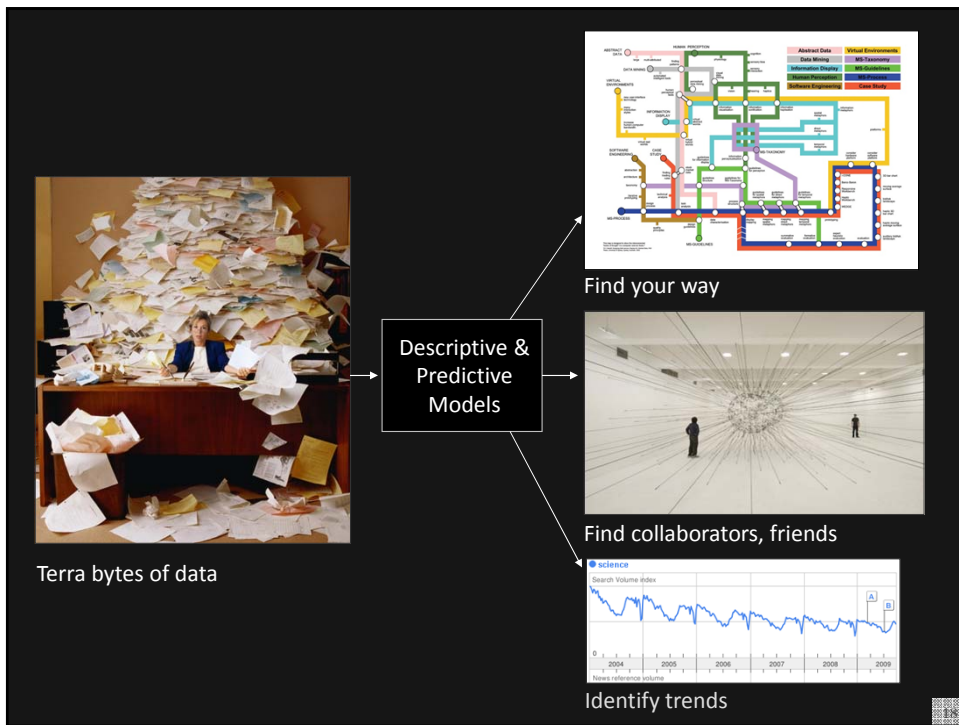


Maps are available for sale and the exhibit can be hosted by anyone.



Empowering Anyone to Visualize STI

The Information Visualization MOOC



Information Visualization MOOC 2015



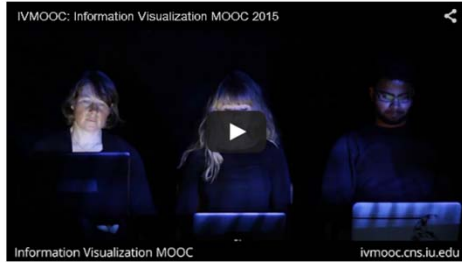
Overview

This course provides an overview about the state of the art in information visualization. It teaches the process of producing effective visualizations that take the needs of users into account.

The course can be taken for three Indiana University credits as part of the [Online Data Science Program](#), as part of the Information and Library Science M.S. program, and as part of the online Data Science M.S. Program offered by the School of Informatics and Computing. Students seeking enrollment information should contact Rhonda Spencer at 812-855-2018, ilsmain@indiana.edu or datasci@indiana.edu.

Among other topics, the course covers:

- Data analysis algorithms that enable extraction of patterns and trends in data
- Major temporal, geospatial, topical, and network visualization techniques
- Discussions of systems that drive research and development.



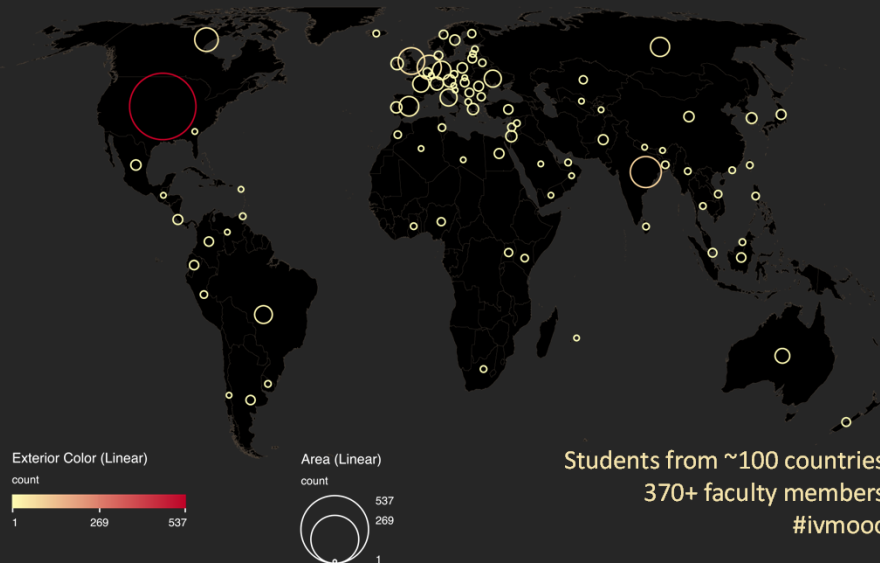
[Register for Course](#)

Already registered? [Click here to go to the course.](#)
Forgot your password? [Click here to reset it.](#)

Register for free at <http://ivmooc.cns.iu.edu>. Class restarted in January 13, 2015.

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The Information Visualization MOOC ivmooc.cns.iu.edu



Course Schedule

Part 1: Theory and Hands-On

- **Session 1** – Workflow Design and Visualization Framework
- **Session 2** – “When:” Temporal Data
- **Session 3** – “Where:” Geospatial Data
- **Session 4** – “What:” Topical Data

Mid-Term

- **Session 5** – “With Whom:” Trees
- **Session 6** – “With Whom:” Networks
- **Session 7** – Dynamic Visualizations and Deployment

Final Exam

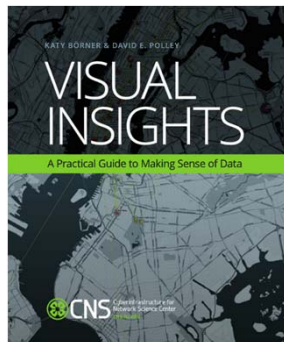
Part 2: Students work in teams on client projects.

Final grade is based on Class Participation (10%), Midterm (30%), Final Exam (30%), and Client Project(30%).



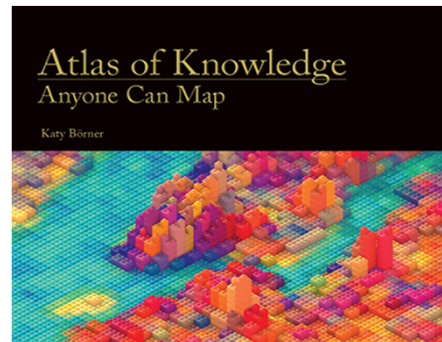
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Books Used in the IVMOOC



Teaches timely knowledge:

Advanced algorithms, tools, and hands-on workflows.



Teaches timeless knowledge:

Visualization framework—exemplified using generic visualization examples and pioneering visualizations.

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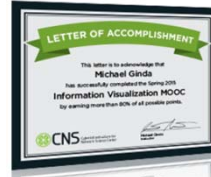
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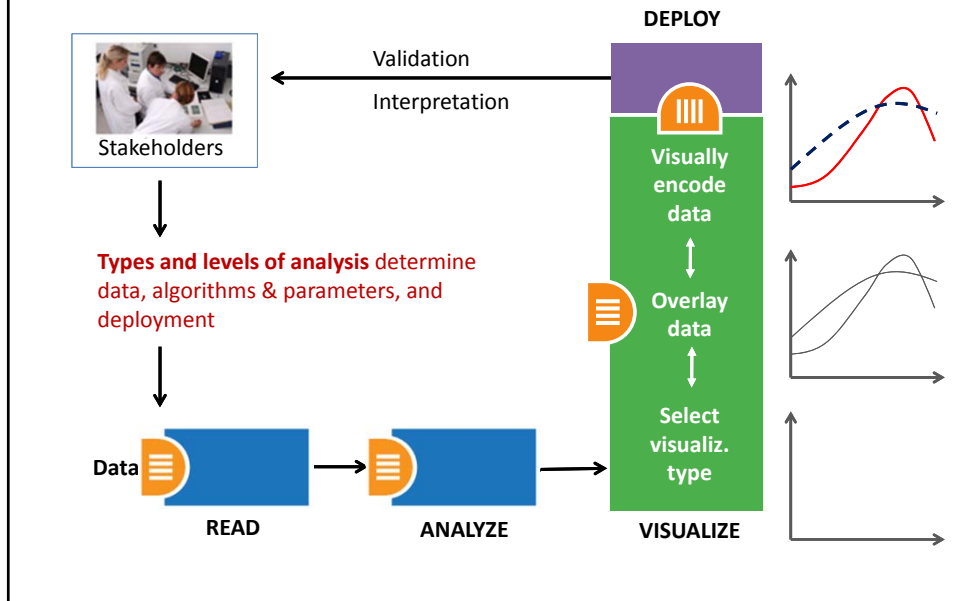
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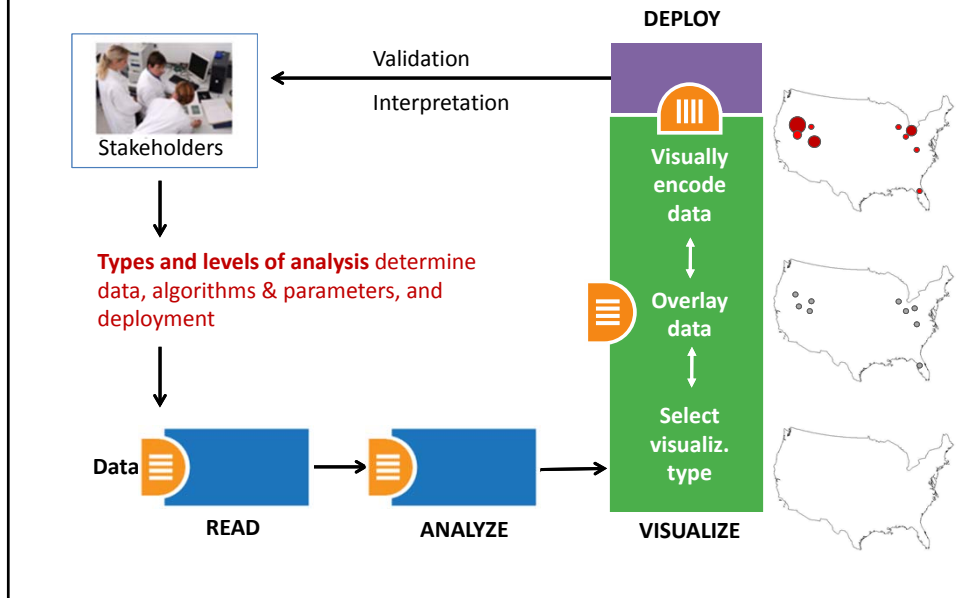


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Needs-Driven Workflow Design



Needs-Driven Workflow Design



Load **One** File and Run **Many** Analyses and Visualizations

Times Cited	Publication Year	City of Publisher	Country	Journal Title (Full)	Title	Subject Category	Authors
12	2011	NEW YORK	USA	COMMUNICATIONS OF THE ACM	Plug-and-Play Macroscopes	Computer Science	Borner, K
18	2010	MALDEN	USA	CTS-CLINICAL AND TRANSLATIONAL SCIENCE	Advancing the Science of Team Science	Research & Experimental Medicine	Falk-Krzesinski, HJ Borner, K Contractor, NJ Fiore, SM Hall, KL Keyton, JS Spring, B Stokols, D Trochim, W Uzzi, B
13	2010	WASHINGTON	USA	SCIENCE TRANSLATIONAL MEDICINE	A Multi-Level Systems Perspective for the Science of Team Science	Cell Biology Research & Experimental Medicine	Borner, K Contractor, NJ Falk-Krzesinski, HJ Fiore, SM Hall, KL Keyton, JS Spring, B Stokols, D Trochim, W Uzzi, B

Statistical Analysis--p. 44

Location	Count	# Citations
Netherlands	13	292
United States	9	318
Germany	11	36
United Kingdom	1	2

Temporal Burst Analysis--p. 48



Geospatial Analysis--p. 52



Geospatial Analysis--p. 52

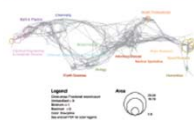


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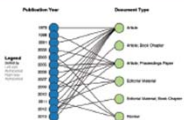
Topical Analysis--p. 56



Paper Citation Network--p. 60



Bi-Modal Network--p. 60



Co-author and many other bi-modal networks.

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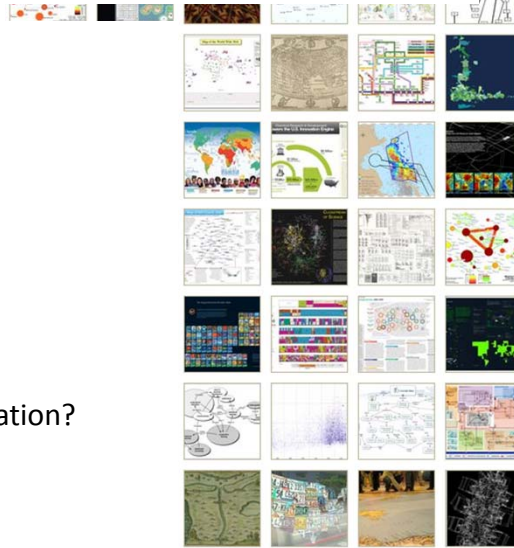
Visualization Frameworks



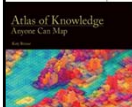
How to Classify Different Visualizations?

By

- User insight needs?
- User task types?
- Data to be visualized?
- Data transformation?
- Visualization technique?
- Visual mapping transformation?
- Interaction techniques?
- Or ?




Tasks	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
TYPES			
Statistical Analysis page 44		Productivity of Russian life sciences research teams page 105	Number of scientists versus population and R&D costs versus country page 105
WHEN: Temporal Analysis page 48	Visualizing decision-making processes page 95	Key events in the development of the video tape recorder page 95	Increased travel and communication speeds page 83
WHERE: Geospatial Analysis page 52	Cell phone usage in Milan, Italy page 100	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 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 page 5

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
<ul style="list-style-type: none"> • categorize/cluster • order/rank/sort • distributions (also outliers, gaps) • comparisons • trends (process and time) • geospatial • compositions (also of text) • correlations/relationships 	<ul style="list-style-type: none"> • nominal • ordinal • interval • ratio 	<ul style="list-style-type: none"> • table • chart • graph • map • network layout 	<ul style="list-style-type: none"> • geometric symbols <ul style="list-style-type: none"> point line area surface volume • linguistic symbols <ul style="list-style-type: none"> text numerals punctuation marks • pictorial symbols <ul style="list-style-type: none"> images icons statistical glyphs 	<ul style="list-style-type: none"> • spatial <ul style="list-style-type: none"> position • retinal <ul style="list-style-type: none"> form color optics motion 	<ul style="list-style-type: none"> • overview • zoom • search and locate • filter • details-on-demand • history • extract • link and brush • projection • distortion



See page 24

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



See page 26

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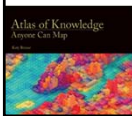
Atlas of Knowledge
Know-Can-Map
See page 24

Visualization Types (Reference Systems)

- 1. Charts:** No reference system—e.g., Wordle.com, pie charts
- 2. Tables:** Categorical axes that can be selected, reordered; cells can be color coded and might contain proportional symbols. Special kind of graph.
- 3. Graphs:** Quantitative or qualitative (categorical) axes. Timelines, bar graphs, scatter plots.
- 4. Geospatial maps:** Use latitude and longitude reference system. World or city maps.
- 5. Network layouts:** Node position might depends on node attributes or node similarity. **Trees:** hierarchies, taxonomies, genealogies. **Networks:** social networks, migration flows.

Types

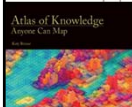
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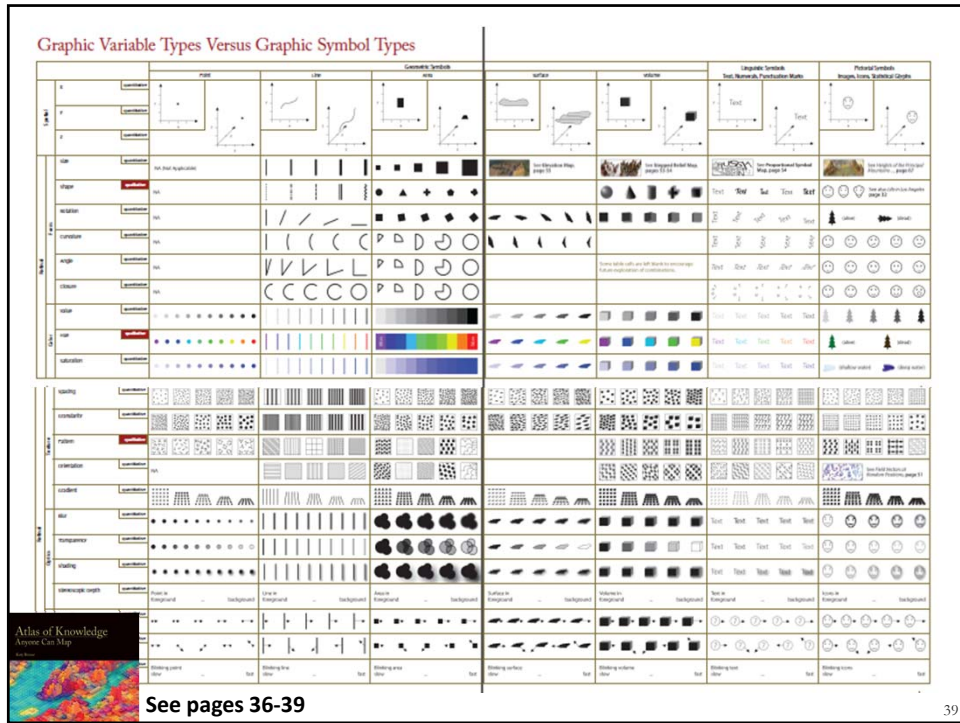
See page 25


Graphic Variable Types Versus Graphic Symbol Types

		Geometric Symbols			
		Point	Line	Area	
Spatial	x	quantitative			
	y	quantitative			
	z	quantitative			
Retinal	Form	Size	quantitative	NA (Not Applicable)	
		Shape	qualitative	NA	
		Rotation	quantitative	NA	
		Curvature	quantitative	NA	
		Angle	quantitative	NA	
		Closure	quantitative	NA	
		Value	quantitative		
Color	Hue	qualitative			
	Saturation	quantitative			



See page 36



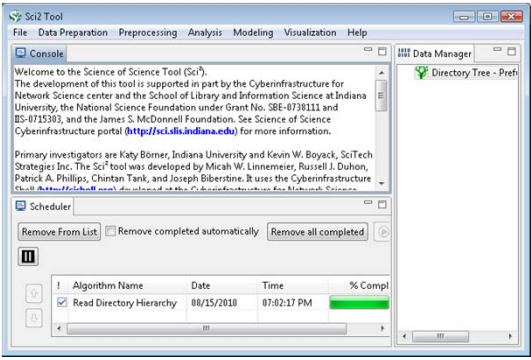


Sci2 Tool – OSGi/CIShell-based Macroscopic

Download for free at <http://sci2.cns.iu.edu>

Use

- **Menu** to read data, run algorithms.
- **Console** to see work log, references to seminal works.
- **Data Manager** to select, view, save loaded, simulated, or derived datasets.
- **Scheduler** to see status of algorithm execution.

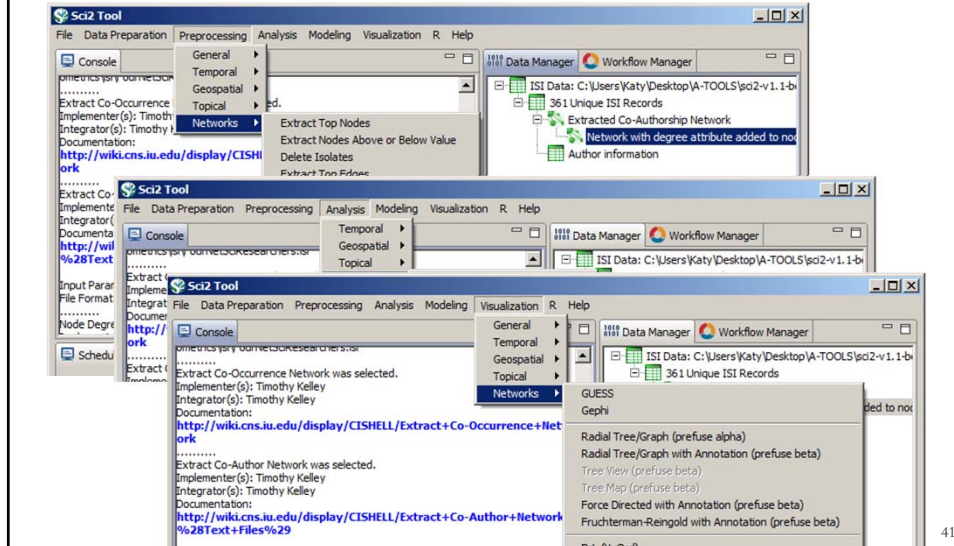


Algorithm Name	Date	Time	% Compl
<input checked="" type="checkbox"/> Read Directory Hierarchy	08/15/2010	07:02:17 PM	100%

All workflows are recorded into a log file (see /sci2/logs/...), and can be re-run for easy replication. If errors occur, they are saved in a error log to ease bug reporting. All algorithms are documented online; workflows are given in Sci2 Manual at <http://sci2.wiki.cns.iu.edu>

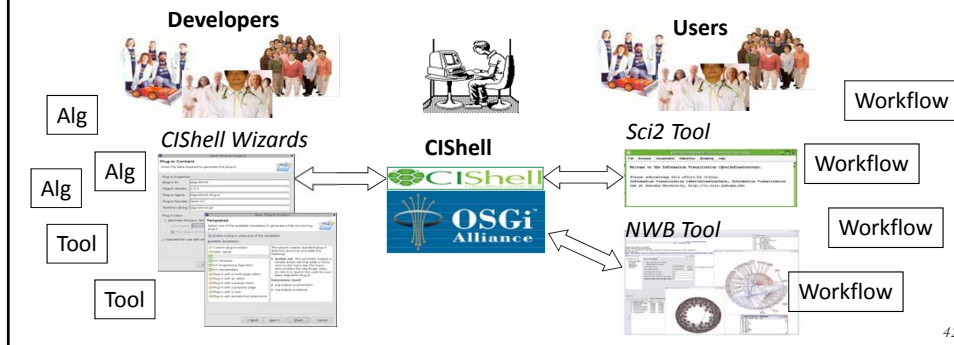
Sci2 Tool Interface Components

Download for free at <http://sci2.cns.iu.edu>



OSGi & CISHell Support the Plug-and-Play of Algorithms

- CISHell (<http://cishell.org>) is an open source software specification for the integration and utilization of datasets, algorithms, and tools.
- It extends the Open Services Gateway Initiative (OSGi) (<http://osgi.org>), a standardized, component oriented, computing environment for networked services widely used in industry since more than 10 years.
- Specifically, CISHell provides “sockets” into which existing and new datasets, algorithms, and tools can be plugged using a wizard-driven process.



CNS Cyberinfrastructure for Network Science Center

EpiC Cyberinfrastructure for Network Science Center

EpiC Tool

File | Compartmental Modeling | Networks | Simulation | Visualization | R | Help

Console

Welcome to the EpiC Tool. The EpiC project is the primary investigator of epidemic processes. The EpiC tool was developed by Joseph Biberstine, Chin Hua Kong, and Russell J. Duhon.

EpiC uses the Cyberinfrastructure Shell (<http://cishell.org>) at the Network Science Center (<http://cns.sls.indiana.edu>) at Indiana University.

Please cite as follows: EpiC Team. (2009). EpiC Tool. Indiana University, <http://cishell.org>.

Scheduler

Remove From List Remove completed automatically Remove all completed

!	Algorithm Name	Date	Time	% Complete

Data Manager

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CNS Cyberinfrastructure for Network Science Center

Client-side visualization framework uses HTML5, Javascript, and SVG.

NETE AV ANALYZER | VISUALIZER

Proportional Symbol Map

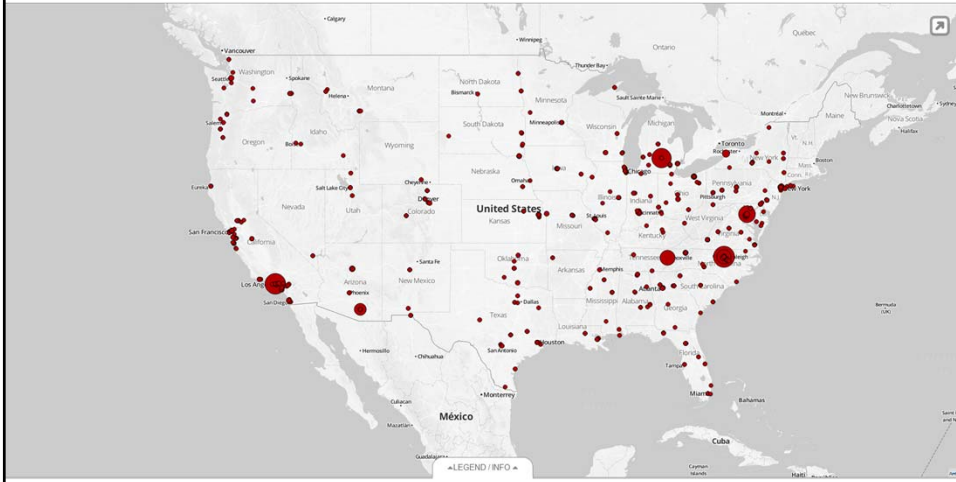
Relationship between Projects and External Organizations - Larry E. Humes, Bernice A. Pescoskido, Generated by NETE March 5, 2014 | 9:34 AM EST

Developed for NIH by CNS and NETE. Responsive design.

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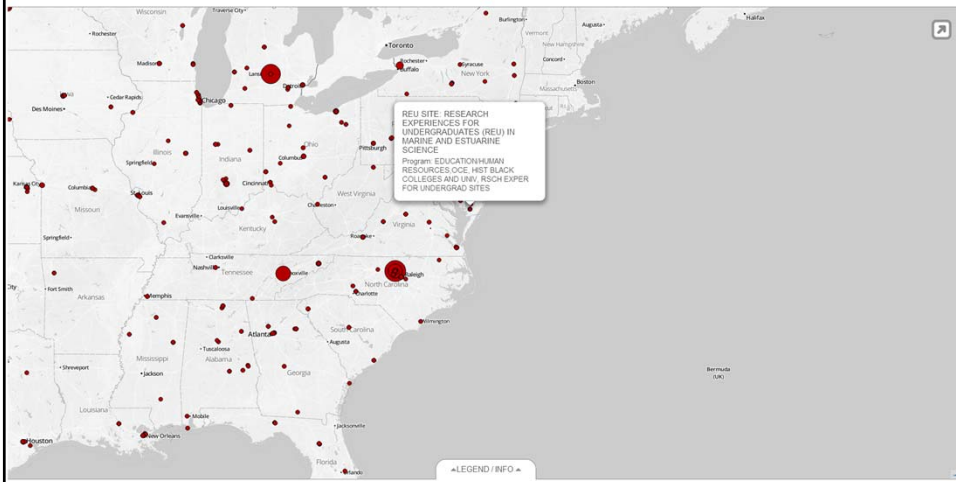
Proportional Symbol Map

Relationship between Projects and External Organizations - Larry E. Humes, Bernice A. Pescosolido; Generated by NETE March 5, 2014 9:34 AM EST



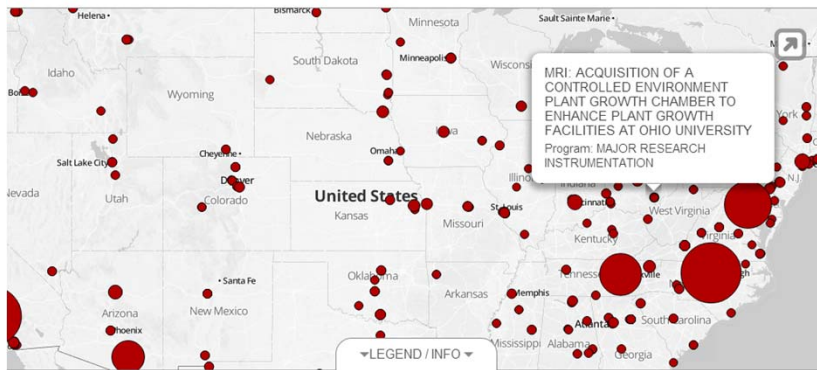
Proportional Symbol Map

Relationship between Projects and External Organizations - Larry E. Humes, Bernice A. Pescosolido; Generated by NETE March 5, 2014 9:34 AM EST



Proportional Symbol Map

Relationship between Projects and External Organizations - Larry E. Humes, Bernice A. Pescosolido, Generated by NETE March 5, 2014 | 9:34 AM EST

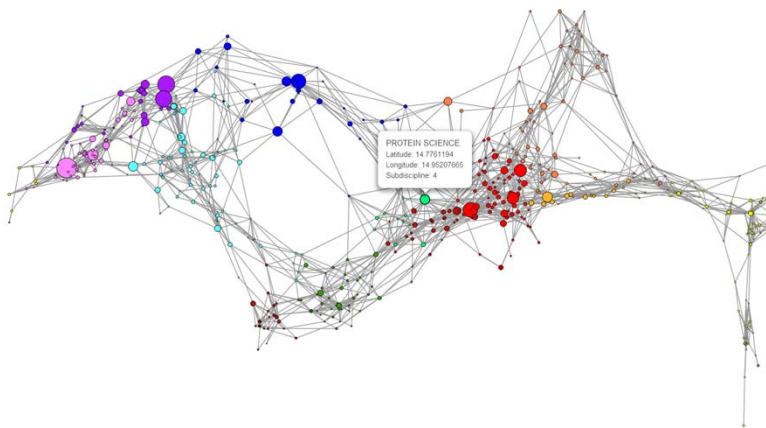


How To Read This Map

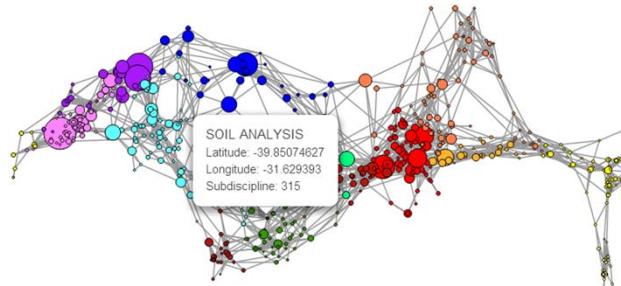
This proportional symbol map shows 52 U.S. states and other jurisdictions using the Albers equal-area conic projection with Alaska, Puerto Rico, and Hawaii inset. Each dataset record is represented by a circle centered at its geolocation. The area, interior color, and exterior color of each circle may represent numeric attribute values. Minimum and maximum data values are given in the legend.

Topic Analysis - Map of Science

Generated from Publications for top 20 projects - Jeffrey R. Alberts, Larry E. Humes, Bernice A. Pescosolido and 9 others, Generated by NETE



LEGEND / INFO



LEGEND / INFO

How To Read This Map

This map is a visual representation of 554 sub-disciplines within 13 disciplines of science and their relationships to one another, shown as points and lines connecting those points respectively. Over top this visualization is drawn the result of mapping a dataset's journals to the underlying sub-discipline(s) those journals contain. Mapped sub-disciplines are shown with size relative to the number of matching journals and color from the discipline.

Course Schedule

Part 1: Theory and Hands-On

- **Session 1** – Workflow Design and Visualization Framework
- **Session 2** – “When:” Temporal Data
- **Session 3** – “Where:” Geospatial Data
- **Session 4** – “What:” Topical Data

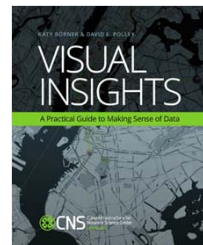
Mid-Term

- **Session 5** – “With Whom:” Trees
- **Session 6** – “With Whom:” Networks
- **Session 7** – Dynamic Visualizations and Deployment

Final Exam

Part 2: Students work in teams on client projects.

Final grade is based on Class Participation (10%), Midterm (30%), Final Exam (30%), and Client Project(30%).



Last 7 Weeks: Students Work in Teams With Clients

Information Visualization MOOC 2015

INDIANA UNIVERSITY

CNS



Client Projects



AIDS as a Global Media Event

Client Name: Vladimir Cajkovic

Project Description (goal/scientific or practical value):

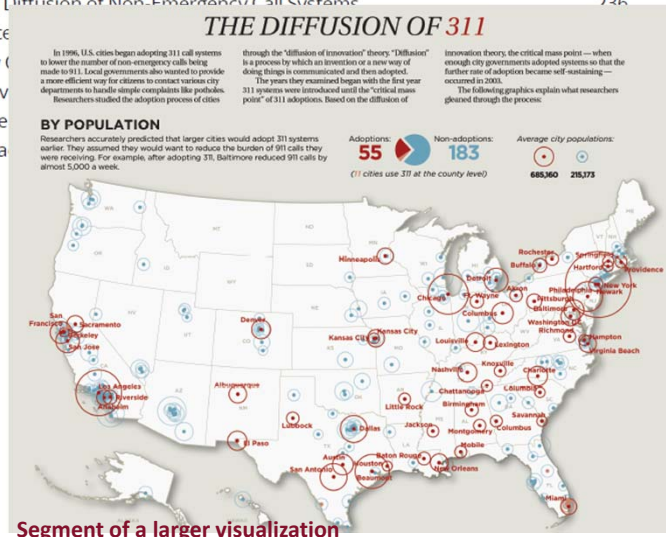
AIDS has radically transformed the world and become the focus of interdisciplinary study and research from a medical, cultural, and media-historical perspective. Over the past 30 years, the German Hygiene Museum in Dresden has collected numerous items –predominantly posters– which have been used in the media campaign to combat the epidemic. It is the world's largest collection of AIDS posters with over 9,000 specimens from 147 countries.

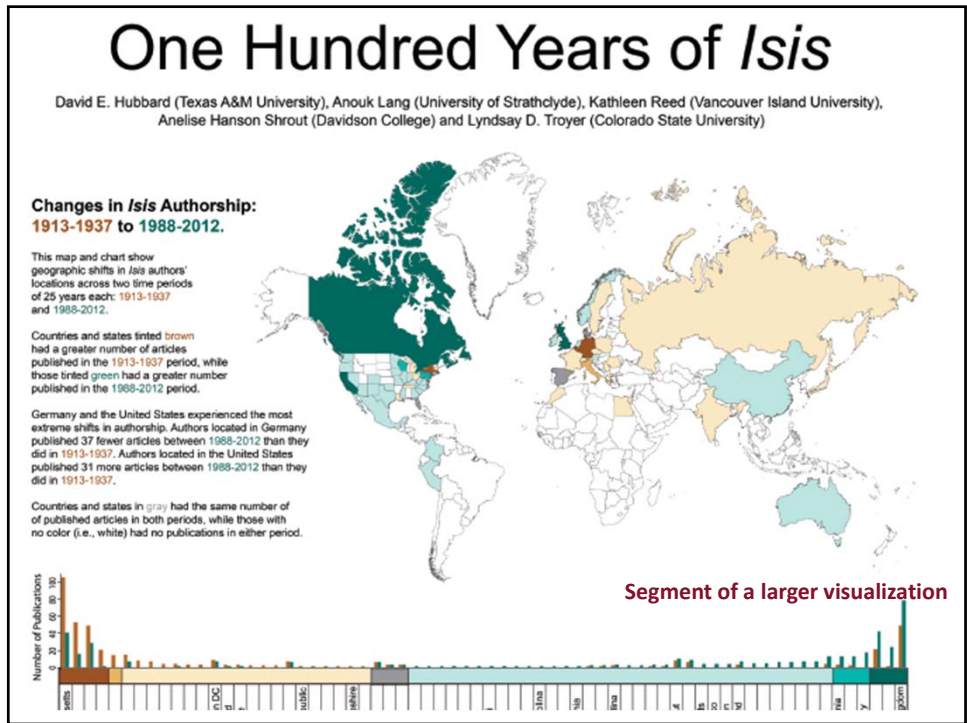
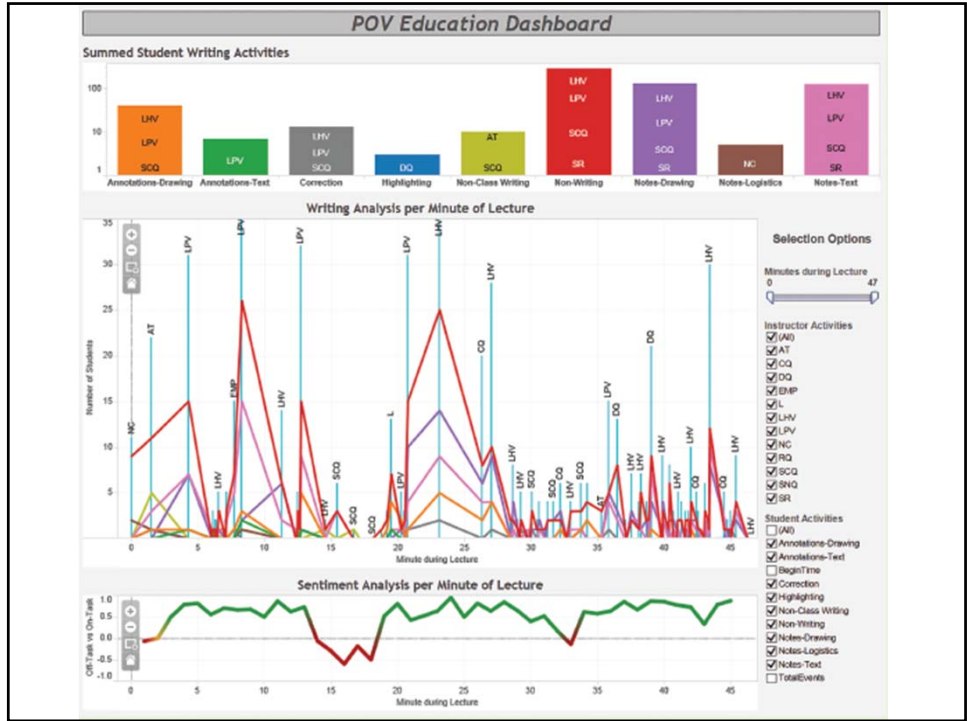
The goal of the project is to visualize the distribution of symbols, gestures, and topics addressed in the posters through space and time so that other researchers and members of the public can understand the development of the cultural response to the AIDS epidemic.

<http://ivmooc.cns.iu.edu/clients.html>

Results of 2013 client projects can be found in the *Visual Insights* book [here](#).

Chapter 8 – Case Studies	235
Understanding the Diffusion of Non-Emergency Call Systems	236
Examining the Success of 311	
Using Point of View to Analyze 311	
Phylet: An Interactive Visualization of 311	
311s: Mapping the Geospatial Diffusion of 311	
Visualizing the Impact of 311	





References

Börner, Katy, Chen, Chaomei, and Boyack, Kevin. (2003). **Visualizing Knowledge Domains**. In Blaise Cronin (Ed.), *ARIST*, Medford, NJ: Information Today, Volume 37, Chapter 5, pp. 179-255. <http://ivl.sjis.indiana.edu/km/pub/2003-borner-arist.pdf>

Shiffrin, Richard M. and Börner, Katy (Eds.) (2004). **Mapping Knowledge Domains**. *Proceedings of the National Academy of Sciences of the United States of America*, 101(Suppl_1). http://www.pnas.org/content/vol101/suppl_1/

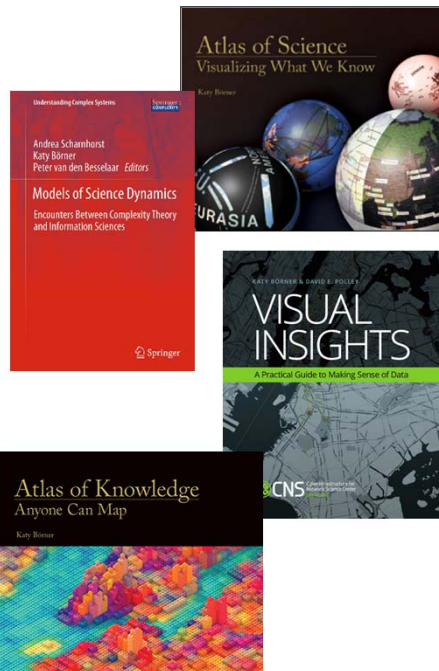
Börner, Katy (2010) **Atlas of Science: Visualizing What We Know**. The MIT Press. <http://scimaps.org/atlas>

Scharnhorst, Andrea, Börner, Katy, van den Besselaar, Peter (2012) **Models of Science Dynamics**. Springer Verlag.

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Katy Börner and David E Polley (2014) **Visual Insights: A Practical Guide to Making Sense of Data**. The MIT Press.

Börner, Katy (2015) **Atlas of Knowledge: Anyone Can Map**. The MIT Press. <http://scimaps.org/atlas2>



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All papers, maps, tools, talks, press are linked from <http://cns.iu.edu>
 These slides will soon be at <http://cns.iu.edu/docs/presentations>
 CNS Facebook: <http://www.facebook.com/cnscenter>
 Mapping Science Exhibit Facebook: <http://www.facebook.com/mappingscience>

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