

Atlas of Knowledge: Anyone Can Map

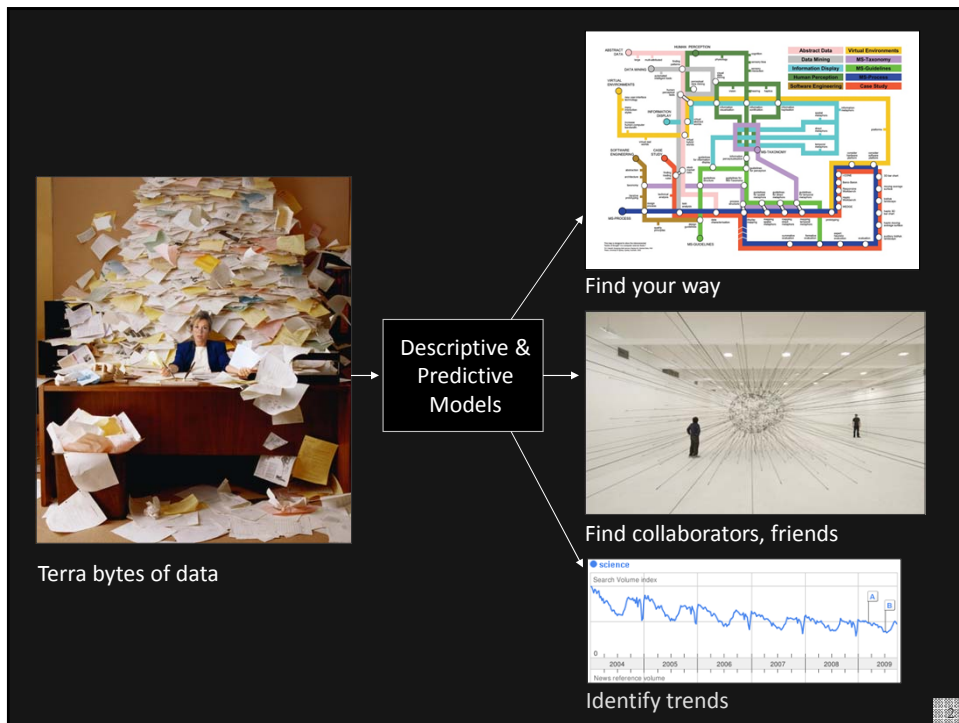
Katy Börner

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

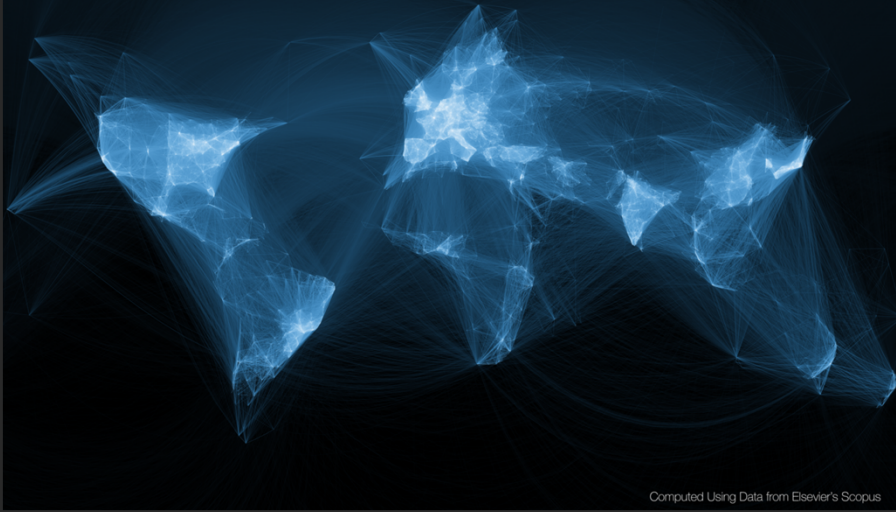
Campus Visualization Partnership (CVP) Lecture at University of Maryland, College Park

April 3, 2015

Language Communities of Twitter - Eric Fischer - 2012



Map of Scientific Collaborations from 2005-2009

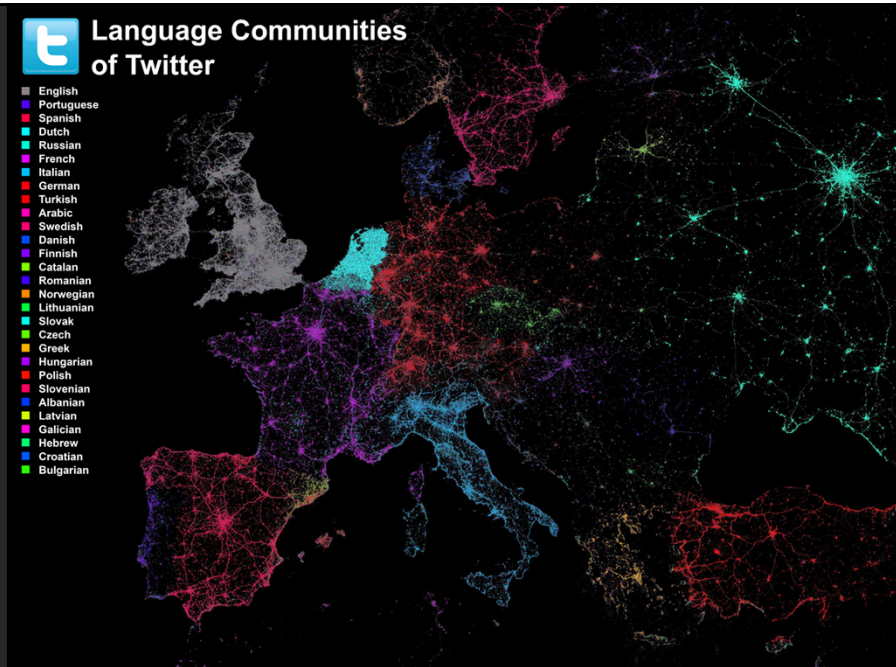


Computed Using Data from Elsevier's Scopus

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

Language Communities of Twitter

- English
- Portuguese
- Spanish
- Dutch
- Russian
- French
- Italian
- German
- Turkish
- Arabic
- Swedish
- Danish
- Finnish
- Catalan
- Romanian
- Norwegian
- Lithuanian
- Slovak
- Czech
- Greek
- Hungarian
- Polish
- Slovenian
- Albanian
- Latvian
- Galician
- Hebrew
- Croatian
- Bulgarian



Language Communities of Twitter - Eric Fischer - 2012

Geographic Map: Where Science Gets Done

North America, South America, Central America, South & East Asia, North & East Asia, Europe, Africa, Oceania, Asia, Australia, Antarctica.

Science Map: How Scientific Disciplines Relate

Math & Physics, Chemistry, Health Professionals, Social Sciences, Medicine, Biotechnology, Infectious Diseases, Brain Research, Humanities, Biology, Earth Sciences, Agricultural, Chemical, Mechanical & Civil Engineering.

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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.

Top Five Continents

- North America - 4,000 records
- South & East Asia - 3,589
- Australia - 2,431
- Africa - 2,206
- South America - 1,562

Top Five Scientific Disciplines

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

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.

Q	W	E	R	T	Y	U	I	O	P
A	S	D	F	G	H	J	K	L	"
Z	X	C	V	B	N	M			
Space									Go

People & Topics

<http://placespaces.org>

Geographic Map: Where Science Gets Done

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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 brushing 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.

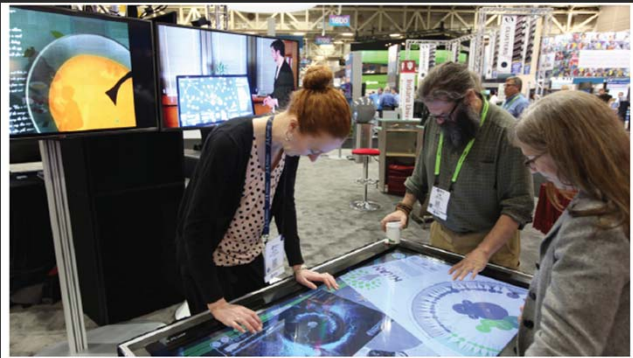
Cancer	Cloning	HIV	Robert G. Edwards	Roger D. Kornberg	Elinor Ostrom
Obesity	Quality of Life	Smoking	Stanley B. Prusiner	Ahmed H. Zewail	View All

Keyword Search

<http://placespaces.org>



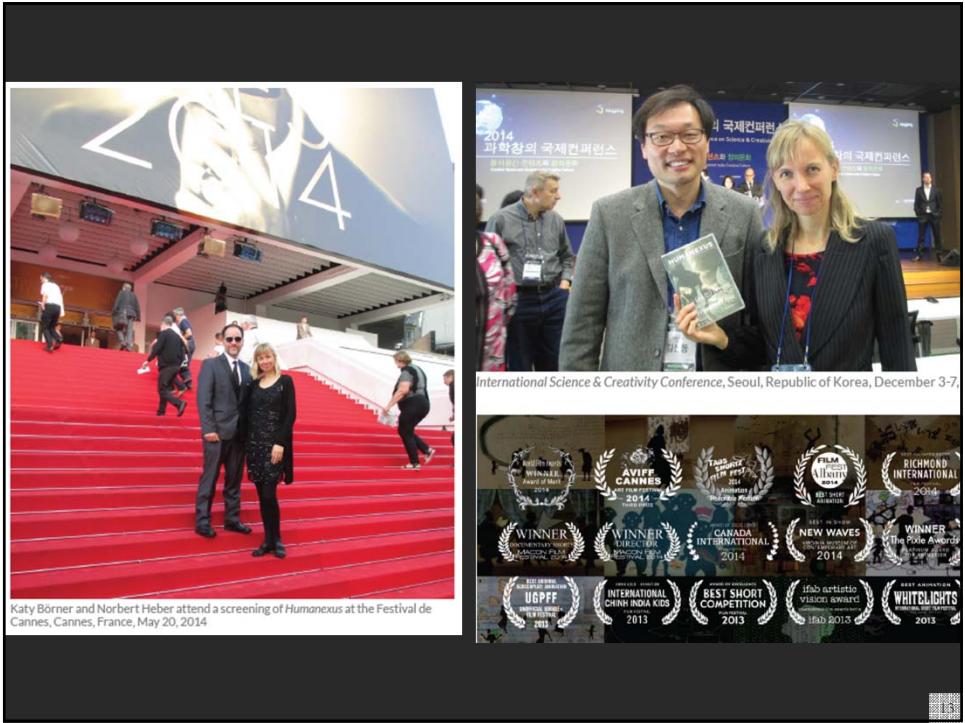
Mapping Science Exhibit on display at MEDIA X, Stanford University
<http://mediax.stanford.edu>, <http://scaleindependentthought.typepad.com/photos/scimaps>

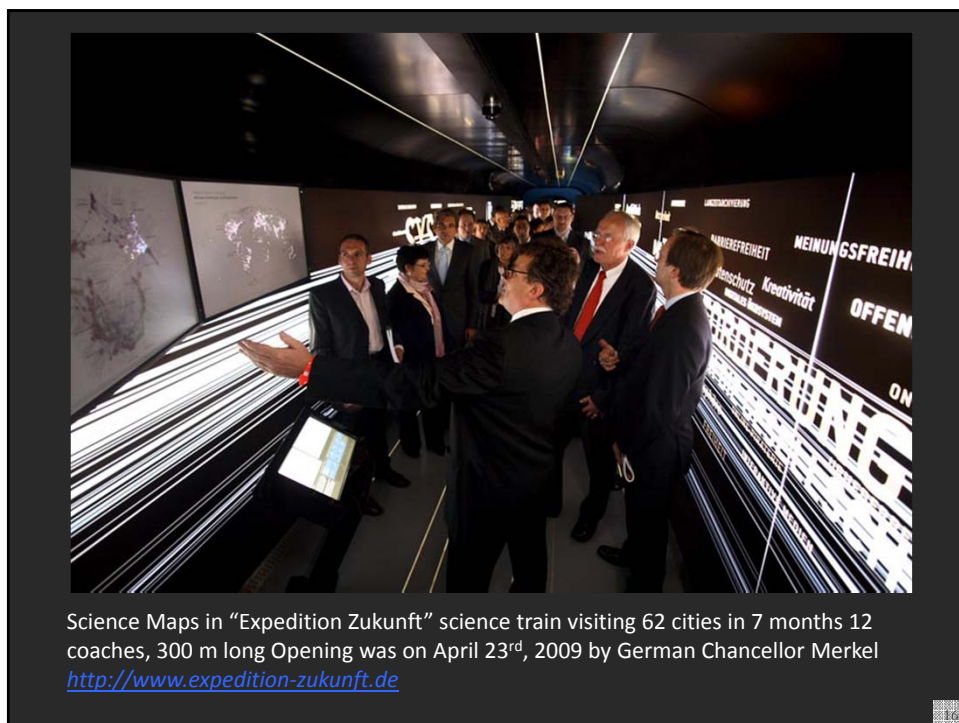
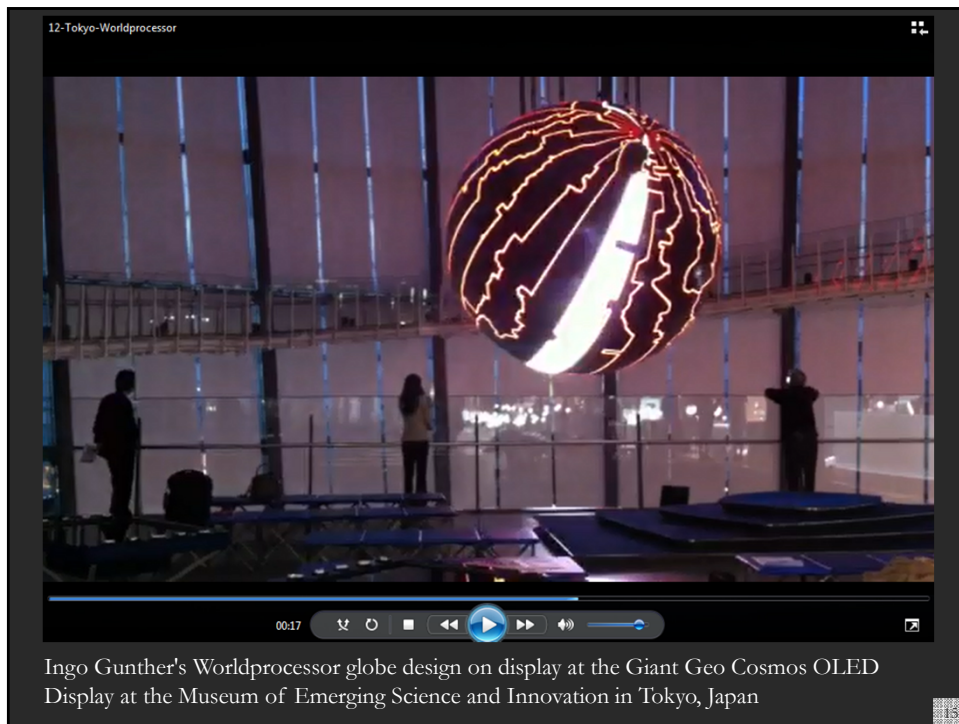


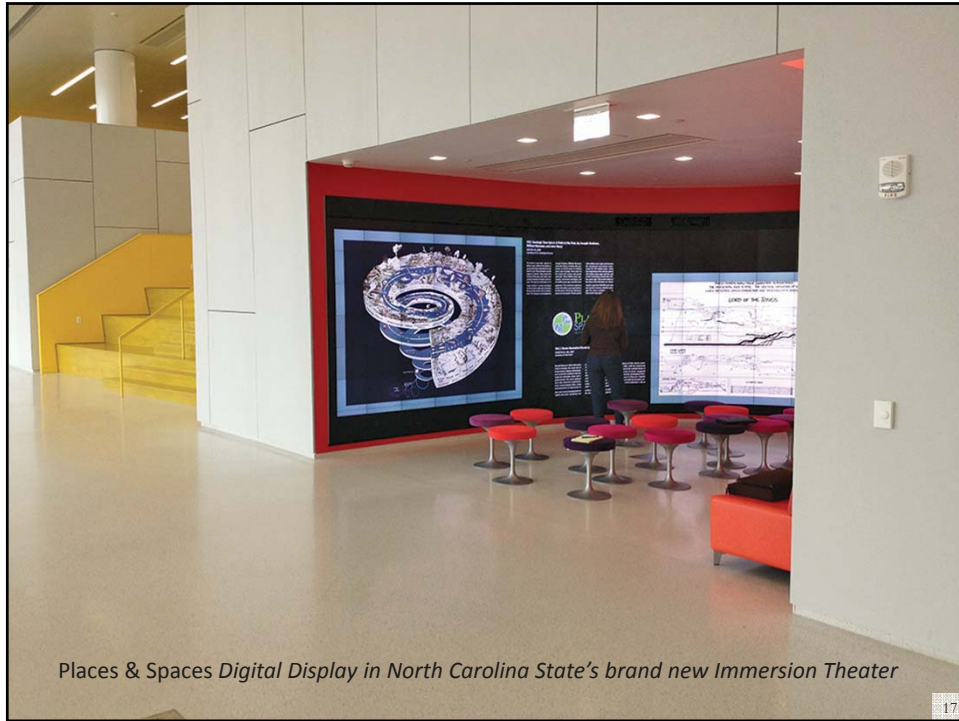
Places & Spaces maps on a touch table at the International Conference for High Performance Computing, Networking, Storage, and Analysis, New Orleans, November 16-21, 2014



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

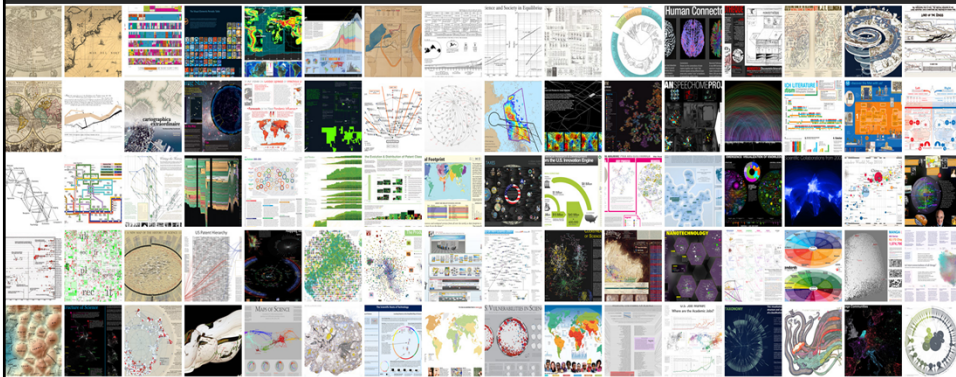






Places & Spaces: Mapping Science Exhibit

<http://scimaps.org>



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

SCIENCE
MAPS
ORG

Empowering Anyone to Visualize STI

Example: The Information Visualization MOOC

Information Visualization MOOC 2015

INDIANA UNIVERSITY CNS

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.

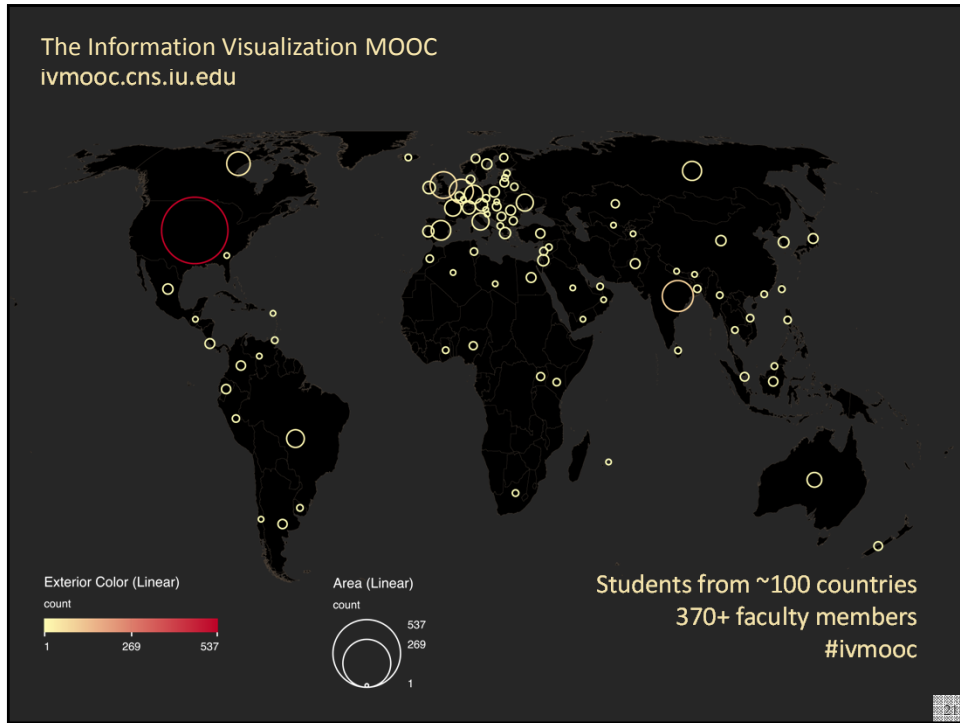
Information Visualization MOOC

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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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

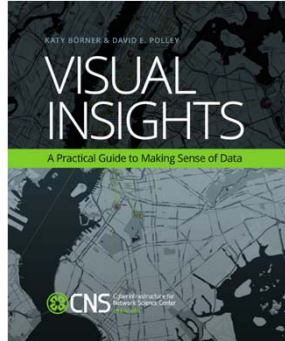
Final Exam

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%).

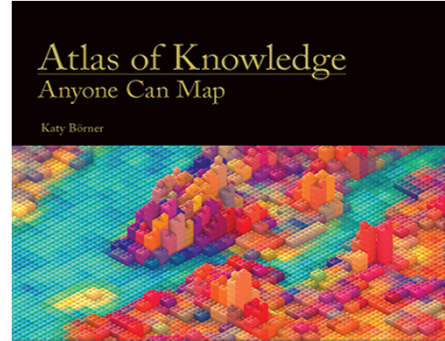


Books Used in the IVMOOC



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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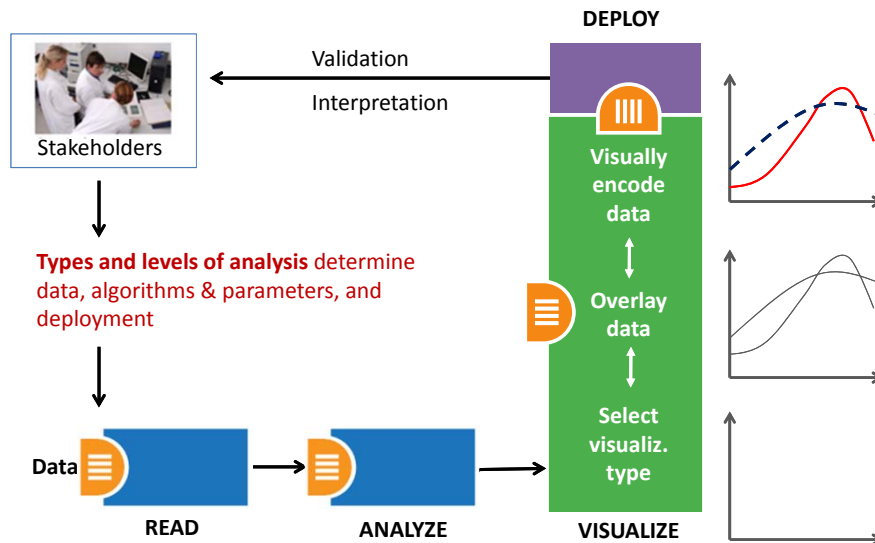
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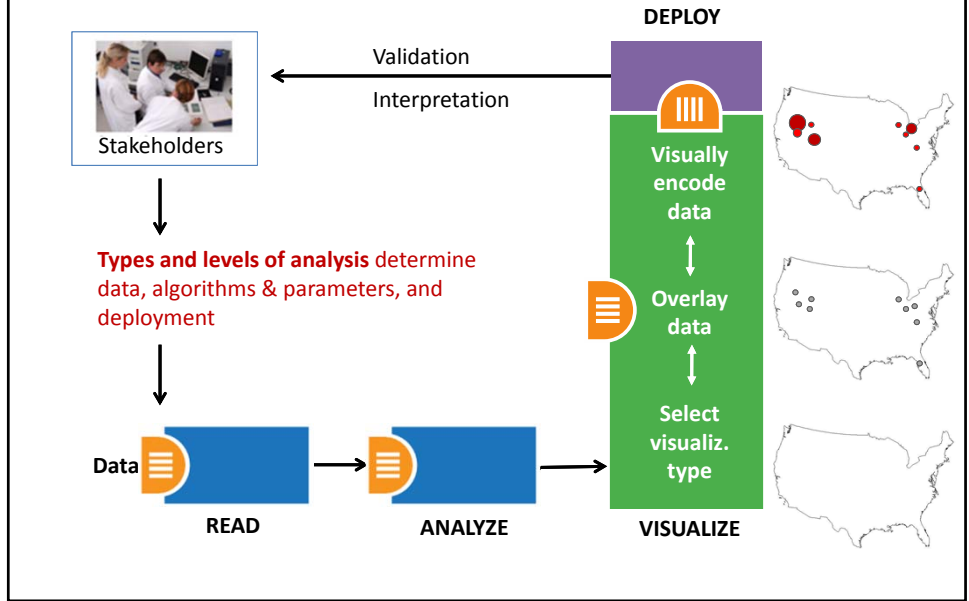


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Needs-Driven Workflow Design



Needs-Driven Workflow Design

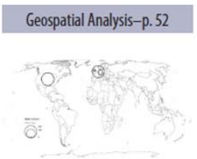
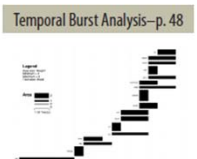


Load **One** File and Run **Many** Analyses and Visualizations

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, J 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, J Spring, B Stokols, D Trochim, W Uzzi, B

Statistical Analysis—p. 44

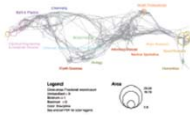
Location	Count	# Citations
Netherlands	13	292
United States	9	318
Germany	11	36
United Kingdom	1	2



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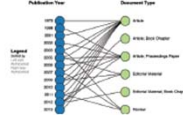
Topical Analysis—p. 56



Paper Citation Network—p. 60



Bi-Modal Network—p. 60



Co-author and many other bi-modal networks.

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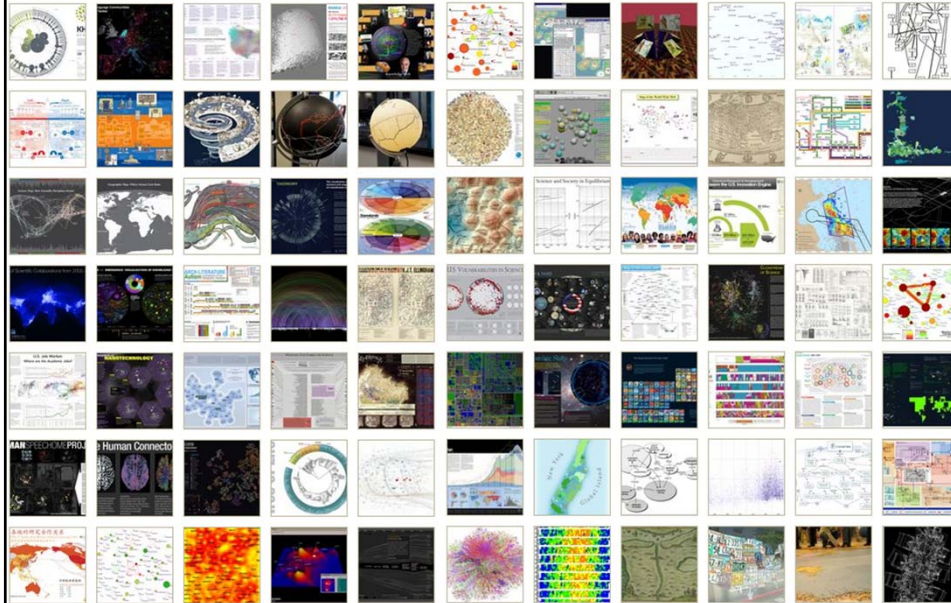
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Visualization Frameworks



How to Classify Different Visualizations?

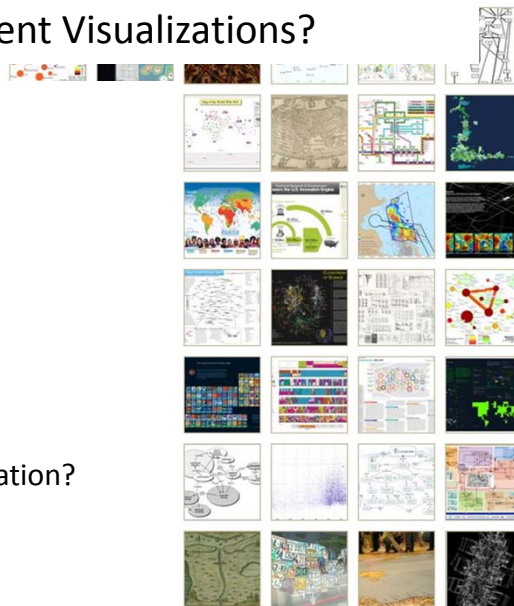
By



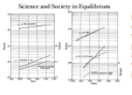


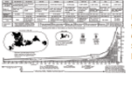
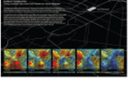
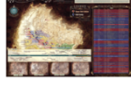







- User insight needs?
- User task types?

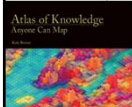
- Data to be visualized?
- Data transformation?

- Visualization technique?
- Visual mapping transformation?
- Interaction techniques?

- Or ?

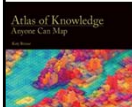


Tasks	LEVELS		
	MICRO: Individual Level about 1–1,000 records page 6	MESO: Local Level about 1,001–100,000 records page 8	MACRO: Global Level more than 100,000 records page 10
TYPES			
Statistical Analysis page 44	 Knowledge cartography page 135	 Productivity of Russian life sciences research teams page 105	 Science and Society in Equilibrium Number of scientists versus population and R&D costs versus GDP 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 95
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

Atlas of Knowledge
Knowers Can Map

See page 26

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

Atlas of Knowledge
Knowers Can Map

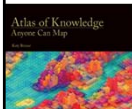
See page 24

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 depend on node attributes or node similarity. **Trees:** hierarchies, taxonomies, genealogies. **Networks:** social networks, migration flows.

Types

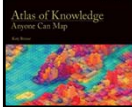
Insight Need Types page 26	Data Scale Types page 28	Visualization Types page 30	Graphic Symbol Types page 32	Graphic Variable Types page 34	Interaction Types page 26
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See page 25

Graphic Variable Types Versus Graphic Symbol Types

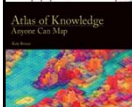
		Geometric Symbols			
		Point	Line	Area	
Spatial	x	quantitative			
	y	quantitative			
	z	quantitative			
Retinal	Form	Size	quantitative NA (Not Applicable)		
		Shape	qualitative NA		
		Rotation	quantitative NA		
		Curvature	quantitative NA		
		Angle	quantitative NA		
		Closure	quantitative NA		
Color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



See page 36

Graphic Variable Types Versus Graphic Symbol Types

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



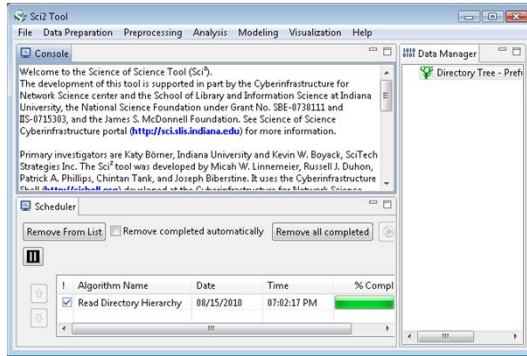
See pages 36-39

Sci2 Tool – OSGi/CIShell-based Macroscope

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.



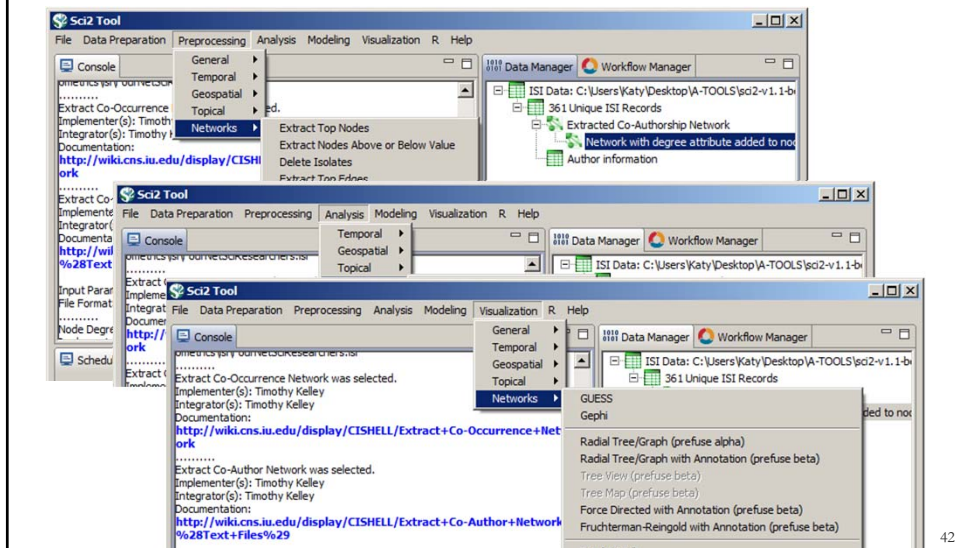
All workflows are recorded into a log file (see /sci2/logs/...), and can be re-run for easy replication. If errors occur, they are saved in a error log to ease bug reporting.

All algorithms are documented online; workflows are given in Sci2 Manual at <http://sci2.wiki.cns.iu.edu>

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Sci2 Tool Interface Components

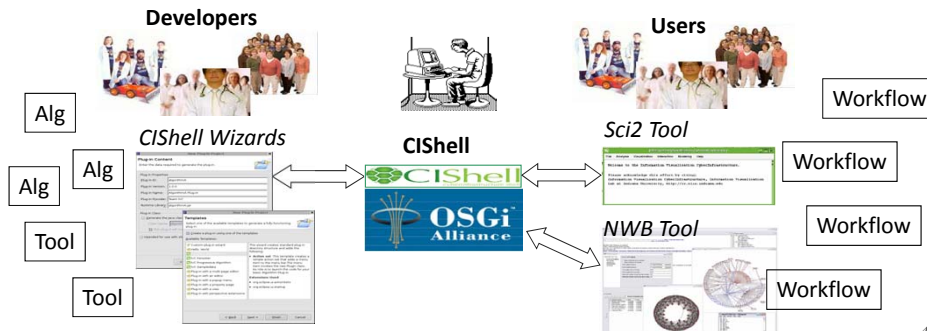
Download for free at <http://sci2.cns.iu.edu>



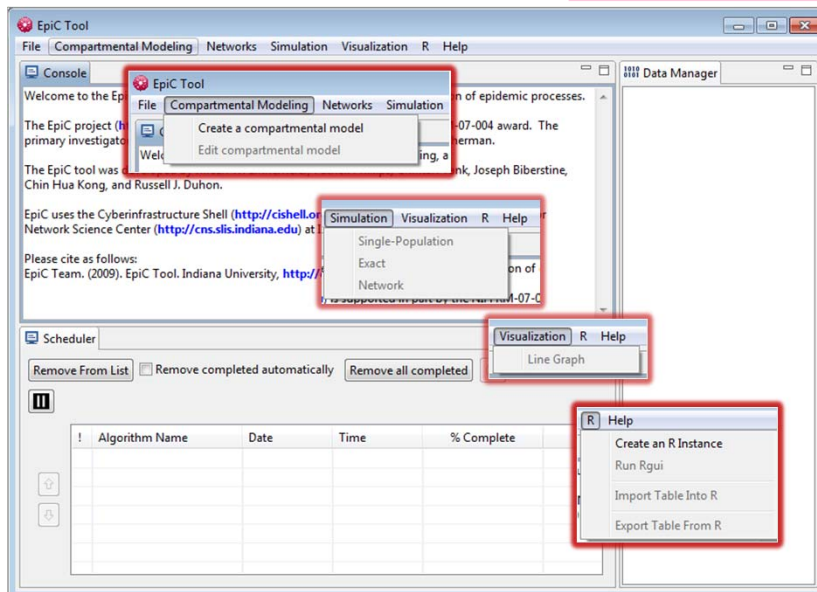
42

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

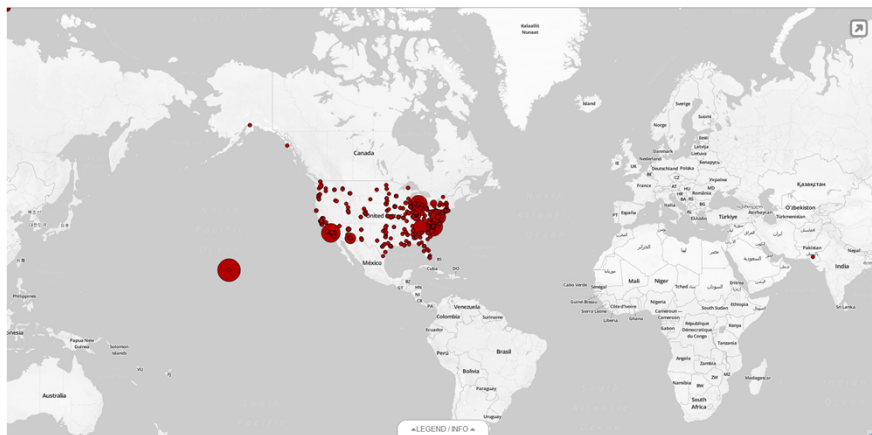
- CShell (<http://cishell.org>) is an open source software specification for the integration and utilization of datasets, algorithms, and tools.
- It extends the Open Services Gateway Initiative (OSGi) (<http://osgi.org>), a standardized, component oriented, computing environment for networked services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



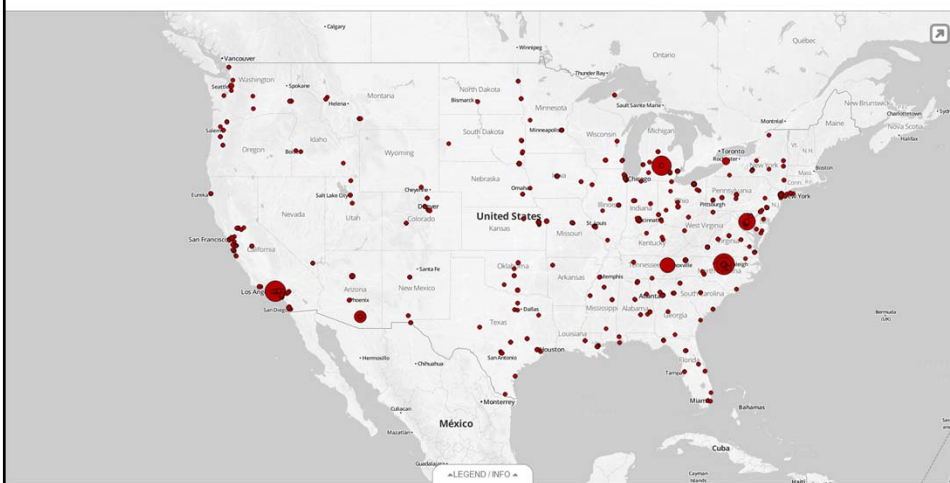
43

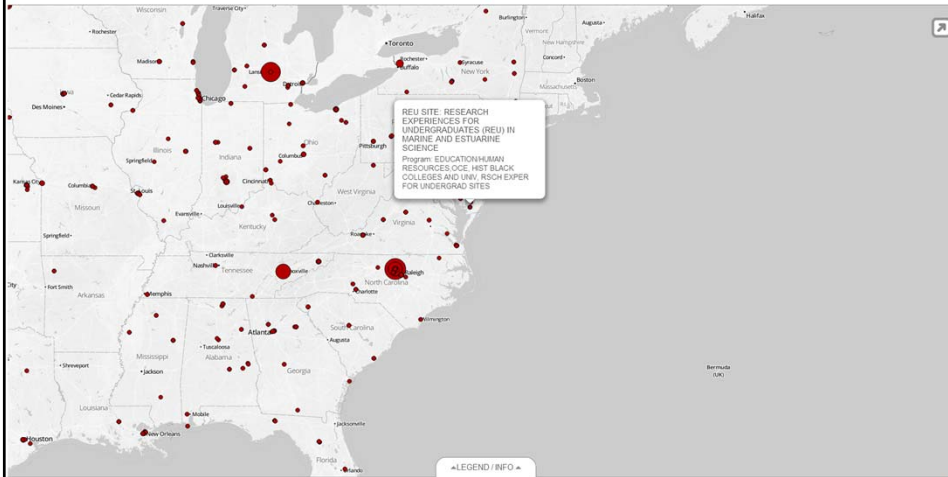


44

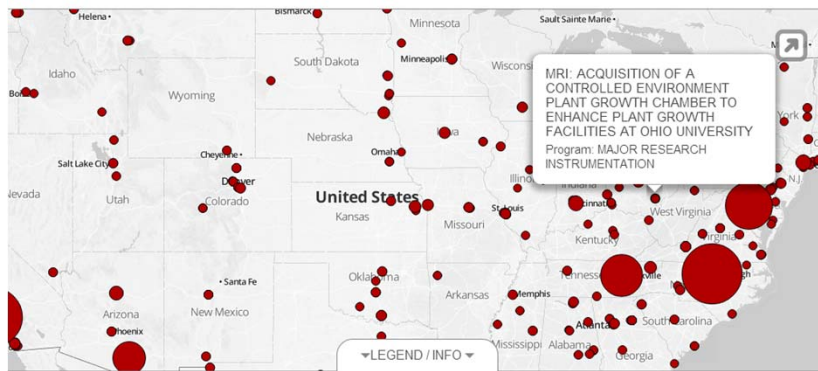


Developed for NIH by CNS and NETE. Responsive design.





LEGEND / INFO



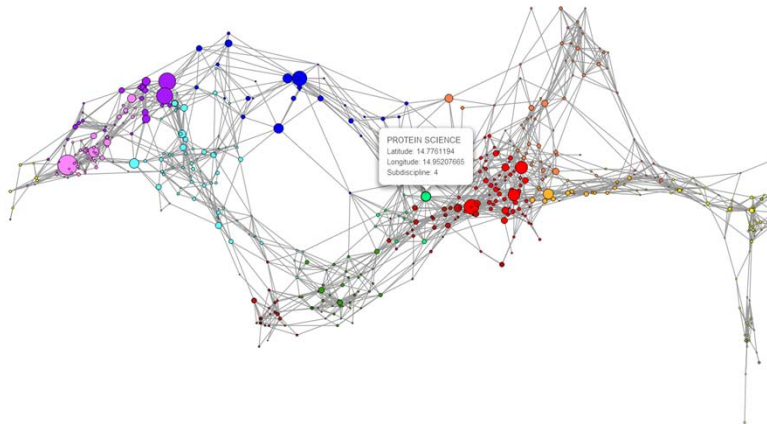
LEGEND / INFO

Amount Awarded

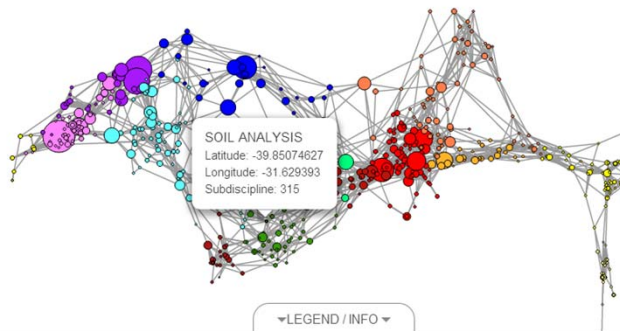


How To Read This Map

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.



LEGEND / INFO



LEGEND / INFO

Total Awards



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

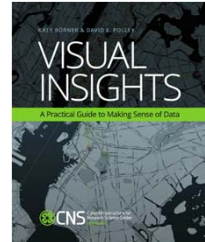
Part 1: Theory and Hands-On

- **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.

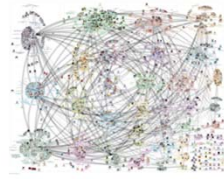
Final grade is based on Class Participation (10%), Midterm (30%), Final Exam (30%), and Client Project(30%).

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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>

One Hundred Years of *Isis*

David E. Hubbard (Texas A&M University), Anouk Lang (University of Strathclyde), Kathleen Reed (Vancouver Island University), Anelise Hanson ShROUT (Davidson College) and Lyndsay D. Troyer (Colorado State University)

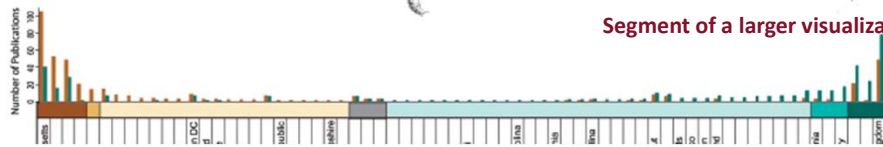
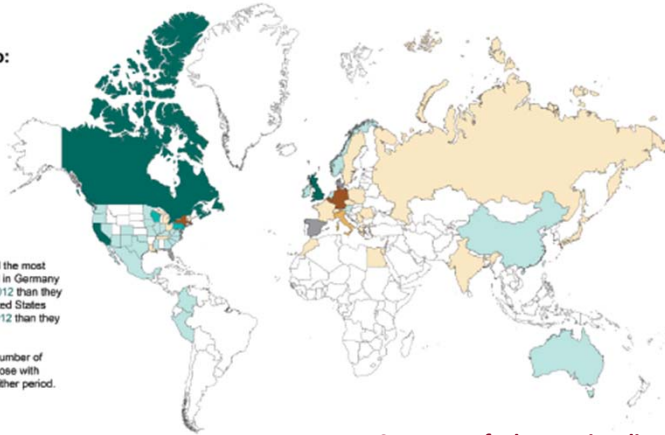
Changes in *Isis* Authorship: 1913-1937 to 1988-2012.

This map and chart show geographic shifts in *Isis* authors' locations across two time periods of 25 years each: 1913-1937 and 1988-2012.

Countries and states tinted brown had a greater number of articles published in the 1913-1937 period, while those tinted green had a greater number published in the 1988-2012 period.

Germany and the United States experienced the most extreme shifts in authorship. Authors located in Germany published 37 fewer articles between 1988-2012 than they did in 1913-1937. Authors located in the United States published 31 more articles between 1988-2012 than they did in 1913-1937.

Countries and states in gray had the same number of published articles in both periods, while those with no color (i.e., white) had no publications in either period.



Segment of a larger visualization

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.slis.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/vo101/suppl_1/

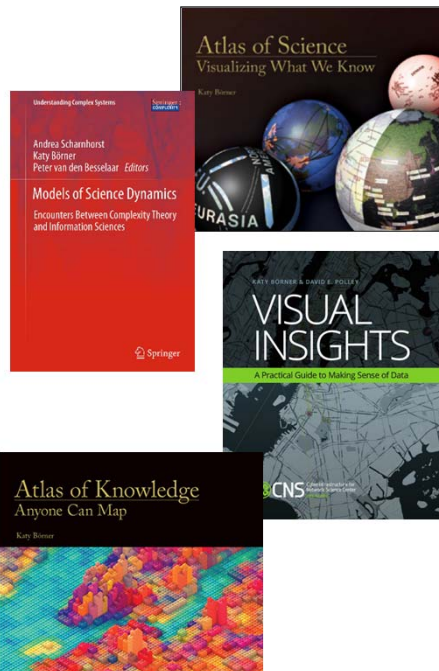
Börner, Katy (2010) **Atlas of Science: Visualizing What We Know**. The MIT Press. <http://scimaps.org/atlas>

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

Katy Börner, Michael Conlon, Jon Corson-Rikert, Cornell, Ying Ding (2012) **VIVO: A Semantic Approach to Scholarly Networking and Discovery**. Morgan & Claypool.

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>



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>