

Plug and Play Macroscopes: Empowering Anyone To Convert Data Into Insights

Katy Börner

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

RKII Room 7111, NHLBI Division of Cardiovascular Sciences
Rockledge Two, 6701 Rockledge Drive, Bethesda, MD

February 11, 2016

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

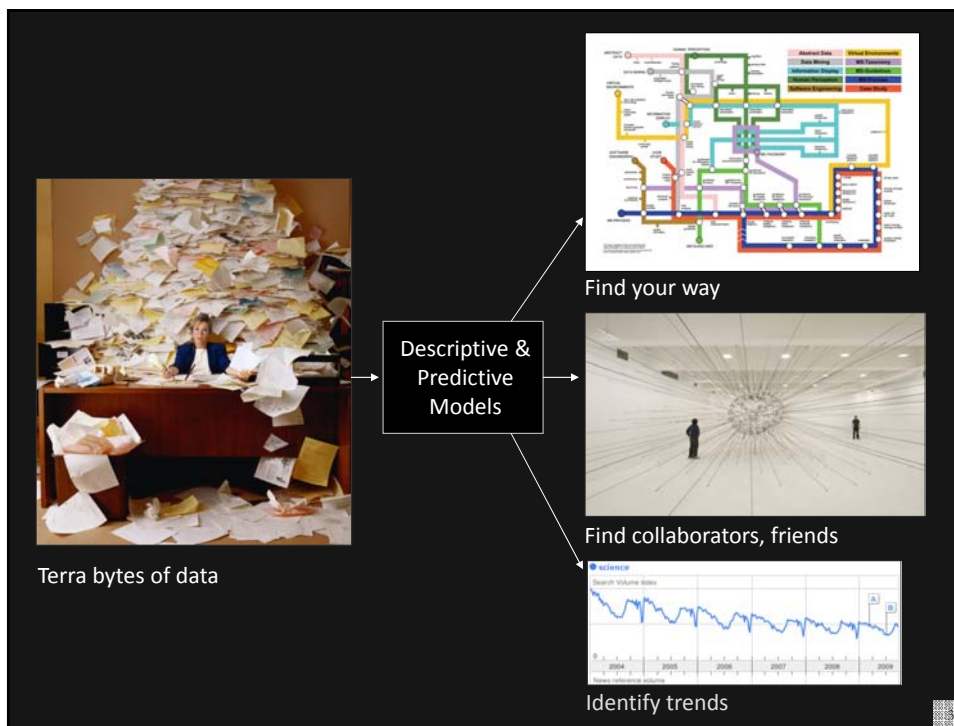
Computed Using Data from Elsevier's Scopus

Map of Scientific Collaborations from 2005-2009



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

Computed Using Data from Elsevier's Scopus



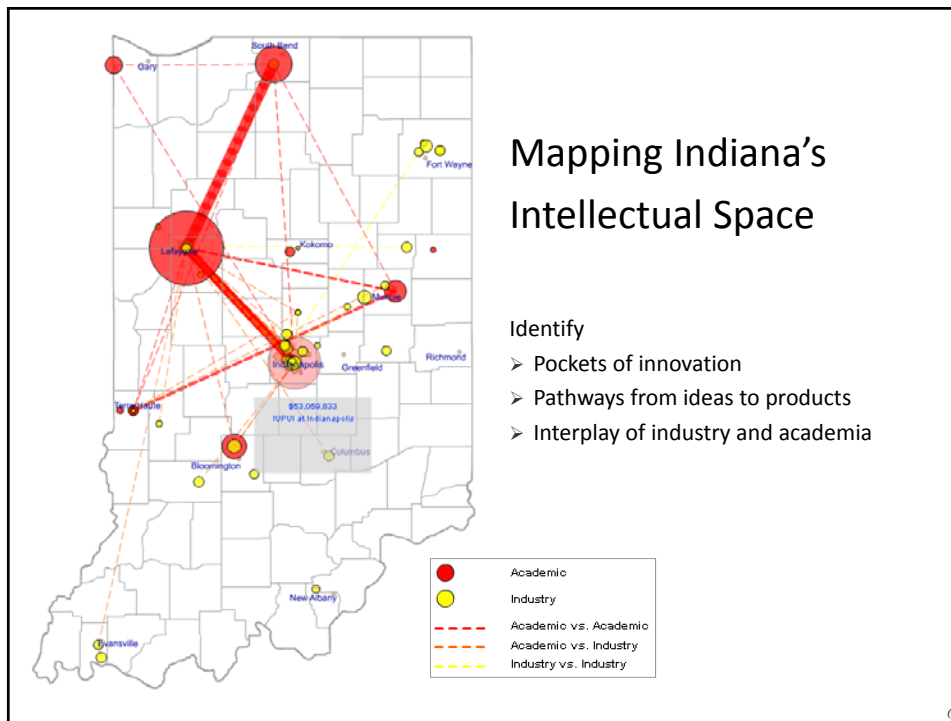
Type of Analysis vs. Level of Analysis

	<i>Micro/Individual (1-100 records)</i>	<i>Meso/Local (101-100,000 records)</i>	<i>Macro/Global (100,000 < records)</i>
Statistical Analysis/Profiling	Individual person and their expertise profiles	Larger labs, centers, universities, research domains, or states	All of NSF, all of USA, all of science.
Temporal Analysis (When?)	Funding portfolio of one individual	Mapping topic bursts in 20-years of PNAS	113 Years of Physics Research
Geospatial Analysis (Where?)	Career trajectory of one individual	Mapping a states intellectual landscape	PNAS publications
Topical Analysis (What?)	Base knowledge from which one grant draws.	Knowledge flows in Chemistry research	VxOrd/Topic maps of NIH funding
Network Analysis (With Whom?)	NSF Co-PI network of one individual	Co-author network	NIH's core competency

Type of Analysis vs. Level of Analysis

	Micro/Individual (1-100 records)	Meso/Local (101-100,000 records)	Macro/Global (100,000 < records)
Statistical Analysis/Profiling	Individual person and their expertise profiles	Larger labs, centers, universities, research domains, or states	All of NSF, all of USA, all of sci
Temporal Analysis (When?)	Funding portfolio of one individual	Topic bursts in PNAS	113 Years of Physics Research
Geospatial Analysis (Where?)	Career trajectory of one individual	Intellectual trajectory	PNAS publications
Topical Analysis (What?)	Base knowledge from research	Research	VxOrd/Topic NIH funding
Network Analysis (With Whom?)	NSF Co-PI network of one	Co-author network	NIH's core com

5



Research Collaborations by the Chinese Academy of Sciences

Huang, Duhon, Hardy & Börner

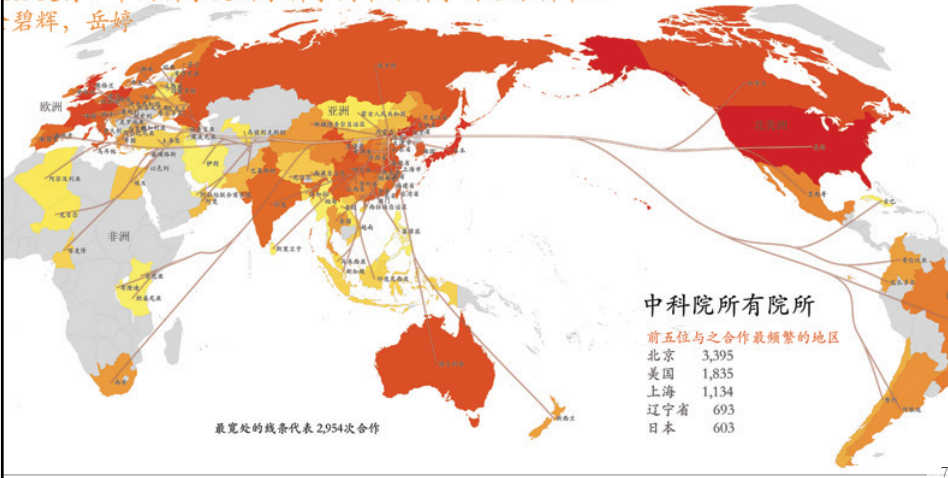
中科院与世界各地的研究合作关系

维霞, Russell J. Duhon, Elisha F. Hardy, Katy Börner, Indiana University, USA



据支持: 中国科学院国家科学图书馆科学前沿分析中心

碧辉, 岳婷



VIVO Researcher Networking System

<http://vivo-netsci.cns.iu.edu/vivo12/vis/map-of-science/Person74>

VIVO connect • share • discover

Index | Log in

Search

Home | People | Organizations | Research | Events

Börner, Katy | Faculty Member

Publications in VIVO

Positions

- Victor H. Yngve Professor of Information Science, [LIBRARY & INFORMATION SCIENCE](#) 2007 -
- Graduate Faculty Member w/Endorsement, [GRADUATE SCHOOL, EXECUTIVE MANAGEMENT/ACADEMIC SUPPORT](#) 2007 -
- Adjunct Professor, [INFORMATICS](#) 2009 -
- Professor Tenured/Tenure-Track, [LIBRARY & INFORMATION SCIENCE](#) 2009 -
- Adjunct Professor, [STATISTICS, Arts & Sciences](#) 2009 - 2012

Contact Info

- katy@indiana.edu
- 812/855-3256

[Co-author Network](#)

[Map of Science](#)

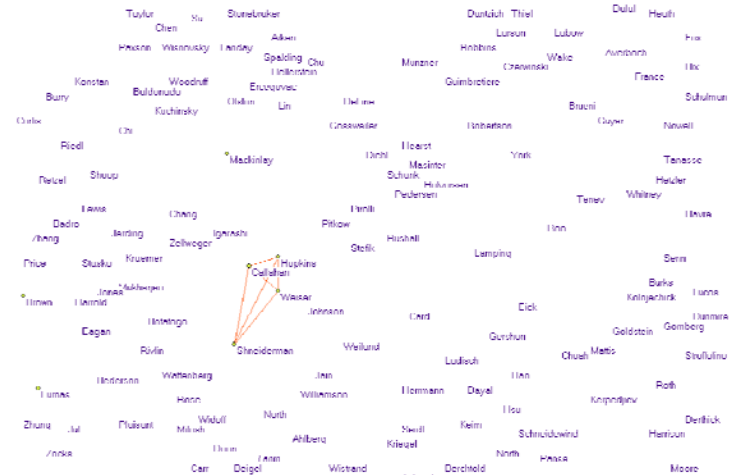
[Co-investigator Network](#)

Publications | Research | Teaching | Contact | View All

8

Mapping the Evolution of Co-Authorship Networks

Ke, Visvanath & Börner. 2004. Won 1st prize at the IEEE InfoVis Contest.



Legend

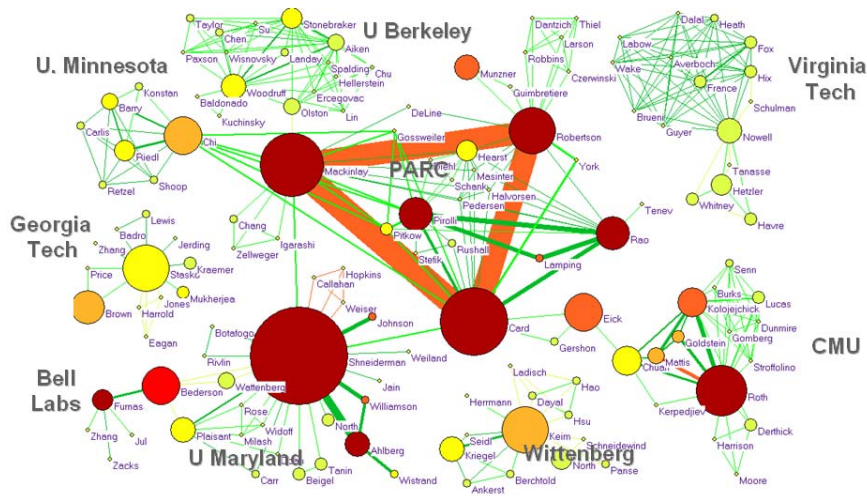
- Nodes - Authors
- Node area size - Number of papers published
- Node color - Number of citations
- Edges - Co-authorship relations
- Edge color - Year of first co-authorship

Node Color Code	Edge Color Code
0-9	85-90
10-19	91-95
20-29	96-00
30-39	01-
40-49	Displayed Year: 1993
50-	

Mapping the Evolution of Co-Authorship Networks
 Weimao Ke, Lalitha Visvanath & Katy Börner
 InfoVis Lab @ Indiana University
 2004

Mapping the Evolution of Co-Authorship Networks

Ke, Visvanath & Börner. 2004. Won 1st prize at the IEEE InfoVis Contest.



Legend

- Nodes - Authors
- Node area size - Number of papers published
- Node color - Number of citations
- Edges - Co-authorship relations
- Edge color - Year of first co-authorship

Node Color Code	Edge Color Code
0-9	85-90
10-19	91-95
20-29	96-00
30-39	01-
40-49	Displayed Year: 2004
50-	

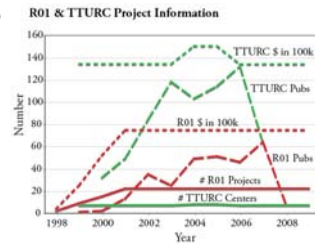
Mapping the Evolution of Co-Authorship Networks
 Weimao Ke, Lalitha Visvanath & Katy Börner
 InfoVis Lab @ Indiana University
 2004

Mapping Transdisciplinary Tobacco Use Research Centers Publications

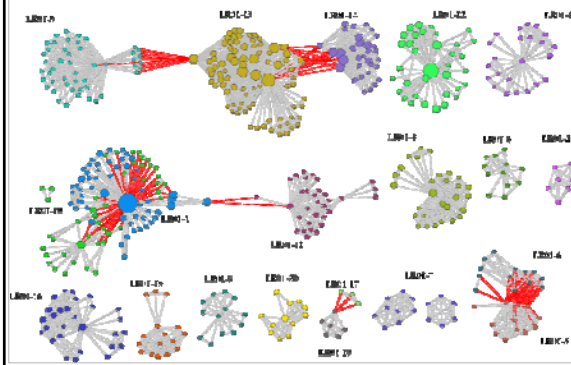
Compare R01 investigator-based funding with TTURC Center awards in terms of number of publications and evolving co-author networks.

Stipelman, Hall, Zoss, Okamoto, Stokols, Börner, 2014.

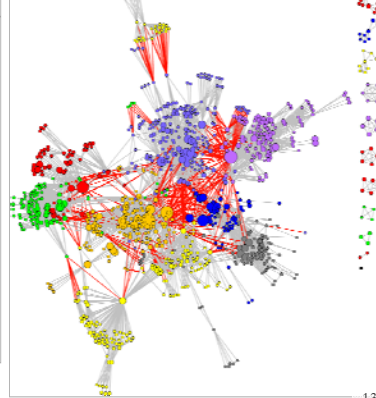
Supported by NIH/NCI Contract HHSN261200800812



Geographical R01 Co-Authorship Network

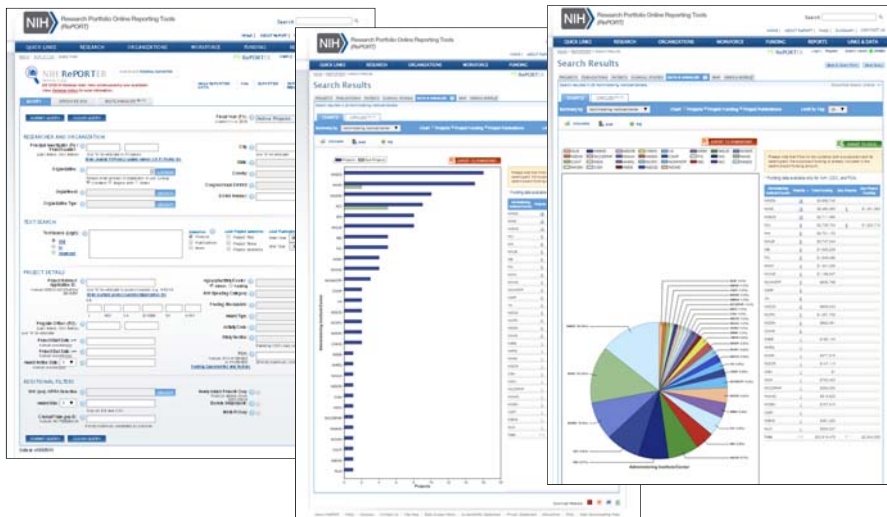


TTURC Co-Authorship Network



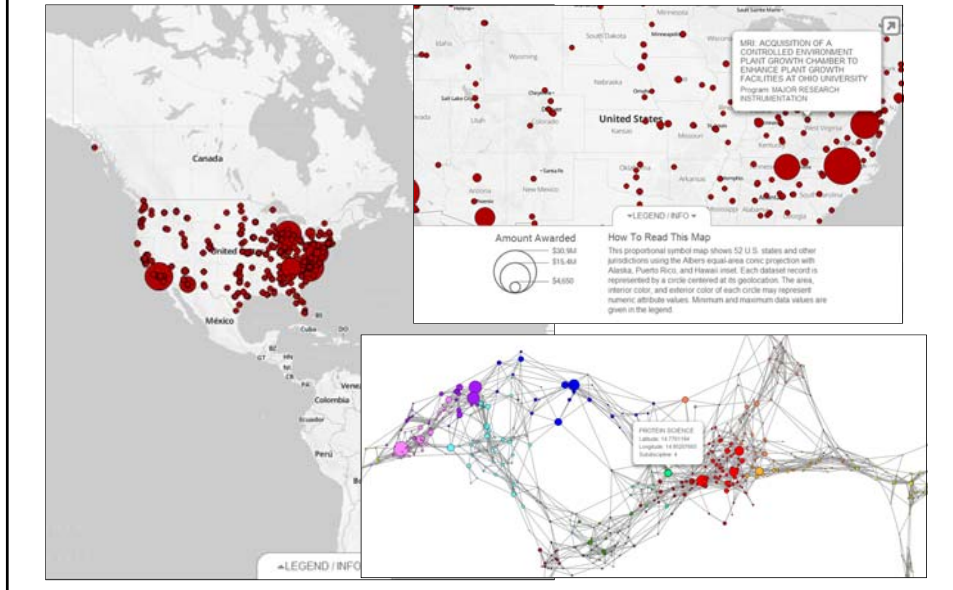
13

NIH RePORTER: Existing Interface

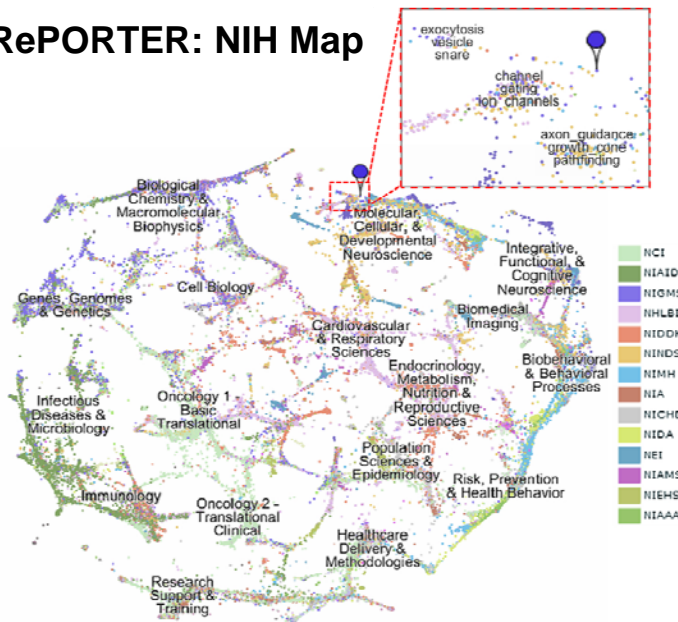


<http://projectreporter.nih.gov>

CIShell/Sci2 World and Science Visualizations of NIH RePORTER Data



NIH RePORTER: NIH Map




<http://nihmaps.org>



Science Maps in "Expedition Zukunft" science train visited 62 cities in 7 months. Opening on April 23rd, 2009 by German Chancellor Merkel

19



 **Kristi Holmes** @kristiholmes · Apr 30
Excited for @cnscenter Places&Spaces at @galterlibrary! @katycns
@NUCATsinstitute #unpackingcrates #viz

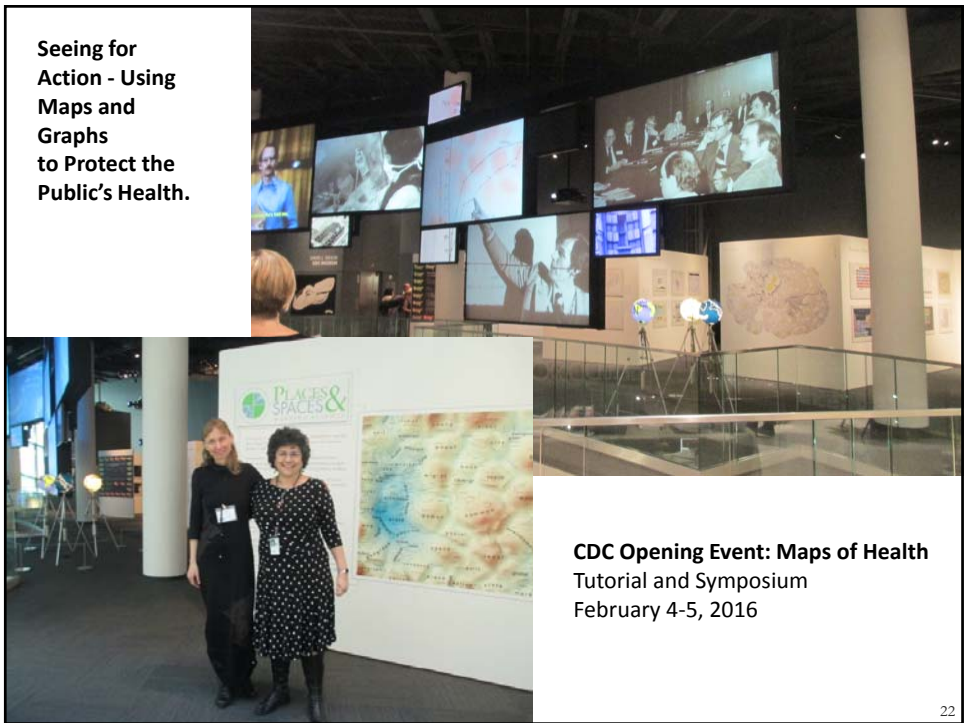
Places & Spaces at Northwestern University
May 14 - September 23, 2015

20



*Places & Spaces Exhibit at the David J. Sencer CDC Museum, Atlanta, GA
January 25-June 17, 2016*



21

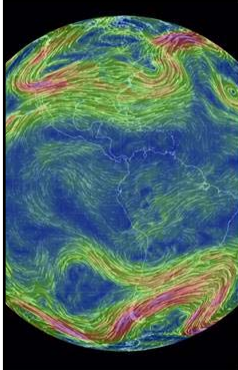


**Seeing for
Action - Using
Maps and
Graphs
to Protect the
Public's Health.**


**CDC Opening Event: Maps of Health
Tutorial and Symposium
February 4-5, 2016**

22



MACROSCOPES FOR INTERACTING WITH SCIENCE




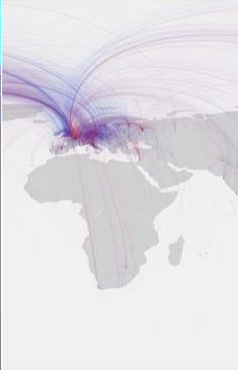
Earth



AcademyScope



Mapping Global Society



Charting Culture

<http://scimaps.org/iteration/11>


Curated by the Cyberinfrastructure for Network Science Center





[About](#)
[People](#)
[Maps & More](#)
[Exhibitions](#)
[Hosting](#)
[Publications](#)
[Store](#)
[News](#)
[Contact](#)



Hidalgo, César A., Bailey Klingler, Albert-László Barabási, and Ricardo Hausmann. 2007. See also The Product Space map from Phase I of Places & Spaces.

Call for Macroscopic Tools for the *Places & Spaces: Mapping Science* Exhibit (2016) <http://scimaps.org/call>

Background and Goals

The *Places & Spaces: Mapping Science* exhibit was created to in-

communicate human activity and scientific progress on a globe that enable the close inspection of large-scale maps in public conferences; (2) novel, interactive macroscopic tools that let

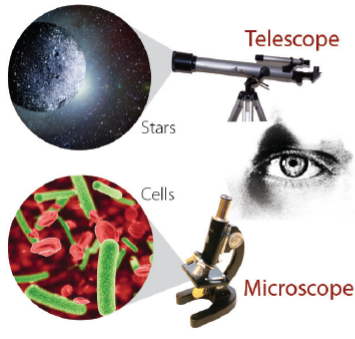
Themes for the upcoming iterations/years are:

- 11th Iteration (2015): Macroscopes for Interacting With Science
- 12th Iteration (2016): Macroscopes for Making Sense of Science
- 13th Iteration (2017): Macroscopes for Forecasting Science
- 14th Iteration (2018): Macroscopes for Economic Decision Makers
- 15th Iteration (2019): Macroscopes for Science Policy Makers

24

Microscopes, Telescopes, Macrosopes Plug-and-Play Macrosopes

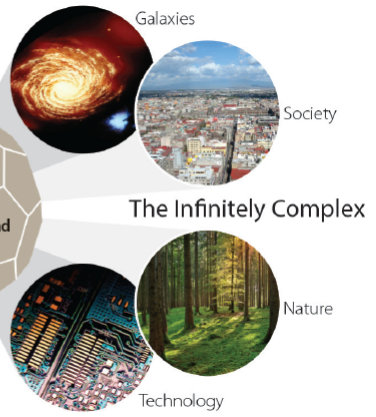
The Infinitely Great



The Infinitely Small



Macroscope



The Infinitely Complex

MEDICAL SPECIALTIES
72
SUBDISCIPLINES

MAP OF SCIENCE: FORECASTING LARGE TRENDS IN SCIENCE

COLLABORATIVE EFFICIENCY

DISCIPLINARY OUTPUT

Science Forecast
S1:E1, 2015

DISCIPLINARY OUTPUT

MATH & PHYSICS

ELECTRONICS, ENERGY & COMPUTERS

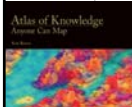
GENETICS

HEALTH

Information Visualization Framework & IVMOOC

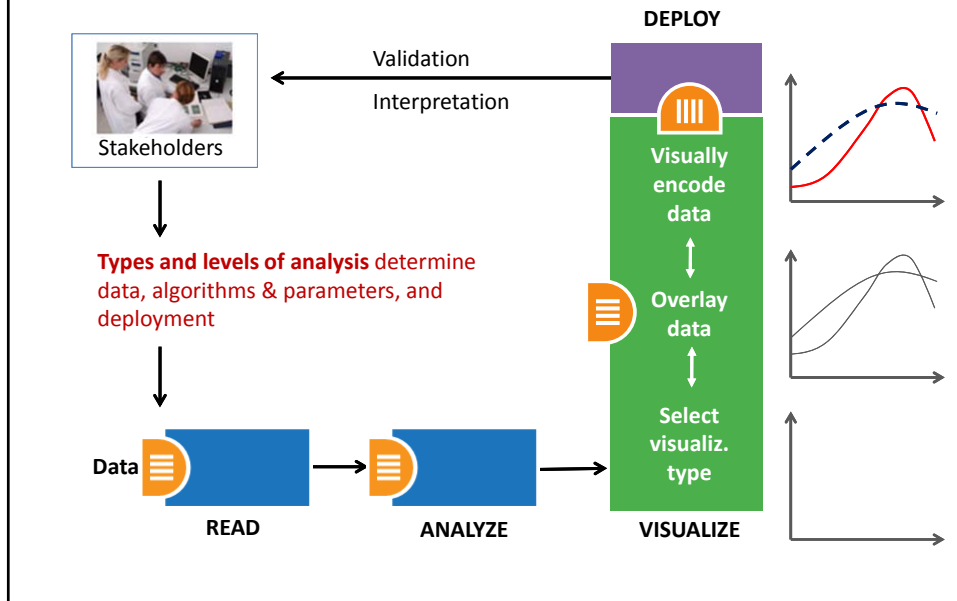


Tasks	LEVELS		
	MICRO: Individual Level about 1-1,000 records page 6	MESO: Local Level about 1,001-100,000 records page 8	MACRO: Global Level more than 100,000 records page 10
TYPES			
Statistical Analysis page 44			
WHEN: Temporal Analysis page 48			
WHERE: Geospatial Analysis page 52			
WHAT: Topical Analysis page 56			
WITH WHOM: Network Analysis page 60			

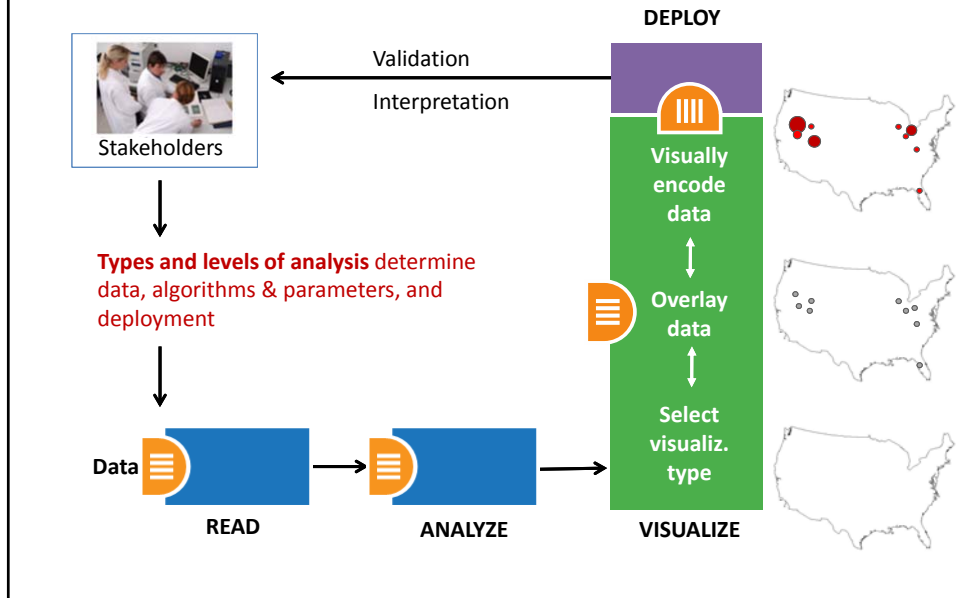


See page 5

Needs-Driven Workflow Design

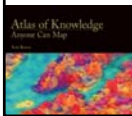


Needs-Driven Workflow Design



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
<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

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

32

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
<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



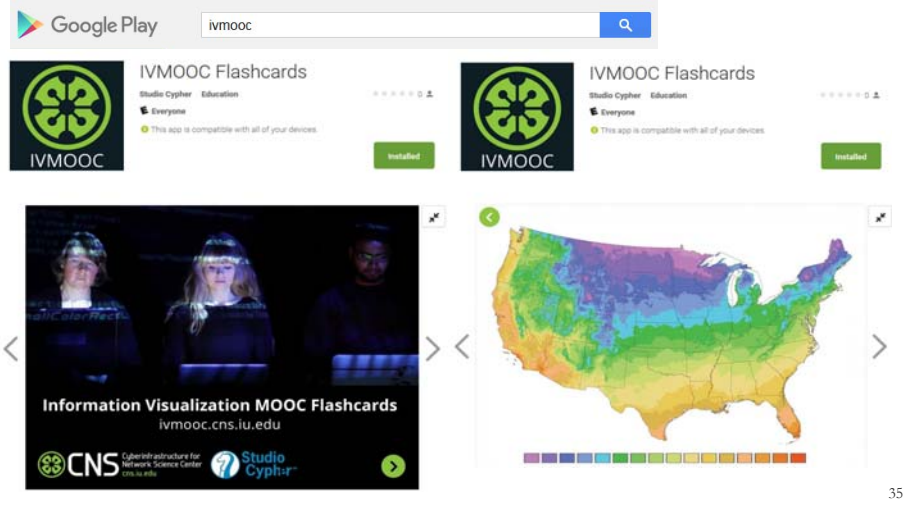
See page 24

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 graphs:** Node position might depend on node attributes or node similarity. **Tree graphs:** hierarchies, taxonomies, genealogies. **Networks:** social networks, migration flows.

IVMOOC App – More than 60 visualizations

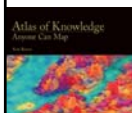
The “IVMOOC Flashcards” app can be downloaded from Google Play and Apple iOS stores.



35

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
<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

Graphic Variable Types Versus Graphic Symbol Types


		Geometric Symbols			
		Point	Line	Area	
Spatial	x	quantitative			
	y	quantitative			
	z	quantitative			
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			

37

Graphic Variable Types Versus Graphic Symbol Types

		Geometric Symbols				Linguistic Symbols				Pictorial Symbols			
		Point	Line	Area	Color	Value	Text, Markers, Punctuation Marks	Images, Icons, Symbolic Objects					
Spatial	x	quantitative											
	y	quantitative											
	z	quantitative											
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											

38

 IVMOOC 2016
MENU



Information Visualization MOOC
ivmooc.cns.iu.edu

Register for free: <http://ivmooc.cns.iu.edu>. Class restarts Jan 12, 2016.

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%).



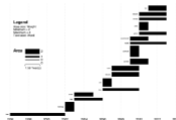
Load **One** File and Run **Many** Analyses and Visualizations

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 Microscopes	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, N 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, N 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

Temporal Burst Analysis—p. 48



Geospatial Analysis—p. 52



Geospatial Analysis—p. 52

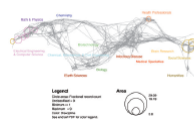


41

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 Microscopes	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, N 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, N Falk-Krzesinski, HJ Fiore, SM Hall, KL Keyton, J Spring, B Stokols, D Trochim, W Uzzi, B

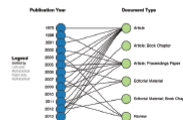
Topical Analysis—p. 56



Paper Citation Network—p. 60



Bi-Modal Network—p. 60



Co-author and many other bi-modal networks.

42



Modeling Science, Technology & Innovation Conference

WASHINGTON D.C. | MAY 17-18, 2016

[View Agenda](#)

This conference is co-funded by the NSF Science of Science and Innovation Policy (SciSIP) program. It brings together international experts and practitioners that develop and apply mathematical, statistical, and computational models to increase our understanding of the structure and dynamics of science, technology and innovation, see details at <http://modsti.cns.iu.edu>.

43

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/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.

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>



44

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>