Envisioning Science and Technology

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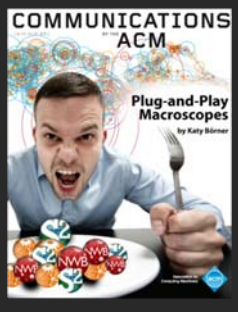
With special thanks to the members at the Cyberinfrastructure for Network Science Center and the Sci2 Tool team

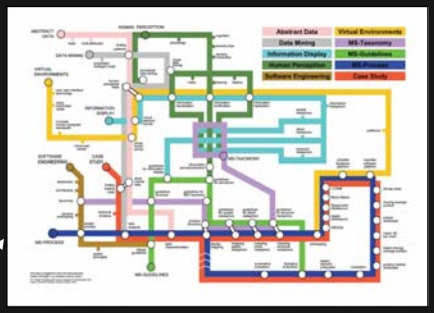


4th Biennial ISPST Conference
Pittsburgh, PA

July 21, 2012`

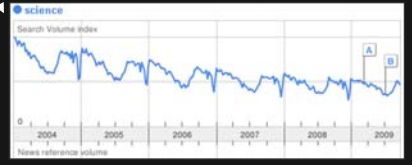
Terra bytes of data

Descriptive & Predictive Models

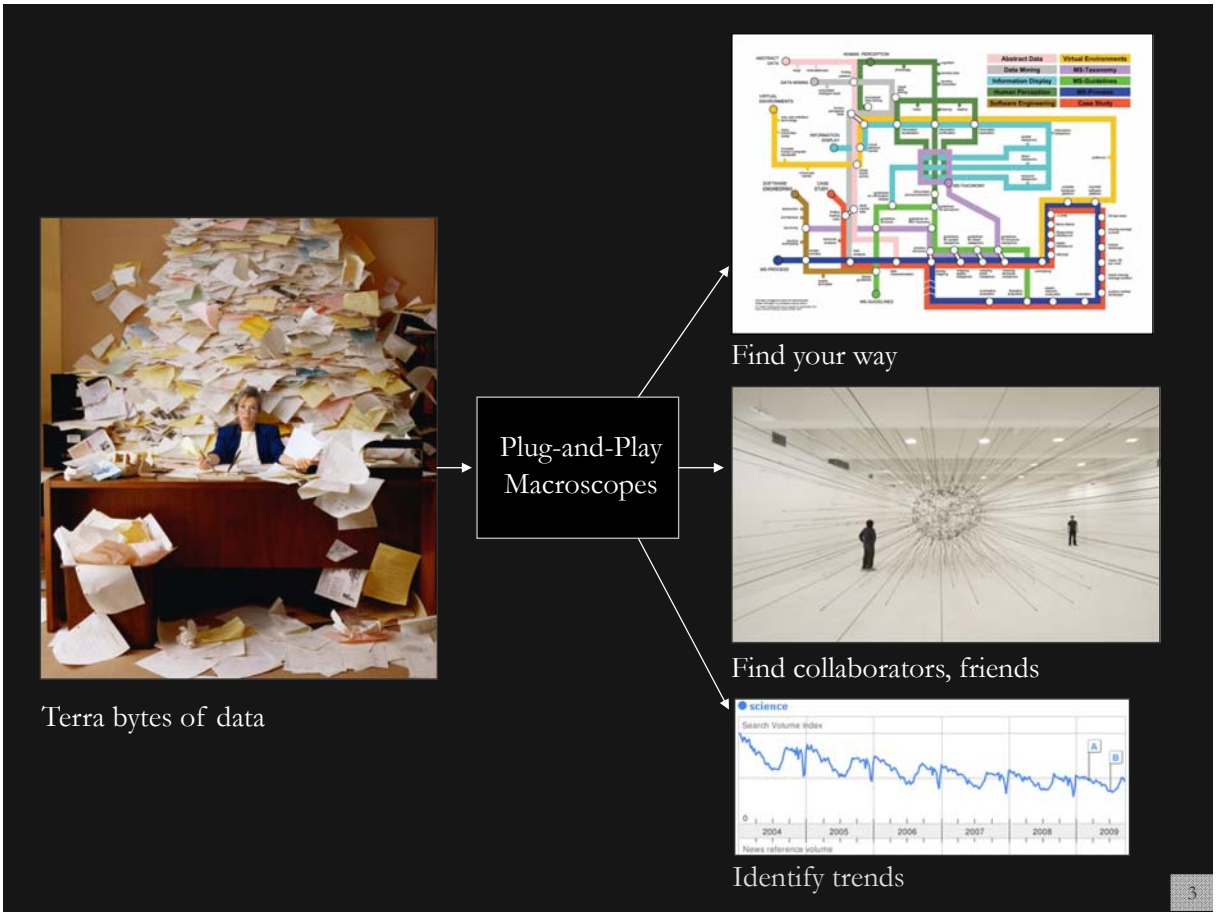


Find your way

Find collaborators, friends



Identify trends



Type of Analysis vs. Level of Analysis

	Micro/Individual (1-100 records)	***Meso/Local (101–10,000 records)***	***Macro/Global (10,000 < 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 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

cyberinfrastructure for NETWORK SCIENCE CENTER
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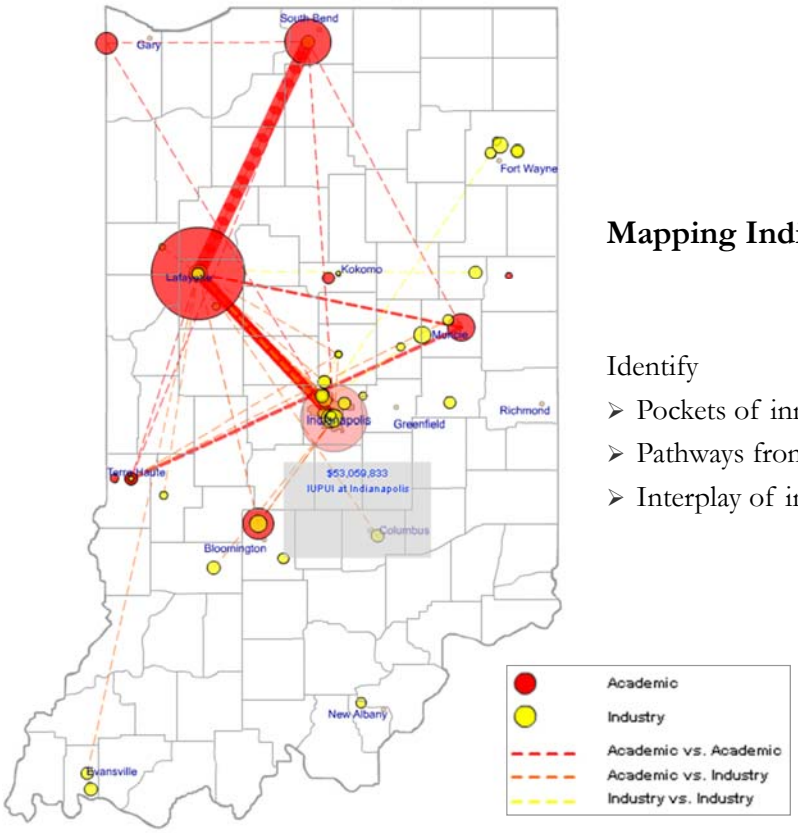


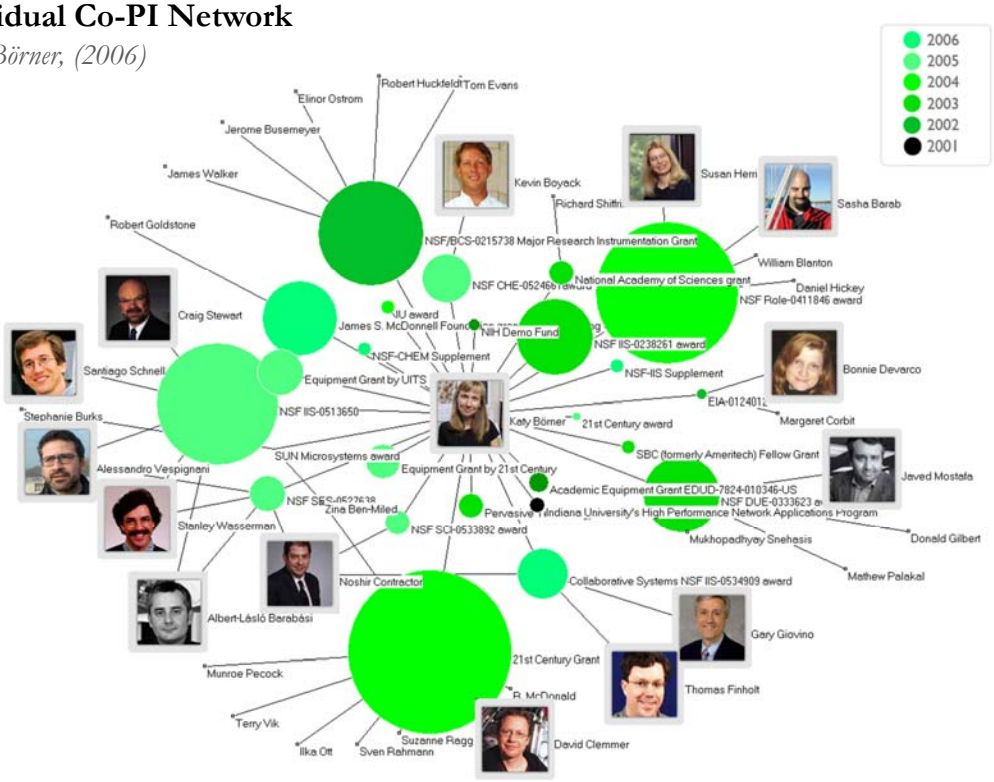
Mapping Indiana's Intellectual Space

Identify

- Pockets of innovation
- Pathways from ideas to products
- Interplay of industry and academia

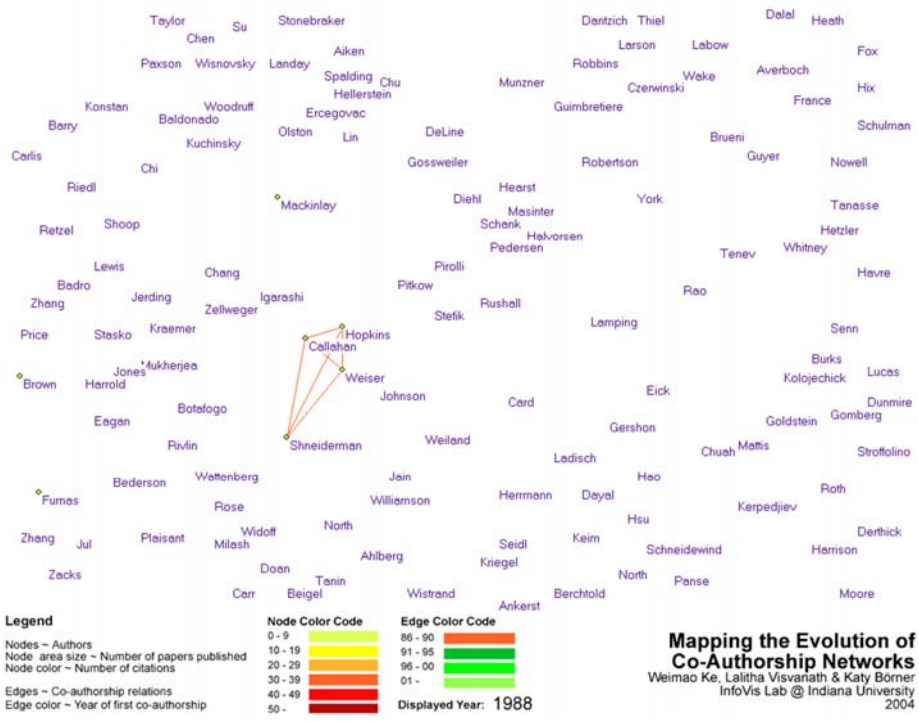
Individual Co-PI Network

Ke & Börner, (2006)



Mapping the Evolution of Co-Authorship Networks

Ke, Visvanath & Börner, (2004) Won 1st price at the IEEE InfoVis Contest.



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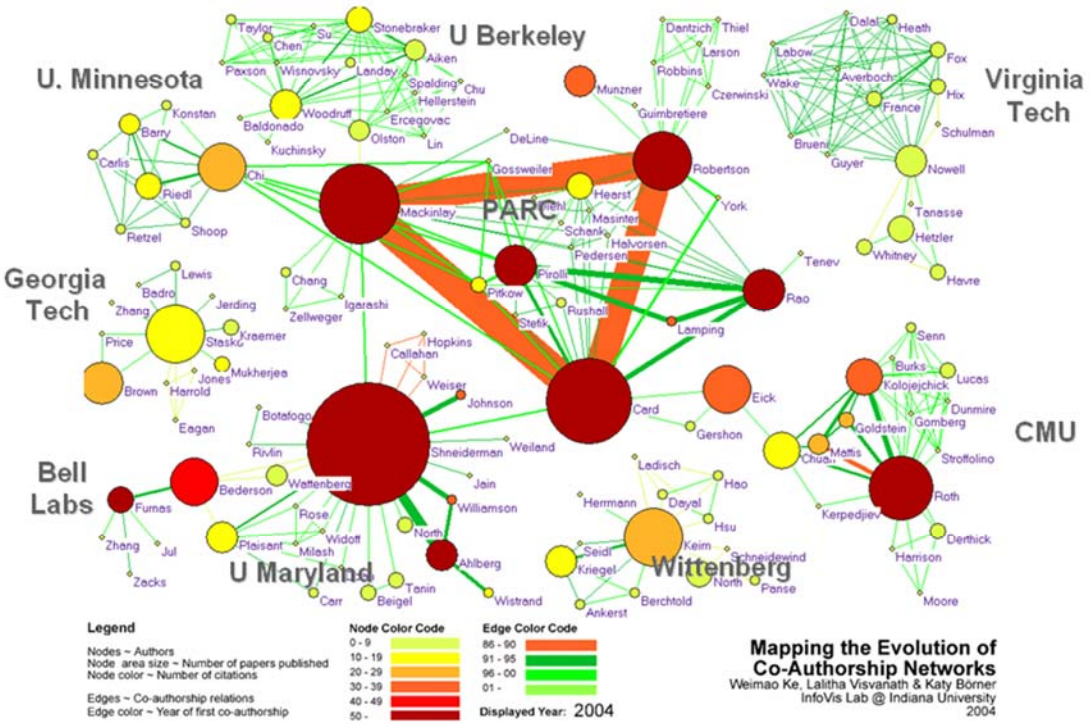
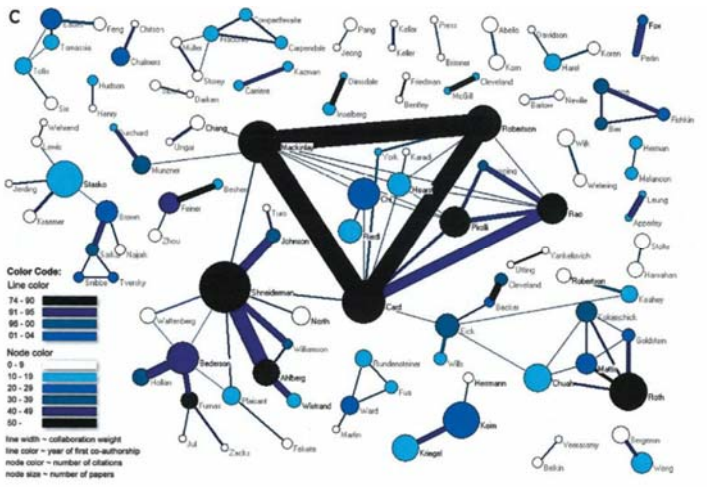


Studying the Emerging Global Brain: Analyzing and Visualizing the Impact of Co-Authorship Teams

Börner, Dall'Asta, Ke & Vespignani (2005) Complexity, 10(4):58-67.



Research question:

- Is science driven by prolific single experts or by high-impact co-authorship teams?

Contributions:

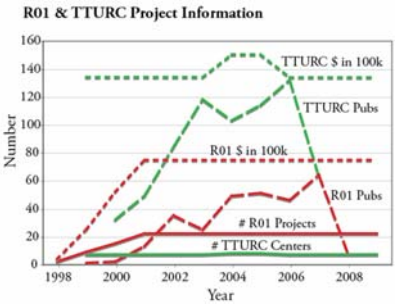
- New approach to allocate citational credit.
- Novel weighted graph representation.
- Visualization of the growth of weighted co-author network.
- Centrality measures to identify author impact.
- Global statistical analysis of paper production and citations in correlation with co-authorship team size over time.
- Local, author-centered entropy measure.

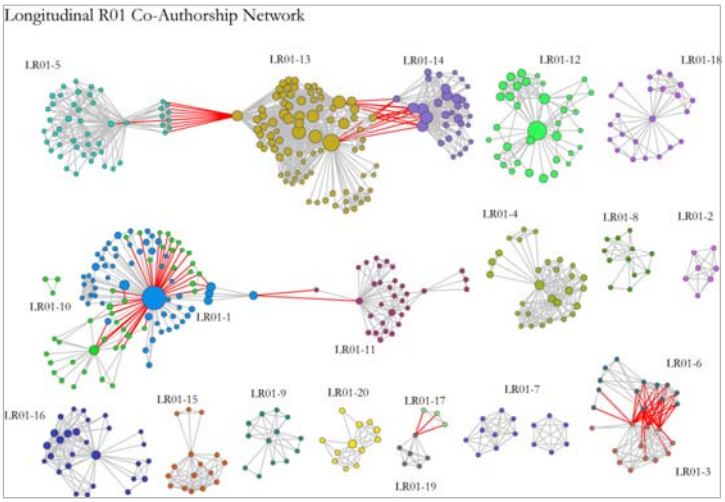
Mapping Transdisciplinary Tobacco Use Research Centers Publications

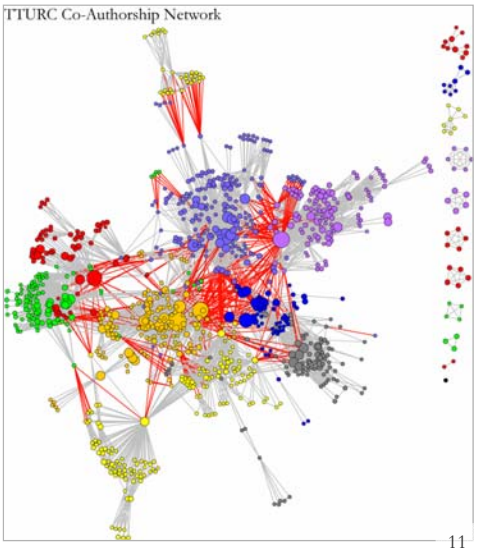
Compare R01 investigator based funding with TTURC Center awards in terms of number of publications and evolving co-author networks.

Zoss & Börner, forthcoming.

Supported by NIH/NCI Contract HHSN261200800812







Mapping Topic Bursts

Co-word space of the top 50 highly frequent and bursty words used in the top 10% most highly cited PNAS publications in 1982-2001.

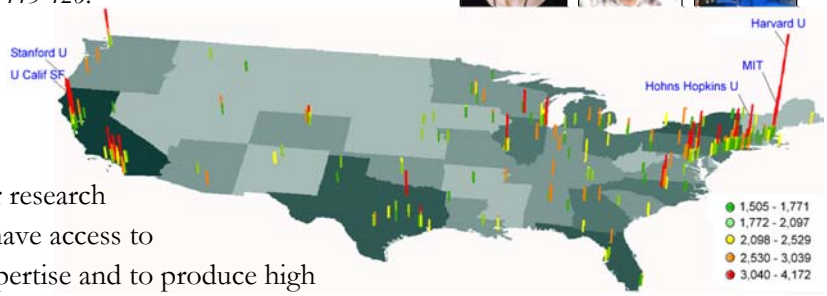
Mane & Börner. (2004) PNAS, 101(Suppl. 1): 5287-5290.

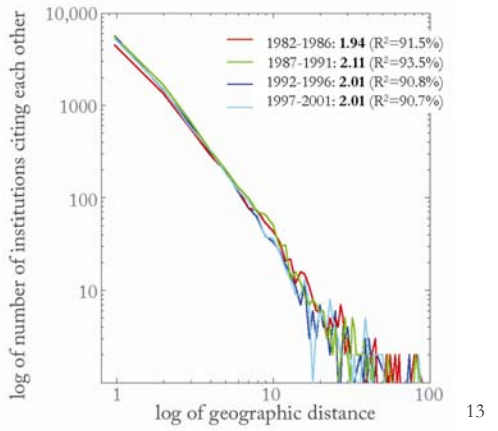
Spatio-Temporal Information Production and Consumption of Major U.S. Research Institutions

Börner, Katy, Penumarthy, Shashikant, Meiss, Mark and Ke, Weimao. (2006) Mapping the Diffusion of Scholarly Knowledge Among Major U.S. Research Institutions. Scientometrics. 68(3), pp. 415-426.

Research questions:

1. Does space still matter in the Internet age?
2. Does one still have to study and work at major research institutions in order to have access to high quality data and expertise and to produce high quality research?
3. Does the Internet lead to more global citation patterns, i.e., more citation links between papers produced at geographically distant research instructions?



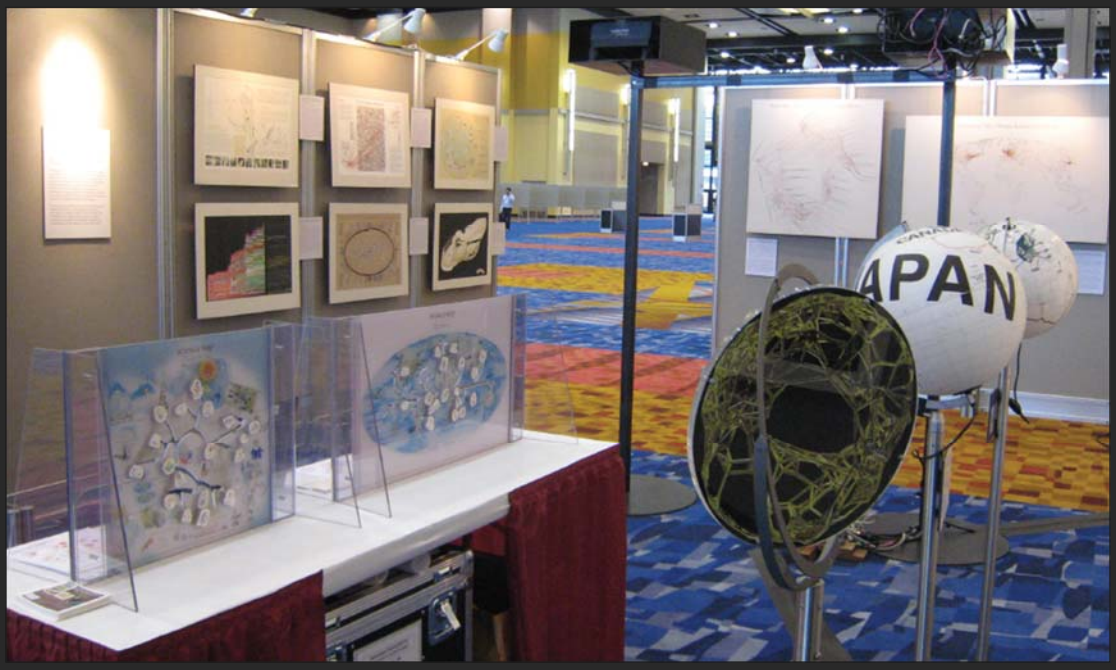


Contributions:

- Answer to Qs 1 + 2 is YES.
- Answer to Qs 3 is NO.
- Novel approach to analyzing the dual role of institutions as information producers and consumers and to study and visualize the diffusion of information among them.

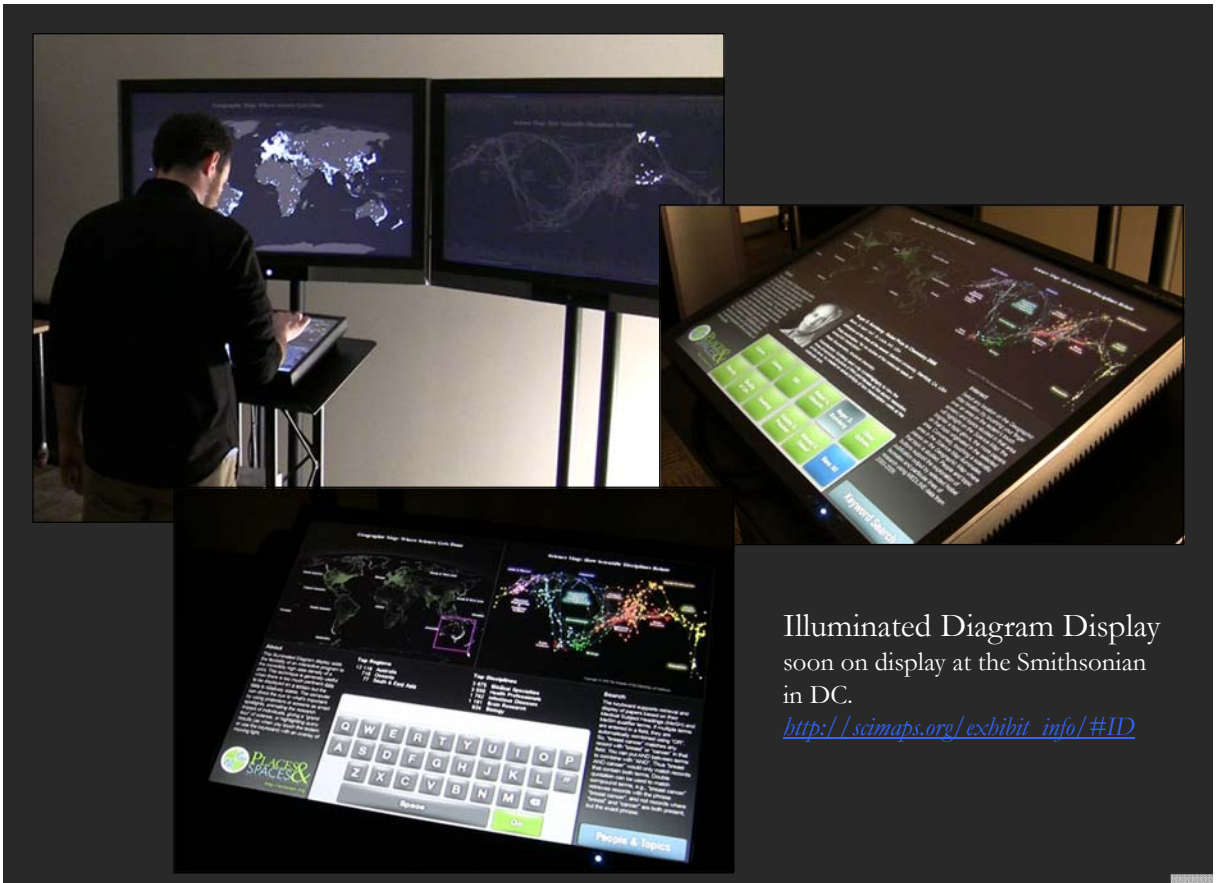
Mapping Science Exhibit – 10 Iterations in 10 years

http://scimaps.org/

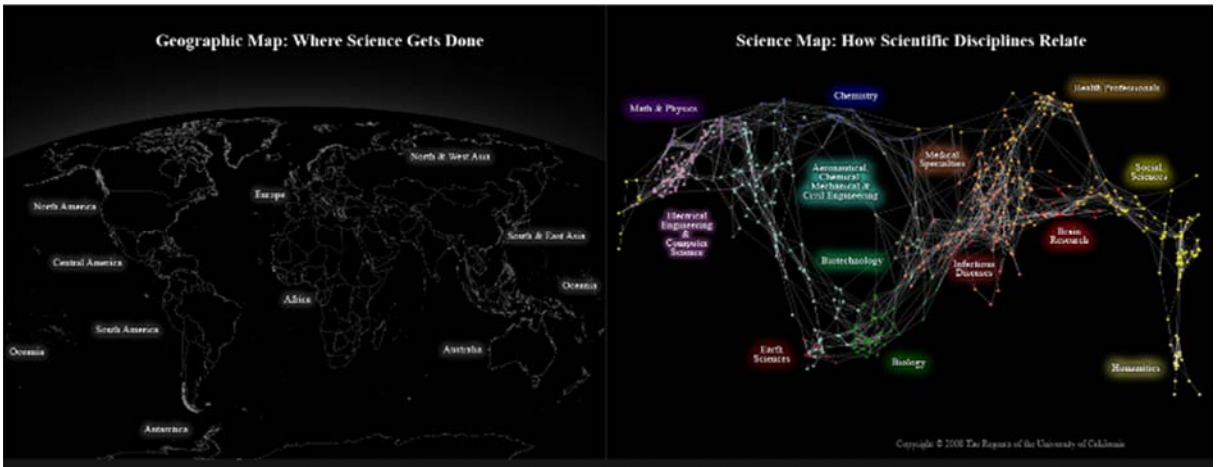


Mapping Science Exhibit at MEDIA X was on May 18, 2009 at Wallenberg Hall, Stanford University,
http://mediax.stanford.edu, *http://scaleindependentthought.typepad.com/photos/scimaps*

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



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



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.

Interact

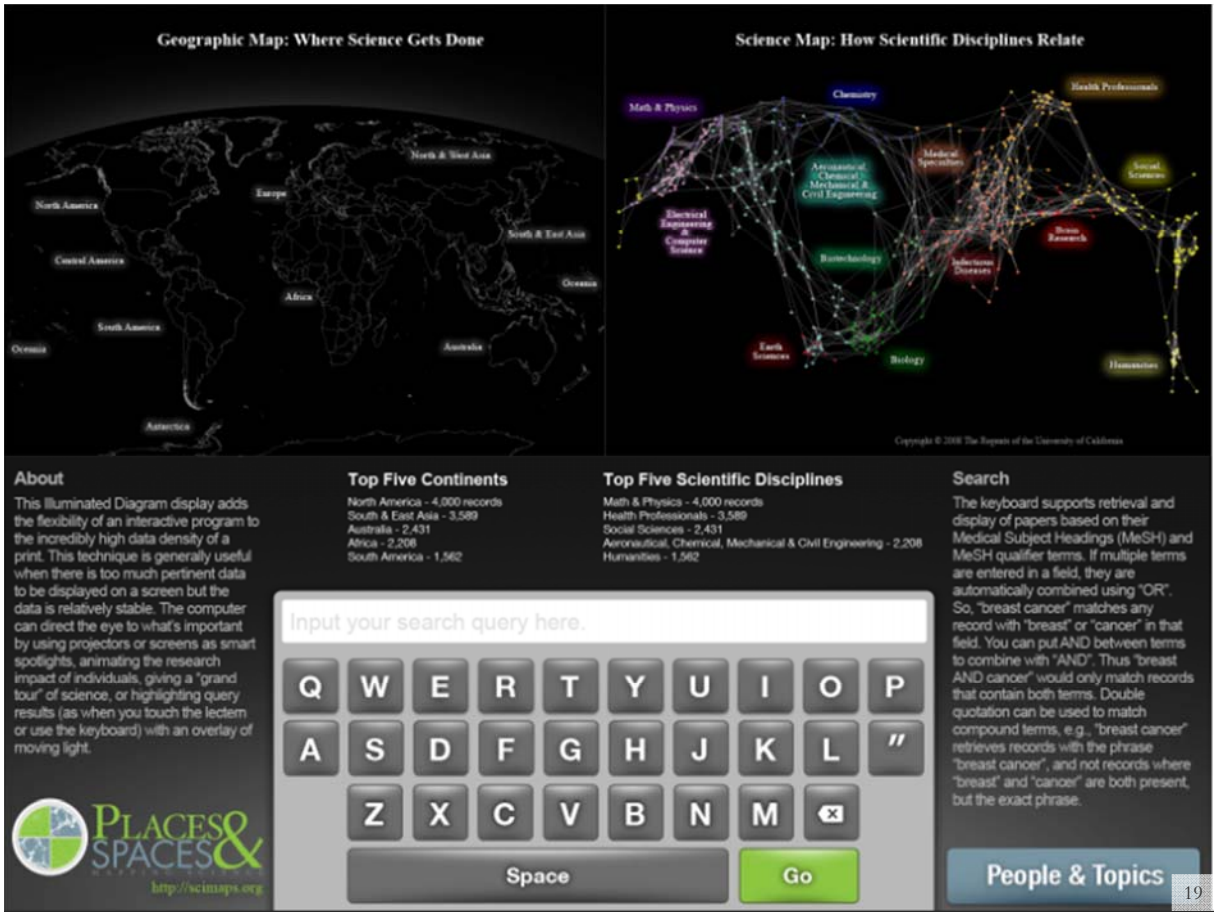
Select any location on the *Geographic Map* location (by brushing your finger over an area on the lectern's touch screen) and topics studied in that area will highlight on the *Science Map*: the brighter a topic glows, the more papers on that topic originated in the selected area. Conversely, touching 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

PLACES & SPACES MAPPING SCIENCE
http://scimaps.org


Geographic Map: Where Science Gets Done
North America
Europe
North & West Asia
South & East Asia
Central America
Africa
Oceania
South America
Australia
Antarctica
Science Map: How Scientific Disciplines Relate
Math & Physics
Chemistry
Health Professionals
Medical Specialties
Social Sciences
Electrical Engineering & Computer Science
Biotechnology
Infectious Diseases
Brain Research
Earth Sciences
Biology
Humanities
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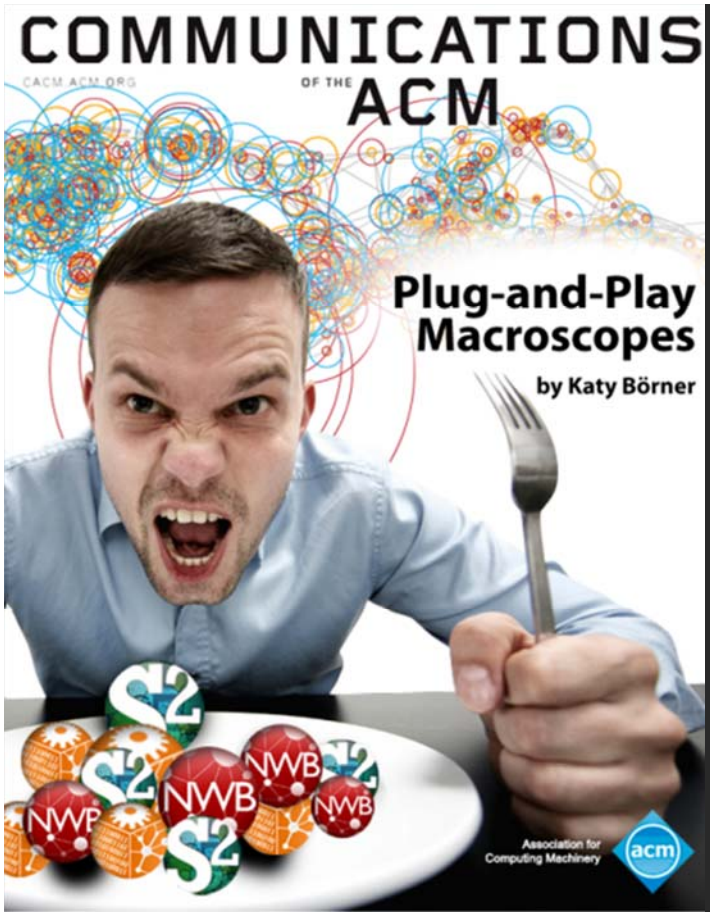
PLACES & SPACES
http://scimaps.org
Top Five Continents
North America - 4,000 records
South & East Asia - 3,589
Australia - 2,431
Africa - 2,208
South America - 1,582
Top Five Scientific Disciplines
Math & Physics - 4,000 records
Health Professionals - 3,589
Social Sciences - 2,431
Aeronautical, Chemical, Mechanical & Civil Engineering - 2,208
Humanities - 1,582
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


INDIANA UNIVERSITY
PLACES AND SPACES EXHIBIT

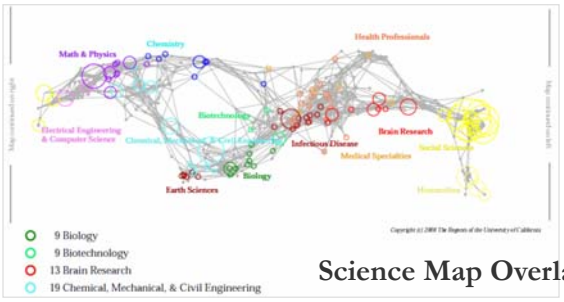


Börner, Katy. (March 2011). Plug-and-Play Macroscopes. *Communications of the ACM, 54(3), 60-69.*

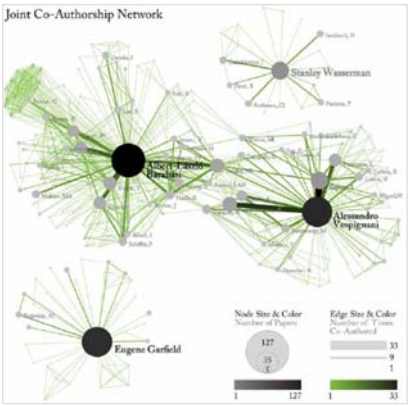
Video and paper are at http://www.scivee.tv/node/27704

Science of Science (Sci²) Tool – Open Code for S&T Assessment

OSGi/CIShell powered tool with NWB plugins and many new scientometrics and visualizations plugins.

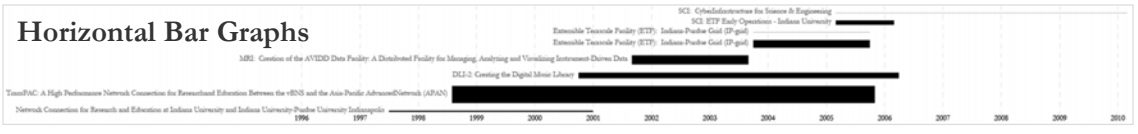


Science Map Overlays



Network Visualizations

Horizontal Bar Graphs



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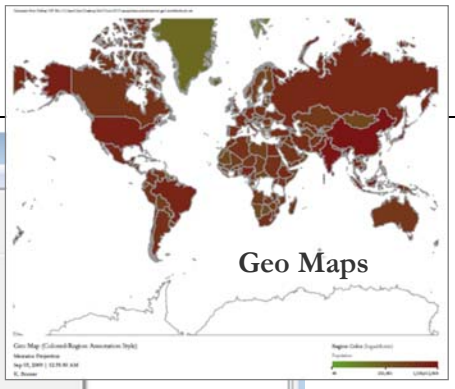
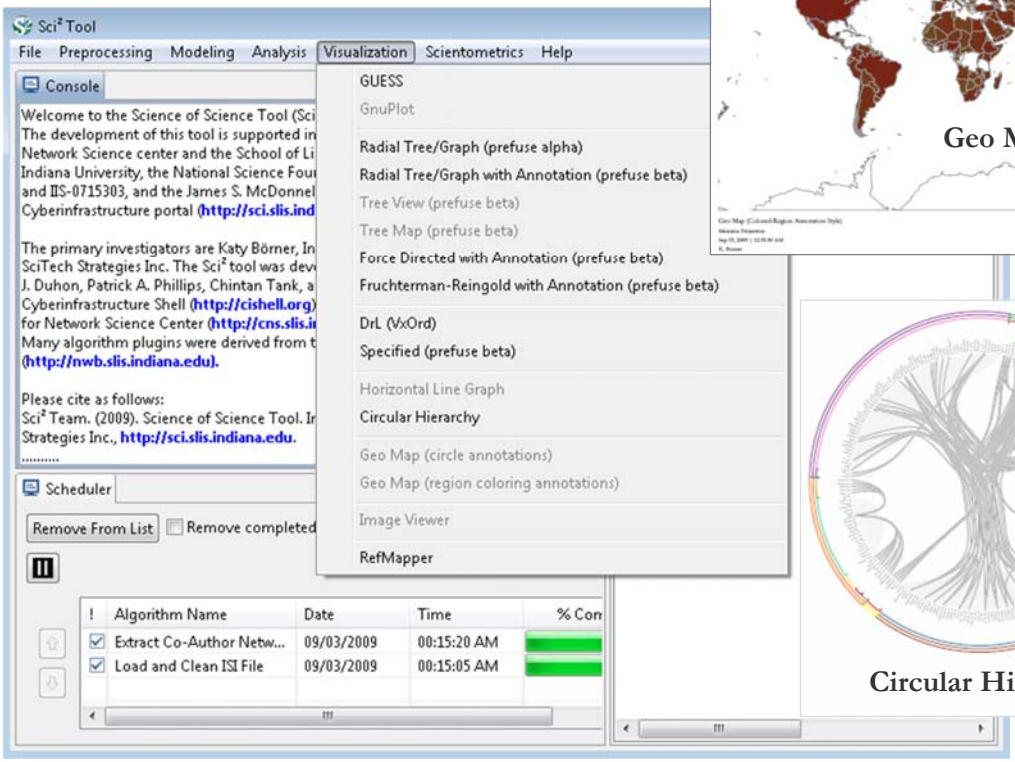
Sci² Tool cont.





Science of Science (Sci²) Tool – Usage

The Sci² Tool is used by the

- National Science Foundation,
- National Institutes of Health,
- US Department of Agriculture, and
- National Oceanic and Atmospheric Administration

Tool registrations come from 73 countries and professions such as

Sci² Tool – Type of Analysis vs. Level of Analysis

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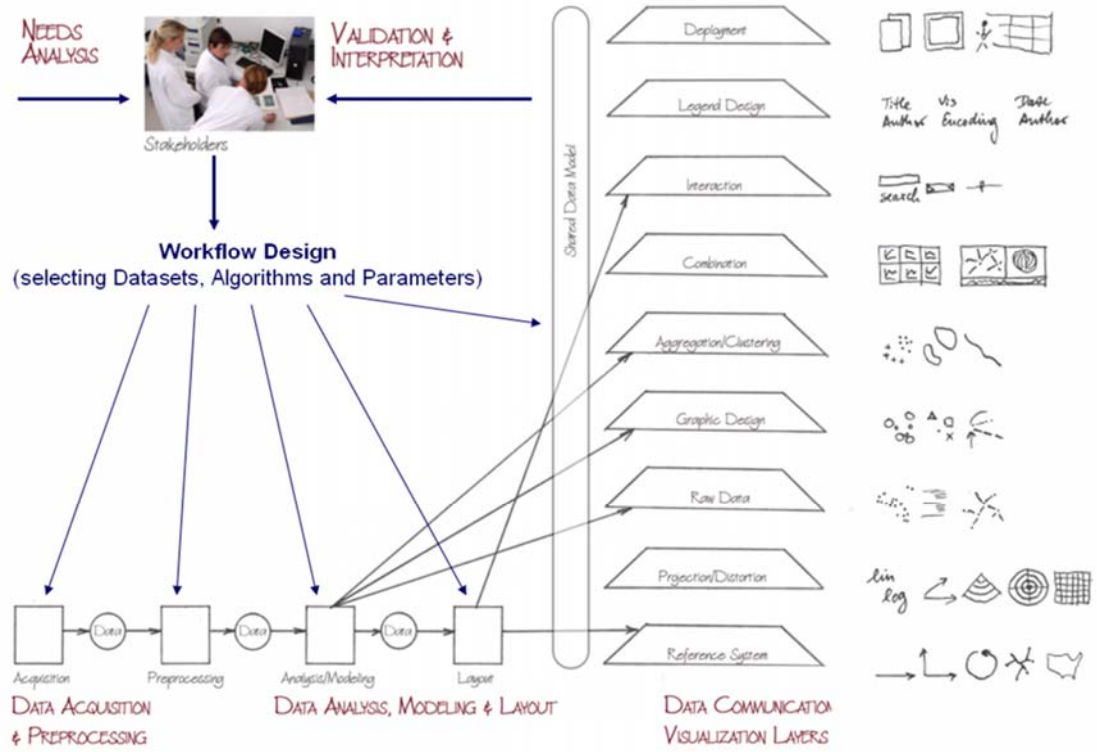
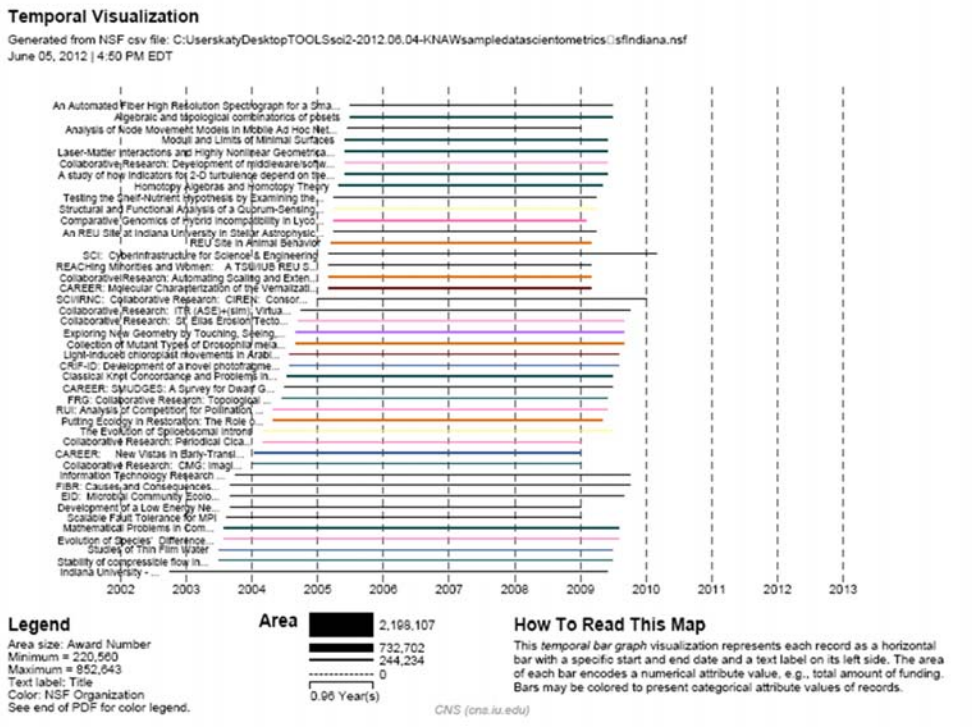
Needs-Driven Workflow Design using a modular data acquisition/analysis/ modeling/ visualization pipeline as well as modular visualization layers.

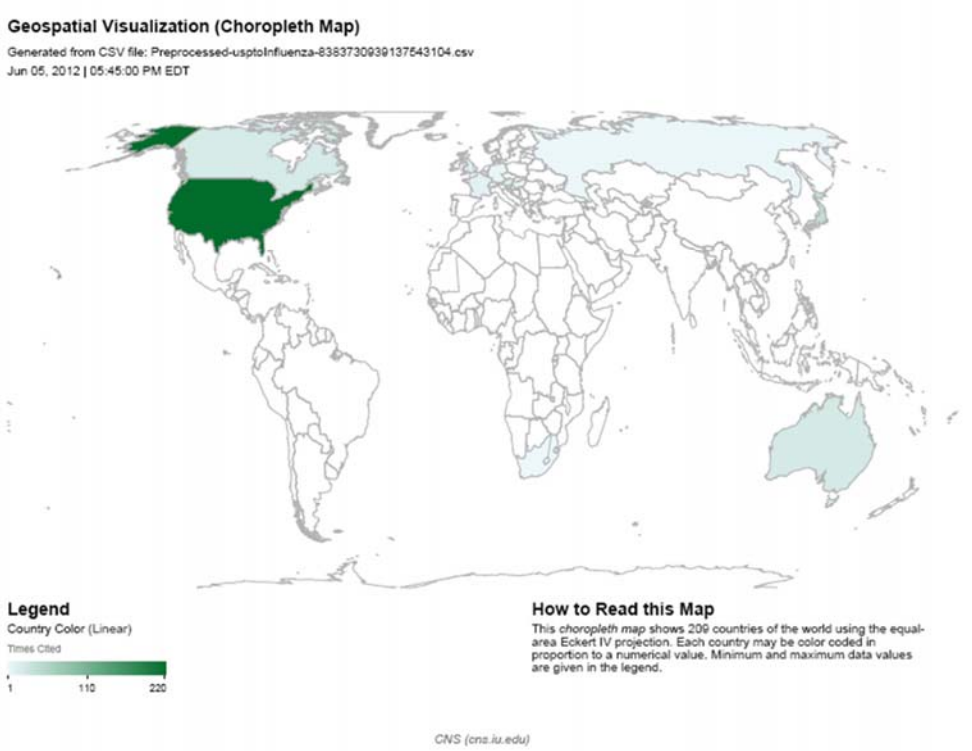


Börner, Katy (2010) Atlas of Science. MIT Press.

Temporal Visualizations



Geospatial Visualizations



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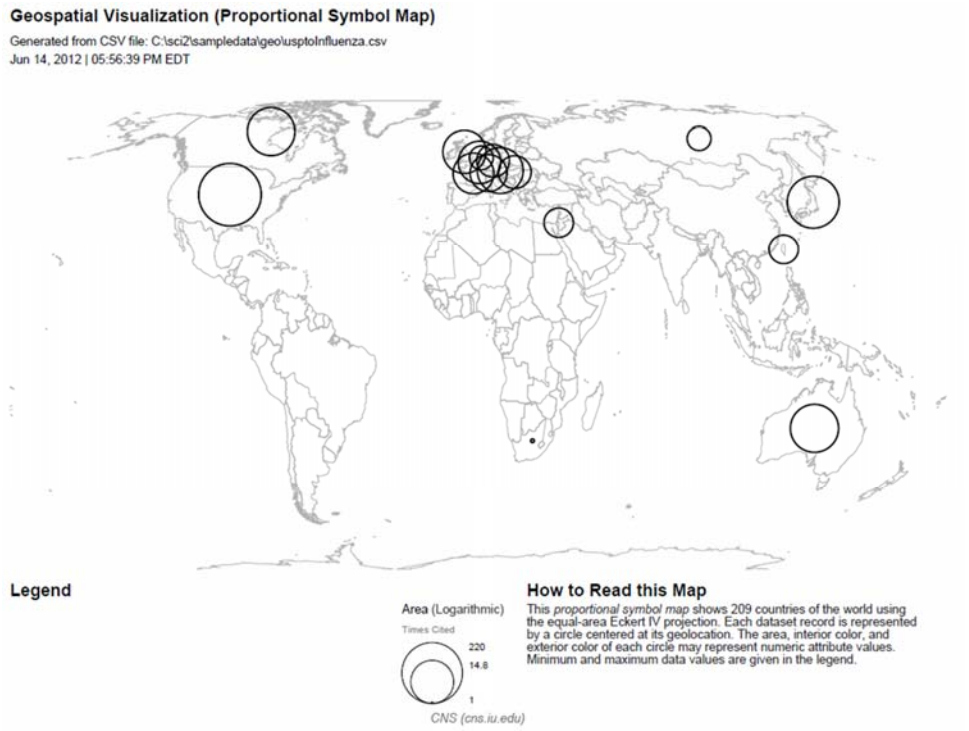
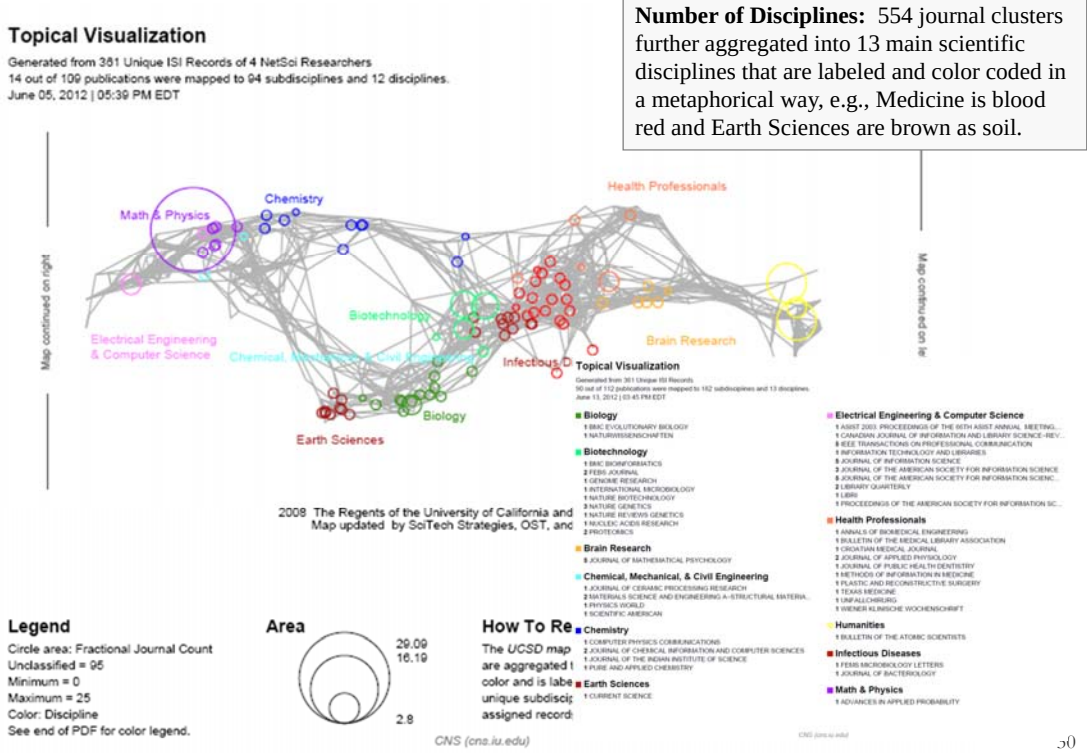


Topical Visualization

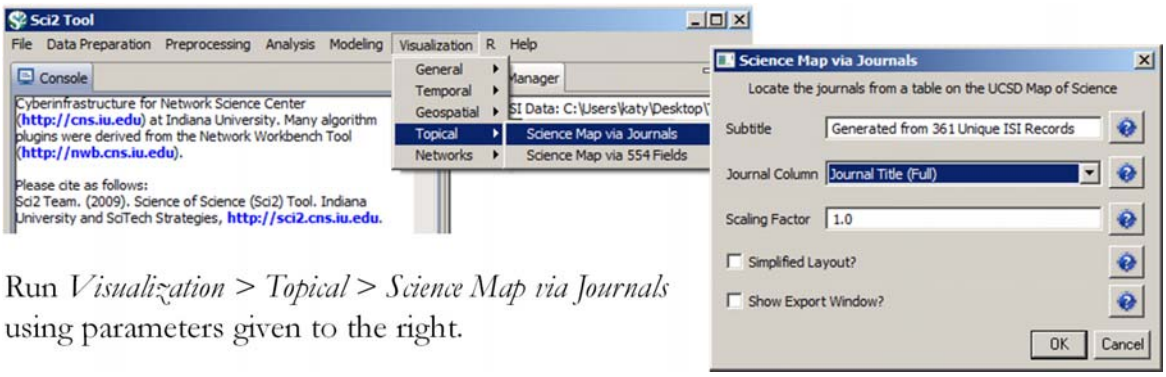
Data: WoS and Scopus paper level data for 2001–2010, about 25,000 separate journals, proceedings, and series.
Similarity Metric: Combination of bibliographic coupling and keyword vectors.
Number of Disciplines: 554 journal clusters further aggregated into 13 main scientific disciplines that are labeled and color coded in a metaphorical way, e.g., Medicine is blood red and Earth Sciences are brown as soil.



DIY Science Maps using the Sci2 Tool

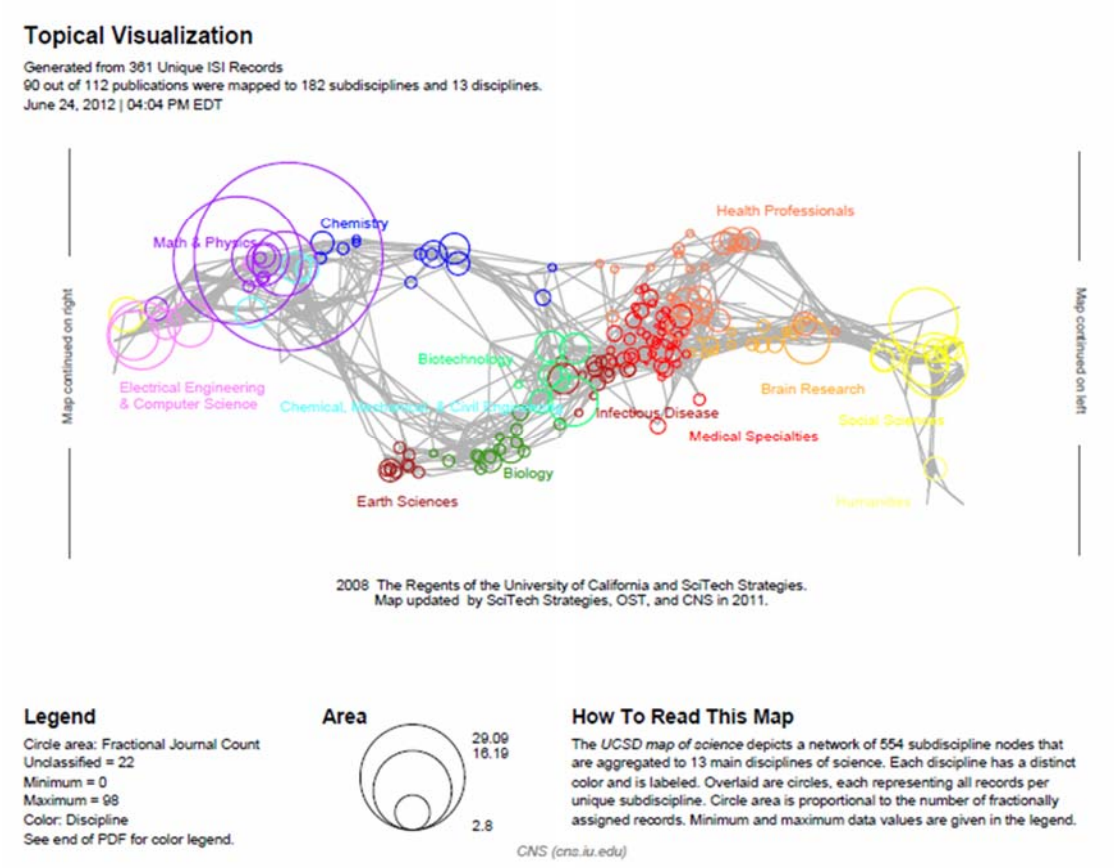
Download Sci2 Tool v1.0 Alpha (June 13, 2012) from http://sci2.cns.iu.edu
Unpack into a /sci2 directory. Run /sci2/sci2.exe
Sci2 Manual is at http://sci2.wiki.cns.iu.edu

Load an ISI (*.isi), Bibtex (*.bib), Endnote Export Format (*.enw), Scopus csv (*.scopus) file such as */sci2/sampledata/scientometrics/isi/FourNetSciResearchers.isi*



Run *Visualization > Topical > Science Map via Journals* using parameters given to the right.

Postscript file will appear in *Data Manager*. Save and open with a Postscript Viewer.



Topical Visualization

Generated from 361 Unique ISI Records
90 out of 112 publications were mapped to 182 subdisciplines and 13 disciplines.
June 24, 2012 | 04:04 PM EDT

Biology
1 BMC EVOLUTIONARY BIOLOGY
1 NATURWISSENSCHAFTEN

Biotechnology
1 BMC BIOINFORMATICS
2 FEBS JOURNAL
1 GENOME RESEARCH
1 INTERNATIONAL MICROBIOLOGY
1 NATURE BIOTECHNOLOGY
3 NATURE GENETICS
1 NATURE REVIEWS GENETICS
1 NUCLEIC ACIDS RESEARCH
2 PROTEOMICS

Brain Research
5 JOURNAL OF MATHEMATICAL PSYCHOLOGY

Chemical, Mechanical, & Civil Engineering
1 JOURNAL OF CERAMIC PROCESSING RESEARCH
2 MATERIALS SCIENCE AND ENGINEERING A-STRUCTURAL MATERIA...
1 PHYSICS WORLD
1 SCIENTIFIC AMERICAN

Chemistry
1 COMPUTER PHYSICS COMMUNICATIONS
2 JOURNAL OF CHEMICAL INFORMATION AND COMPUTER SCIENCES
1 JOURNAL OF THE INDIAN INSTITUTE OF SCIENCE
1 PURE AND APPLIED CHEMISTRY

Earth Sciences
1 CURRENT SCIENCE

Electrical Engineering & Computer Science
1 ASIST 2003: PROCEEDINGS OF THE 66TH ASIST ANNUAL MEETING,...
1 CANADIAN JOURNAL OF INFORMATION AND LIBRARY SCIENCE-REV...
5 IEEE TRANSACTIONS ON PROFESSIONAL COMMUNICATION
1 INFORMATION TECHNOLOGY AND LIBRARIES
5 JOURNAL OF INFORMATION SCIENCE
3 JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE
5 JOURNAL OF THE AMERICAN SOCIETY FOR INFORMATION SCIENC...
2 LIBRARY QUARTERLY
1 LIBRI
1 PROCEEDINGS OF THE AMERICAN SOCIETY FOR INFORMATION SC...

Health Professionals
1 ANNALS OF BIOMEDICAL ENGINEERING
1 BULLETIN OF THE MEDICAL LIBRARY ASSOCIATION
1 CROATIAN MEDICAL JOURNAL
2 JOURNAL OF APPLIED PHYSIOLOGY
1 JOURNAL OF PUBLIC HEALTH DENTISTRY
1 METHODS OF INFORMATION IN MEDICINE
1 PLASTIC AND RECONSTRUCTIVE SURGERY
1 TEXAS MEDICINE
1 UNFALLCHIRURG
1 WIENER KLINISCHE WOCHENSCHRIFT

Humanities
1 BULLETIN OF THE ATOMIC SCIENTISTS

Infectious Diseases
1 FEMS MICROBIOLOGY LETTERS
1 JOURNAL OF BACTERIOLOGY

Math & Physics
1 ADVANCES IN APPLIED PROBABILITY

Topical Visualization

Generated from 361 Unique ISI Records
90 out of 112 publications were mapped to 182 subdisciplines and 13 disciplines.
June 24, 2012 | 04:04 PM EDT

Math & Physics
10 APPLIED PHYSICS LETTERS
1 BRAZILIAN JOURNAL OF PHYSICS
3 CHAOS SOLITONS & FRACTALS
1 COMPLEXITY
1 COMPUTATIONAL MATERIALS SCIENCE
11 EUROPEAN PHYSICAL JOURNAL B
12 EUROPHYSICS LETTERS
2 INTERNATIONAL JOURNAL OF MODERN PHYSICS B
6 JOURNAL OF PHYSICS A-MATHEMATICAL AND GENERAL
1 JOURNAL OF STATISTICAL MECHANICS-THEORY AND EXPERIMENT
1 JOURNAL OF STATISTICAL PHYSICS
1 JOURNAL OF THE KOREAN PHYSICAL SOCIETY
1 MATERIALS SCIENCE AND ENGINEERING B-SOLID STATE MATERIAL...
3 NATURE PHYSICS
3 NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SEC...
12 PHYSICA A
5 PHYSICAL REVIEW A
2 PHYSICAL REVIEW B
45 PHYSICAL REVIEW LETTERS
2 REVIEWS OF MODERN PHYSICS

Medical Specialties
1 ANNALS OF INTERNAL MEDICINE
1 REVISTA DE INVESTIGACION CLINICA

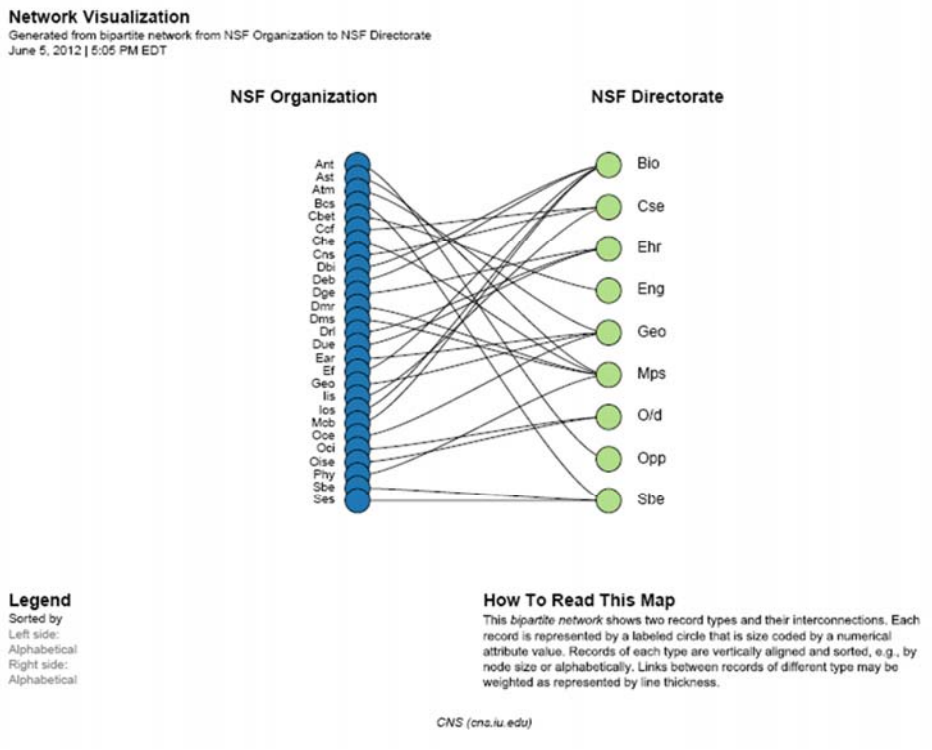
Social Sciences
1 ADMINISTRATIVE SCIENCE QUARTERLY
1 AMERICAN BEHAVIORAL SCIENTIST
1 AMERICAN SOCIOLOGICAL REVIEW
1 ANNALS OF THE AMERICAN ACADEMY OF POLITICAL AND SOCIAL S...
1 ARBOR-CIENCIA PENSAMIENTO Y CULTURA
3 BRITISH JOURNAL OF MATHEMATICAL & STATISTICAL PSYCHOLOGY
1 JOURNAL OF CLASSIFICATION

Social Sciences
2 JOURNAL OF MATHEMATICAL SOCIOLOGY
3 JOURNAL OF THE AMERICAN STATISTICAL ASSOCIATION
2 PSYCHOLOGICAL BULLETIN
5 PSYCHOMETRIKA
1 RECHERCHE
5 SCIENTOMETRICS
1 SOCIAL FORCES
6 SOCIAL NETWORKS
3 SOCIOLOGICAL METHODS & RESEARCH

Multiple Categories
1 BRITISH MEDICAL JOURNAL
2 JAMA-JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION
1 JOURNAL OF THEORETICAL BIOLOGY
18 NATURE
44 PHYSICAL REVIEW E
5 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE ...
6 SCIENCE

Unclassified
1 ALGORITHMS AND MODELS FOR THE WEB-GRAPHS, PROCEEDINGS
2 AMERICAN DOCUMENTATION
2 ASIST 2002: PROCEEDINGS OF THE 65TH ASIST ANNUAL MEETING, ...
1 BIOLOGIYA MORYA-MARINE BIOLOGY
1 BULLETIN OF THE AMERICAN SOCIETY FOR INFORMATION SCIENCE
1 CHEMIKER-ZEITUNG
3 CHEMTECH
1 COMBINATORIAL AND ALGORITHMIC ASPECTS OF NETWORKING
7 CURRENT COMMENTS
3 CURRENT CONTENTS/LIFE SCIENCES
1 FEDERATION PROCEEDINGS
5 FRACTALS-AN INTERDISCIPLINARY JOURNAL ON THE COMPLEX GE...
1 FRONTIERS OF LIBRARIANSHIP-SYRACUSE UNIVERSITY

Network Visualizations



Geomap with Gephi Network Overlay

See 4.7.6 on http://sci2.wiki.cns.iu.edu

File with geolocations and linkage info, e.g., an isi biblio-graphy file. →

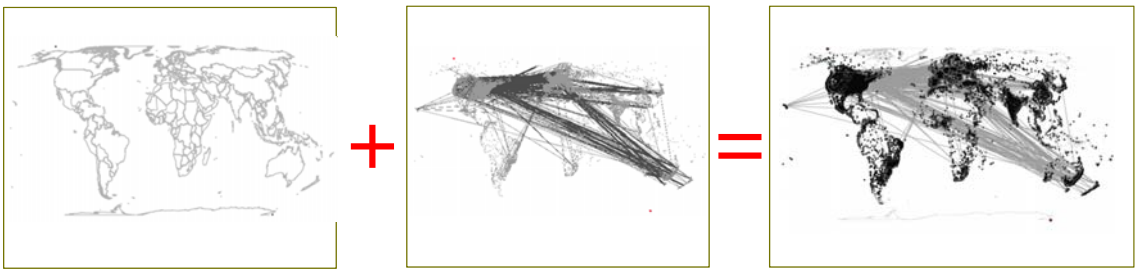
Use Yahoo! Geocoder to identify Latitude, Longitude for each geolocation
Extract attributes per geolocation, e.g., total times cited (TC)
Extract linkages and their attributes, e.g., number of co-occurences
See sample /geo/LaszloBarabasiGeo.net with co-occurrence of "Research Addresses" and full counting of TC per geolocation.

↓

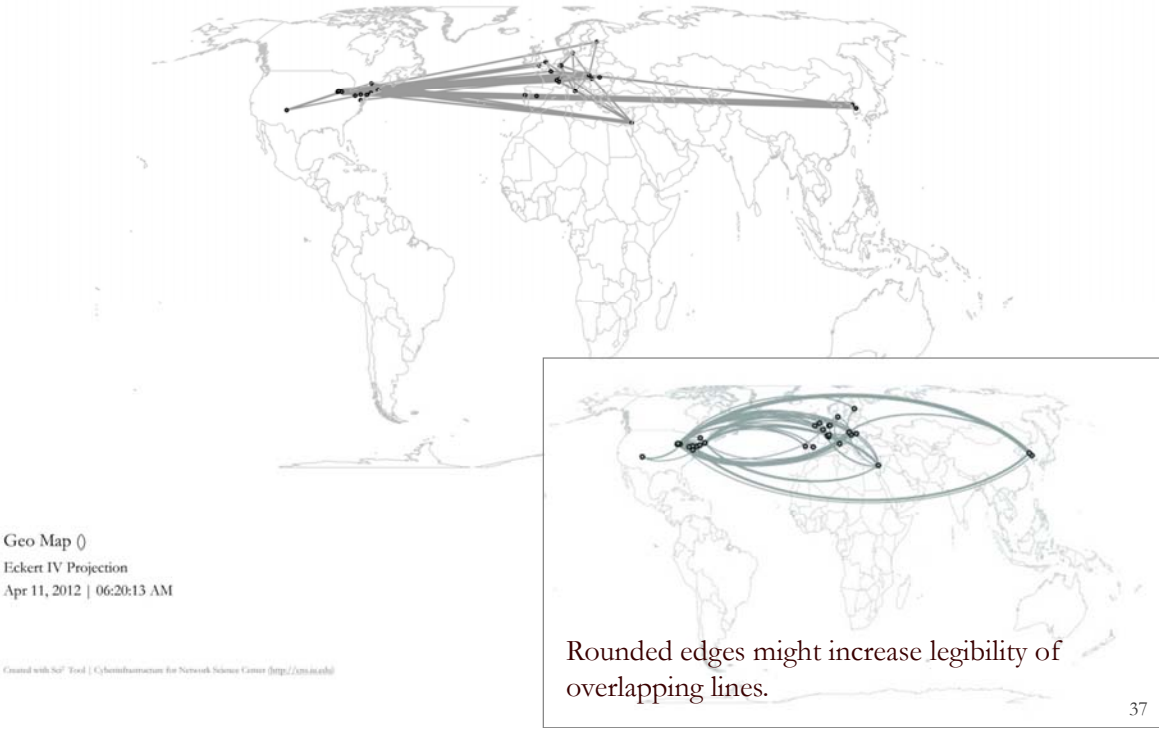
Read into Sci2 Tool to generate geomap and network file →

Layout network in Gephi →

Combine geomap and network in Photoshop

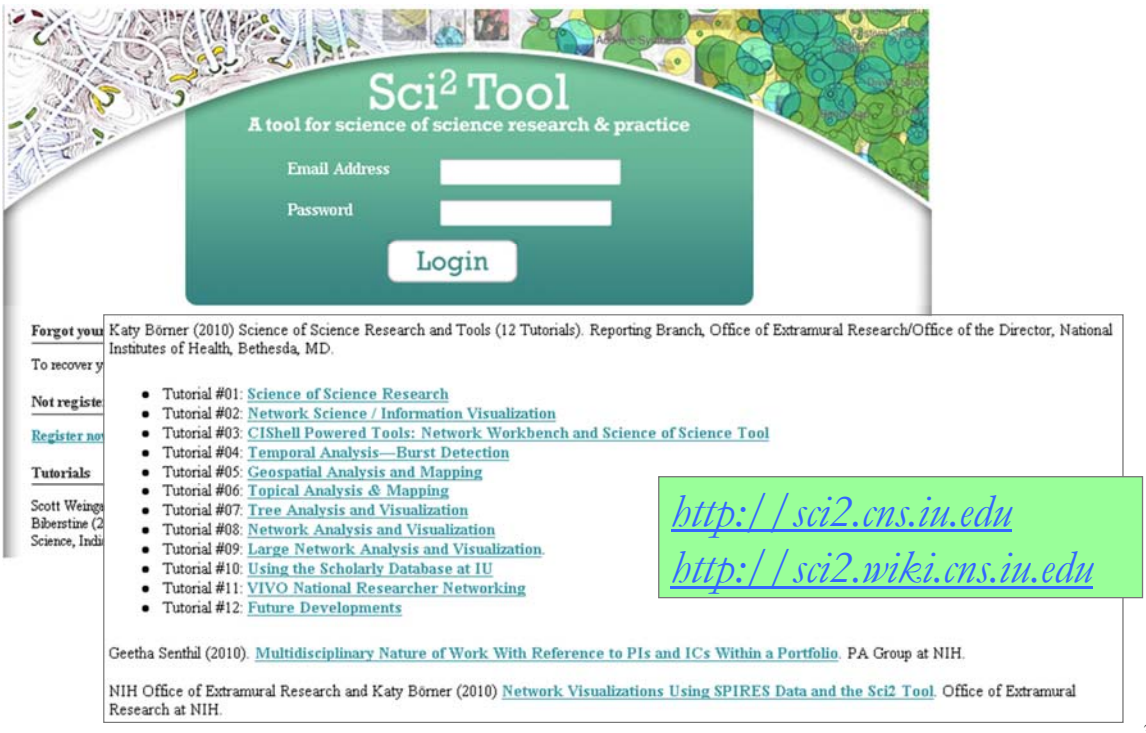


Practice these steps using "LaszloBarabasi-collaborations.net" linked from Sci2 wiki:
4.7.6 Using Gephi to Render Networks Overlaid on GeoMaps



Rounded edges might increase legibility of overlapping lines.

Code & Documentation

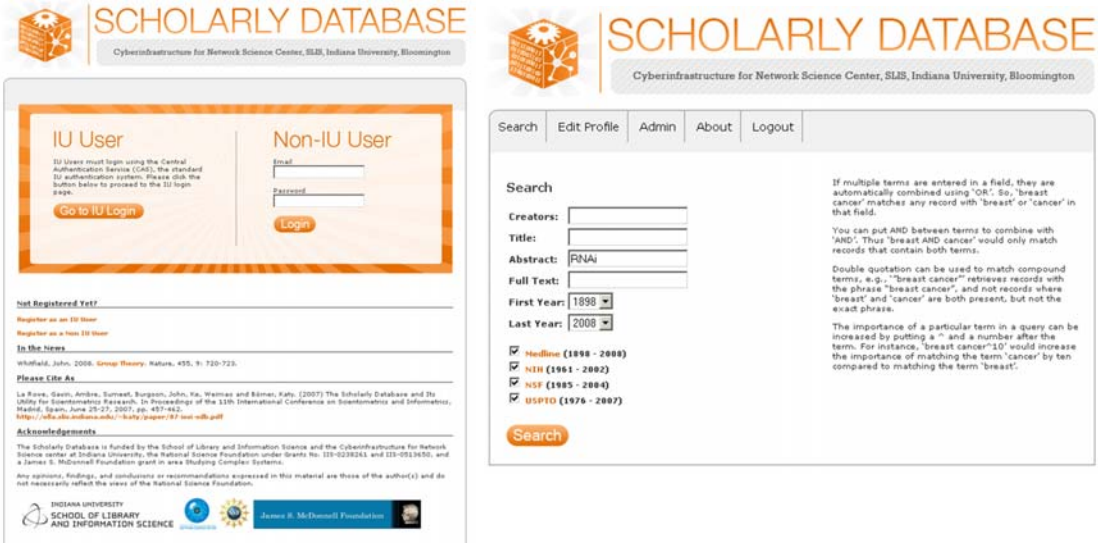


http://sci2.cns.iu.edu
http://sci2.wiki.cns.iu.edu

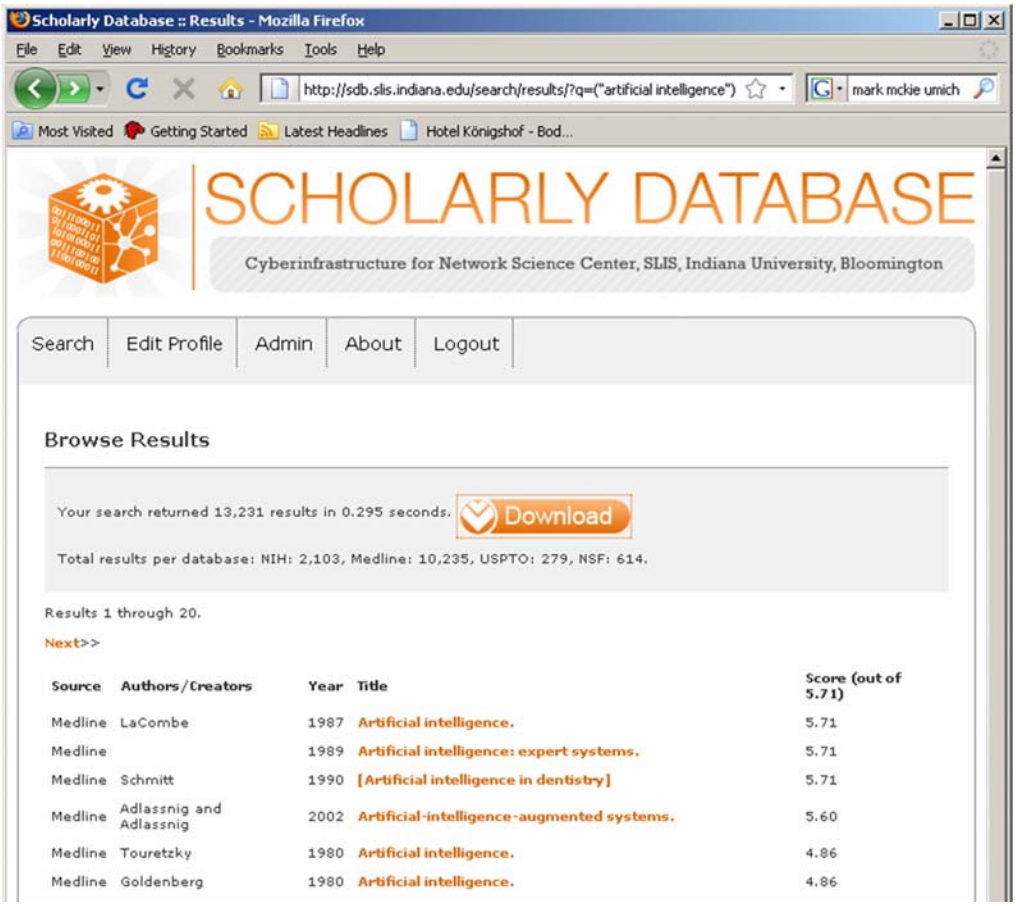
Scholarly Database at Indiana University

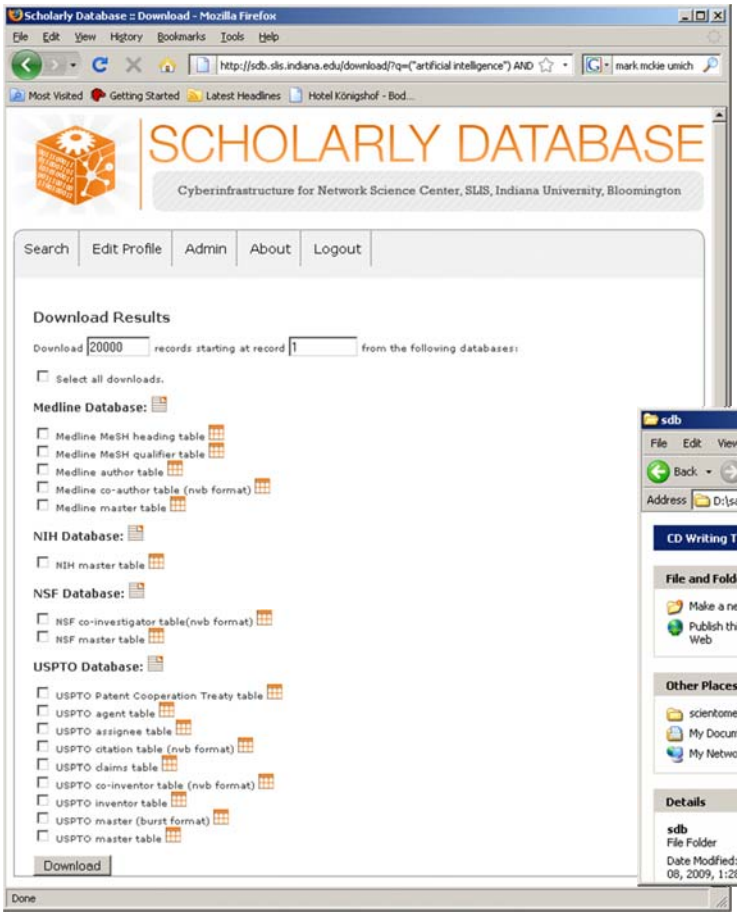
http://sdb.wiki.cns.iu.edu

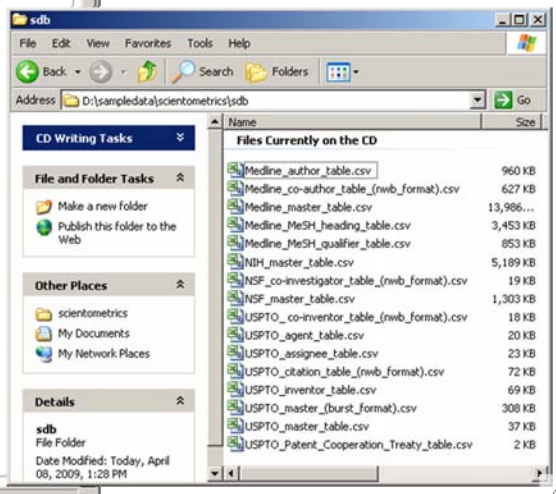
Supports federated search of 25 million publication, patent, grant records.
Results can be downloaded as data dump and (evolving) co-author, paper-citation networks.



Register for free access at http://sdb.cns.iu.edu







Since March 2009:
Users can download networks:
- Co-author
- Co-investigator
- Co-inventor
- Patent citation

and tables for
burst analysis in NWB.

OSGi/CIShell Adoption

A number of other projects recently adopted OSGi and/or CIShell:

USA

- *Cytoscape* (http://cytoscape.org) Led by Trey Ideker at the University of California, San Diego is an open source bioinformatics software platform for visualizing molecular interaction networks and integrating these interactions with gene expression profiles and other state data (Shannon et al., 2002).
- *MAEviz* (https://wiki.ncsa.uiuc.edu/display/MAE/Home) Managed by Jong Lee at NCSA is an open-source, extensible software platform which supports seismic risk assessment based on the Mid-America Earthquake (MAE) Center research.

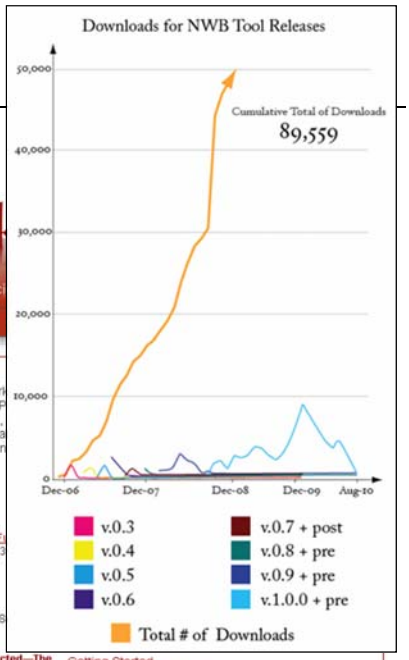
Europe

- *Taverna Workbench* (http://taverna.org.uk) Developed by the myGrid team (http://mygrid.org.uk) led by Carol Goble at the University of Manchester, U.K. is a free software tool for designing and executing workflows (Hull et al., 2006). Taverna allows users to integrate many different software tools, including over 30,000 web services.
- *TEXTrend* (http://textrend.org) Led by George Kampis at Eötvös Loránd University, Budapest, Hungary supports natural language processing (NLP), classification/mining, and graph algorithms for the analysis of business and governmental text corpuses with an inherently temporal component.
- *DynaNets* (http://www.dynanets.org) Coordinated by Peter M.A. Sloot at the University of Amsterdam, The Netherlands develops algorithms to study evolving networks.
- *SISOB* (http://sisob.lcc.uma.es) An Observatory for Science in Society Based in Social Models.

As the functionality of OSGi-based software frameworks improves and the number and diversity of dataset and algorithm plugins increases, the capabilities of custom tools will expand.

Network Workbench Tool

http://nwb.slis.indiana.edu



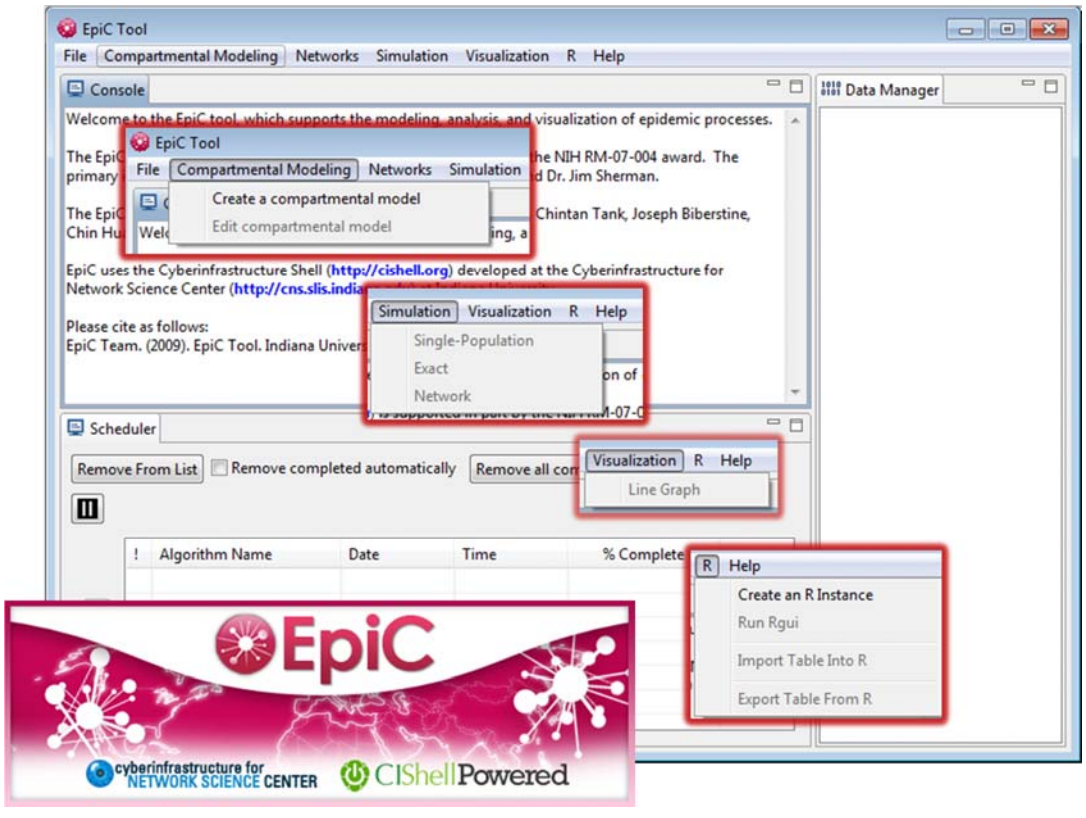
The Network Workbench (NWB) tool supports researchers, educators, and practitioners interested in the study of biomedical, social and behavioral science, physics, and other networks.

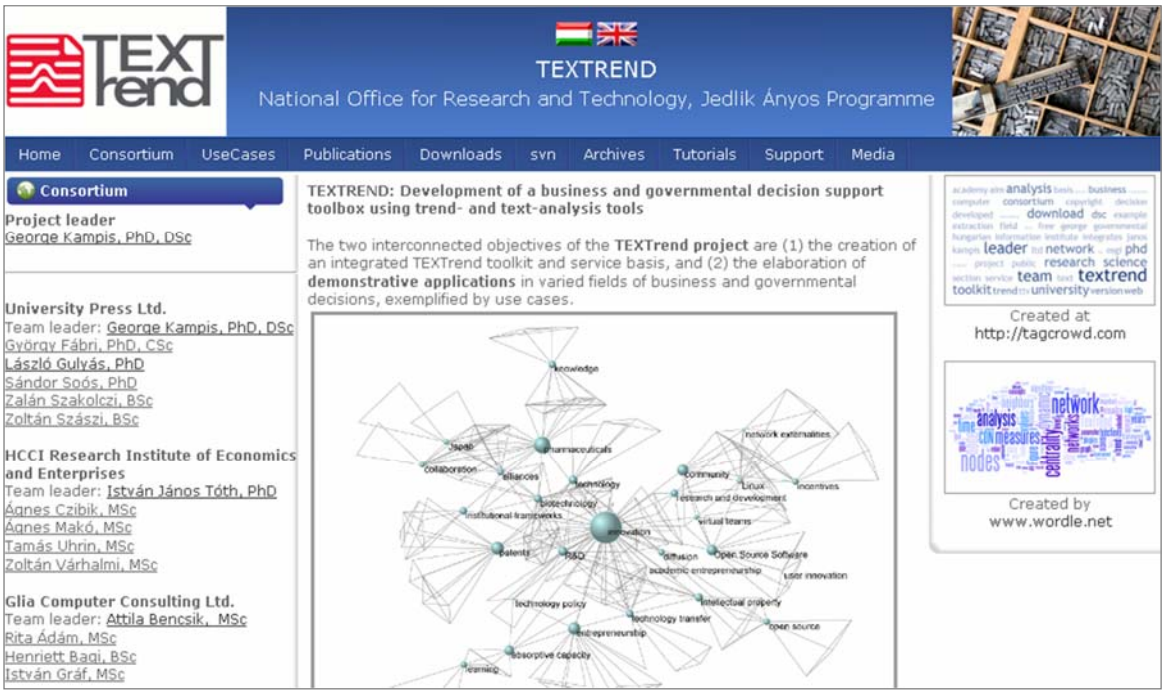
In February 2009, the tool provides more 169 plugins that support the preprocessing, analysis, modeling, and visualization of networks.

More than 50 of these plugins can be applied or were specifically designed for S&T studies.

It has been downloaded more than 125,000 times since December 2006.

Herr II, Bruce W., Huang, Weixia (Bonnie), Penumarthy, Shashikant & Börner, Katy. (2007). Designing Highly Flexible and Usable Cyberinfrastructures for Convergence. In Bainbridge, William S. & Roco, Mihail C. (Eds.), Progress in Convergence - Technologies for Human Wellbeing (Vol. 1093, pp. 161-179), Annals of the New York Academy of Sciences, Boston, MA.





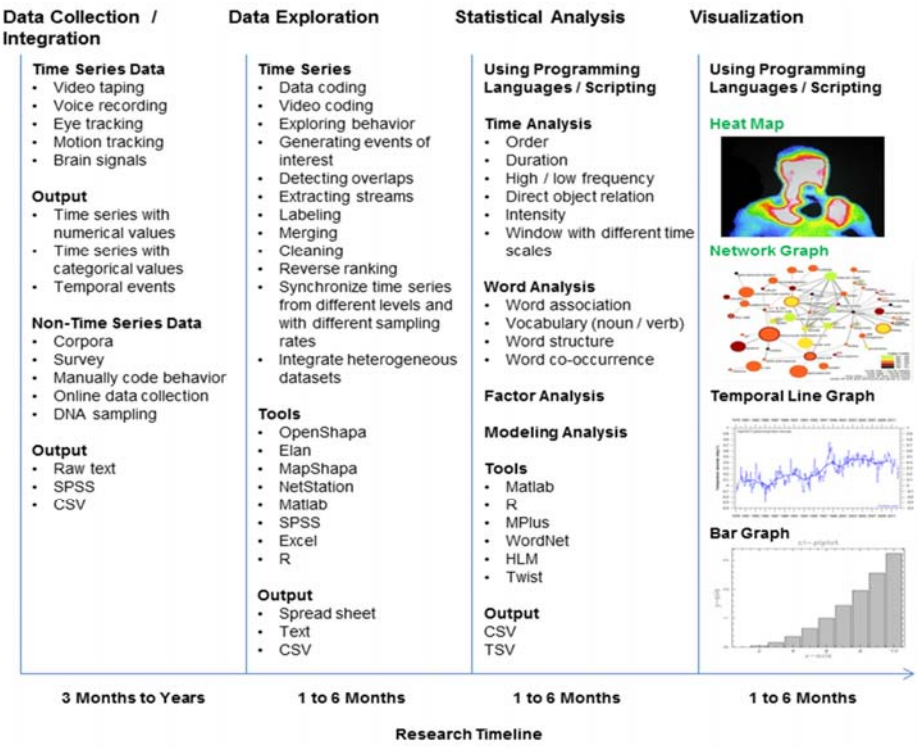
TEXTrend adds R bridge, WEKA, Wordij, CFinder, and more.

See the latest versions of TEXTrend Toolkit modules at

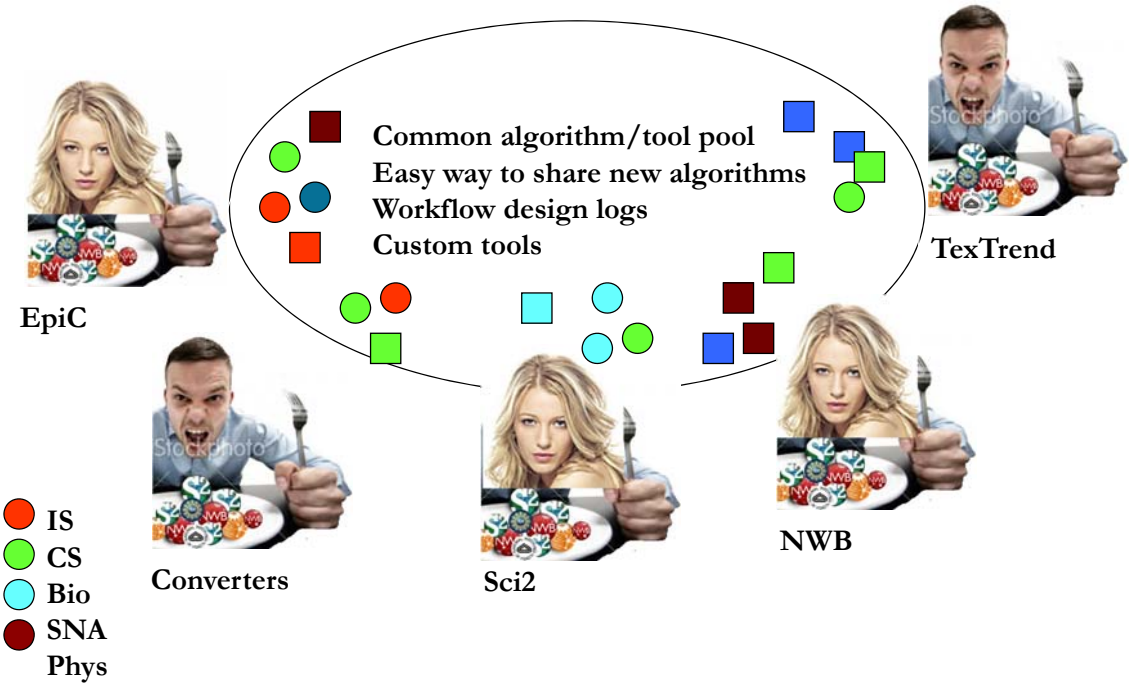
http://textrend.org/index.php?option=com_content&view=article&id=47&Itemid=53

NIH Proposal: Multi-Scale Mining and Visualization of Human Development

Katy Börner and Chin Hua Kong, SLIS; Linda Smith, Chen Yu, John Bates, Psychology and Brain Sciences, Indiana University



OSGi/CIShell-Powered Tools Support Algorithm Sharing



CIShell – Integrate New Algorithms

About the Cyberinfrastructure Shell

The Cyberinfrastructure Shell (CIShell) is an open source, community-driven platform for the integration and utilization of datasets, algorithms, tools, and computing resources. Algorithm integration support is built in for Java and most other programming languages. Being Java based, it will run on almost all platforms. The software and specification is released under an Apache 2.0 License.

CIShell is the basis of Network Workbench, TexTrend, Sci² and the upcoming EpiC tool.

CIShell supports remote execution of algorithms. A standard web service definition is in development that will allow pools of algorithms to transparently be used in a peer-to-peer, client-server, or web front-end fashion.

CIShell Features

A framework for easy integration of new and existing algorithms written in any programming language

Using CIShell, an algorithm writer can fully concentrate on creating their own algorithm in whatever language they are comfortable with. Simple tools are provided to then take their algorithm and

Learn More...

- CIShell Papers
- CIShell Powered Tools
- Algorithms
- Plugins (coming soon)
- Misc. Tool Documentation
- CIShell Web Services (coming soon)
- Screenshots

Getting Started...

- Documentation & Developer Resources
- Download

Getting Involved...

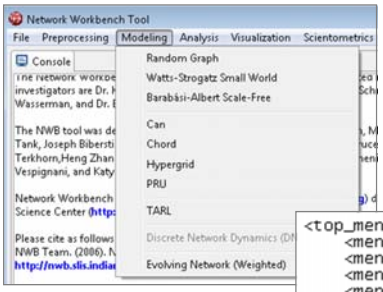
- Contact Us

CIShell Developer Guide is at http://cishell.wiki.cns.iu.edu

Additional Sci2 Plugins are at http://sci2.wiki.cns.iu.edu/3.2+Additional+Plugins

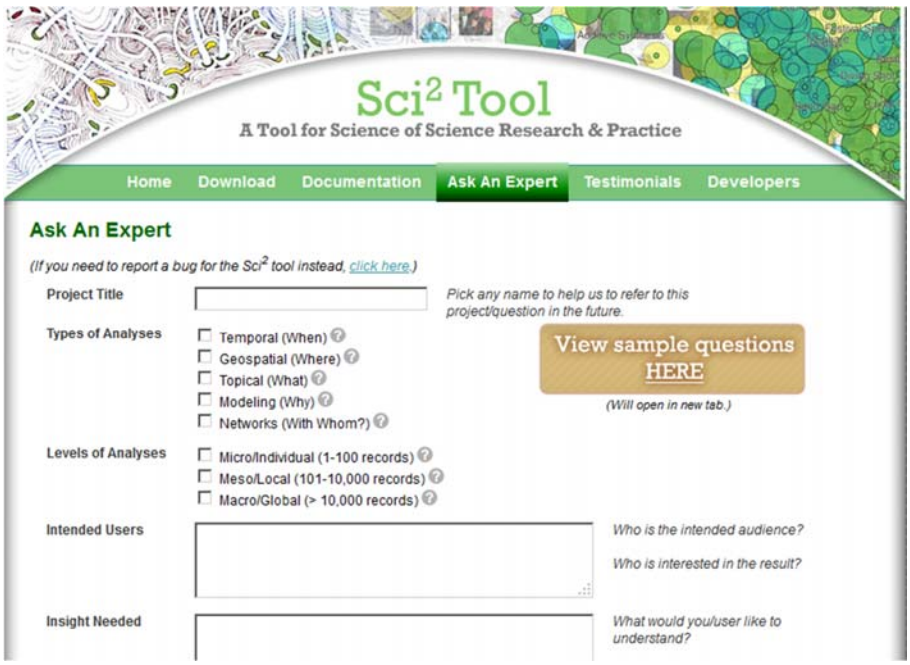
CIShell – Customize Menu

- The file *'yourtooldirectory/configuration/default_menu.xml'* encodes the structure of the menu system.
- In NWB Tool, the Modeling menu (left) is encoded by the following piece of xml code:




```
<top_menu name="Modeling">
    <menu pid="edu.iu.nwb.modeling.erdosrandomgraph"/>
    <menu pid="edu.iu.nwb.modeling.smallworld"/>
    <menu pid="edu.iu.nwb.modeling.barabasialbert"/>
    <menu type="break"/>
    <menu pid="edu.iu.iv.modeling.p2p.can.CanAlgorithm"/>
    <menu pid="edu.iu.iv.modeling.p2p.chord.ChordAlgorithm"/>
    <menu pid="edu.id.iv.modeling.p2p.hypergrid.Hypergrid"/>
    <menu pid="edu.iu.iv.modeling.p2p.pru.PruAlgorithm"/>
    <menu type="break"/>
    <menu pid="edu.iu.iv.modeling.tarl.TarlAlgorithm"/>
    <menu type="break"/>
    <menu pid="edu.iu.nwb.modeling.discretenetworkdynamics.DNDAlgorithm"/>
    <menu type="break"/>
    <menu pid="edu.iu.nwb.modeling.weighted.evolvingnetwork"/>
</top_menu>
```


Need Help? Ask an Expert!



https://sci2.cns.iu.edu/user/ask.php

References

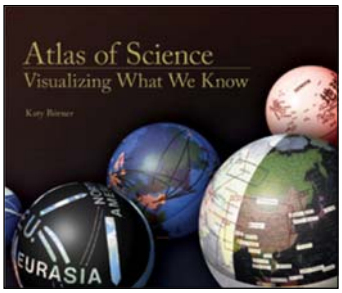
Börner, Katy, Chen, Chaomei, and Boyack, Kevin. (2003). **Visualizing Knowledge Domains.** In Blaise Cronin (Ed.), *ARIST*, Medford, NJ: Information Today, Volume 37, Chapter 5, pp. 179-255.
http://ivl.slis.indiana.edu/km/pub/2003-borner-arist.pdf

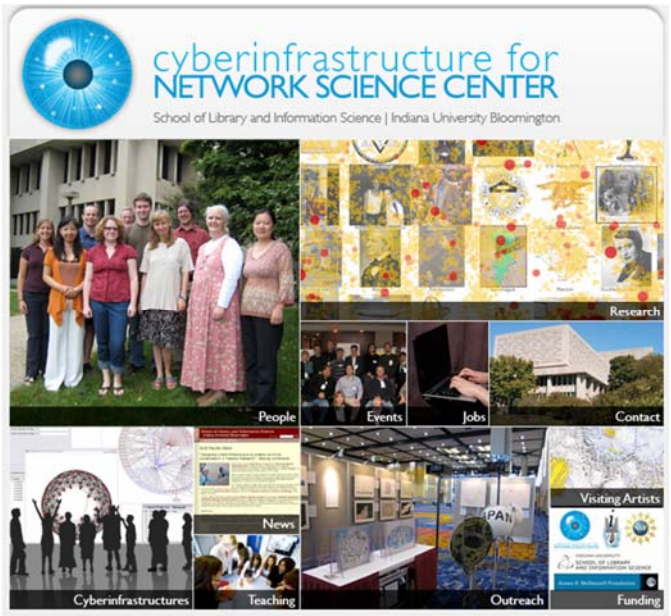
Shiffrin, Richard M. and Börner, Katy (Eds.) (2004). **Mapping Knowledge Domains**. *Proceedings of the National Academy of Sciences of the United States of America*, 101(Suppl_1).
http://www.pnas.org/content/vol101/suppl_1/

Börner, Katy, Sanyal, Soma and Vespignani, Alessandro (2007). **Network Science.** In Blaise Cronin (Ed.), *ARIST*, Information Today, Inc., Volume 41, Chapter 12, pp. 537-607.
http://ivl.slis.indiana.edu/km/pub/2007-borner-arist.pdf

Börner, Katy (2010) **Atlas of Science**. MIT Press.
http://scimaps.org/atlas

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





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

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