

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

Katy Börner

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

International Symposium on User-Centered Social Media
University of Duisburg-Essen, Germany

December 21, 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

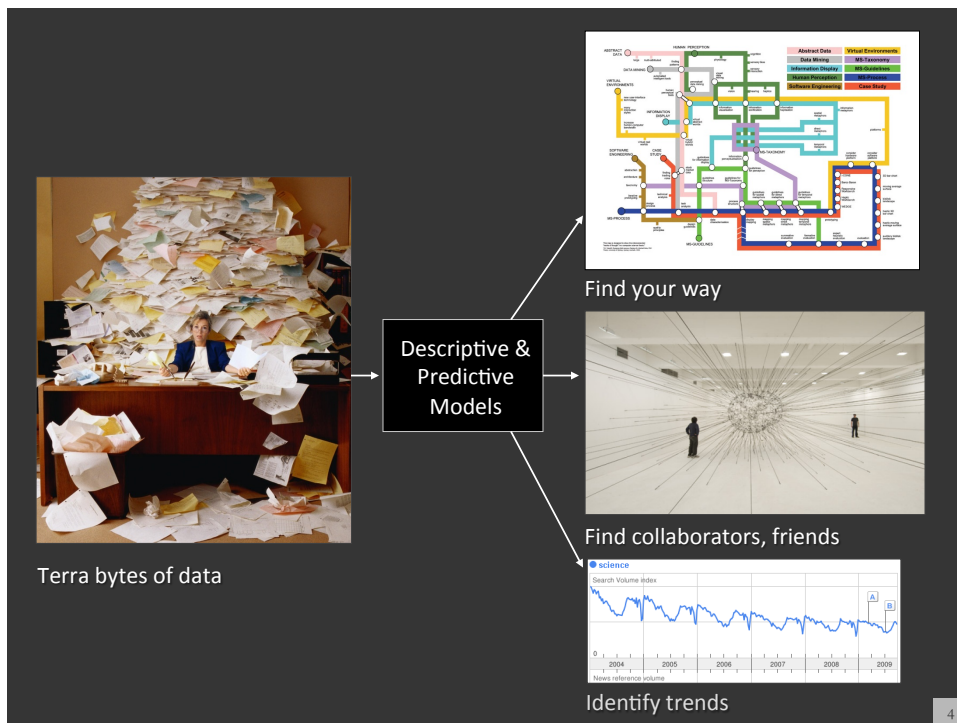


Olivier H. Beauchesne, 2011. Map of Scientific Collaborations from 2005-2009.

Computed Using Data from Elsevier's Scopus

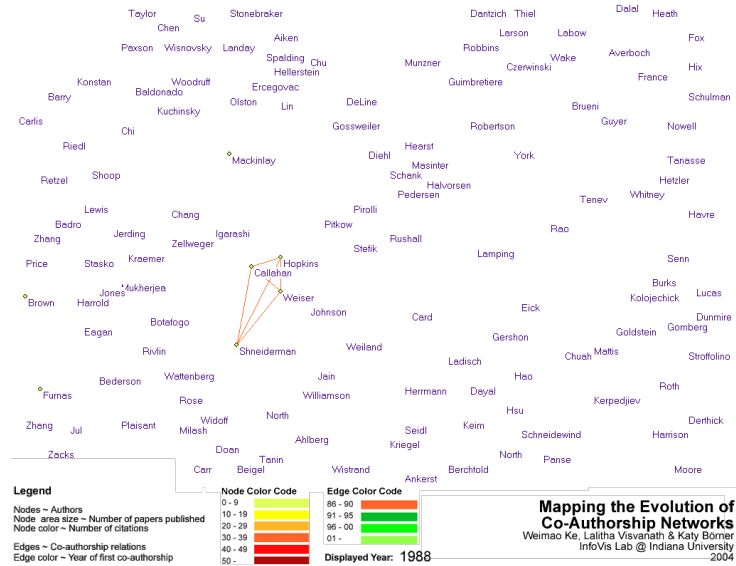
The Power of Data Visualizations

3



Mapping the Evolution of Co-Authorship Networks

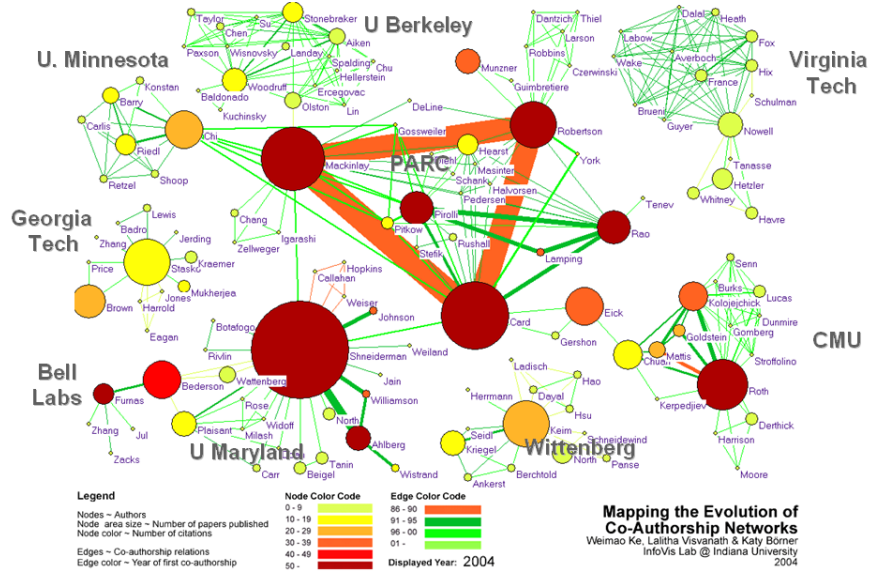
Ke, Visvanath & Börner. 2004. Won 1st prize at the IEEE InfoVis Contest.



5

Mapping the Evolution of Co-Authorship Networks

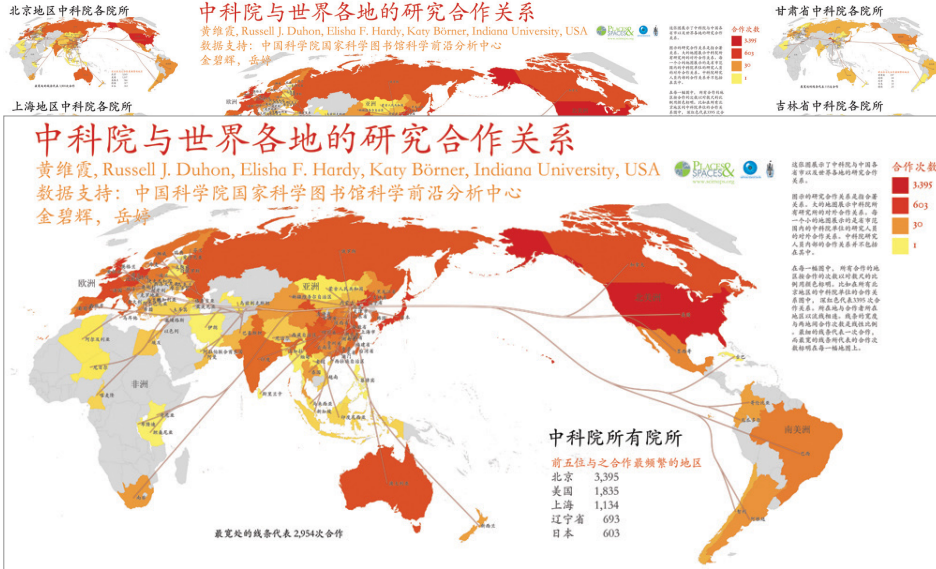
Ke, Visvanath & Börner. 2004. Won 1st prize at the IEEE InfoVis Contest.



6

Research Collaborations by the Chinese Academy of Sciences

Huang, Duhon, Hardy & Börner



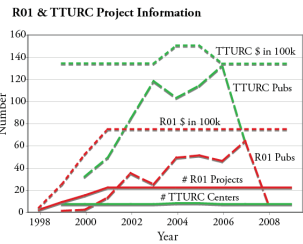
7

Mapping Transdisciplinary Tobacco Use Research Centers Publications

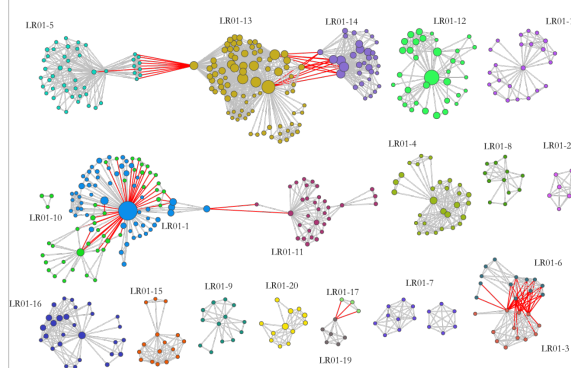
Compare R01 investigator-based funding with TTURC Center awards in terms of number of publications and evolving co-author networks.

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

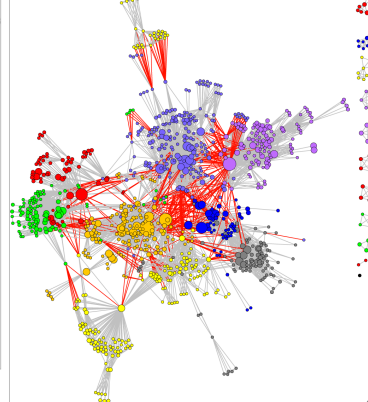
Supported by NIH/NCI Contract HHSN261200800812



Longitudinal R01 Co-Authorship Network



TTURC Co-Authorship Network



8

The Global 'Scientific Food Web'

Mazloumian, Amin, Dirk Helbing, Sergi Lozano, Robert Light, and Katy Börner. 2013. "Global Multi-Level Analysis of the 'Scientific Food Web'". *Scientific Reports* 3, 1167. <http://cns.iu.edu/docs/publications/2013-mazloumian-food-web.pdf>

Contributions:

Comprehensive global analysis of scholarly knowledge production and diffusion on the level of continents, countries, and cities.

Quantifying knowledge flows between 2000 and 2009, we identify global sources and sinks of knowledge production. Our knowledge flow index reveals, where ideas are born and consumed, thereby defining a global 'scientific food web'.

While Asia is quickly catching up in terms of publications and citation rates, we find that its dependence on knowledge consumption has further increased.

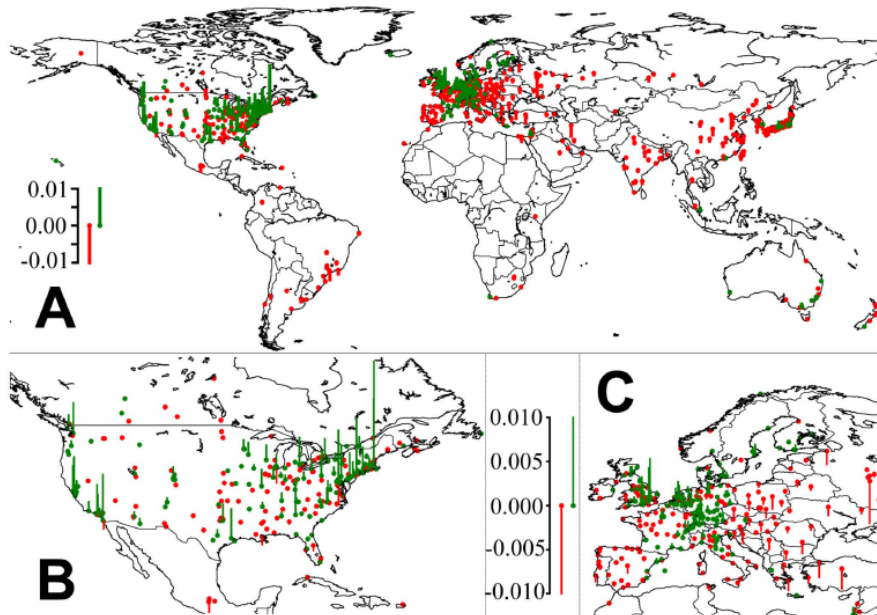
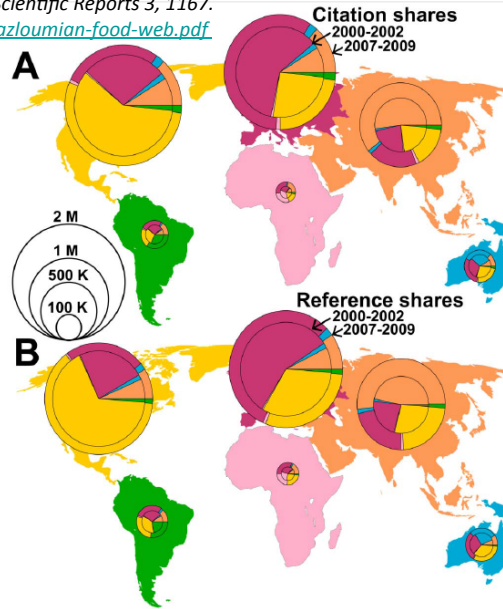
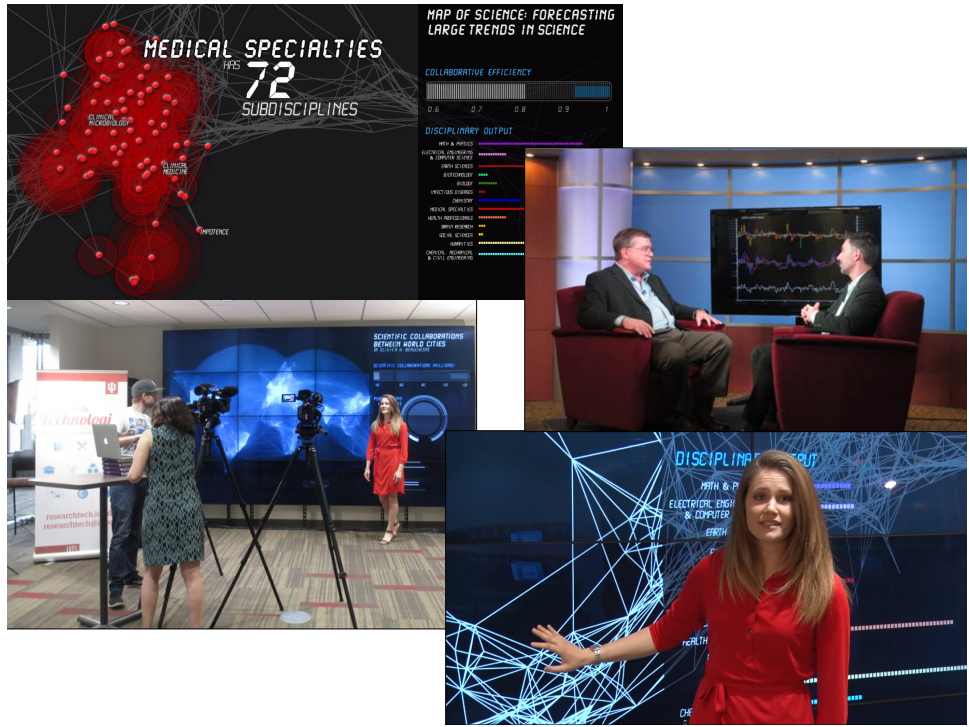
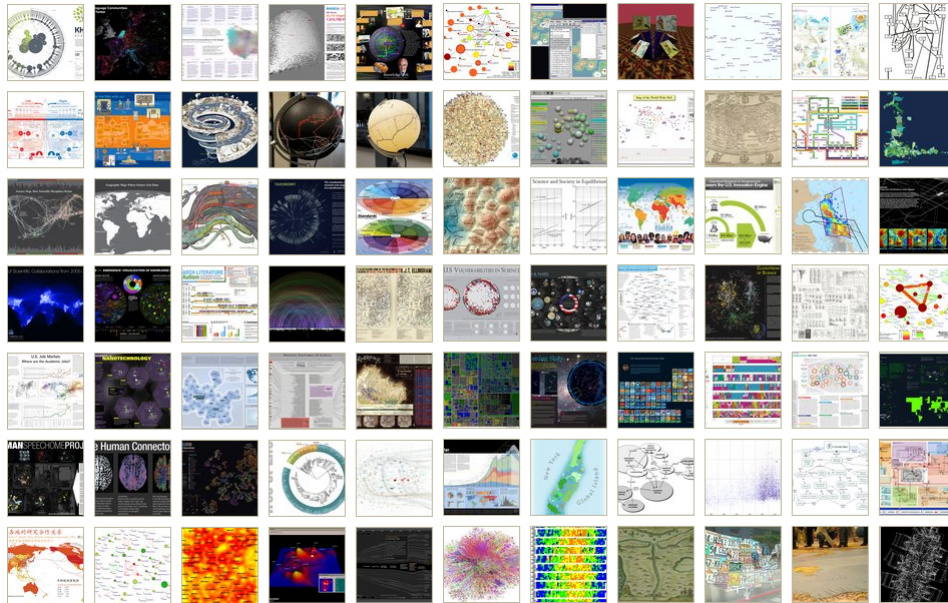


Figure 2 | World map of the greatest knowledge sources and sinks, based on our scientific fitness index. Green bars indicate that the number of citations received is over-proportional, red that the number of citations received is lower than expected (according to a homogeneous distribution of citations over all cities that have published more than 500 papers). It can be seen that most scientific activity occurs in the temperate zone. Moreover, areas of high fitness tend to be areas that are performing economically well (but the opposite does not hold).

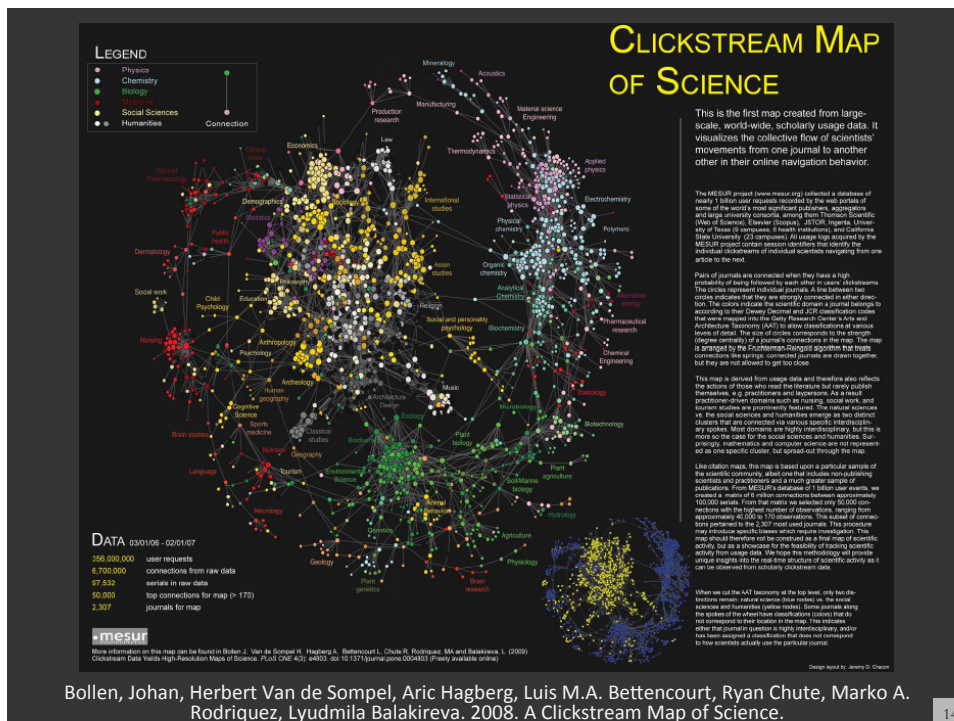
9

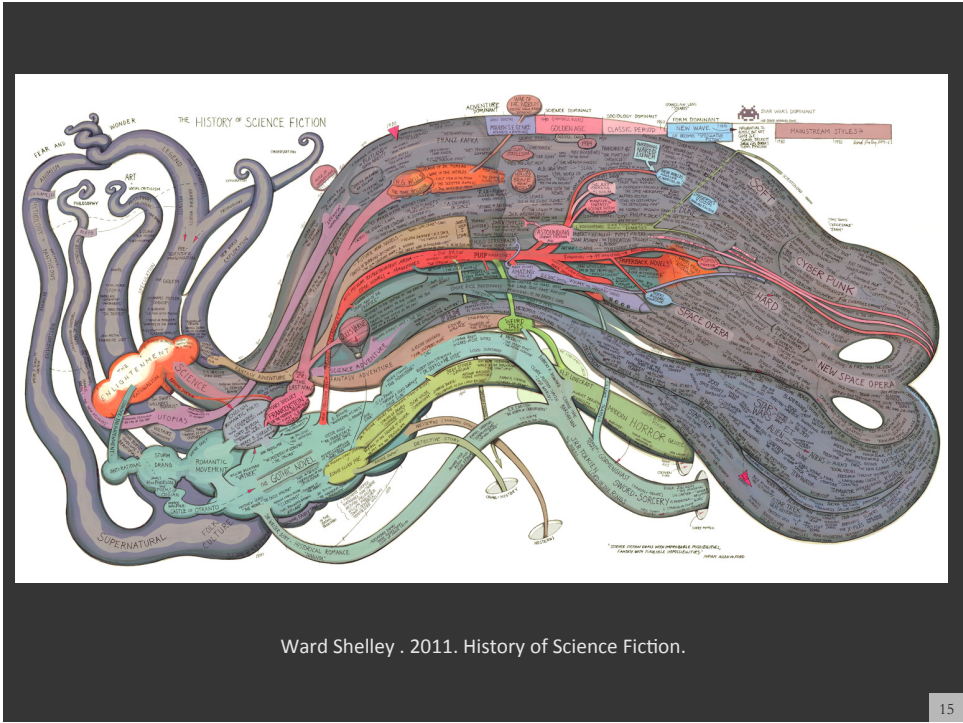
10



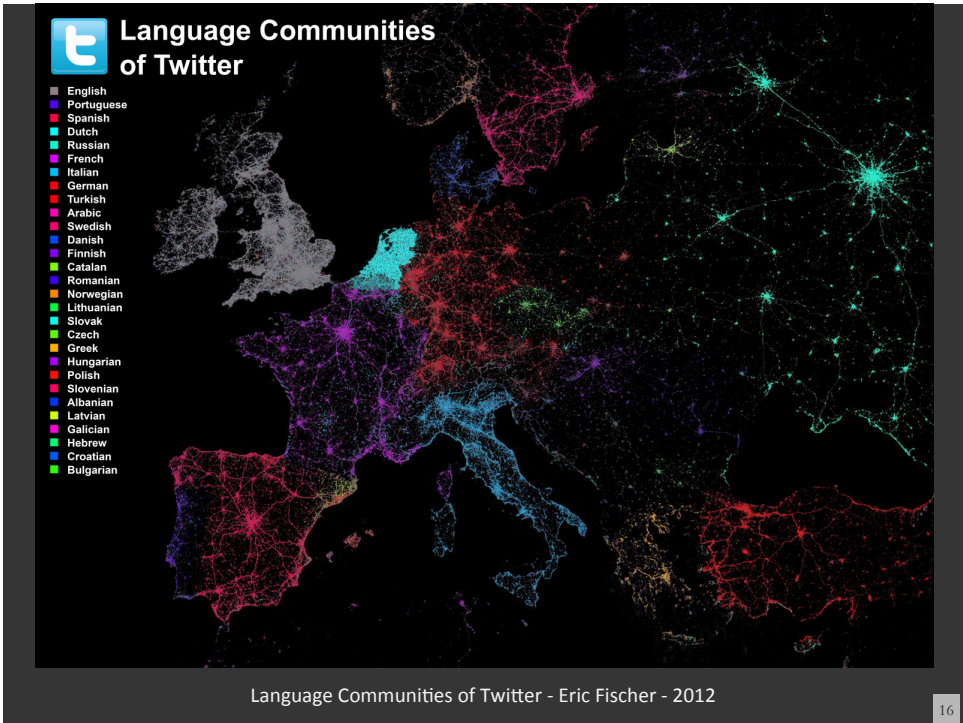


Places & Spaces: Mapping Science Exhibit, online at <http://scimaps.org>



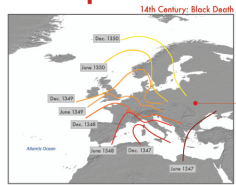


15



16

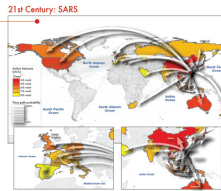
Impact of Air Travel on Global Spread of Infectious Diseases



Epidemic spreading pattern changed dramatically after the development of modern transportation systems.

In pre-industrial times disease spread was mainly a spatial diffusion phenomenon. During the spread of Black Death in the 14th century Europe, only few traveling means were available and typical trips were limited to ordinary short distances on the time scale of one day. Historical studies confirm that the disease diffused smoothly generating an epidemic front traveling on a confining wave through the continent at an approximate velocity of 200-400 miles per year.

The SARS outbreak on the other hand was characterized by a patchy and heterogeneous spatiotemporal pattern mainly due to the air transportation network identified as the major channel of epidemic diffusion and ability to connect far apart regions in a short time period. The SARS maps are obtained with a data-driven stochastic computational model aimed at the study of the SARS epidemic pattern and analysis of the accuracy of the model's predictions. Simulation results describe a spatiotemporal evolution of the disease (color coded countries) in agreement with the historical data. Analysis on the robustness of the model's forecasts leads to the emergence and identification of epidemic pathways on the most probable routes of propagation of the disease. Only few potential channels are selected (arrows, width indicates the probability of propagation along that path) out of the huge number of possible paths the infection could take by following the complex nature of airline connections (light grey, source: IATA).



Forecasts of the Next Pandemic Influenza

Seasonal



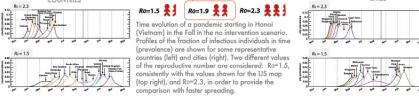
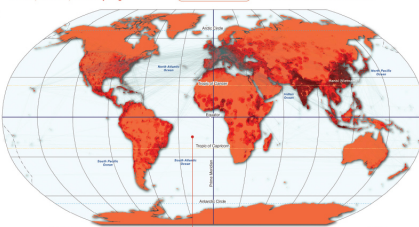
Forecasts are obtained with a stochastic computational model which explicitly incorporates data on worldwide air travel and detailed census data to simulate the global spread of an influenza pandemic. The modeling approach considers infection dynamics (i.e., virus transmission, onset of symptoms, infectiousness, recovery, etc.) among individuals living in urban areas around the world, and assumes that individuals are allowed to travel from one city to another by means of the airline transportation network.

Geographical

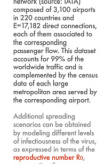


Numerical simulations provide results for the temporal and geographic evolution of the pandemic influenza in 3,100 urban areas located in 220 different countries. The model allows to study different spreading scenarios, characterized by different initial outbreak conditions, both geographically and seasonal.

The central map represents the cumulative number of cases in the world after the first year from the start of a pandemic influenza with $R_0=1.9$ originating in Hanoi (Vietnam) in the Spring.



Reproductive Number (R0)



The model includes the worldwide air transportation network (source: IATA) composed of 3,100 airports in 220 countries and 61,712 direct connections, each of them associated to the corresponding passenger flow. This dataset accounts for 99% of the worldwide traffic and is complemented by the census data of each large metropolitan area served by the corresponding airport.

Intervention



Additional spreading scenarios can be obtained by modifying different levels of infectiousness of the virus, as expressed in terms of the reproductive number R_0 , representing the average number of infections generated by a sick person in a fully susceptible population. Intervention strategies modeling the use of antiviral drugs can be considered. Two scenarios are compared: an uncooperative strategy in which countries only use their own stockpiles, and a cooperative intervention which envisions a limited worldwide sharing of the resources.

Impact of Air Travel on Global Spread of Infectious Diseases - Vittoria Colizza, Alessandro Vespignani - 2007

Logiciand

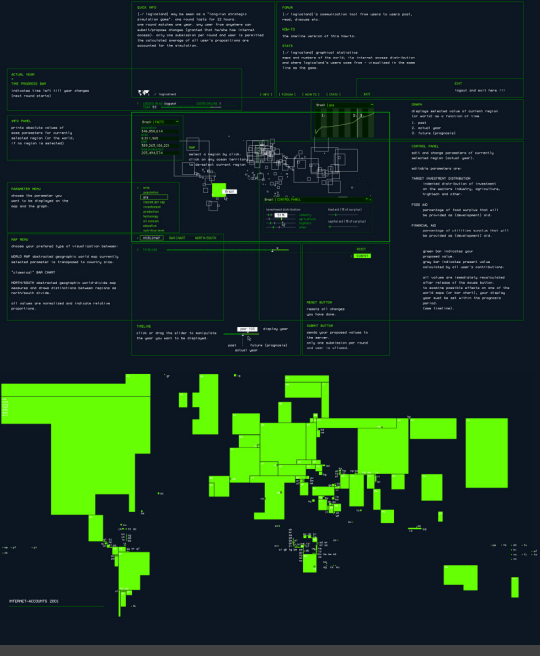
PARTICIPATIVE GLOBAL SIMULATION (MALL SOCIAL SIM-NET)

1. **Introduction** is a research project that explores the impact of computer-mediated environments on social interactions. The project is based on the idea of a participative global simulation, where individuals from different parts of the world interact in a virtual space. The simulation is designed to study the emergence of social structures and patterns of behavior in a complex, multi-agent system. The project is led by Michael Ashauer, Maia Gusberti, and Nik Thoenen.

2. **Methodology** involves the use of a multi-agent simulation framework. The simulation is implemented in a distributed manner, allowing for the participation of a large number of users. The agents are represented as individuals with various attributes and behaviors. The simulation is run on a network of computers, with each computer representing a different geographical location. The data generated by the simulation is analyzed to identify patterns and trends in the system.

3. **Results** show that the simulation exhibits a rich variety of social structures and patterns of behavior. The system evolves from a state of low connectivity to a state of high connectivity, with the emergence of a central hub-and-spoke structure. The simulation also shows the emergence of social norms and conventions, which are influenced by the interactions between the agents. The results suggest that computer-mediated environments can play a significant role in the development of social structures and patterns of behavior.

4. **Conclusion** highlights the importance of participative global simulation in the study of social interactions. The simulation provides a unique perspective on the emergence of social structures and patterns of behavior in a complex, multi-agent system. The results of the simulation suggest that computer-mediated environments can play a significant role in the development of social structures and patterns of behavior. The project is ongoing, and future work will focus on extending the simulation to include more complex social interactions and patterns of behavior.



Logiciand Participative Global Simulation - Michael Ashauer, Maia Gusberti, Nik Thoenen - 2002



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

19



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

20



Illuminated Diagram Display on display at the Smithsonian in DC. http://scimaps.org/exhibit_info/#ID

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 - 2,431
- 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.

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

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

Copyright © 2008 The Regents of the University of California

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.

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.

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

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.

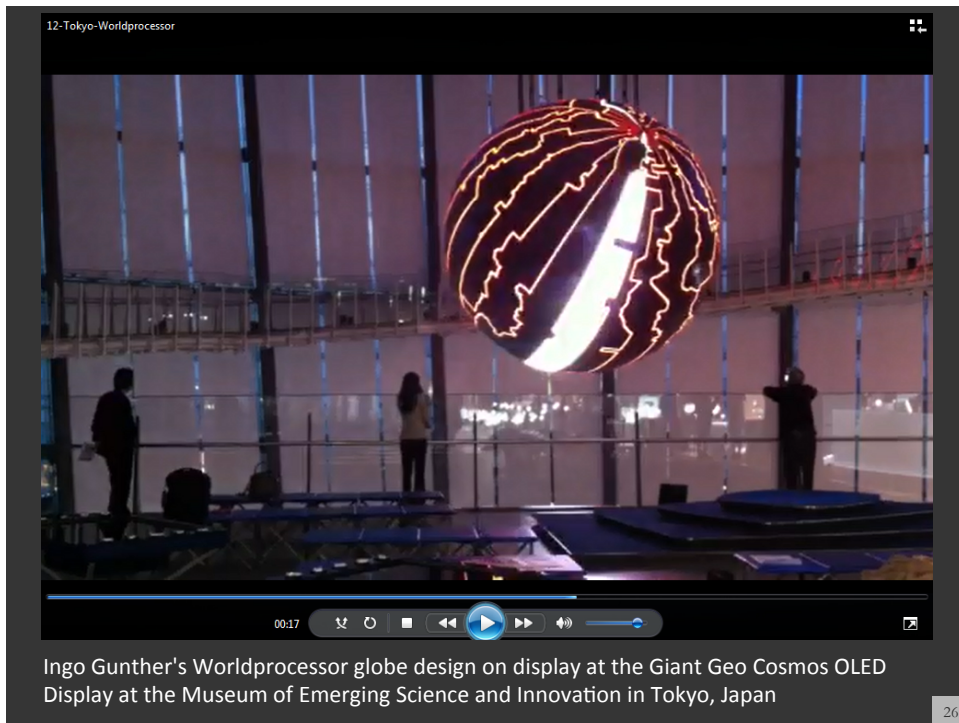
Keyword Search

23

Science Maps in "Expedition Zukunft" science train visiting 62 cities in 7 months 12 coaches, 300 m long Opening was on April 23rd, 2009 by German Chancellor Merkel
<http://www.expedition-zukunft.de>

24

12





Hidalgo, César A., Bailey Klinger, 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 (2015)

<http://scimaps.org/call>

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
- 16th Iteration (2020): Macroscopes for Scholars

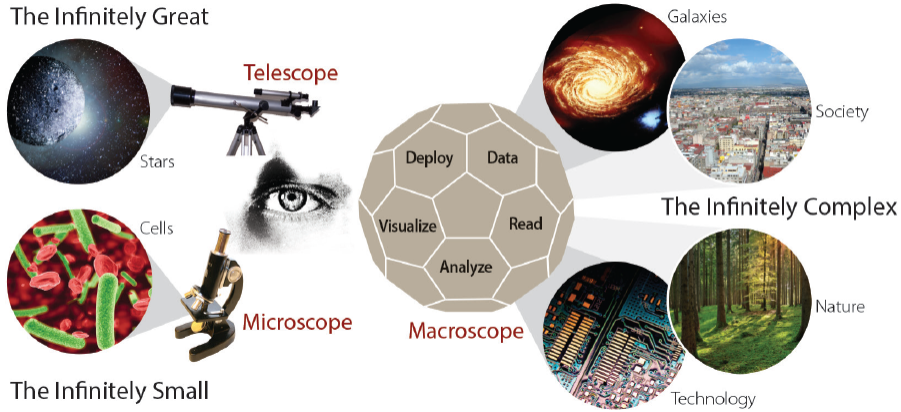
27

Plug-and-Play Macroscopes

28



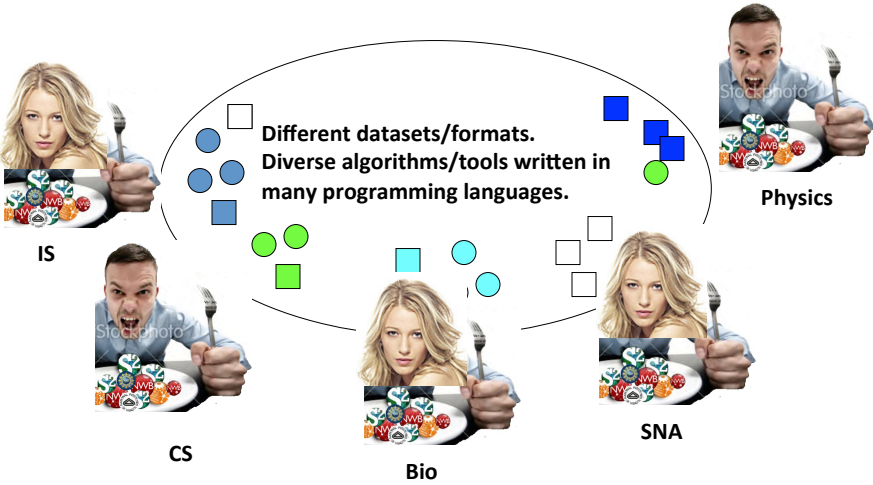
Microscopes, Telescopes, Macroscopes



29



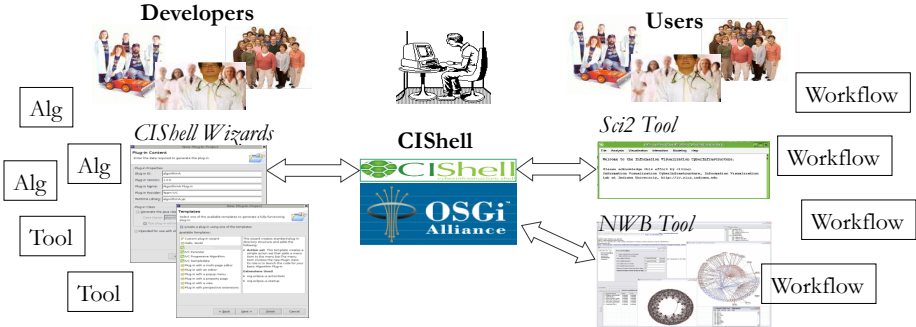
Plug-and-Play Macroscopes



30



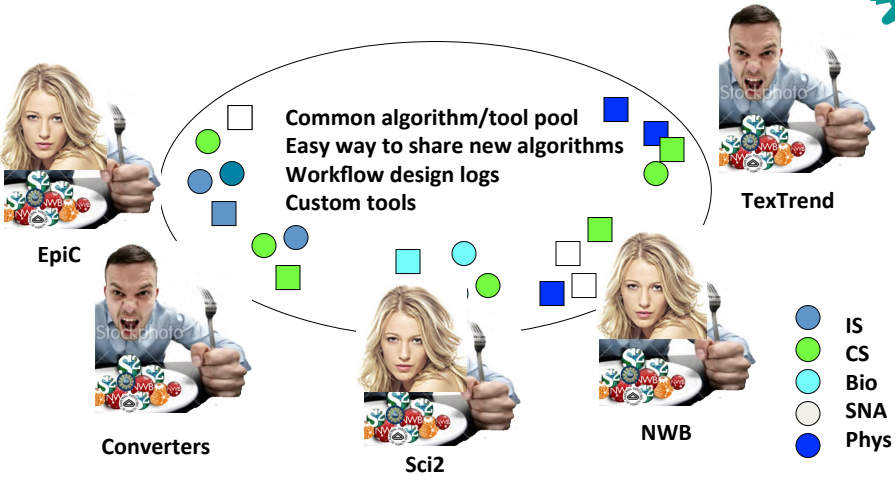
Plug-and-Play Macroscopes



31








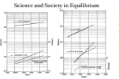


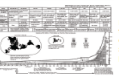
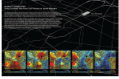
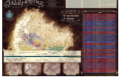

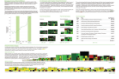





Plug-and-Play Macroscopes

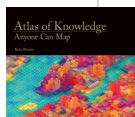


32

Information Visualization Framework & IVMOOC

33

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 110	 Productivity life sciences research page 105	 Science and Society in Equilibration Number of Russian 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 95
WITH WHOM: Network Analysis page 60	 World Finance Corporation network page 87	 Electronic and new media art page 153	 World-wide scholarship collaboration networks page 127

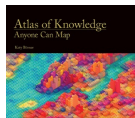


See page 5

34

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

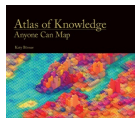
Visualization Framework

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

36

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

37

Graphic Variable Types Versus Graphic Symbol Types

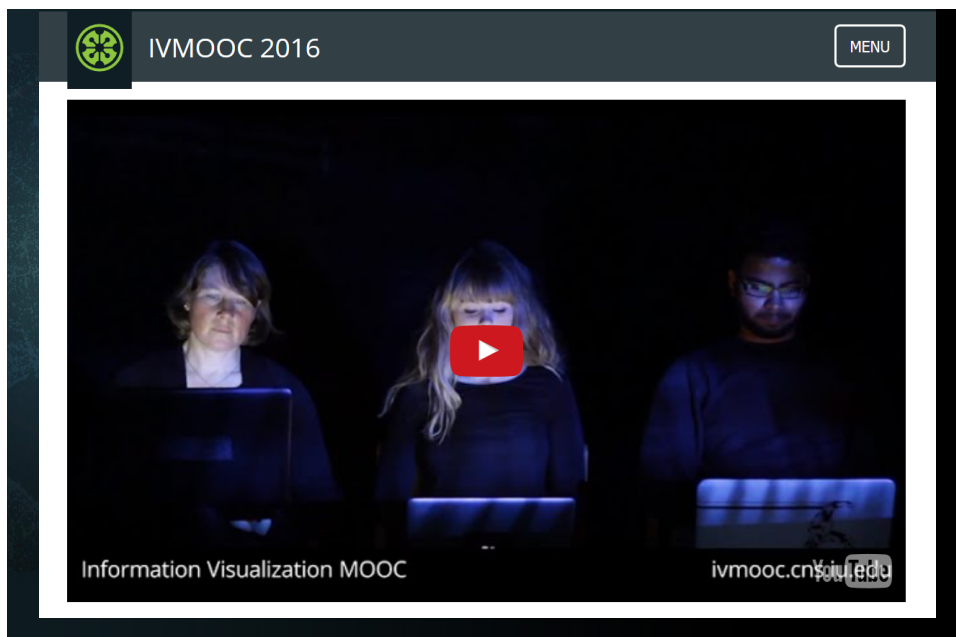
			Point	Line	Geometric Symbols	
					Area	
Spatial	x	quantitative				
	y	quantitative				
	z	quantitative				
Retinal	Form	Size	quantitative	NA (Not Applicable)		
		Shape	qualitative	NA		
		Rotation	quantitative	NA		
		Curvature	quantitative	NA		
		Angle	quantitative	NA		
	Color	Closure	quantitative	NA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

38

Graphic Variable Types Versus Graphic Symbol Types

Type	Variable	Geometric Symbols				Algebraic Symbols				Physical Symbols			
		point	line	area	volume	text	mathematical	units	graphs	text	mathematical	units	graphs
POINT	color	...	...	...	...	...	...	...	...	...	...	...	...
	shape	...	...	...	...	...	...	...	...	...	...	...	...
	rotation	...	...	...	...	...	...	...	...	...	...	...	...
	position	...	...	...	...	...	...	...	...	...	...	...	...
LINE	color	...	...	...	...	...	...	...	...	...	...	...	...
	shape	...	...	...	...	...	...	...	...	...	...	...	...
	rotation	...	...	...	...	...	...	...	...	...	...	...	...
	position	...	...	...	...	...	...	...	...	...	...	...	...
AREA	color	...	...	...	...	...	...	...	...	...	...	...	...
	shape	...	...	...	...	...	...	...	...	...	...	...	...
	rotation	...	...	...	...	...	...	...	...	...	...	...	...
	position	...	...	...	...	...	...	...	...	...	...	...	...
VOLUME	color	...	...	...	...	...	...	...	...	...	...	...	...
	shape	...	...	...	...	...	...	...	...	...	...	...	...
	rotation	...	...	...	...	...	...	...	...	...	...	...	...
	position	...	...	...	...	...	...	...	...	...	...	...	...
TEXT	color	...	...	...	...	...	...	...	...	...	...	...	...
	shape	...	...	...	...	...	...	...	...	...	...	...	...
	rotation	...	...	...	...	...	...	...	...	...	...	...	...
	position	...	...	...	...	...	...	...	...	...	...	...	...

39



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

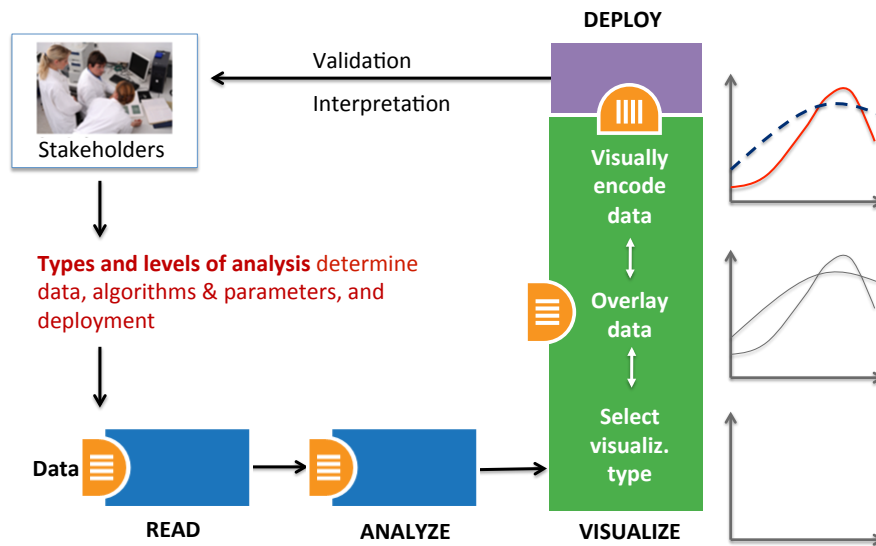


Part 2: Students work in teams on client projects.

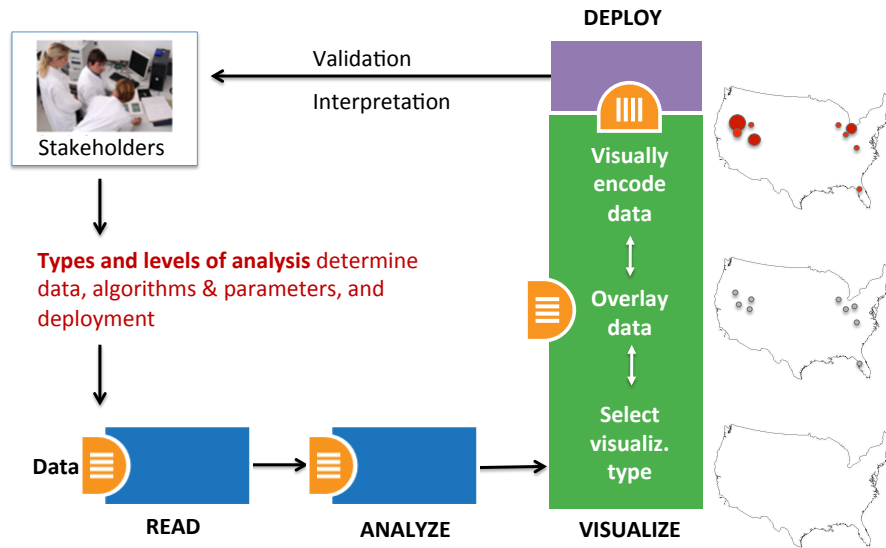
Final grade is based on Class Participation (10%), Midterm (30%), Final Exam (30%), and Client Project(30%).

41

Needs-Driven Workflow Design



Needs-Driven Workflow Design

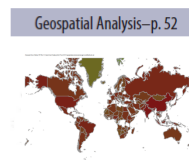
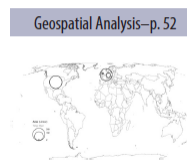
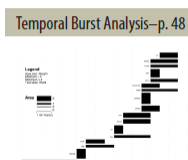


Load **One** File and Run **Many** Analyses and Visualizations

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 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

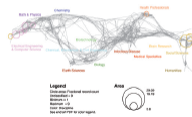
Location	Count	# Citations
Netherlands	13	292
United States	9	318
Germany	11	36
United Kingdom	1	2



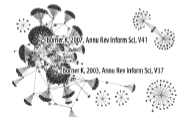
Load **One** File and Run **Many** Analyses and Visualizations

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

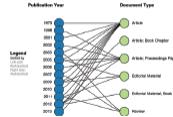
Topical Analysis—p. 56



Paper Citation Network—p. 60



Bi-Modal Network—p. 60



Co-author and many other bi-modal networks.

45

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%).

46

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://vl.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/

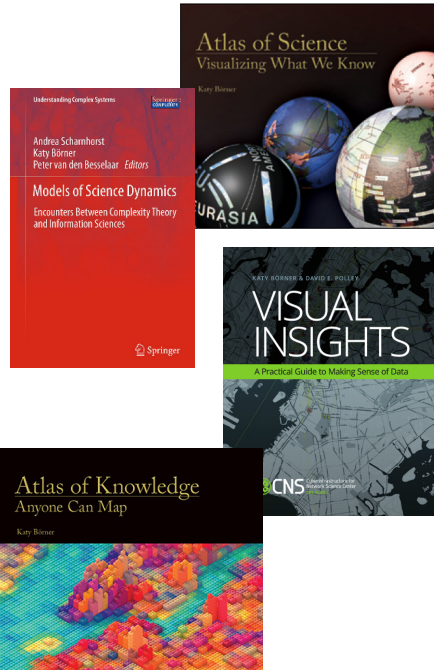
Börner, Katy (2010) **Atlas of Science: Visualizing What We Know**. The MIT Press. <http://scimaps.org/atlas>

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>



47

All papers, maps, tools, talks, press are linked from <http://cns.iu.edu>

These slides are at <http://cns.iu.edu/docs/presentations>

CNS Facebook: <http://www.facebook.com/cnscenter>

Mapping Science Exhibit Facebook: <http://www.facebook.com/mappingscience>

48