Visualizing Nanoscience and Technology

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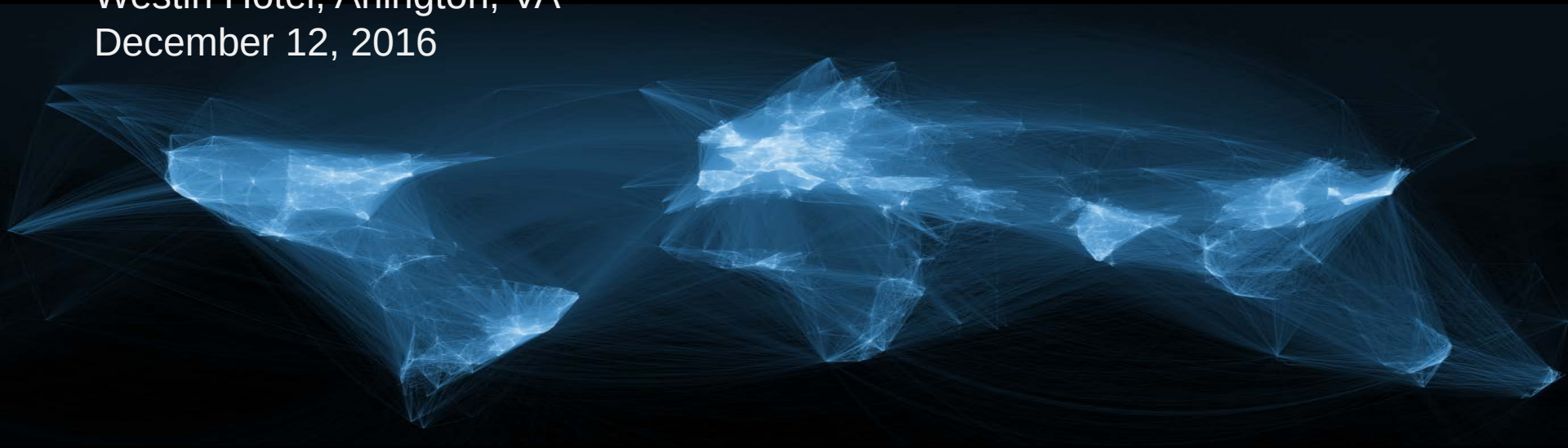
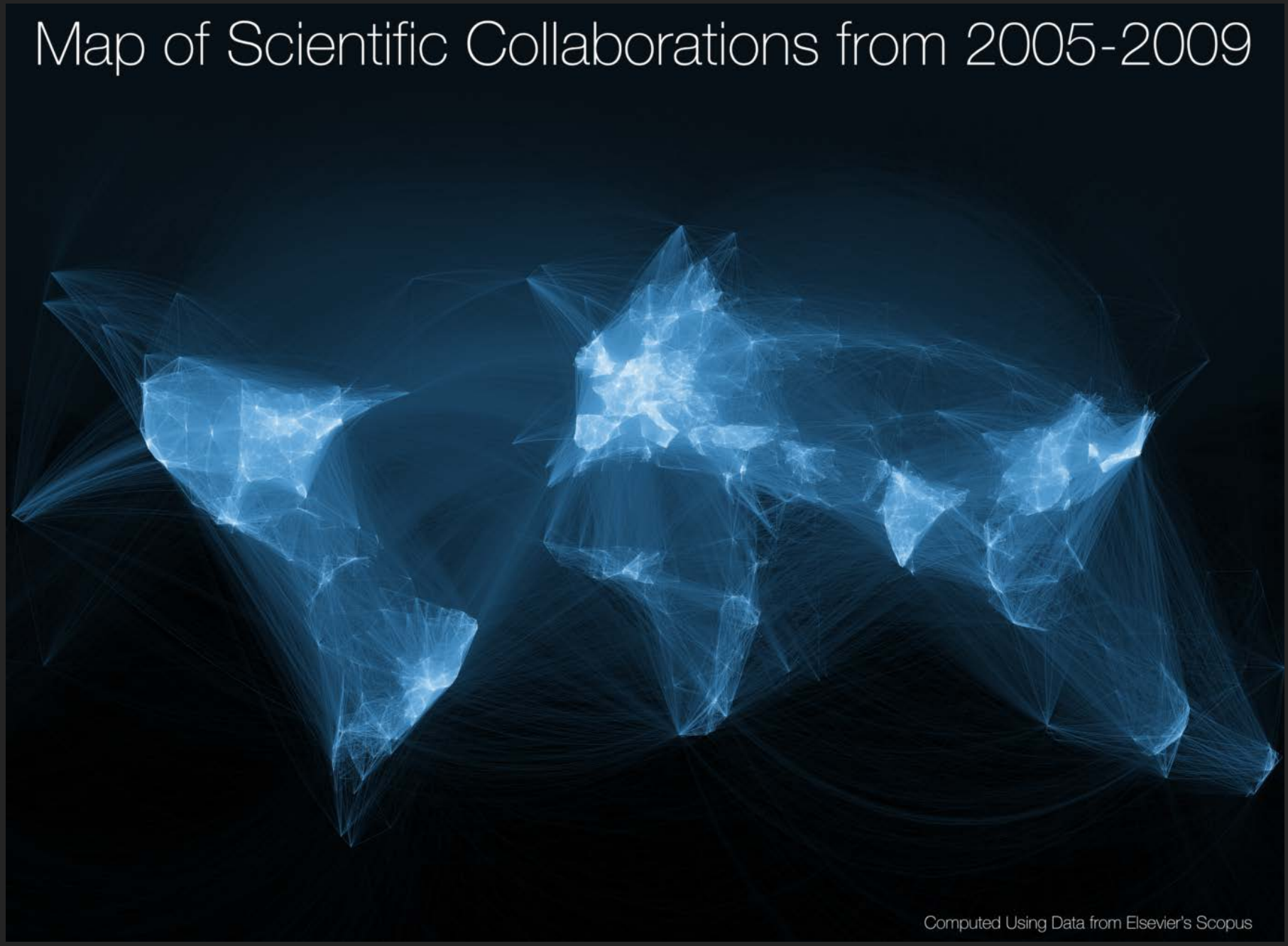
2016 NSF Nanoscale Science and Engineering Grantees Conference

Westin Hotel, Arlington, VA
December 12, 2016



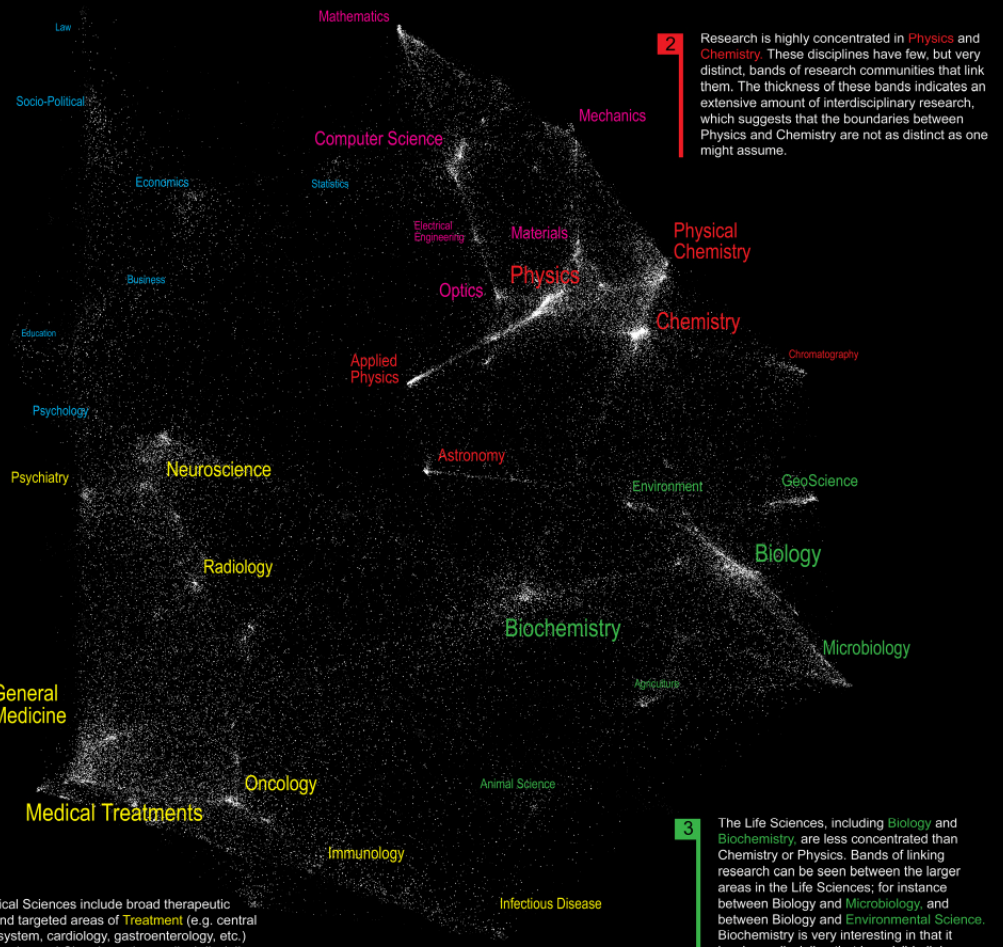


VII.6 *Map of Scientific Collaborations from 2005-2009* - Olivier H. Beauchesne - 2011

The Structure of Science

5 The Social Sciences are the smallest and most diffuse of all the sciences. Psychology serves as the link between Medical Sciences (Psychiatry) and the Social Sciences. Statistics serves as the link with Computer Science and Mathematics.

1 Mathematics is our starting point, the purest of all sciences. It lies at the outer edge of the map. Computer Science, Electrical Engineering, and Optics are applied sciences that draw upon knowledge in Mathematics and Physics. These three disciplines provide a good example of a linear progression from one pure science (Mathematics) to another (Physics) through multiple disciplines. Although applied, these disciplines are highly concentrated with distinct bands of research communities that link them. Bands indicate interdisciplinary research.



2 Research is highly concentrated in Physics and Chemistry. These disciplines have few, but very distinct, bands of research communities that link them. The thickness of these bands indicates an extensive amount of interdisciplinary research, which suggests that the boundaries between Physics and Chemistry are not as distinct as one might assume.

4 The Medical Sciences include broad therapeutic studies and targeted areas of Treatment (e.g. central nervous system, cardiology, gastroenterology, etc.) Unlike Physics and Chemistry, the medical disciplines are more spread out, suggesting a more multi-disciplinary approach to research. The transition into Life Sciences (via Animal Science and Biochemistry) is gradual.

3 The Life Sciences, including Biology and Biochemistry, are less concentrated than Chemistry or Physics. Bands of linking research can be seen between the larger areas in the Life Sciences; for instance between Biology and Microbiology, and between Biology and Environmental Science. Biochemistry is very interesting in that it is a large discipline that has visible links to disciplines in many areas of the map, including Biology, Chemistry, Neuroscience, and General Medicine. It is perhaps the most interdisciplinary of the sciences.

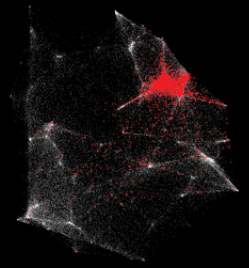
We are all familiar with traditional maps that show the relationships between countries, provinces, states, and cities. Similar relationships exist between the various disciplines and research topics in science. This allows us to map the structure of science.

One of the first maps of science was developed at the Institute for Scientific Information over 30 years ago. It identified 41 areas of science from the citation patterns in 17,000 scientific papers. That early map was intriguing, but it didn't cover enough of science to accurately define its structure.

Things are different today. We have enormous computing power and advanced visualization software that make mapping of the structure of science possible. This galaxy-like map of science (left) was generated at Sandia National Laboratories using an advanced graph layout routine (VxOrd) from the citation patterns in 800,000 scientific papers published in 2002. Each dot in the galaxy represents one of the 96,000 research communities active in science in 2002. A research community is a group of papers (9 on average) that are written on the same research topic in a given year. Over time, communities can be born, continue, split, merge, or die.

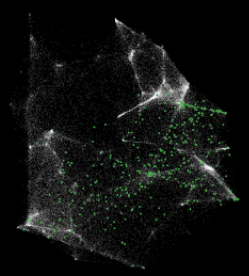
The map of science can be used as a tool for science strategy. This is the terrain in which organizations and institutions locate their scientific capabilities. Additional information about the scientific and economic impact of each research community allows policy makers to decide which areas to explore, exploit, abandon, or ignore.

We also envision the map as an educational tool. For children, the theoretical relationship between areas of science can be replaced with a concrete map showing how math, physics, chemistry, biology and social studies interact. For advanced students, areas of interest can be located and neighboring areas can be explored.



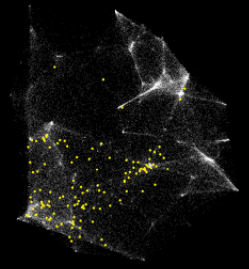
Nanotechnology

Most research communities in nanotechnology are concentrated in Physics, Chemistry, and Materials Science. However, many disciplines in the Life and Medical Sciences also have nanotechnology applications.



Proteomics

Research communities in proteomics are centered in Biochemistry. In addition, there is a heavy focus in the tools section of chemistry, such as Chromatography. The balance of the proteomics communities are widely dispersed among the Life and Medical Sciences.



Pharmacogenomics

Pharmacogenomics is a relatively new field with most of its activity in Medicine. It also has many communities in Biochemistry and two communities in the Social Sciences.

I.10 *The Structure of Science* - Kevin W. Boyack and Richard Klavans - 2005

The EMERGENCE of NANOTECHNOLOGY

MAPPING THE NANO REVOLUTION

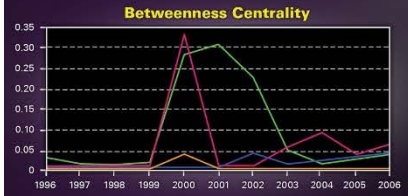
The emergence of nanotechnology has been one of the major scientific-technological revolutions in the last decade and it led to a structural reorganization of major fields of science. Price (1965) showed that fields of science and their development can be mapped using aggregated citations among the journals in the fields and their relevant environments.

The frames to the right show the evolving journal citation network for the years 1998-2003. Distances are proportional to cosine values between the citation patterns of the respective journals. Textual descriptions of key events during the development of *Nanotechnology* are given below each frame. Most notably, leading papers in *Science* and *Nature* catalyzed the breakthrough around 2000.

CHANGING ROLES OF DIFFERENT JOURNALS

The interdisciplinarity of a journal can be measured using betweenness centrality (BC)—journals that occur on many shortest paths between other journals in a network have higher BC value than those that do not. In the maps, sizes of nodes are proportional to the betweenness centrality of the respective journal in the citation network.

From being a specialist journal in applied physics, the journal *Nanotechnology* obtains a high BC value in the years of the transition, ca. 2001. This is preceded by the "intervention" of *Science*. After the transition, the new field of nanotechnology is established, new journals such as *Nano Letters* published by the influential American Chemical Society take the lead, and a new specialty structure with low BC value journals results.

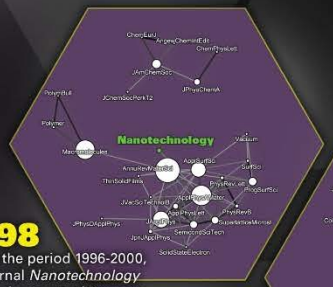


An animated sequence of this evolution is at: http://www.leydesdorff.net/journals/nanotech.

References

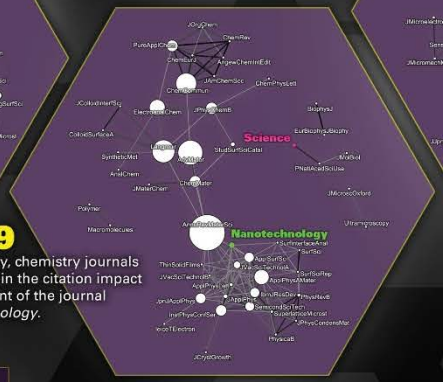
Leydesdorff, L. and T. Schank. 2008. Dynamic Animations of Journal Maps: Indicators of Structural Change and Interdisciplinary Developments. *Journal of the American Society for Information Science and Technology*, 59(11), 1810-1818.

Price, Derek J. de Solla (1965). Networks of scientific papers. *Science*, 149, no. 3683, 510- 515.



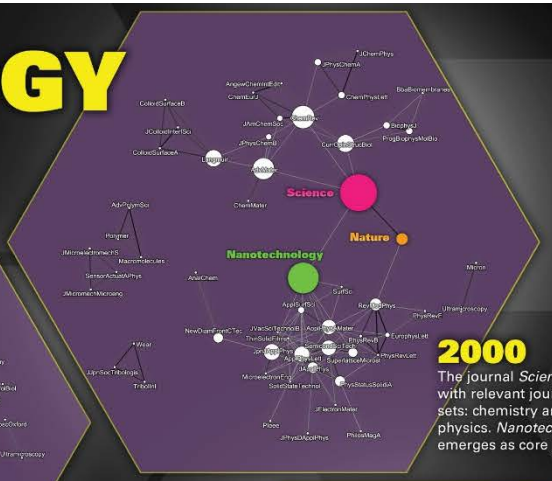
1998

During the period 1996-2000, the journal *Nanotechnology* is part of a group of journals in applied physics.



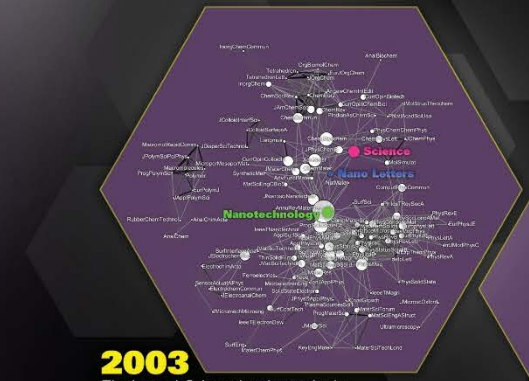
1999

Increasingly, chemistry journals play a role in the citation impact environment of the journal *Nanotechnology*.



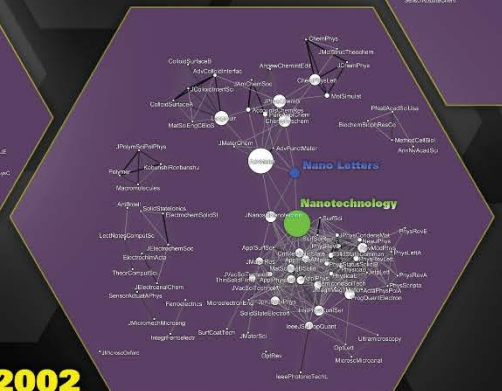
2000

The journal *Science* interfaces with relevant journals in both sets: chemistry and applied physics. *Nanotechnology* emerges as core journal.



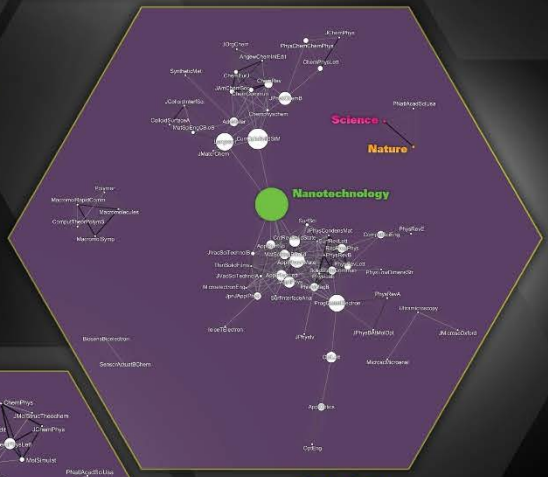
2003

The journal *Science* is relevant in the citation impact environment, but now functions as one of the specialist journals in nanotechnology. *Nanoscience* further develops as an increasingly integrated network of journals.



2002

Other journals in nanoscience and technology begin to emerge, and the bridging role of the journal *Nanotechnology* gradually subsides. *Nano Letters* and the *Journal of Nanoscience and Nanotechnology* join the new field of nanotechnology.



2001

The journal *Nanotechnology* now provides the interface between chemistry and physics. The "intervention" by *Science* is no longer needed.

LEGEND

- *Science*
- *Nature*
- *Nanotechnology*
- *Nano Letters*

Values: 0.8, 0.22, 0.33

Design by Michael J. Stamper and Katy Börner

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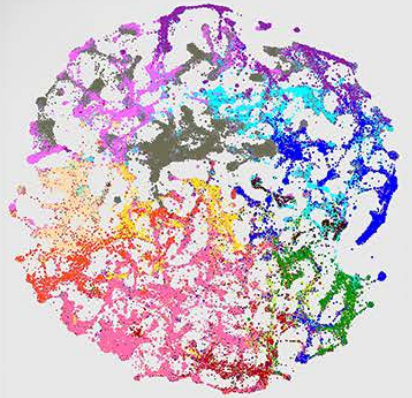
IDENTIFYING EMERGING TOPICS IN SCIENCE AND TECHNOLOGY

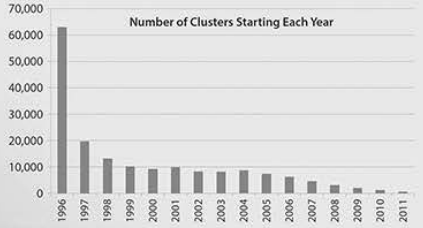
(finding the needles in the haystack)

A novel approach to identifying emerging topics in science and technology has been developed. Two models of science and technology have been created using 16 years (1996-2011) of Scopus (20 million articles) and USPTO (3 million patents) data. These two models—one based on direct citation, and one based on co-citation—are used together to nominate the most emergent topics in S&T at a particular point in time.

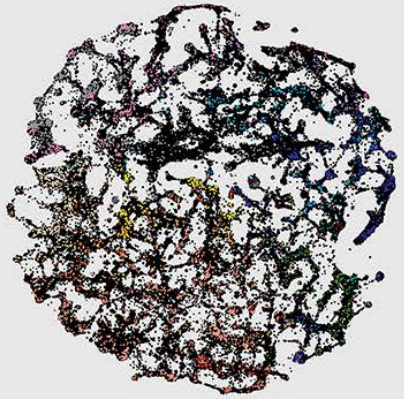
Step 1: Map All of Science and Technology



The map above was created using a combination of direct citation and text mining. First, 20 million articles from Scopus were clustered using direct citation links and the new modularity-based clustering methodology from Waltman & van Eck at Leiden University. Second, 3 million patents from the USPTO were clustered using the same direct citation method. Third, a BM25 text similarity was computed between all clusters, whether articles or patents. Using this text similarity, clusters were positioned relative to each other in the map above. Each of the 149,611 article clusters is colored based on the journals that comprise the cluster. The 27,114 patent clusters are colored gray.



Step 2: Burn Off the Straw

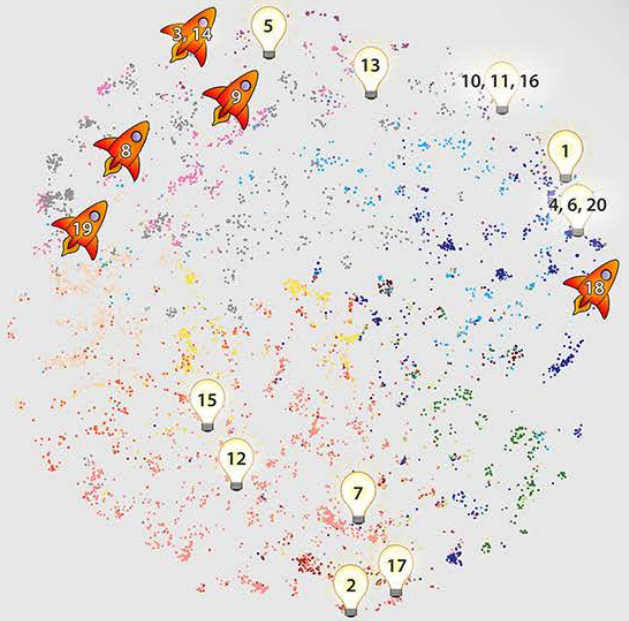


Most of the clusters in the direct citation map are very old (71%), having started a decade or more ago. Another 25% are in their prime, starting between 2002-2007. Emerging topics are, by definition, very new. In the map above, all clusters starting in 2007 or earlier have been blackened, or burned off. The 4% of clusters retaining their original color are those that began in 2008 or later and are still active.

To determine which of these clusters are most emergent, we further filter these clusters to those whose articles are also in new clusters in our co-citation model of science (not shown). Clusters are then ranked using a growth index. The locations of the top-20 emerging clusters for the year 2010 based on the growth index are shown in the map to the right. Emerging clusters can continue to be emergent in additional years if their growth characteristics are strong enough.

Interestingly, some emerging topics are based on scientific discoveries while others spring from technological innovation. Scientific discoveries are those where a new or unexpected finding is made or fundamental knowledge is gained. Technological innovations are those where existing science or technology is used to create new devices or capabilities that serve specific purposes. For the top-20 emerging areas in 2010, roughly one third of them (6) are based on technological innovations. The remainder are based on scientific discoveries.

Step 3: Highlight the BRIGHTEST Needles



Top-20 Emerging Topics in 2010

1 – iron-based superconductors
2 – swine flu (H1N1) pandemic
3 – spectrum sensing in cognitive radio
4 – graphene nanosheets and nanocomposites
5 – Horava-Lifshitz quantum gravity
6 – graphene oxide nanosheets
7 – induced pluripotent stem cells
8 – MapReduce framework
9 – signal recovery from compressed sensing
10 – graphene transistors and optical devices
11 – zigzag graphene nanoribbons
12 – cardiovascular events in type 2 diabetes
13 – transformative optics
14 – spectrum allocation in cognitive radio
15 – IDH1 and IDH2 mutations in cancer
16 – epitaxial graphene
17 – H1N1 pandemic and seasonal flu
18 – crystallographic validation
19 – social tagging
20 – mechanical properties of graphene

IX.9 *Identifying Emerging Topics in Science and Technology* - Kevin W. Boyack, Richard Klavans, and Henry G. Small - 2013

X.2 *Map of the Internet* - Martin Vargic - 2014

FACEBOOK
PINTEREST
MYSPACE
TWITTER
TUMBLR
BLOGSPOT
BING
YAHOO!
REDDIT
DIGG
WIKIA
WIKIPEDIA
TAGGED
ORKUT
ASK
DEVIANTART
4CHAN
GOOGLEPLUS
GMAIL
QUORA
9GAG
GOOGLE
DATA OCEAN
YOUTUBE
YANDEX
BUZZFEED
CHROME
INTERNET EXPLORER
IGN
VIMEO
GAMESPOT
RAPID SHARE
DROPBOX
THE CAPITOL
MOZILLA
OPERA
BLUEHOST
SAFARI
CONDUIT
MEGA
MEGA-UPLOAD
FLICKR
DESPICABLE SEA
SEA OF ARCHIVES
BITTORRENT
WAREZ
GO DADDY
HOST-GATOR
SOFTONIC
ANDROID
REDTUBE
HARDSEX TUBE
SEA
INFORMATION SEA
APP SEA
DEVELOPER
CNN
BBC
BRITANNICA
YELP
BOOKING
SOHU
163
360
BAIDU
MAIL.RU
SOSO
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RENREN
NETFLIX
VICE
NYTIMES
ATOS
MICROS
CONDUIT
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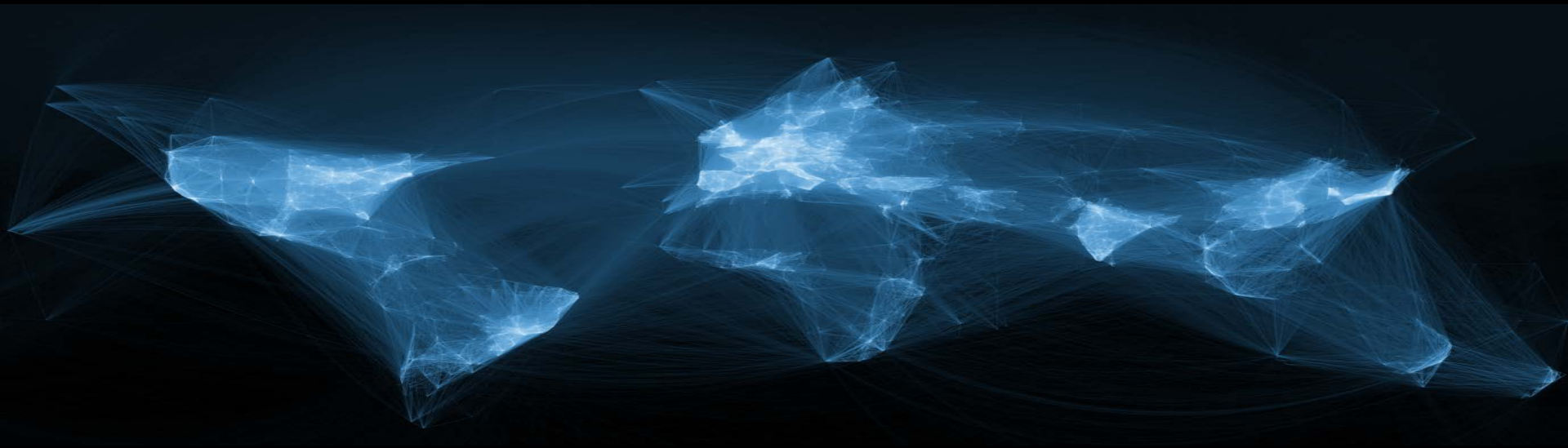
Increasing Data Visualization Literacy



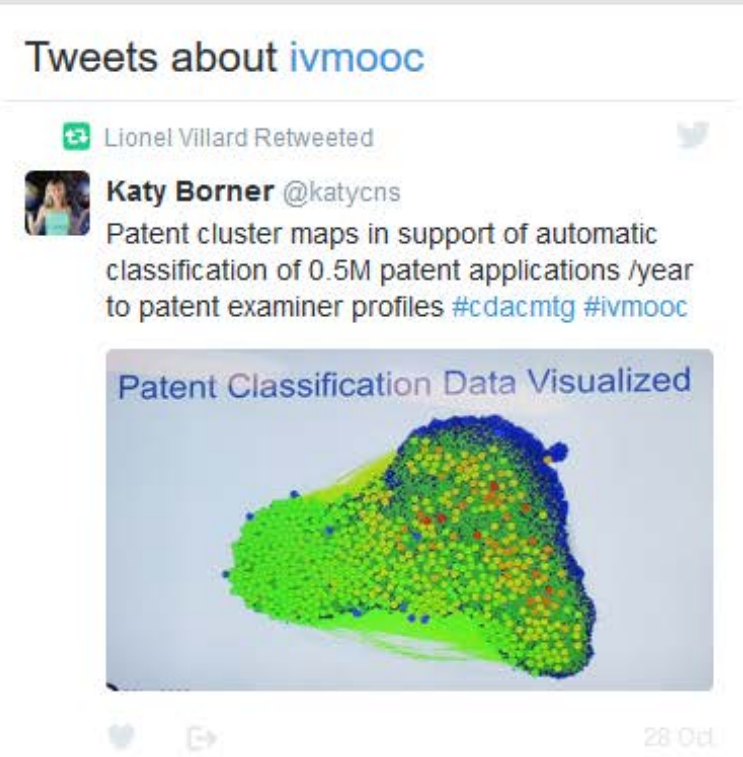
Data Visualization Literacy

Data visualization literacy (ability to read, make, and explain data visualizations) requires

- *literacy* (ability to read and write text, e.g., in titles, axis labels, legend),
- *visual literacy* (ability to find, interpret, evaluate, use, and create images and visual media), and
- *data literacy* (ability to read, create, and communicate data).

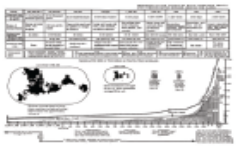
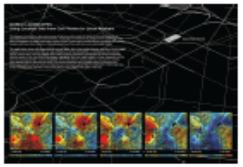
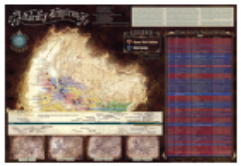
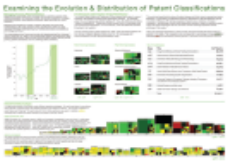
Information Visualization MOOC 2017

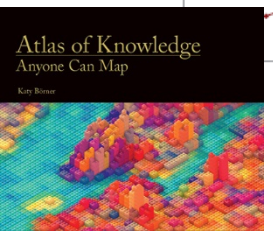
OVERVIEW | SCHEDULE | EVENTS | INSTRUCTORS | READINGS | GRADING | FAQ | CONTACT



The course can be taken for free or for Indiana University credits as part of the Online Data Science Program or the ILS M.S. program. Register for free at http://ivmooc.cns.iu.edu. Next class starts January 10, 2017.

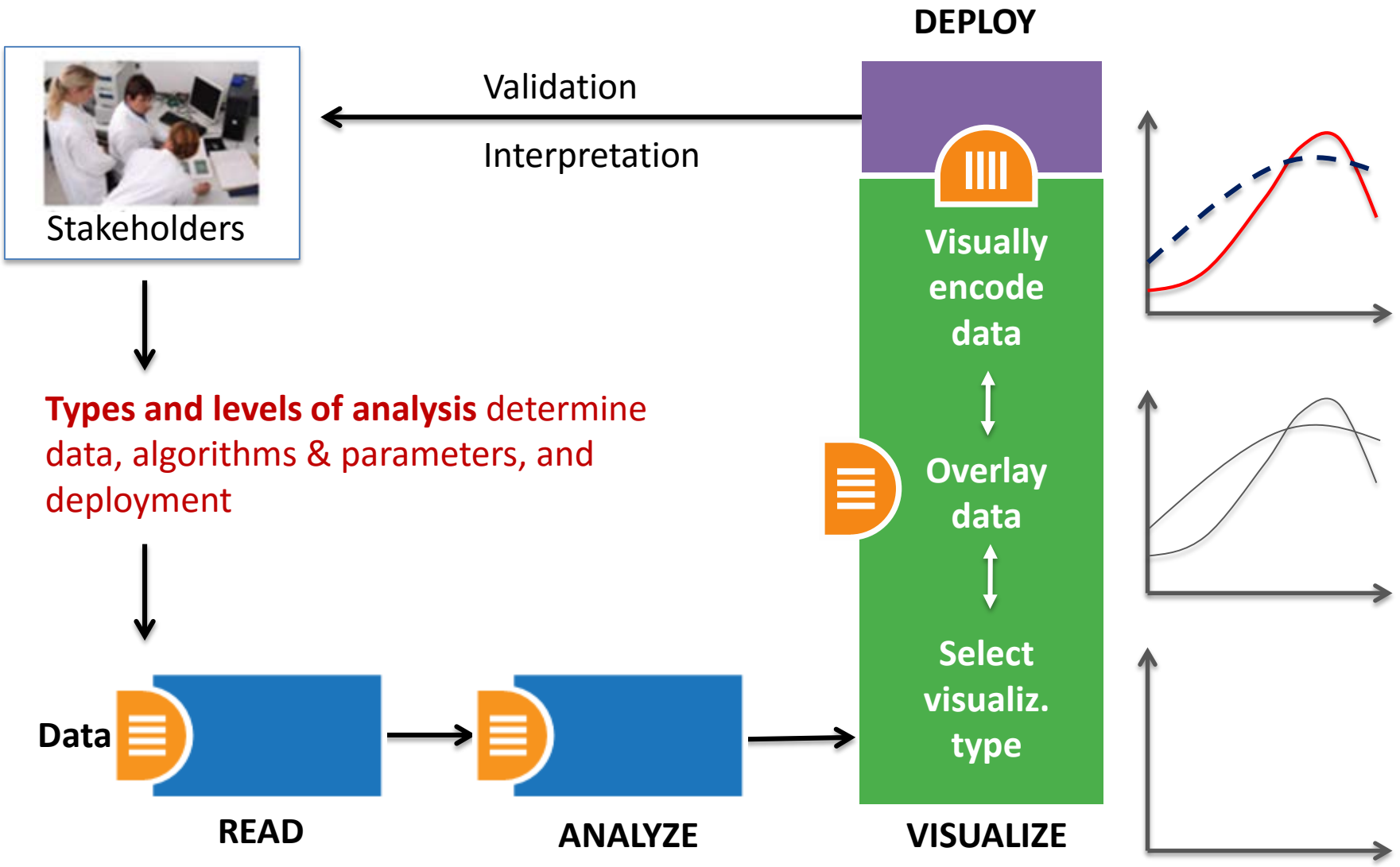
Tasks

TYPES	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
Statistical Analysis page 44	Knowledge Cartography page 135	Productivity of Russian life sciences research teams page 105	Number of 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 93
WITH WHOM: Network Analysis page 60	World Finance Corporation network page 87	Electronic and new media art networks page 133	World-wide scholarly collaboration networks page 157

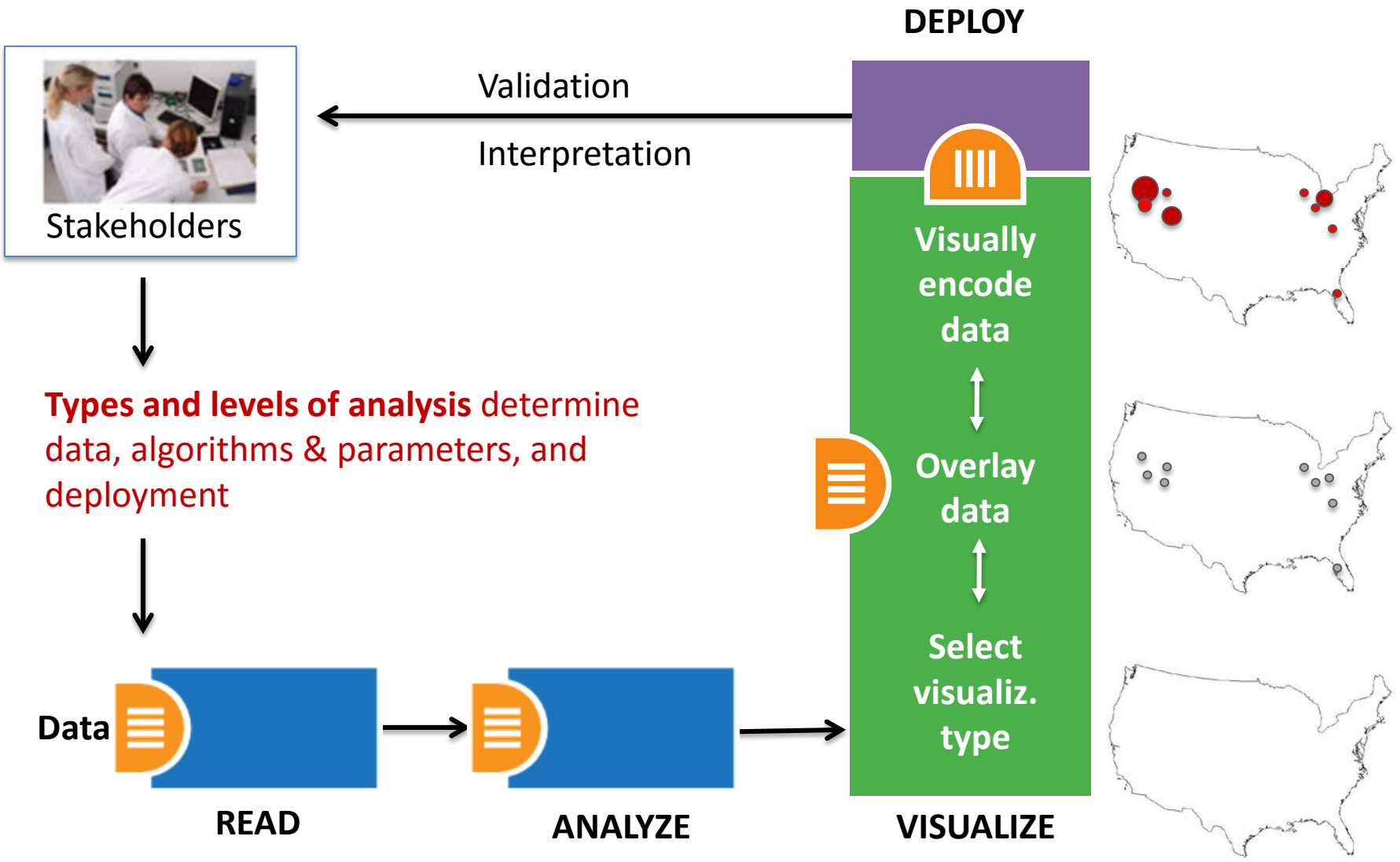


See page 5

Needs-Driven Workflow Design



Needs-Driven Workflow Design



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

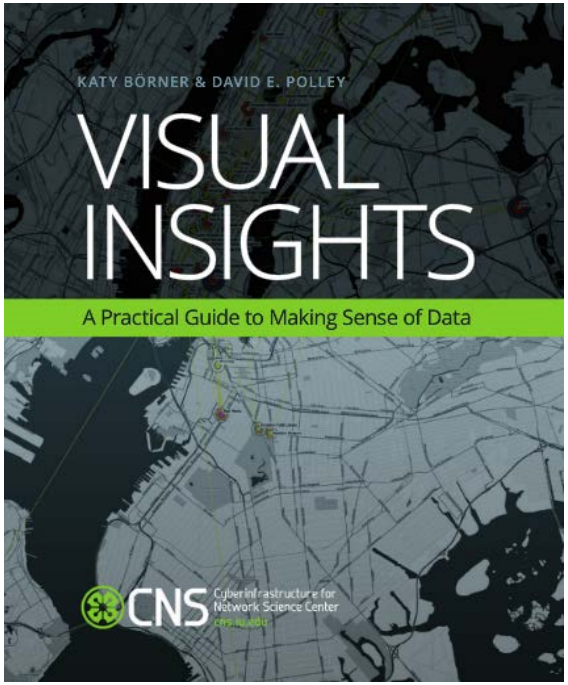
- **Session 5** – “With Whom:” Trees
- **Session 6** – “With Whom:” Networks
- **Session 7** – Dynamic Visualizations and Deployment

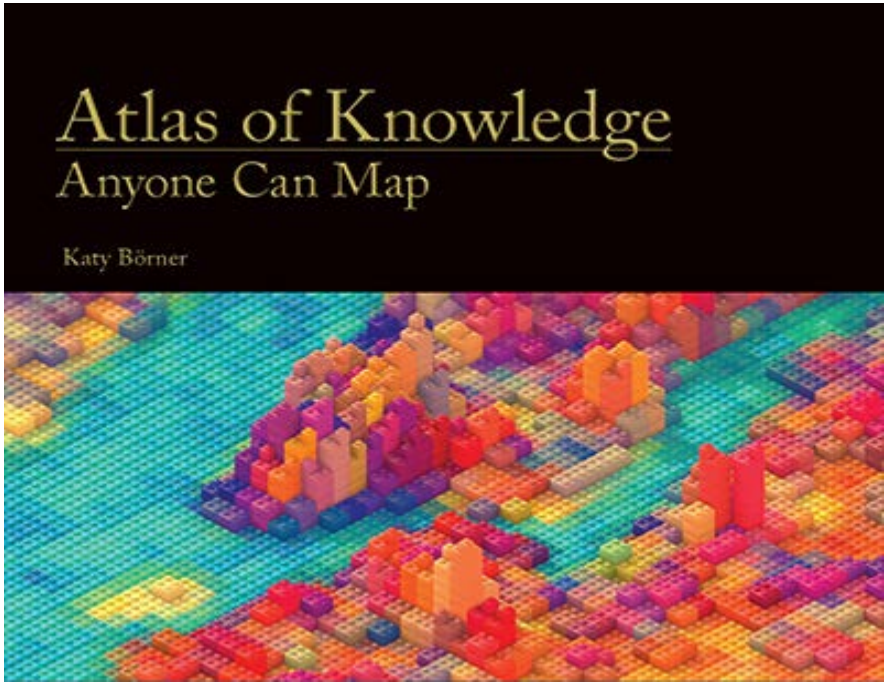
Final Exam

Part 2: Students work in teams on client projects.

Final grade is based on Homework (10%), Midterm (20%), Final Exam (30%), Client Project (30%), and Class Participation (10%).

Books Used in the IVMOOC





Teaches timely knowledge:

Advanced algorithms, tools, and hands-on workflows.

Teaches timeless knowledge:

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

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

Times Cited	Publication Year	City of Publisher	Country	Journal Title (Full)	Title	Subject Category	Authors
12	2011	NEW YORK	USA	COMMUNICATIONS OF THE ACM	Plug-and-Play Macroscopes	Computer Science	Borner, K
18	2010	MALDEN	USA	CTS-CLINICAL AND TRANSLATIONAL SCIENCE	Advancing the Science of Team Science	Research & Experimental Medicine	Falk-Krzesinski, HJ|Borner, K|Contractor, 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

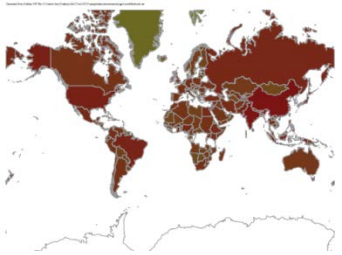
Statistical Analysis–p. 44

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

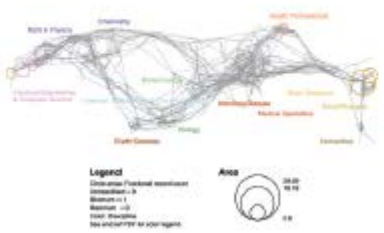
Geospatial Analysis–p. 52



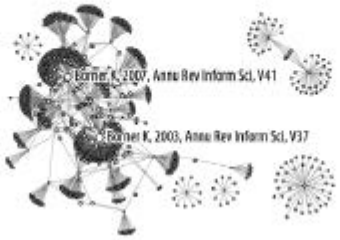
Load **One** File and Run **Many** Analyses and Visualizations

Times Cited	Publication Year	City of Publisher	Country	Journal Title (Full)	Title	Subject Category	Authors
12	2011	NEW YORK	USA	COMMUNICATIONS OF THE ACM	Plug-and-Play Macroscopes	Computer Science	Borner, K
18	2010	MALDEN	USA	CTS-CLINICAL AND TRANSLATIONAL SCIENCE	Advancing the Science of Team Science	Research & Experimental Medicine	Falk-Krzesinski, HJ|Borner, K|Contractor, 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

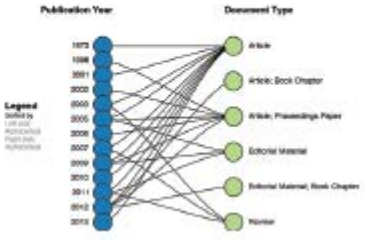
Topical Analysis–p. 56



Paper Citation Network–p. 60

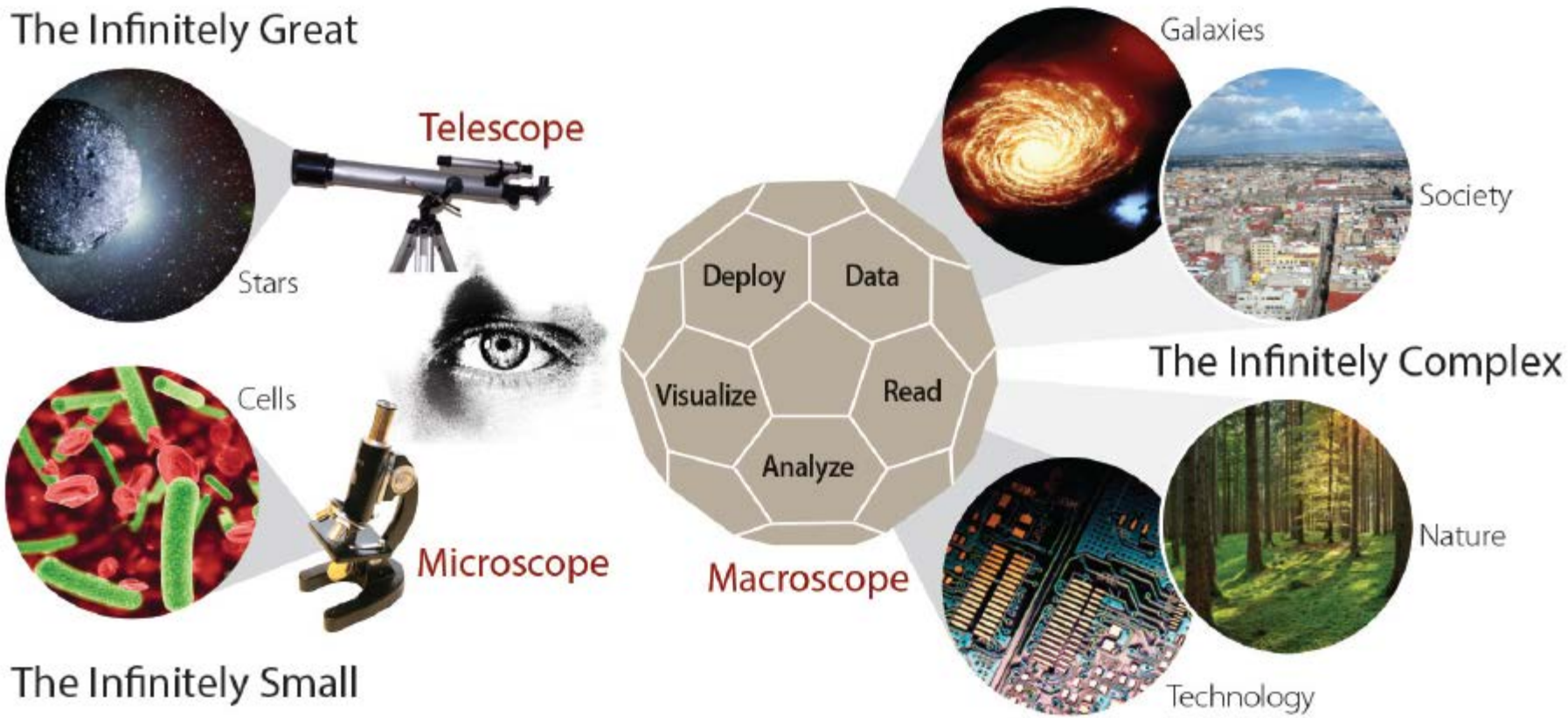


Bi-Modal Network–p. 60



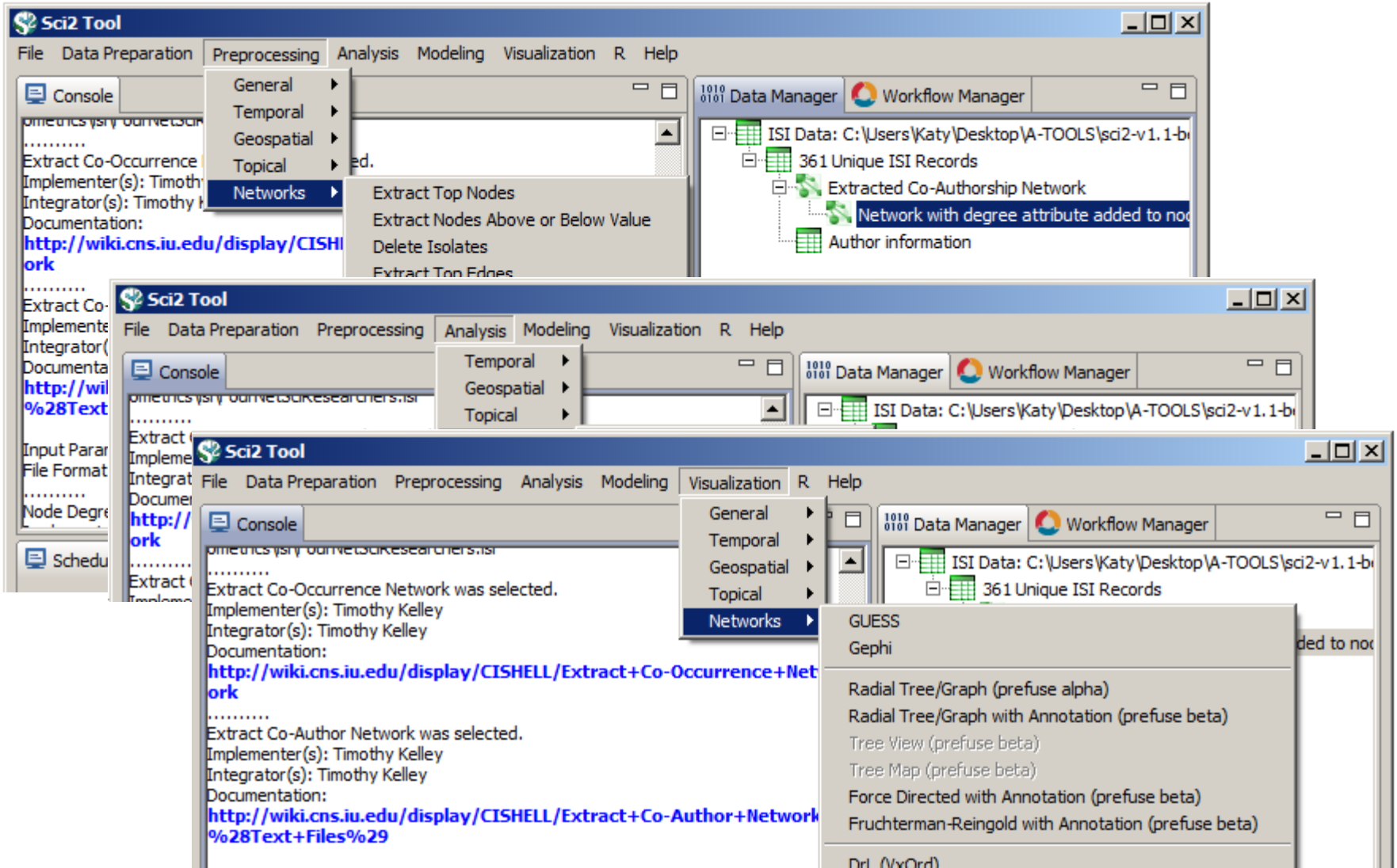
Co-author and many other bi-modal networks.

Microscopes, Telescopes, Macroscopes Plug-and-Play Macroscopes



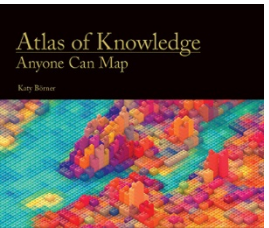
Sci2 Tool Interface Components

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



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
• categorize/cluster • order/rank/sort • distributions (also outliers, gaps) • comparisons • trends (process and time) • geospatial • compositions (also of text) • correlations/relationships	• nominal • ordinal • interval • ratio	• table • chart • graph • map • network layout	• geometric symbols point line area surface volume • linguistic symbols text numerals punctuation marks • pictorial symbols images icons statistical glyphs	• spatial position • retinal form color optics motion	• overview • zoom • search and locate • filter • details-on-demand • history • extract • link and brush • projection • distortion



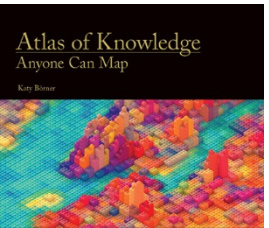
See page 24

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

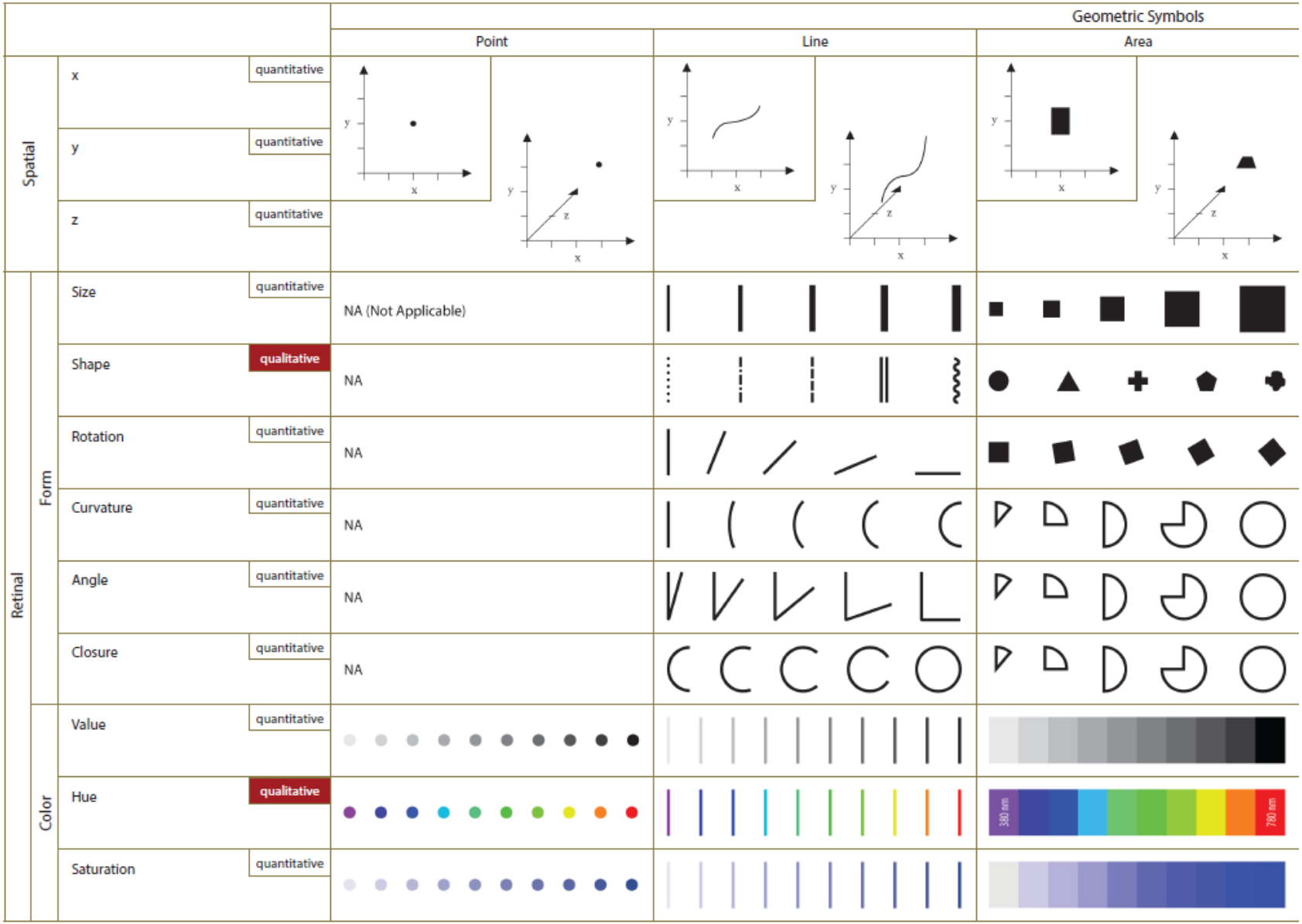
Visualization Framework

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
• categorize/cluster • order/rank/sort • distributions (also outliers, gaps) • comparisons • trends (process and time) • geospatial • compositions (also of text) • correlations/relationships	• nominal • ordinal • interval • ratio	• table • chart • graph • map • network layout	• geometric symbols point line area surface volume • linguistic symbols text numerals punctuation marks • pictorial symbols images icons statistical glyphs	• spatial position • retinal form color optics motion	• overview • zoom • search and locate • filter • details-on-demand • history • extract • link and brush • projection • distortion

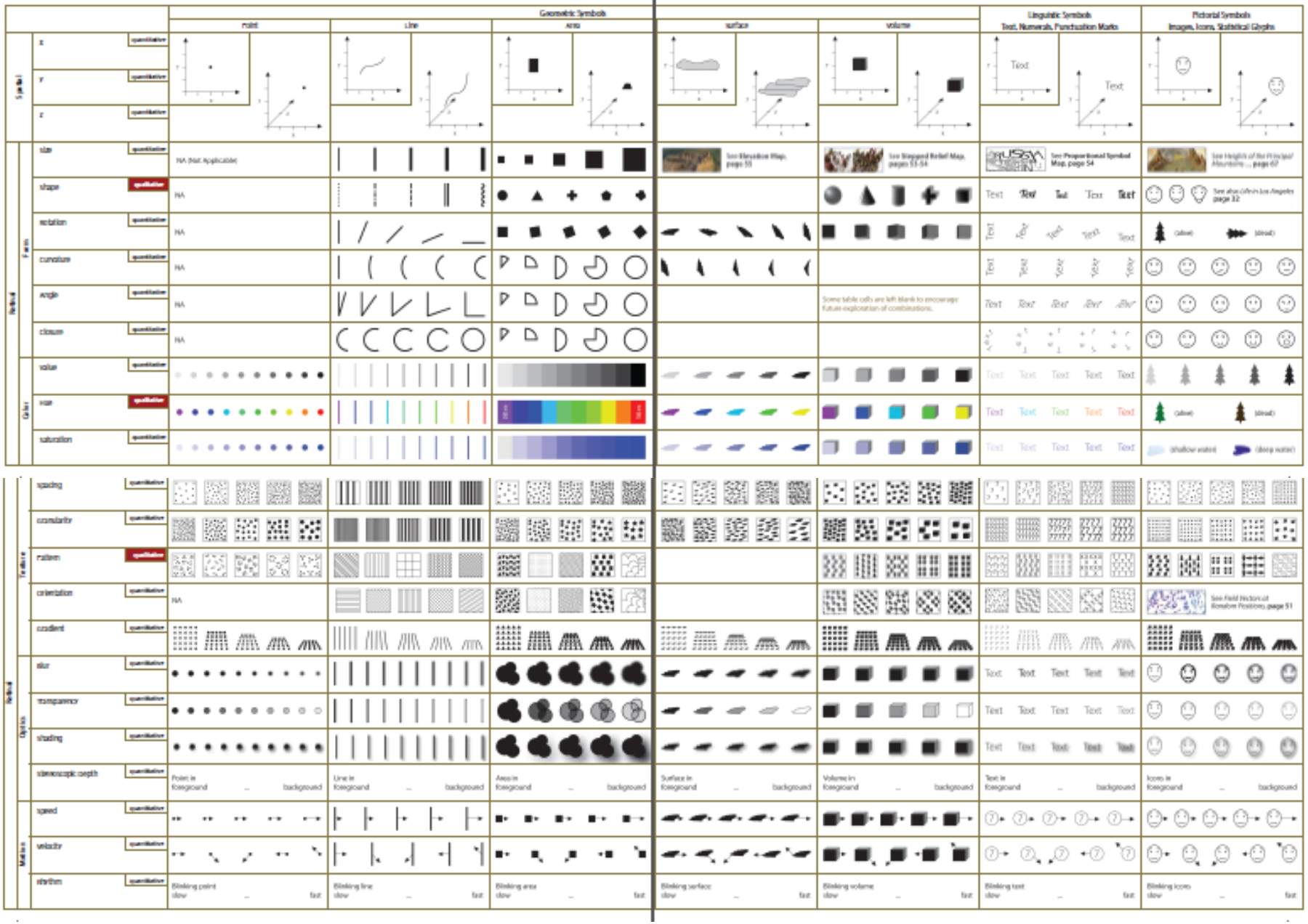


See page 24

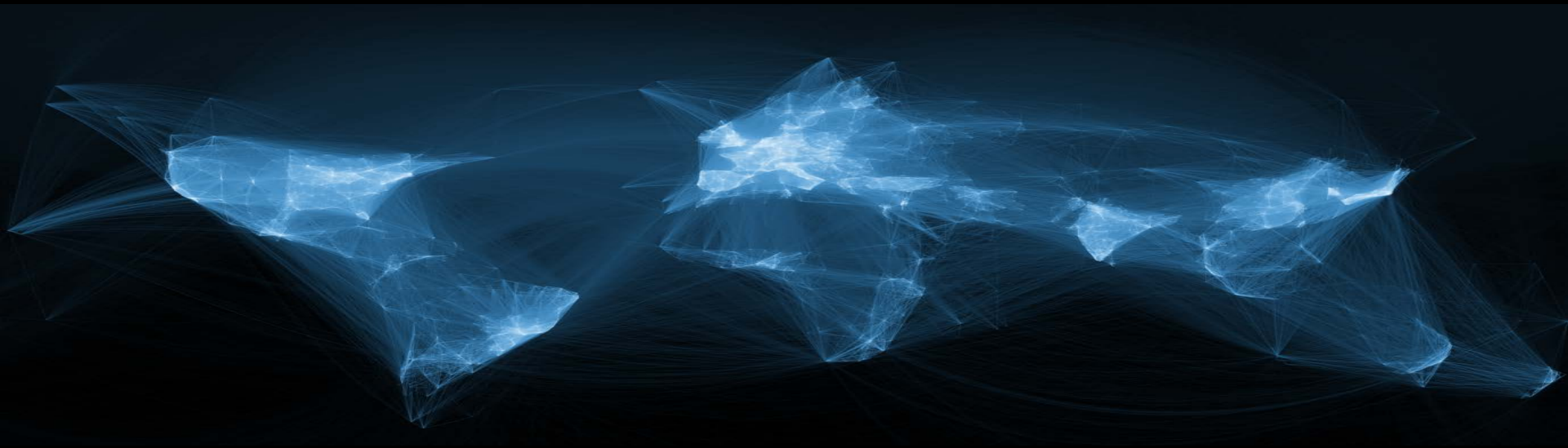
Graphic Variable Types Versus Graphic Symbol Types



Graphic Variable Types Versus Graphic Symbol Types

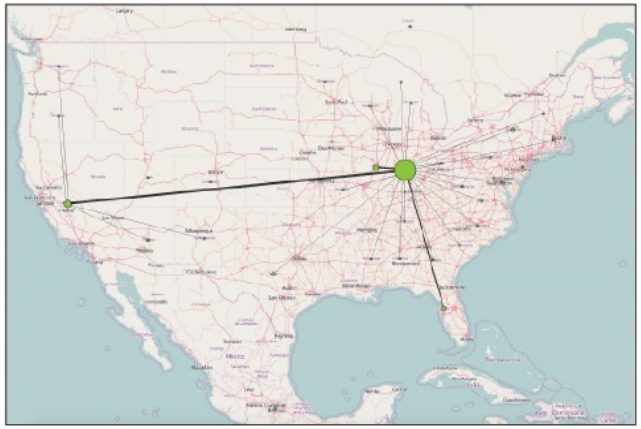


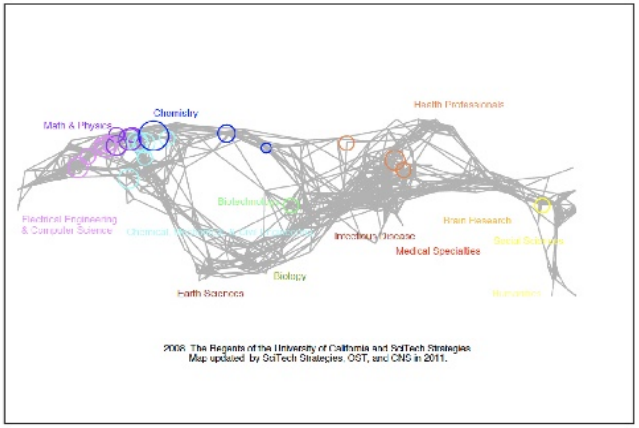
Visualizing Engineering Research Centers

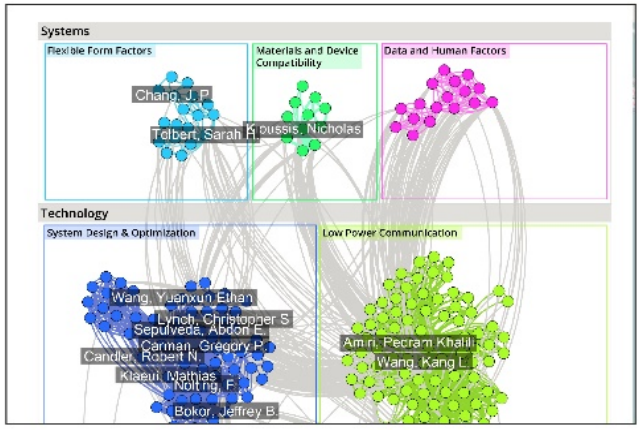


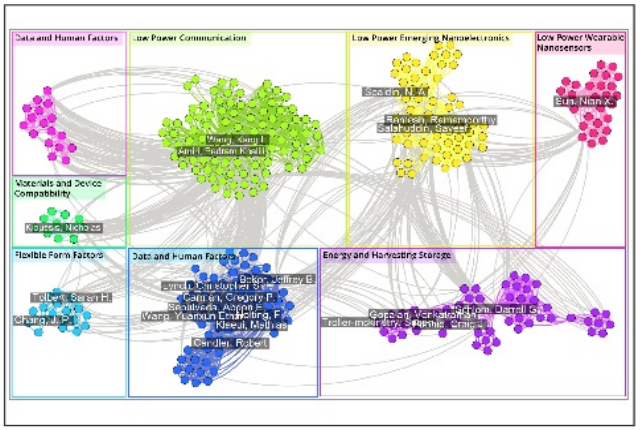
Engineering Research Observatory

CNS Team at ISE, IU and NanoHub team at Purdue U









TANMS Engineering Research Center
Evolving Co-Authorship Network
CNS @ Indiana University
2016

Displayed Year: 2012

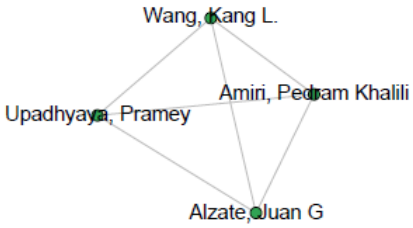
Legend
Nodes ~ Authors
Node area size ~ Number of papers published
Node color ~ Year of first paper

Edges ~ Co-authorship relations
Edge thickness ~ Number of times co-authored

Node Color Code
2012
2013
2014
2015
2016

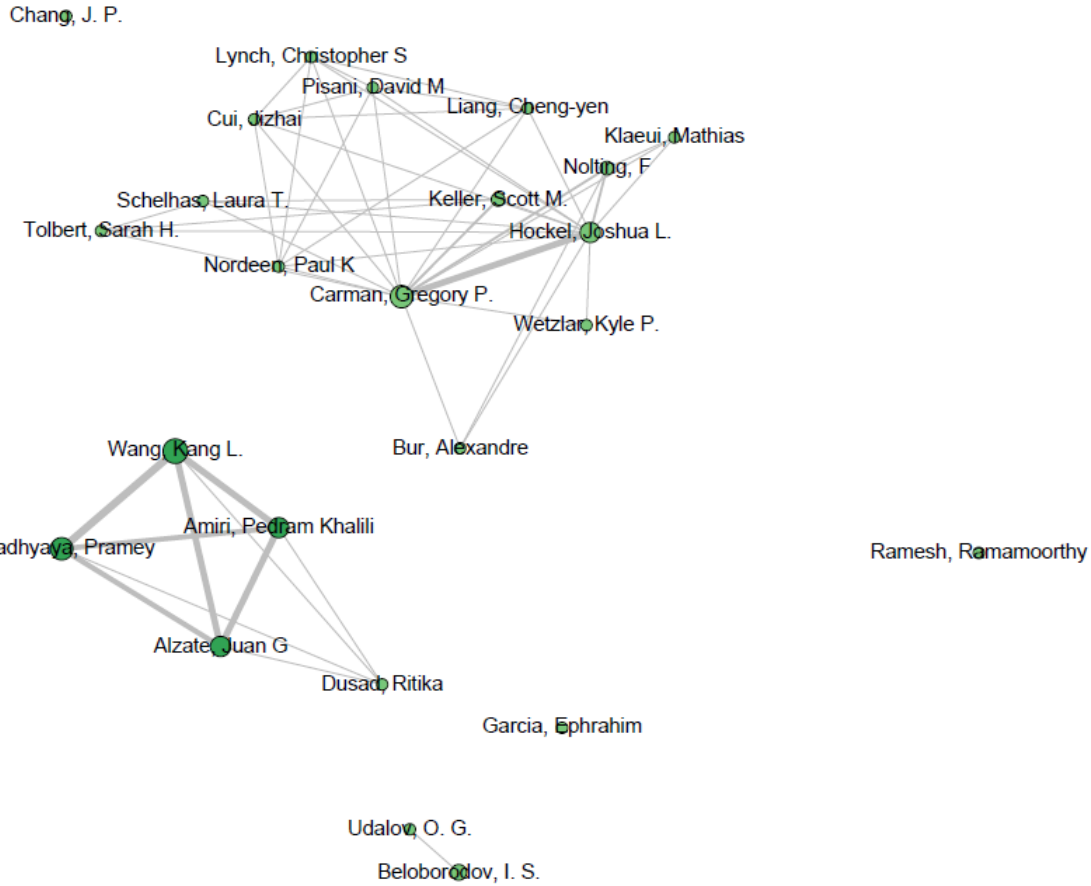
Node Area Size
47
16
1

Edge Thickness
29
14
1



TANMS Engineering Research Center
Evolving Co-Authorship Network
CNS @ Indiana University
2016

Displayed Year: 2013



Legend
Nodes ~ Authors
Node area size ~ Number of papers published
Node color ~ Year of first paper

Edges ~ Co-authorship relations
Edge thickness ~ Number of times co-authored

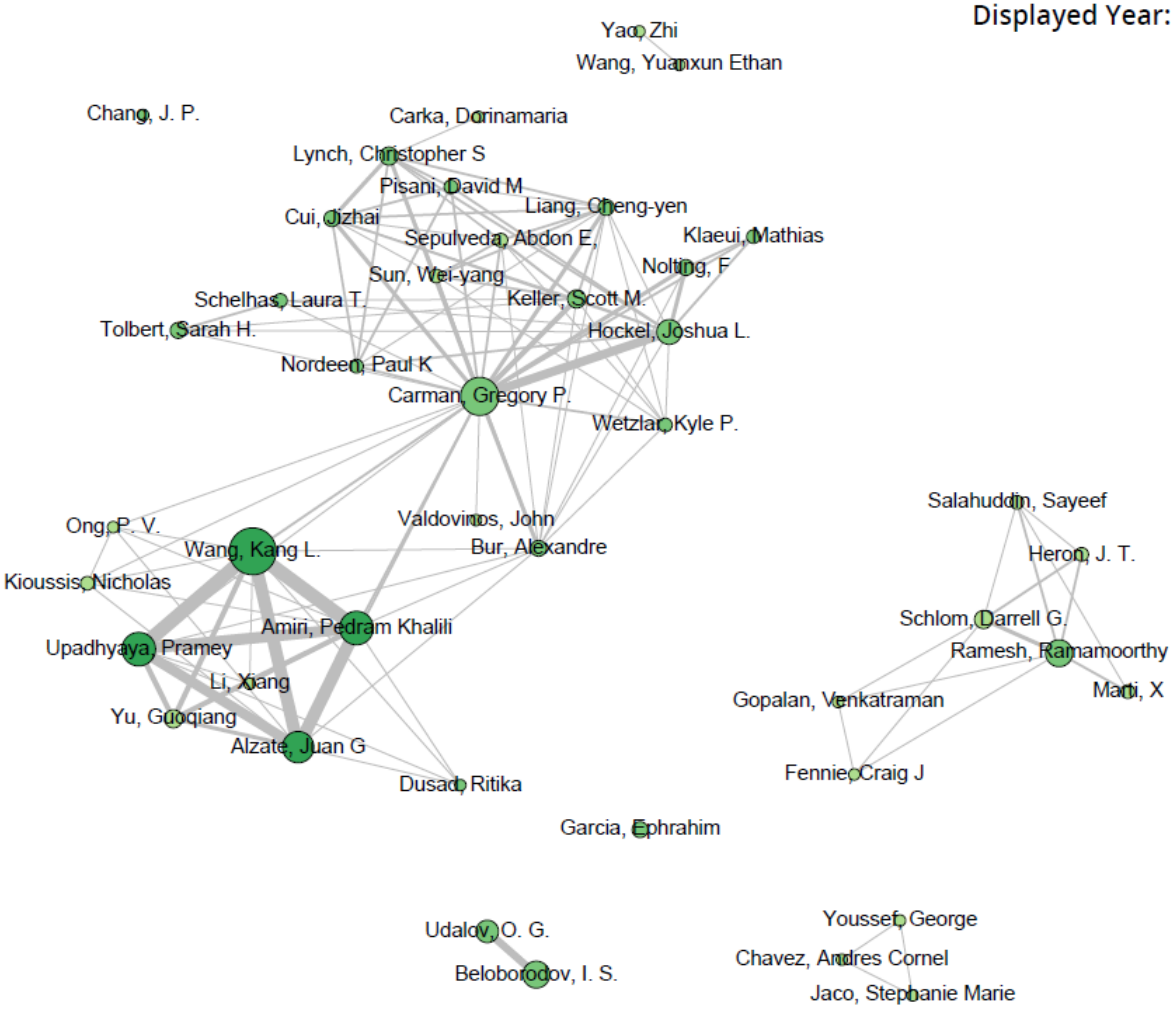
Node Color Code
2012
2013
2014
2015
2016

Node Area Size
47
16
1

Edge Thickness
29
14
1

TANMS Engineering Research Center
Evolving Co-Authorship Network
CNS @ Indiana University
2016

Displayed Year: 2014



Legend
Nodes ~ Authors
Node area size ~ Number of papers published
Node color ~ Year of first paper

Edges ~ Co-authorship relations
Edge thickness ~ Number of times co-authored

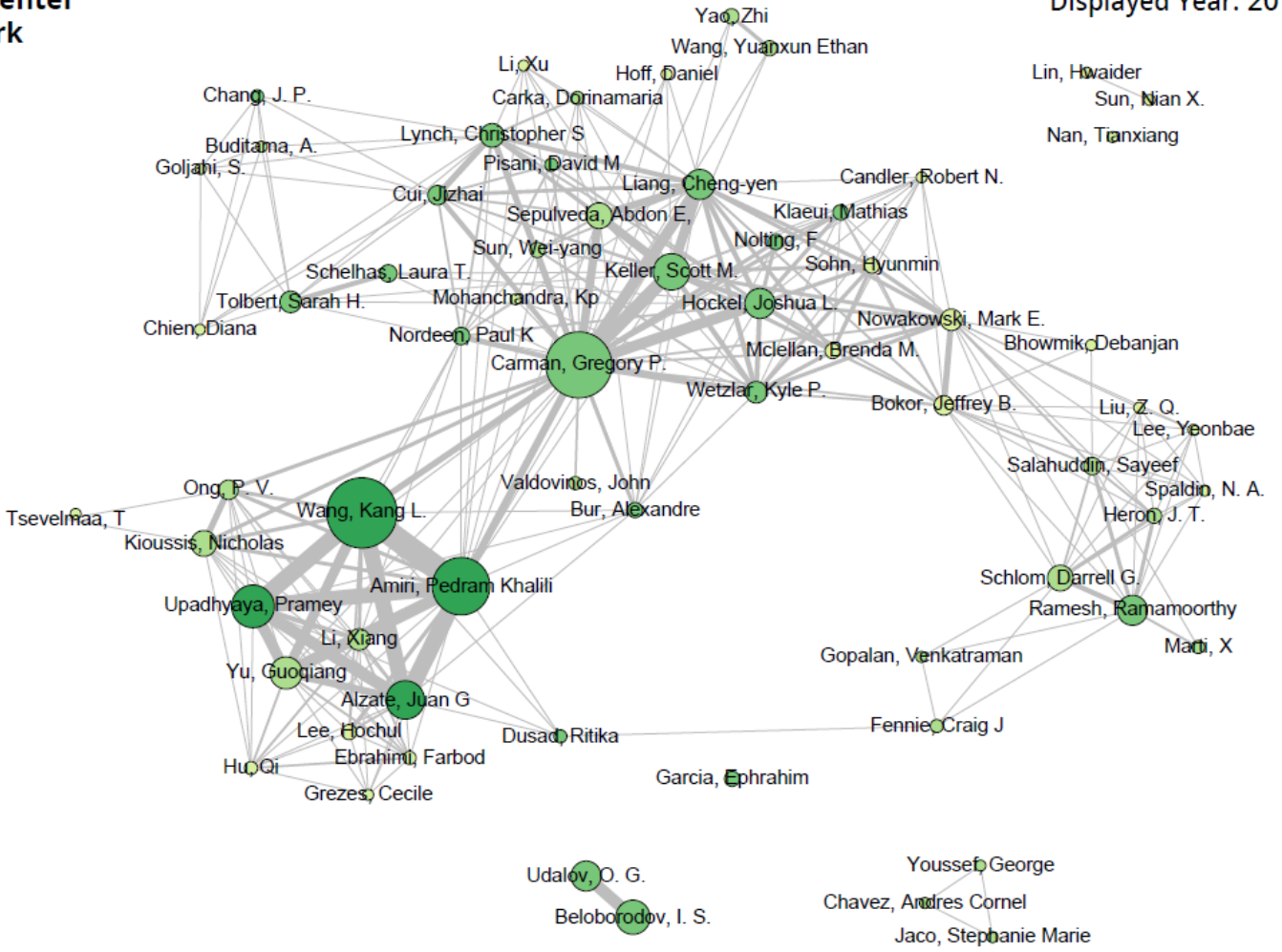
Node Color Code
2012
2013
2014
2015
2016

Node Area Size
47
16
1

Edge Thickness
29
14
1

TANMS Engineering Research Center
Evolving Co-Authorship Network
CNS @ Indiana University
2016

Displayed Year: 2015



Legend
Nodes ~ Authors
Node area size ~ Number of papers published
Node color ~ Year of first paper

Edges ~ Co-authorship relations
Edge thickness ~ Number of times co-authored

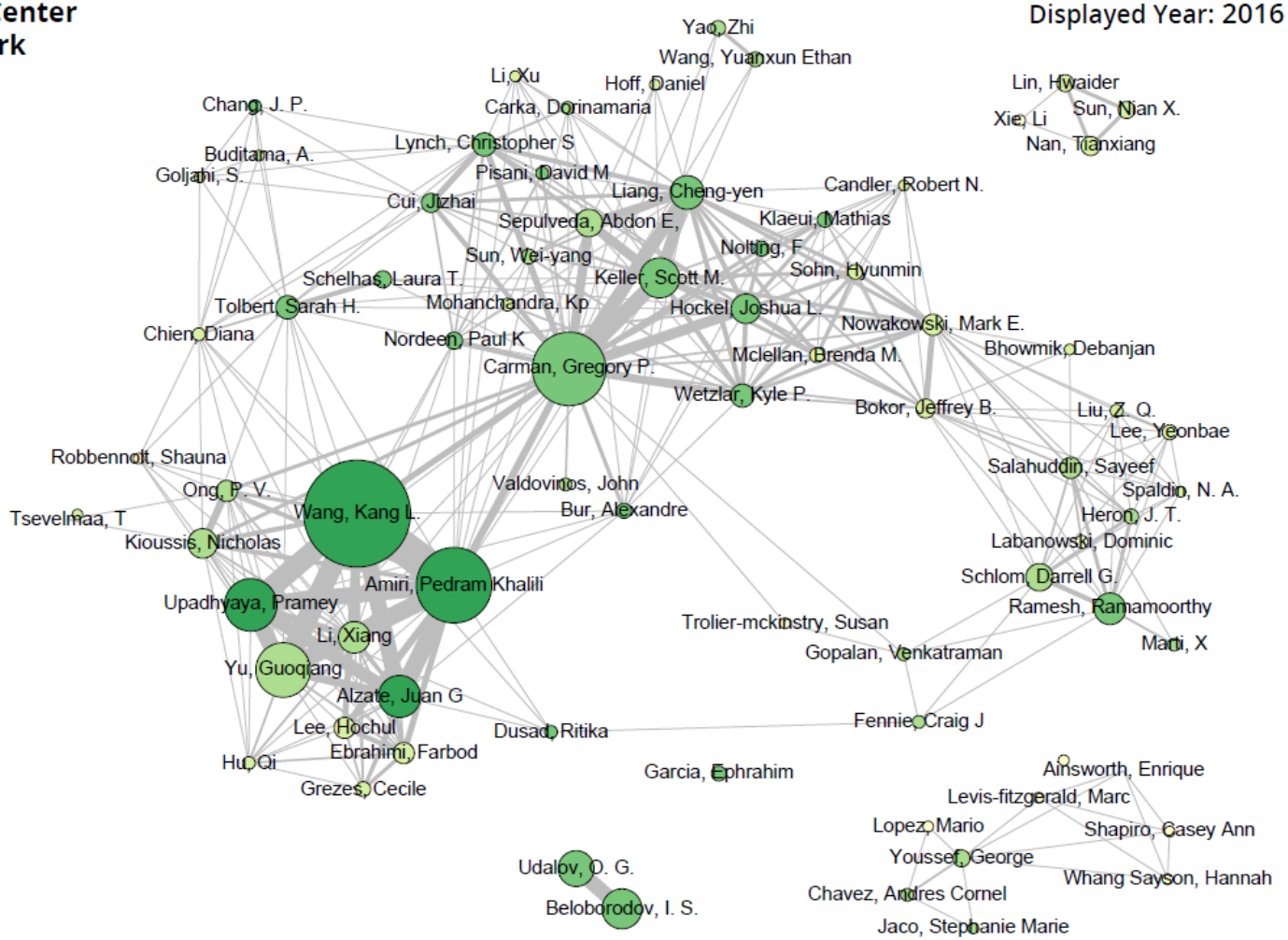
Node Color Code
2012
2013
2014
2015
2016

Node Area Size
47
16
1

Edge Thickness
29
14
1

TANMS Engineering Research Center
Evolving Co-Authorship Network
CNS @ Indiana University
2016

Displayed Year: 2016



Legend
Nodes ~ Authors
Node area size ~ Number of papers published
Node color ~ Year of first paper

Edges ~ Co-authorship relations
Edge thickness ~ Number of times co-authored

Node Color Code
2012
2013
2014
2015
2016

Node Area Size
47
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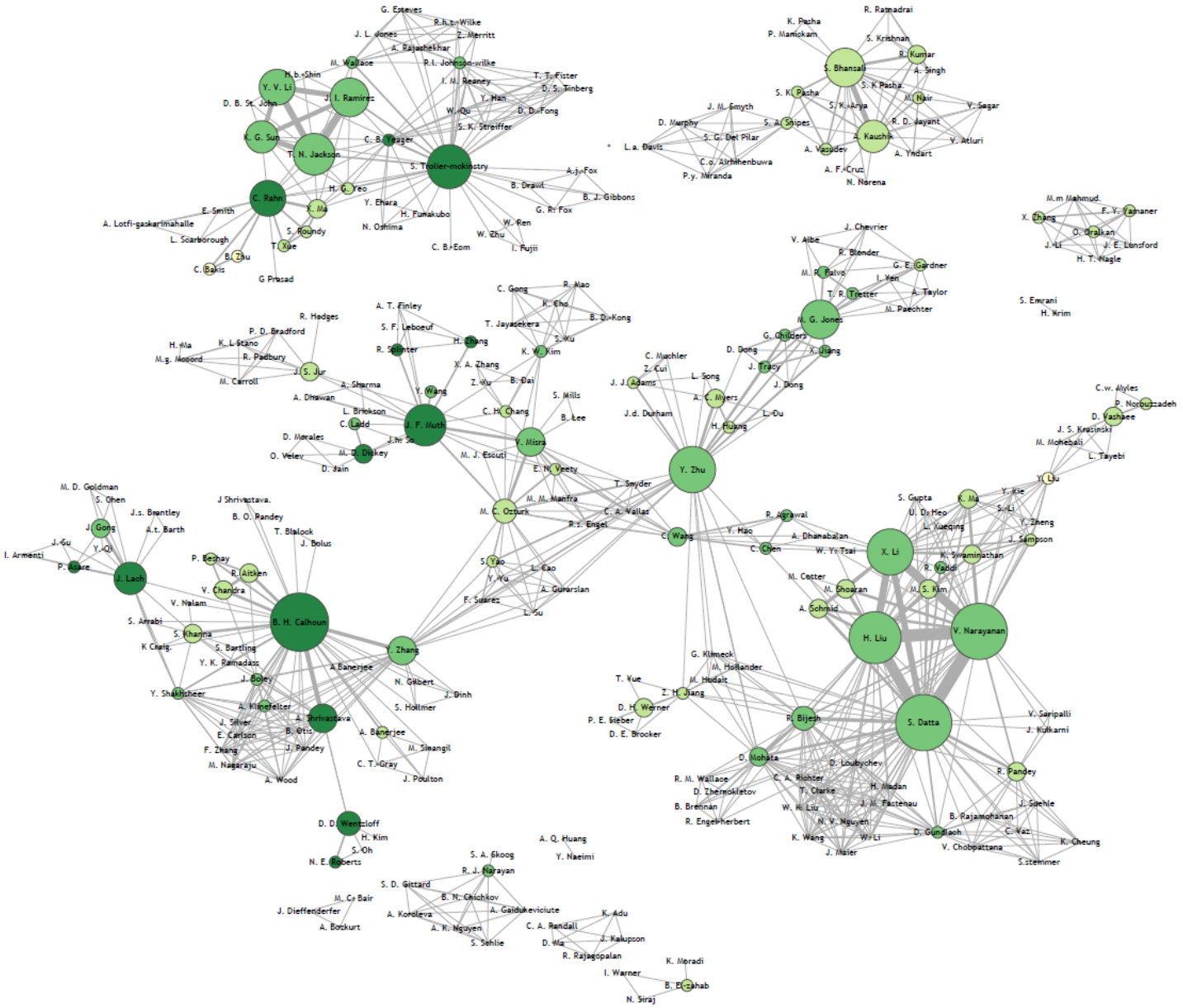
Edge Thickness
29
14
1



Legend

Nodes ~ Authors
Node area size ~ Number of papers published
Node color ~ Year of first paper

Edges ~ Co-authorship relations
Edge thickness ~ Number of times co-authored

Node Color Code

2012
2013
2014
2015

Node Area Size

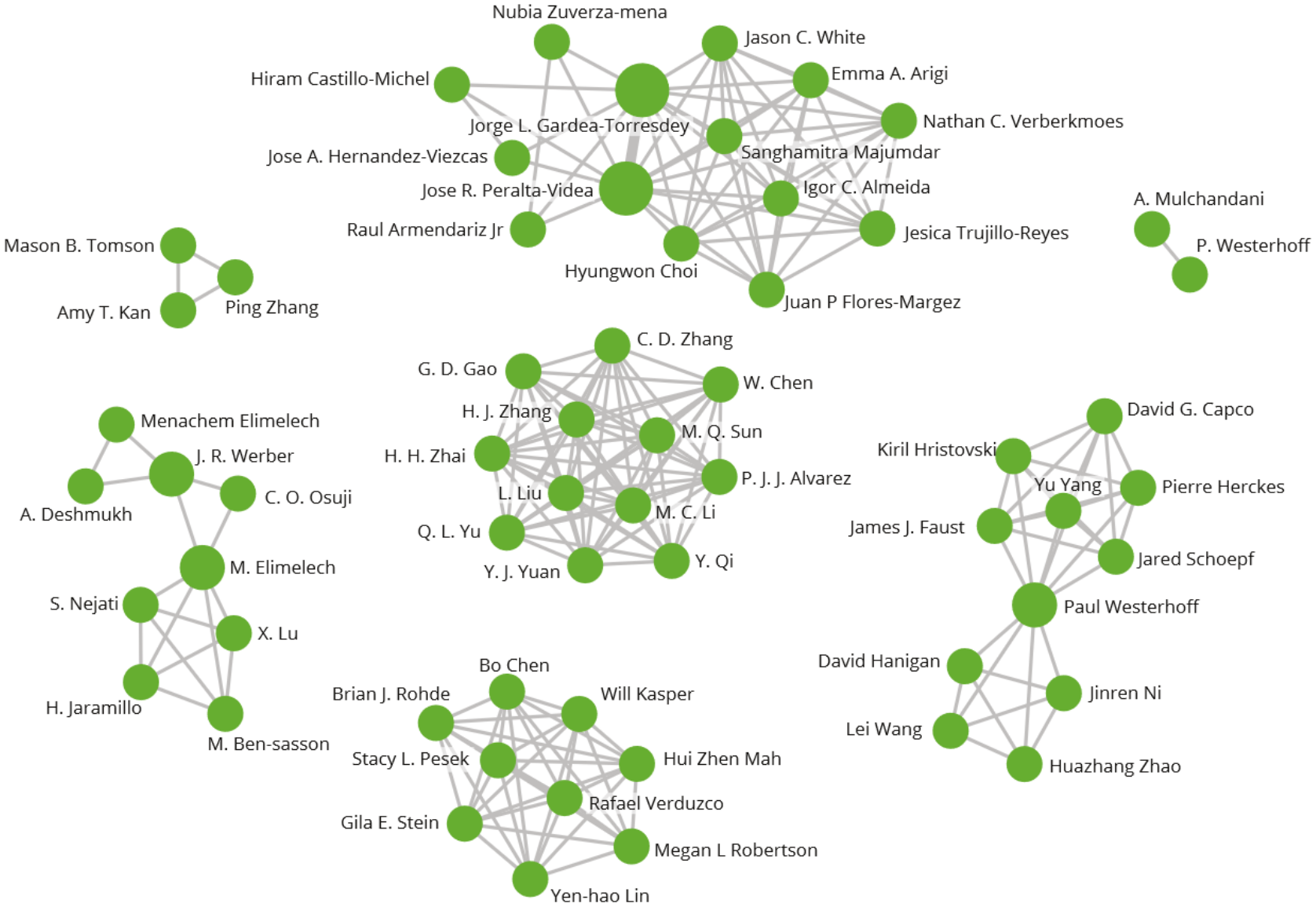
19
4
1

Edge Thickness

14
7
1

Displayed Year: 2015

ASSIST Engineering Research Center
Evolving Co-Authorship Network
CNS @ Indiana University
2016



Legend

Node area size

3
1

Number of papers published

Edge weight

3
1

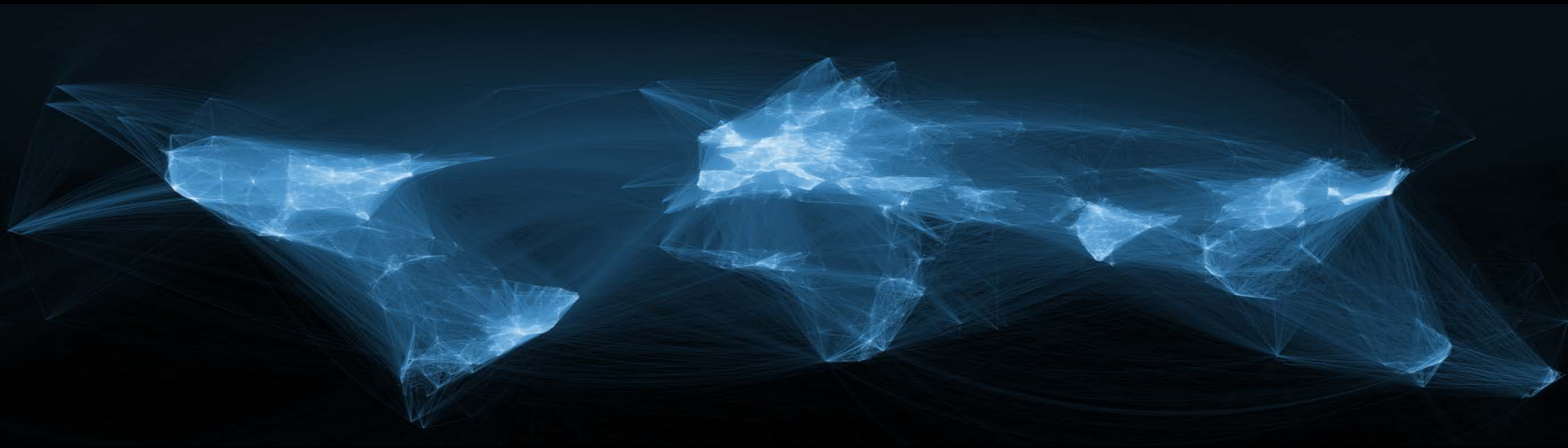
Number of papers co-authored

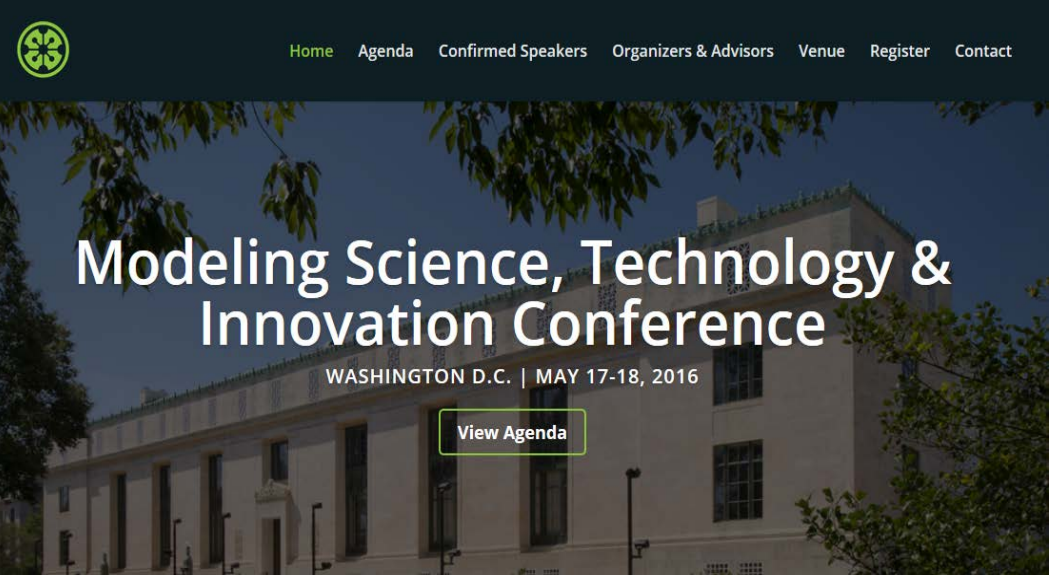
NEWT Co-authorship for 2015 - 2016

CNS @ Indiana University

2016

Modelling S&T Developments





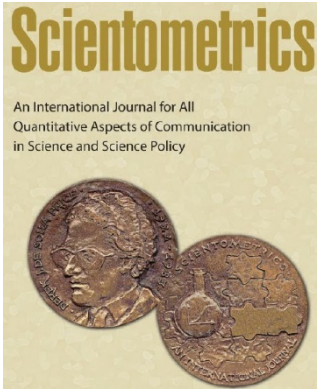
Government, academic, and industry leaders discussed challenges and opportunities associated with using big data, visual analytics, and computational models in STI decision-making.

Conference slides, recordings, and report are available via http://modsti.cns.iu.edu/report

Special Issue of *Scientometrics*:

Simulating the Processes of Science, Technology, and Innovation

Bruce Edmonds, Andrea Scharnhorst, Katy Börner & Staša Milojević (Editors)



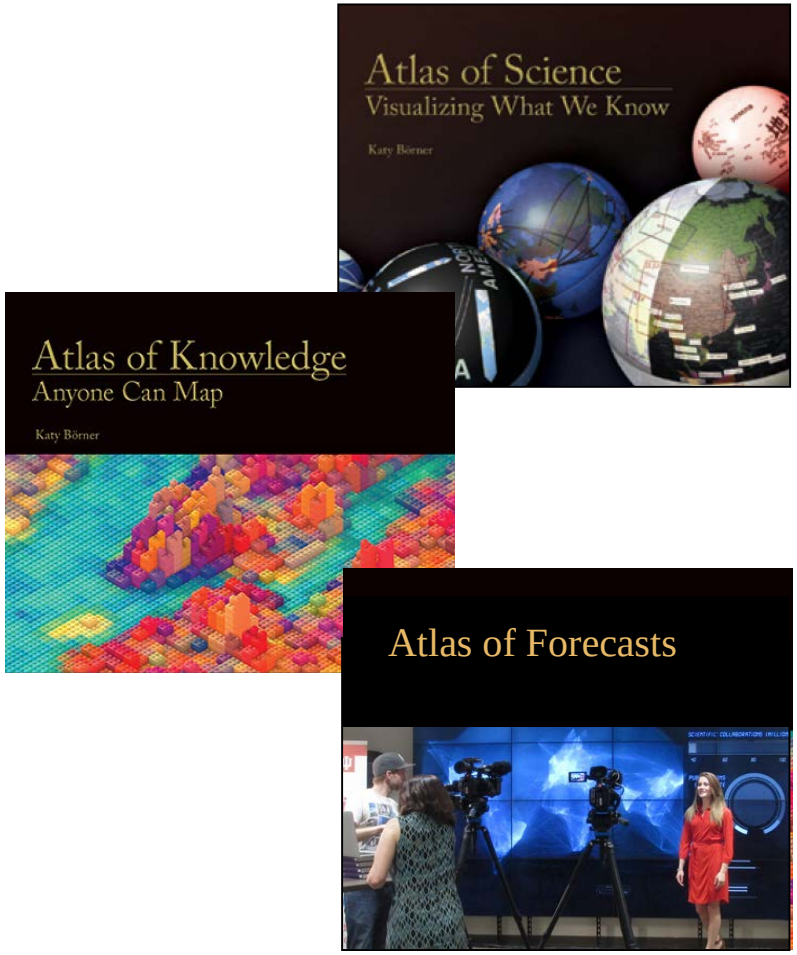
- ***Rogier De Langhe:*** Towards the Discovery of Scientific Revolutions in Scientometric Data
- ***Sabine Brunswicker, Sorin Matei, Michael Zentner, Lynn Zentner and Gerhard Klimeck:*** Creating Impact in the Digital Space: Digital Practice Dependency in Scientific Developer Communities
- ***Johan Bollen et al.:*** An Efficient System to Fund Science: From Proposal Review to Peer-to-Peer Distributions
- ***Petra Ahrweiler:*** Agent-based Simulation for Science, Technology and Innovation Policy
- ***David Chavalarias:*** What's Wrong With Science? Modeling Collective Discovery Processes With the Nobel Game
- ***Jeff Alstott, Giorgio Triulzi, Bowen Yan and Jianxi Luo:*** Mapping Technology Space by Normalizing Patent Technology Networks

Atlas Trilogy

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

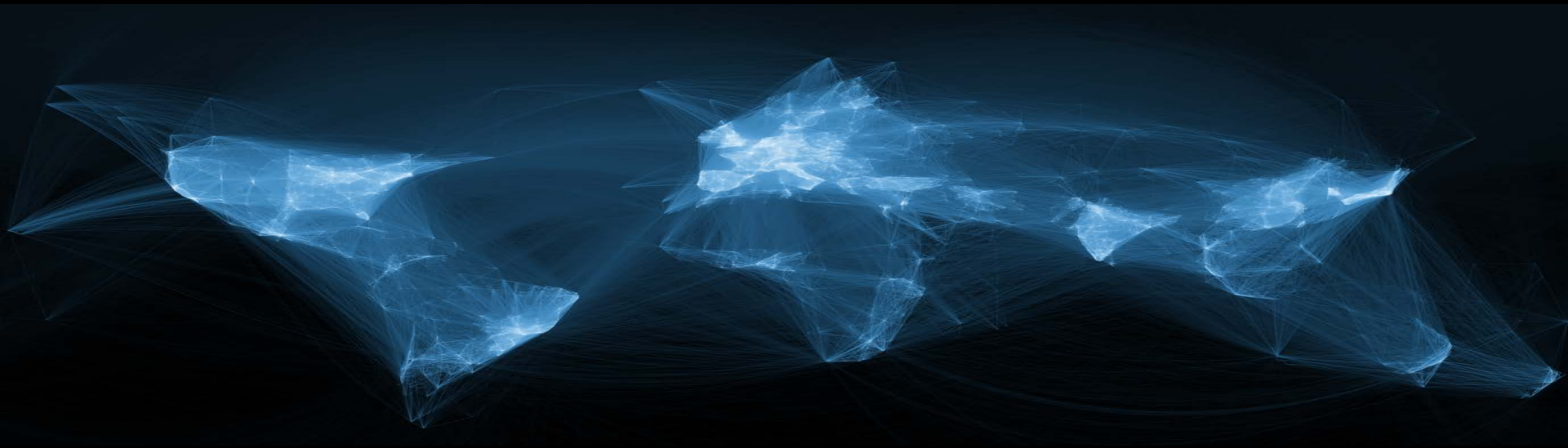
Börner, Katy (2015) **Atlas of Knowledge: Anyone Can Map**. The MIT Press.
http://scimaps.org/atlas2

Börner, Katy (2020) **Atlas of Forecasts: Predicting and Broadcasting Science, Technology, and Innovation**. The MIT Press.



Upcoming Sackler Colloquium on "**Modelling and Visualizing Science and Technology Developments**" will take place in December 2017 at the Beckman Center, Irvine, CA.

Communicating S&T Development to Different Audiences



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

PLACES & SPACES
MAPPING SCIENCE

Curated by the Cyberinfrastructure for Network Science Center

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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 Macroscope Tools for the *Places & Spaces: Mapping Science* Exhibit (2017) http://scimaps.org/call

Background and Goals

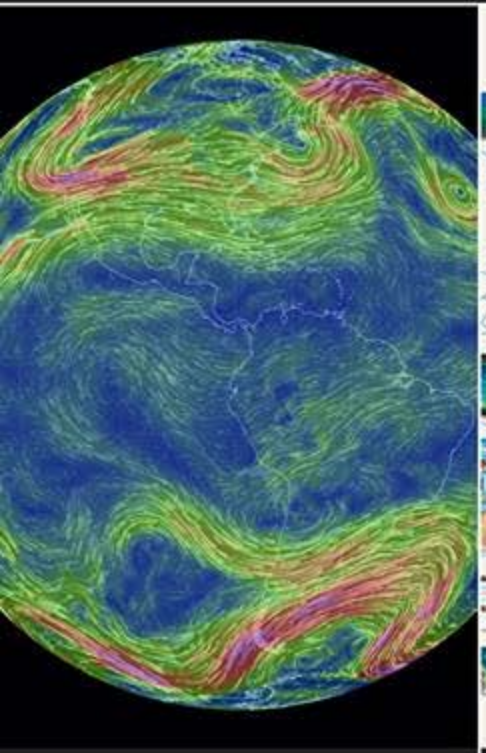
The *Places & Spaces: Mapping Science* exhibit was created to in
communicate human activity and scientific progress on a glol
that enable the close inspection of large-scale maps in public
conferences; (2) novel, interactive macroscope tools that let

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

MACROSCOPES FOR INTERACTING WITH SCIENCE

PLACES & SPACES
MAPPING SCIENCE
scimaps.org



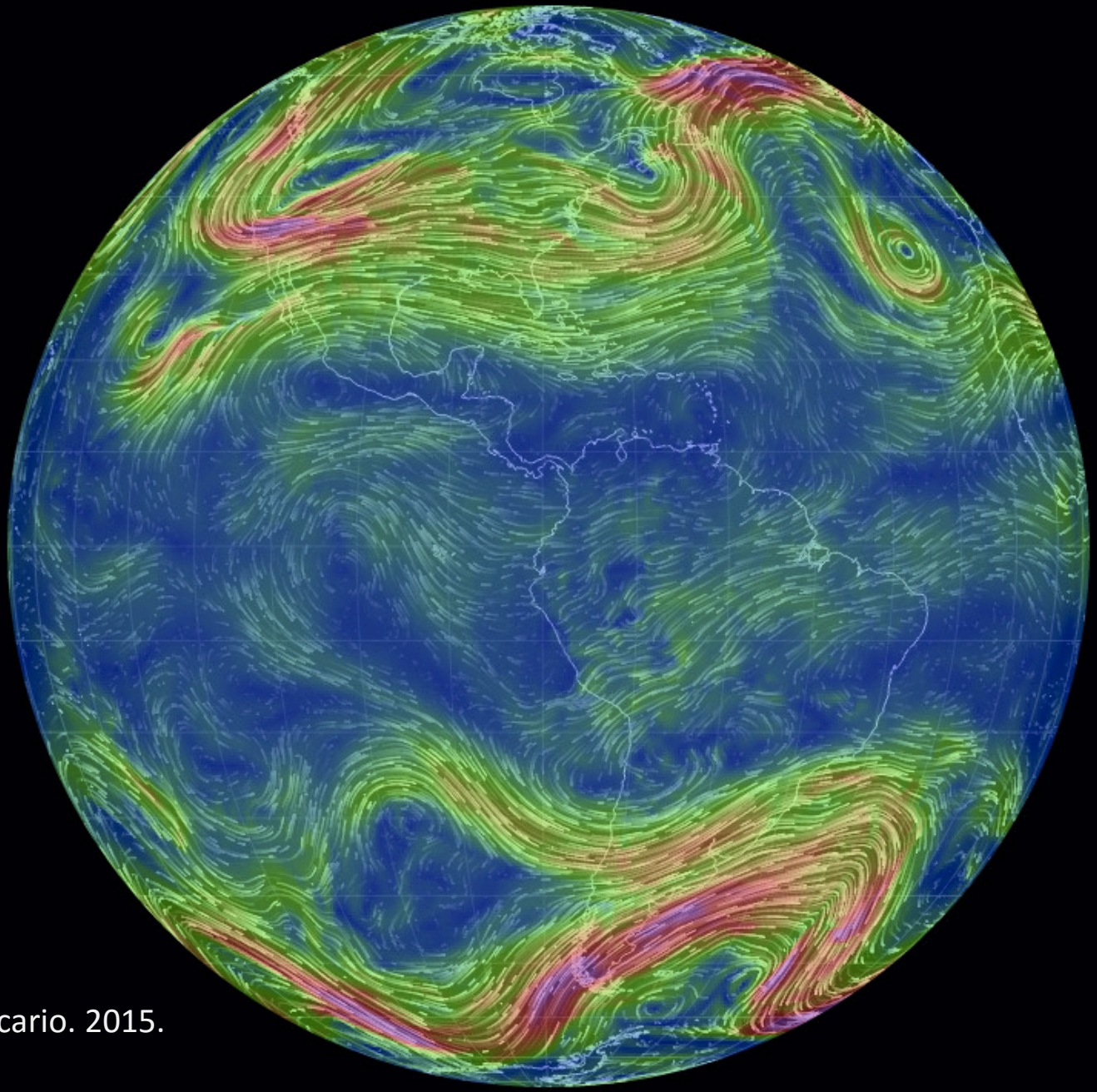
Earth

AcademyScope

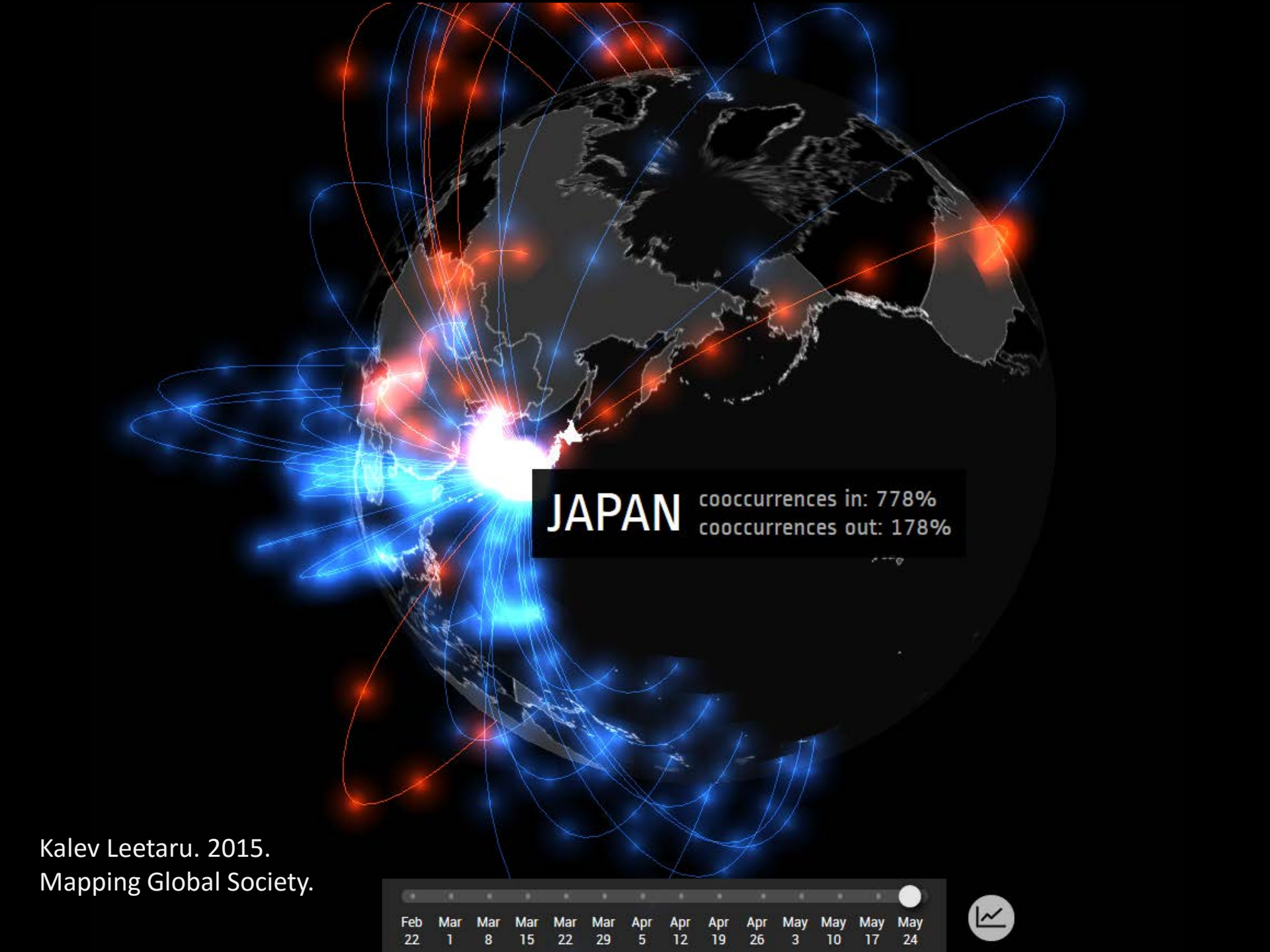
Mapping Global Society

Charting Culture

http://scimaps.org/iteration/11



Cameron Beccario. 2015.
Earth.



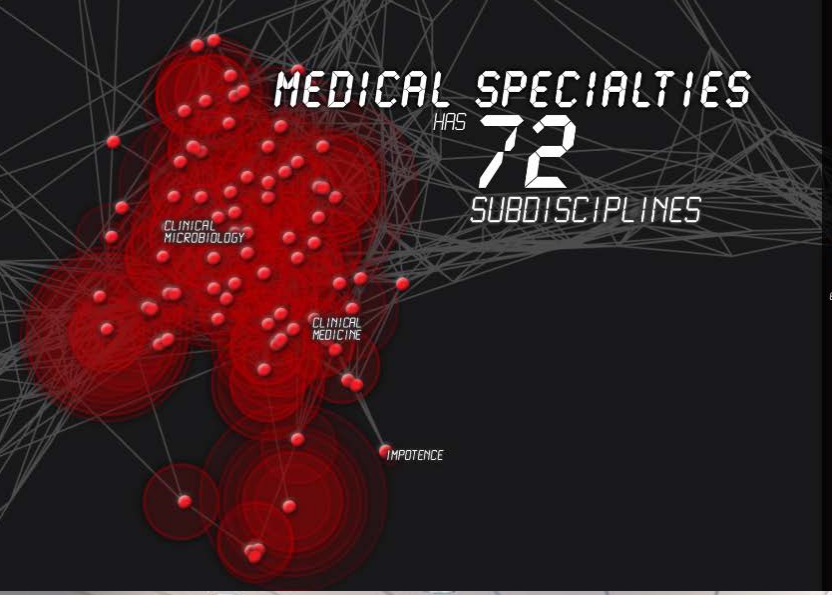
Kalev Leetaru. 2015.
Mapping Global Society.

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

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

Maps of Health Exhibit
David J. Sencer CDC Museum
Atlanta, GA

Jan 25-Jun 17, 2016



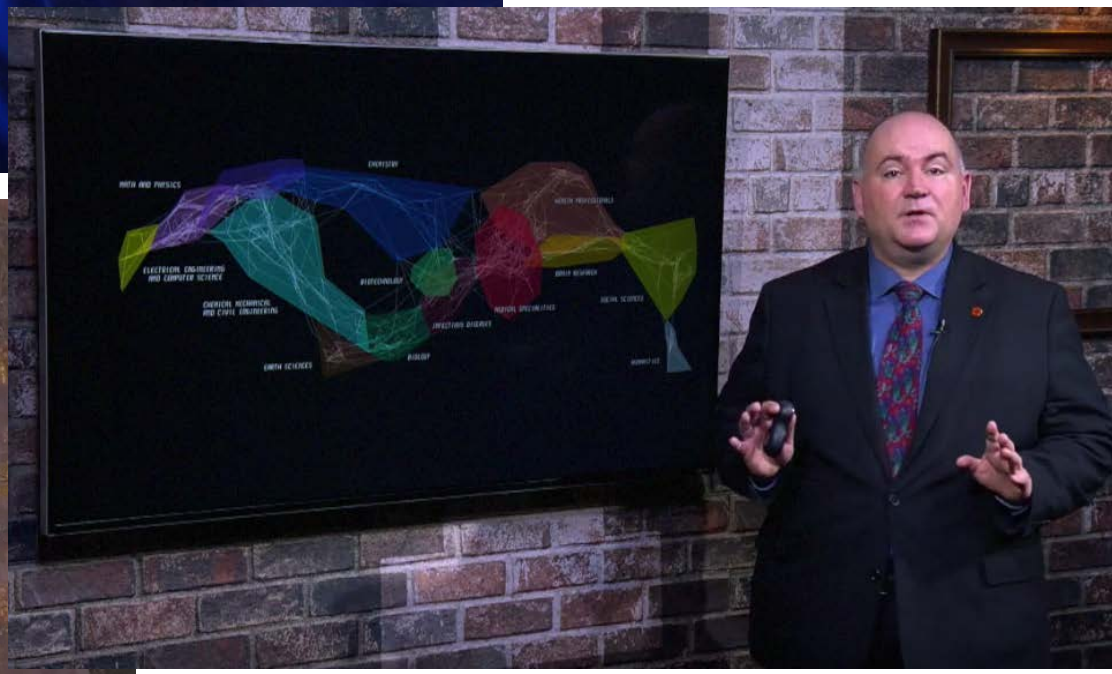
Science Forecast S1:E1, 2015

Dr. Johan Bollen

Science Forecast S1:E2, 2016

Dr. Rob Porter

Science Forecast
S1:E3, 2016



Dr. Bernice Pescosolido

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

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